International Journal of Advanced Technology in Civil Engineering

Volume 1 | Issue 2 Article 5

April 2012

Accident Analysis and Prediction of Model on National Highways

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Abstract **-** Rapid growth of population coupled with increased economic activities has favored in tremendous growth of motor vehicles. This is one of the primary factors responsible for road accidents. It is observed that few works have been carried out on statistical analysis of accidents particularly on two-lane National Highways.

For this paper stretch of NH-77 has been selected from Hajipur to Muzaffarpur. The accidental data was collected for last eleven years, 2000-2010 from the Police Stations where FIR was lodged. The collected data were analyzed to evaluate the effect of influencing parameters on accident rate. Heavy vehicles like truck are involved in maximum number of accidents on the selected stretch. It is estimated that a heavy vehicles is involved in almost 48% accidents followed by two-wheelers 16%, car 12% and bus 10%. There is no definite trend for monthly variation in accident on a study section but the accidents in month of July and January are generally higher. Accident rate in terms of number of accidents per km-year increases with traffic volume. But the accidents rate in terms of number of accident per million-vehicle kilometer-year (MVKY) decreases with increase in traffic volume. Accident rate per MVKY increases during the study year, whereas both injury and fatality rate per MVKY show a declining trend over the study period. The developed model for accident prediction represents that the number of accidents per-km-year increases with AADT and decreases with improvement in road condition.

Key word **-** *FIR, Statistical analysis, Regression model*

I. INTRODUCTION

The highway network is accelerated at a fast rate and the safety of vehicular movements becomes a concern for everybody due to reporting of loss of lives and properties along with fatal injuries and periodical obstruction of traffic flow. National highways provide the efficient mobility and accessibility function. The increasing road accidents have created social problems due to loss of lives and human miseries. Road accidents are essentially caused by interactions of the vehicles, road users and roadway conditions. Each of these basic elements comprises a number of sub elements like pavement characteristics, geometric features, traffic characteristics, road user's behavior, vehicle design, driver's characteristics and environmental aspects.

Valli & Sarkar (1997) examined the possibility of using the speeds formula on accidents rate estimation for Indian condition and proposed a model for road accidents in India based on that. Victor & Vasudeman (1998) made a detail study and analysis on bus related accident in Tamil Nadu taking data from fine bus Transport Corporations. Chand (1999) made an attempt to examine the accident frequently and trend of bus related accidents with special references to public Road Transport under takings in India.Baviskar (1999) studied road accidents in Nashik Municipal corporation area and highlighted the distribution and accidents pattern in the city at micro level during the period 1980-1989.Saija et al (2000) had made a detailed study on road accident spectrum analysis of Gujrat.Singh & Misra (2000) analyzed the road accident spectrum for the city of Patna.Chakraborty et al (2001) studied the aggression to risk taking behaviors that leads a threat to road safety. Jenna et al (2001) developed a model for prediction of accidents in Indian urban roads taking field data from Ernakulum. Mohan Dinesh (2007) deals a **s**ustainable transport system that provide mobility and accessibility to all urban residents in a safe and environment friendly mode of transport.

A. NEED AND OBJECTIVES OF STUDY

As per the NATPAC 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.

The objectives of the present study are listed below:

1. To study the monthly and annual variation in accident rate on selected stretch.

2. To study the effect of traffic volume on accident rate.
3. To develop an accident prediction model based on AADT and road condition.

II. DATA COLLECTION

The busiest NH-77 passing through two cities namely Hajipur and Muzaffarpur, the stretch of this road has length 70km is selected for data collection and statistical analysis of accidents, as road shown in Bihar Road Map [Fig. -1].With the prior permission of the concerned Senior Superintendent of Police (S.S.P), the accident data were collected from the six Police stations situated along the NH-77. These Police stations are Hajipur, Sarai, Bhagwanpur, Goraul, Kudhani and Turki.The police stations have their own FIR records of several years. Accident, Fatality and Injury data were collected month wise in every year from each police station records during year 2000 to 2010. The type of vehicles involved in accidents as recorded in the FIR was also noted down. The categories of vehicles include Tuck, Bus, Tractor, Jeep, Car, Tempoo, Motorcycle and Bicycle etc. Further, monthly-obtained data were sorted out year wise, represented in percentage over the study year as shown in Table-1.

Year	Fatality in %	Injury in %	Total Accident in %
2000	6.15	2.33	3.15
2001	1.54	3.00	2.56
2002	7.69	8.33	8.27
2003	15.38	9.00	9.25
2004	15.38	10.00	10.43
2005	13.85	11.33	11.81
2006	10.77	12.00	12.00
2007	7.69	11.67	10.43
2008	6.15	14.00	13.58
2009	10.77	13.33	13.39
2010	4.62	5.33	5.31

Table -1: Accident, Injury & Fatality in % on NH-77

A. DATA COLLECTED FROM P.W.D. RECORDS

P.W.D. (Public works Department) records are the main source for traffic volume data & road map. In addition to the above, road conditions information were also obtained from PWD records. Traffic survey was conducted at Sarai market on NH-77 at about 8km from Hajipur. Traffic volume for the year of count 2008 was extracted and represent in form of Commercial Vehicles per day (CVPD) & PCU/day, shown in Table-2.It is assumed that the traffic volume is uniform throughout the study stretch.

As the yearly traffic census data was not available for all the years, the available data were used to predict traffic volume on a road in each year for the period 2000-2010 as shown in Table-3.A growth rate (r) of 7.5 % per year was assumed for this purpose. A formula was used for forecasting as follows:

$$A = P(1 \pm \frac{r}{100})^n$$

where A = Predicted year traffic volume, P = Present year traffic volume, n = years of count and minus sign indicates before the present year traffic count and plus sign indicates after the present year traffic count.

Table -2: Traffic Volume Data

Name/No. of the road	Year of count	Traffic Volume	
		CVPD	PCU/day
NH-77	2005	9507	15128

Table-3: Predicted Traffic Volume

Year	PCU/day
2000	7499.93
2001	8108.03
2002	8765.44
2003	9476.15
2004	10244.49
2005	11075.12
2006	11973.10
2007	12943.90
2008	13993.40
2009	15128.00
2010	16262.60

III. ANALYSIS OF DATA AND DISCUSSION OF RESULTS

The data collected reflects the view of the reporting Police Officer. According to the literature review accidental data collected from the Police Station is not the complete information because all accidents are not recorded in their FIR (First information report). Therefore, all accidental data may be increased by 25-30%.

In this paper all accidental data are increased by 30%. All accidental data were analyzed, using the software MS EXCEL. As per the pilot survey, accidents cause has been recognized that occur due to (i) Driver's

fault (ii) Failure of the motor vehicle (iii) Road condition and, (iv) Environmental condition.

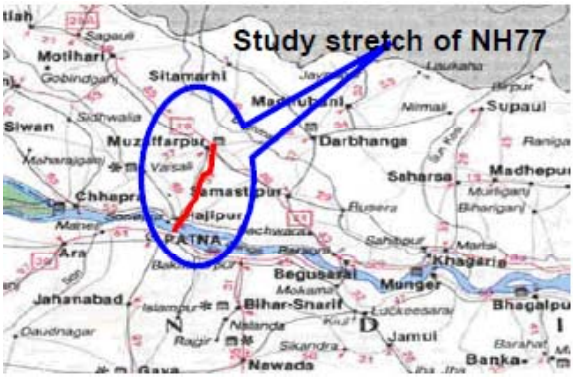

Fig.1: Map showing the study stretch

A. ANNUAL VARIATION IN ACCIDENTS

Fig.-2 shows the annual variation in accidents during 2000-2010.It is observed that percentage accidents are increasing relatively in most of the year. In year 2010 accident rate fall down suddenly, this type of situation occur may be due to the maintenance of the road is executed in the same year.

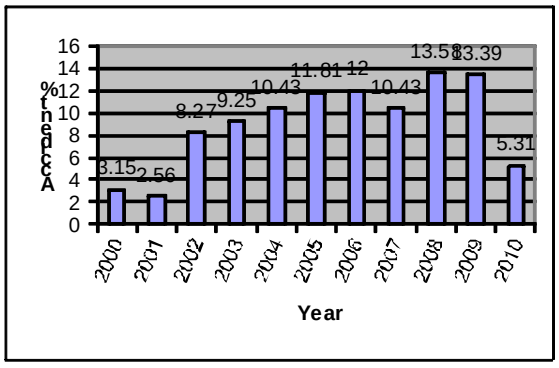

Fig.2: Annual Variation in accidents during 2000-2010 on NH-77

B. MONTHLY VARIATION OF ACCIDENTS

Average monthly variation in accidents during year 2000-2010 on NH-77 road section is shown in bar chart; Fig.-3.These results indicate that there is no definite trend for monthly variation in accidents. Accidents in the month of July are quite high. It may be due to rainy season in this month. The earthen shoulder gets deteriorated in rains and pavement surface becomes slippery. Also, it is observed that accidents rate is comparatively higher in the month of December – January of the year. No definite reason can be attributed to this trend but it might be due to poor or low visibility (fog condition) in winter seasons

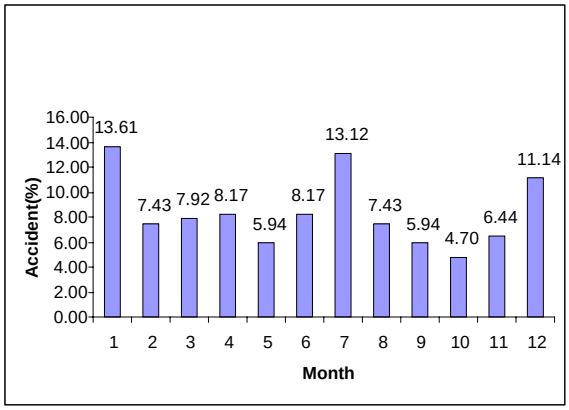

Fig.3: Average monthly variation in accidents during 2000-2010 on NH-77

C. ANNUAL VARIATION IN FATALITY, INJURY AND ACCIDENTS

Fig.-4 shows the comparison of Fatality, Injury and Accidents in percentage. Fatality in the year 2003 and 2004 is quite high. Injury rate during the whole study year are increasing relatively and the accident rate is as mentioned in the fig-4. However, High fatality rate gives the challenge to the Traffic Engineer to prevent the casualty. Therefore, Traffic Engineer has to study the cause of casualty and to suggest corrective treatment at potential locations.

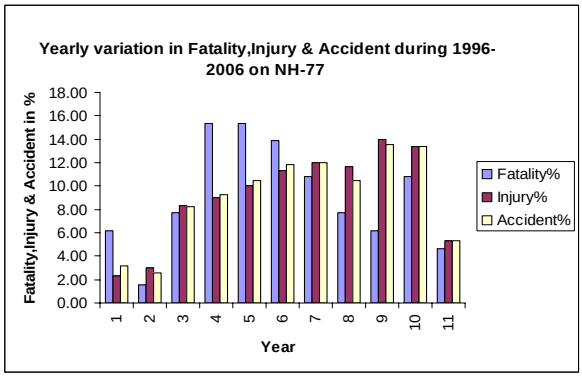

Fig.4: Yearly variation in fatality, injury & accident during 2000-2010 on NH-77

D. VEHICLES INVOLVED IN ACCIDENTS

Fig.-5 shows the percentage accidents involving a particular type of vehicle. It is observed that Truck are involved in maximum number of accidents almost 48%. It may be due to the most of the Truck driver are driving their vehicles after drink of alcohol or they are not

aware about the condition /maintenance of their vehicles. It is followed by Motorcycle (16%), Car (12%), Bus (10%), Tempo (5%), Jeep & Tractor (3%), cycle (2%) and Pedestrian (1%).

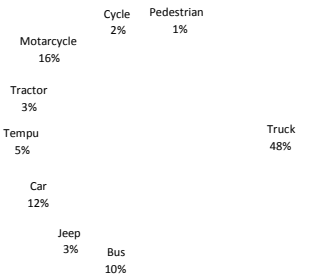

Fig.-5: Vehicles composition involved in accidents

E. ACCIDENTS AS RELATED TO TRAFFIC VOLUME

To observe the relationship between accident rate and traffic volume, accident rate is presented in two forms. In first case, it was the number of accidents that occurred in a road section per km per year and presented as accident per km-year. In second case, it was the number of accidents that occurred in a road section per million vehicles (MV) taken in terms of PCU per kilometer (k) per year (y), represented as accident per MVKY (Accidents per million vehicles-km-years).

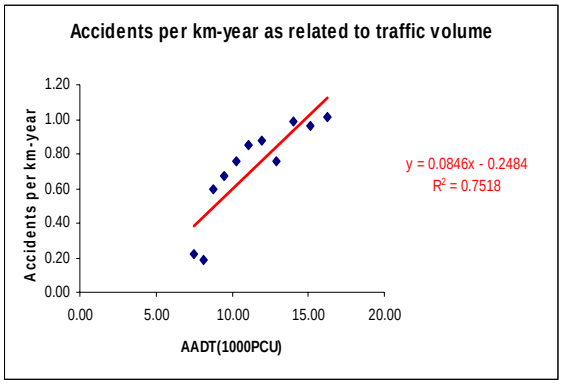

Fig.6: Accidents per km-year as related to traffic volume

It is observed that accident rate increases with increase of AADT.The data supporting the linear trend line relationships may be sensitive to the design and operational feature of the Highway.

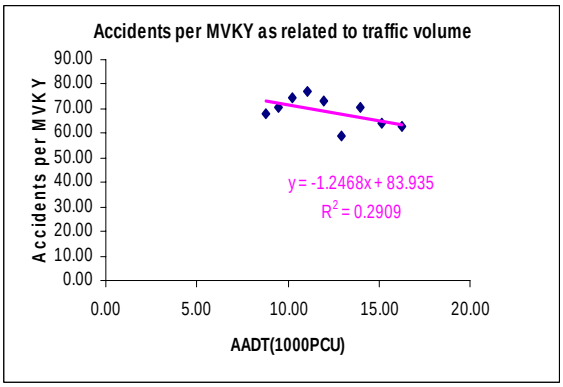

Fig.-7: Accident per MVKY as related to traffic volume

Figure-7 shows the accidents per million-vehicle-kilometer –year decreases slowly with increase in the AADT.It may again be due to design and operational features of the highway and influence of other parameters like roadside features, degree of side slope, climate condition and operational environment.

F. TREND OF ACCIDENTS DURING 2000-2010

The annual trend of MVKY is shown in fig.8.Linear variation means accident rate per MVKY increases in each subsequent year. This increasing trend in accident rate may be due to detoriation in road and shoulder conditions and the road users did not adopt general awareness. Even though the failures of the motor vehicle are mainly driver's fault, result the accidents.

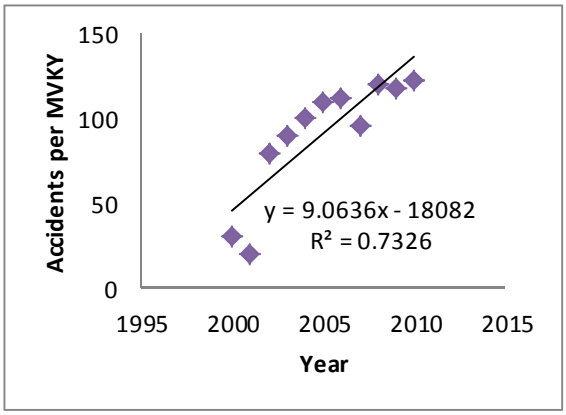

Fig.-8: Trend of accidents during 2000-2010

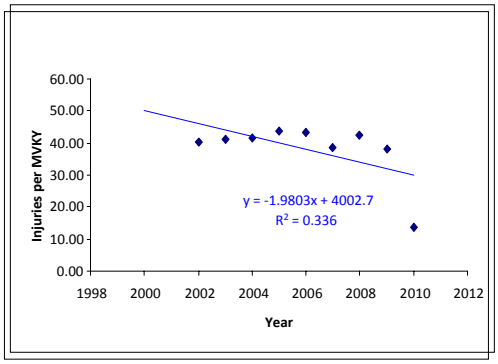

Fig-9: Trend of injuries during 2000-2010

G. TREND OF INJURIES DURING 2000-2010

The annual trend of injuries is shown in Fig.9.Scattered points do not show the definite trend, this may be due to the insufficient relatively closer values. A linear trend line is fitted to show the trend because logically true but have coefficient of determination/correlation is very less. It was found that injuries per MVKY decrease over the period 2000-2010.This trends may be attributed to incautiousness driving of small sized vehicles and also priority goes to motorcyclists.

H. TREND OF FATALITIES DURING 2000-2010

The observed values are not showing the definite trend of fatalities. The fatality rate per MVKY has decreased substantially over the years. Ref Fig.10.

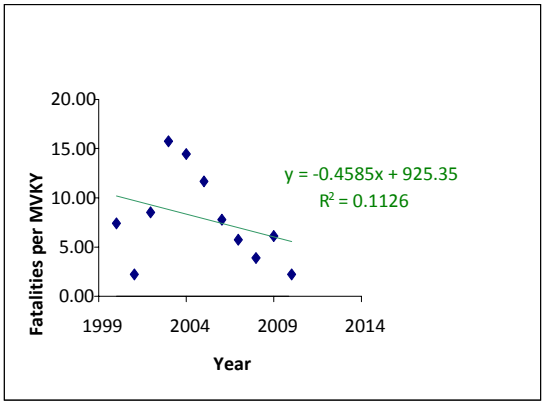

Fig.10: Trend of fatalities during 2000-2010

IV. ACCIDENT PREDICTION MODEL

The portion of the Highways and shoulder, where maintenance work was carried out in a particular year were noted down from the PWD records. Chandra and Dev Raj (1999) suggested that the section of a road and its shoulder may be ranked on a 5-point scale as shown below:

Excellent = 5, Good = 4, Average = 3,

Poor = 2 and Bad = 1

The excellent means road and shoulders was maintained very recently and bad means road and shoulders were not maintained within last four years and these have deteriorated to the extent that vehicles cannot use them. This decimal way of ranking is primarily due to the maintenance works not being carried out in a single year for the whole stretch of a road. The accidents per km-year were regressed with AADT and road shoulder conditions rank.

The general form of equation is represented as:

Accident /km-year =C_0 + C_1 (AADT) + C_2 (Road and Shoulder Condition Rank [CR])

Accidental data collected for the study stretch of NH-77 was used to develop the Accident Model. Regression analysis is used in the present study, for finding out a best prediction model for accidents on National Highways. The accident data collected from different police stations were regressed against the AADT and CR.

C_0 =1.21, C_1 = 4 x 10^{-6},

C_2 = 0.183, R^2 = 0.895

The prediction model for NH-77 may be represented as

Accident/km-year = 1.21 + 4 x 10^{-6}(AADT)

-0.183(CR)

The above equations indicate that the accident/km-year increases with AADT, but decreases with improvement in condition of road or shoulders or both.

A. VALIDATION OF THE MODEL

Using the AADT of the selected stretch of the road and road and shoulder condition rank (CR) are assigned as per site visit. The accident prediction model was validated for the road stretches between Kudhani to Sitamardhi road on NH-77.The estimated values from the accident prediction model were tested by Chi-squared test.

Table-4: Estimated accidents at 5 locations for validation

Locations	1	2	3	4	5
Accidents estimated from prediction model	0.87	0.70	0.70	0.51	0.69

Sum of the accidents rate = 0.87+0.70+0.70+0.51+0.69 =3.47, the expected number of accidents rate = 3.47/5 =0.69, Chi-square = 0.87, Degree of freedom, d_f = 5-1= 4 and H_0 = it is a good fit, Chi-square for d_f = 4 and 5% significance level = 9.488, since 0.87 <<9.488

Hence,H_0 is correct. Therefore, It was found that estimated accident rate from accident prediction model were significant at 5% level of significance.

V. CONCLUSIONS

The following conclusions are drawn:

1. There is no definite trend for monthly variation in accident on a section of highway. But the accident in months of July is generally higher. It may be due to fast deterioration of earthen shoulder by rain in these months. Accident in month of January has relatively high value; it may be due to the foggy weather.
2. Heavy vehicles like truck are involved in maximum number of accidents on National Highways. It is estimated that a heavy vehicles is involved in almost 48 % accidents followed by two-wheelers (motorcycle) 16%, car12% and Bus10%.
3. Accident rate in terms of number of accidents per km-year increases with traffic volume. But the accidents rate in terms of number of accident per million-vehicle kilometer-year (MVKY) decreases with increase in traffic volume.
4. Accidents rate per MVKY increases during the study year, whereas, both injury and fatality rate per MVKY show a declining in trend over time.
5. Accident prediction model developed in the present study show that number of accidents per km-year increases with AADT and decreases with improvement in road/shoulder condition.

Accident prediction model was validated by Chi-squared test and found to have a good linear relationship between AADT and CR.

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