Accident Analysis and Crash Prediction Modeling on National Highways

Sanket Amle
Department of Civil Engineering
G H Raisoni College of Engineering, Nagpur 440016

Prof. Sujesh D. Ghodmare
Department of Civil Engineering
G H Raisoni College of Engineering, Nagpur 440016

Dr. B. V. Khode
Department of Civil Engineering
G H Raisoni College of Engineering, Nagpur 440016

Abstract

Though comprehensive road safety plans have been formulated which focus on education, enforcement measures and emergency care, there is a lack of sound and rational engineering measures to improve the road safety in our country. This paper aims to analyze, evaluate and identify effective road safety treatment measures for a rural national highway. The study area will be the national highway- 6 connecting Nagpur to Kondhali. Accident data of past 3 to 5 years will be collected for the analysis. Basic aim of this study will be articulate, carry out complete analysis of crash data, and identify the critical stretch in the national highway which would require immediate safety improvements. Critical sketch is identified. This could aid the highway safety audits in country for identifying specific regions in national highways depending upon the geometric element which is aimed to improve as part of safety improvement programs. Similarly a crash prediction model is developed which will be correlating the number of accidents and parameters like lane width, shoulder width, average daily traffic and number of junctions in divided sections.
Keywords: Crash causes, data, critical sketch

I. INTRODUCTION

Crash prevention and control is on the 4 E's, a fifth E is gaining popularity in road safety studies worldwide. This fifth E is evaluation and it broadly aims at assessing the road safety using safety performance indicators. Such indicators are reliable, simple and efficient tools for comprehensive road safety analysis. Though comprehensive road safety plans have been formulated in India that focus on education, enforcement measures and emergency care, there is a lack of sound and rational engineering measures to improve the road safety.

II. PROCEDURE

The main data requirements for the evaluation purpose will be:
1) Accident data
2) Geometric Features
3) Spot Speed

A. Accident Data:

The accident data required for the study is collected from the records of the police which are being collected as a part of a National Highway Authority of India (NHAI) project with the following particulars:

- Accident location
- Accident date and time
- Nature if accident
- Classification of accident
- Cause of accident
- Road features and road condition at the spot
- Weather condition at time of accident
- Intersection type and control
- Number of person affected as per the injury (fatal, major, minor)

B. Geometric Features:

The geometric features of the road is collected for the development of correlative analysis. Carriageway width, shoulder type, shoulder width and condition will be needed to be evaluated.

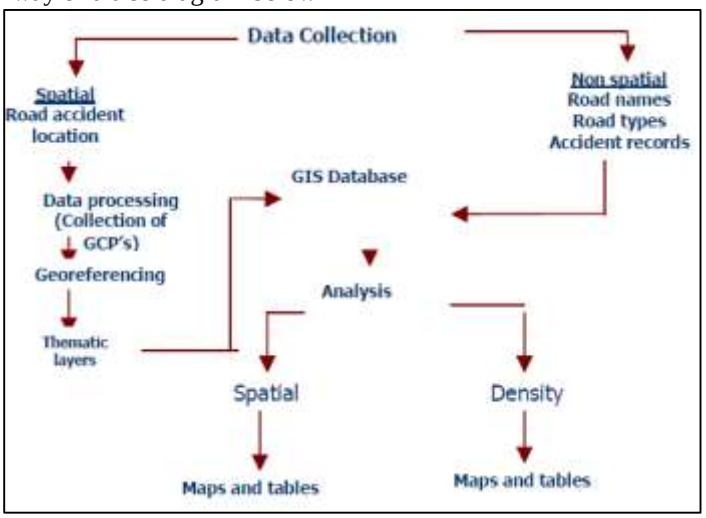
C. *Spot Speed:*

Spot speed: This data is collected by video graphic survey. Speed can be derived using simple tracing paper method or using the software Irfan view. It will be collected during peak hours.

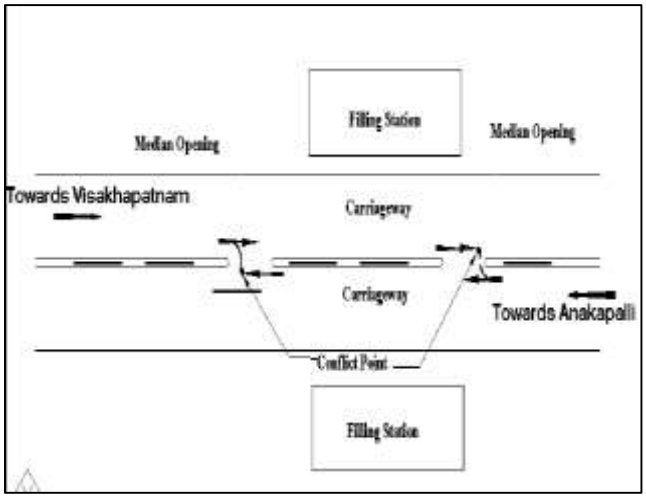
Traffic count: It can be calculated by counting traffic for 3 hours and then multiplying it by proper expansion factor for 24 hours for Average daily traffic (ADT).

III. LITERATURE REVIEW

For NH-58 from Meerut to Muzzaffanagar used accident records from police station and topological maps. They collected ground control points using GPS and The peak period was found to be between 14.00 - 16.00 hrs. Installation of warning and informative signs and redesigning of the intersection was suggested at places where cross movement of pedestrians was more. The methodology adopted by Apparao is shown in way of a tree diagram below



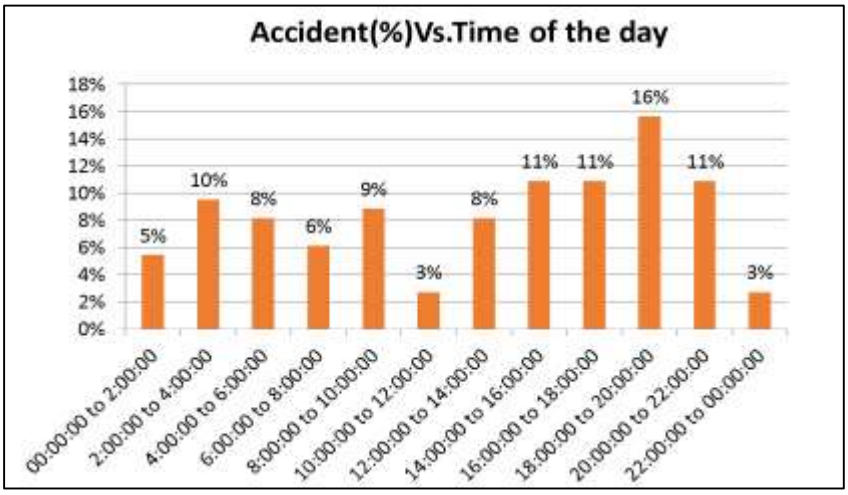
In the study conducted on NH- between Anakapalli to Vishakhapatnam using moving observer method and accident data from the concerned police station. Four black spots were selected and on their analysis the main reason for accidents on the first spot was the direct access of local traffic to the NH and through the sharp curve. For this, proper sign boards, marking and proper illumination during night were considered to improve the situation. The other spot had median openings because of the petrol pump located nearby and thus wrong turns were the reason so closure of the openings was suggested as fueling facility was provided on both the sides as shown in the diagram below



These results were found to be in permissible limits. Traffic studies and road geometrics comprising of SSD, super elevation and length of curve were also calculated. The topography of area resulted and narrow curves but due to tendency of drivers to overtake on blind curves with OSD very less caused accidents usually due to overturning. The foggy winters and excessive rainfall in this area reduce the SSD and increase the reaction time leading to collisions. The remedial measures included fluorescent sign boards at blind spots and turns, retaining walls to prevent landslide

In the study on national highway-3 between Indore to Dhmnod analyzed ADT, total number of accidents, their area-wise and casualty-wise distribution in year 2009, 2010, 2011 and concluded that increasing accidents were due to high speed and more

traffic. The accidents were more during 6 p.m. to 8 p.m. as more number of buses travel at this time. They explained it with help of a graph as given below



Further they also gave out the severity index for the same as shown in the table below.

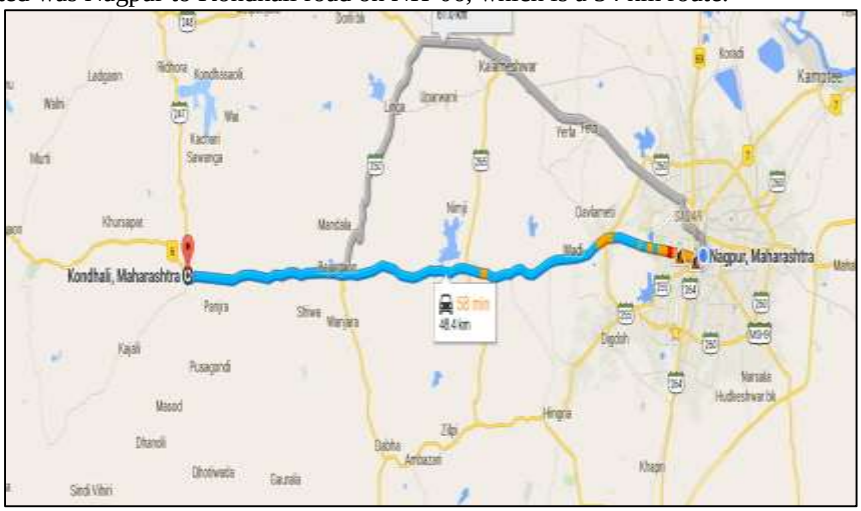
S.N.	Year	Severity Index
1	2009	19.97
2	2010	18.42
3	2011	20.8

Used simulation and Artificial Neural Network technique to develop crash prediction models for Vadodara city

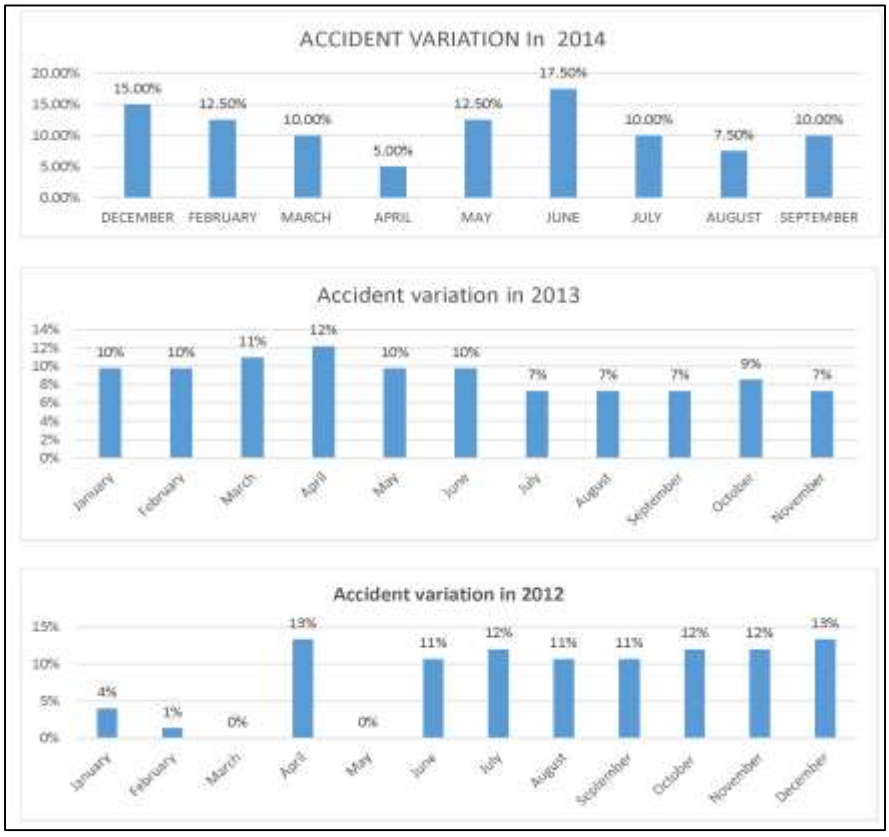
. They suggest that it is necessary to further refine the models using more number of explanatory variables for getting a more realistic picture in predicting crashes. Kalaga and Silanda (2002) states that a quadratic model gives the best fit for relating crash count to average daily traffic.

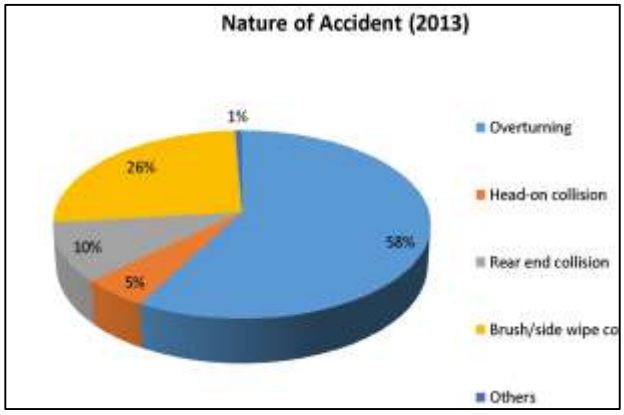
IV. ACCIDENT DATA ANALYSIS OBSERVATIONS

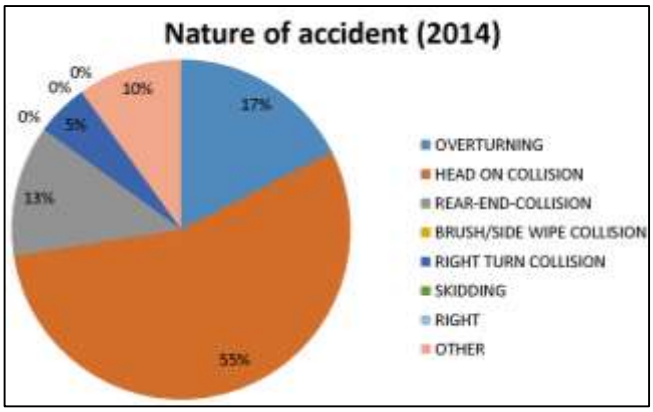
The study corridor selected was Nagpur to Kondhali road on NH-06, which is a 54 km route.



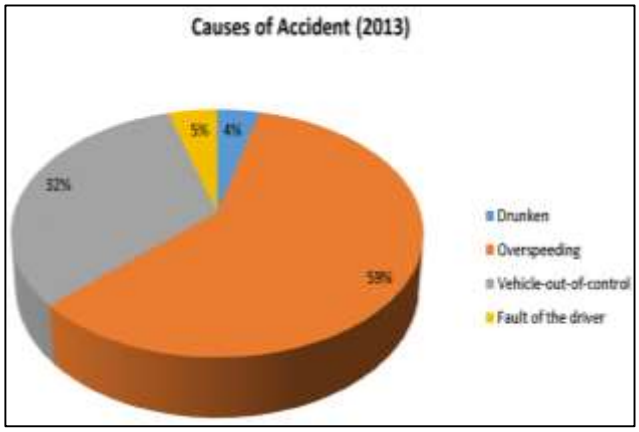
The below given graphs gives monthly variation in accidents on the selected study corridor:

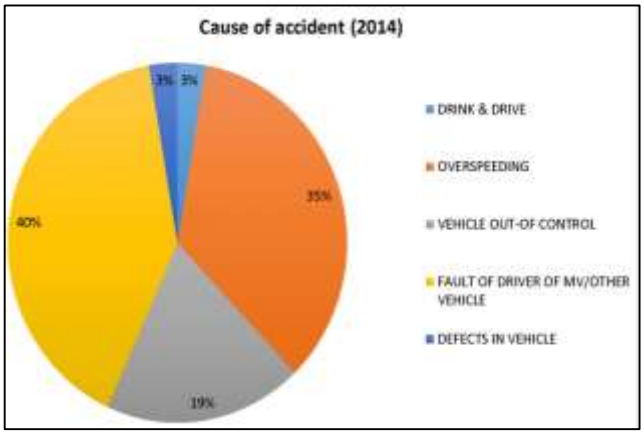




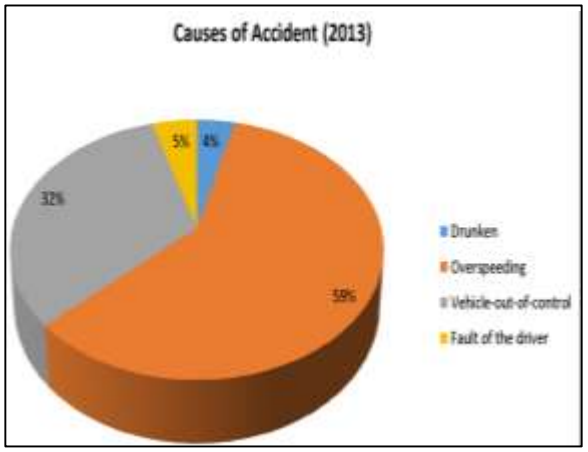


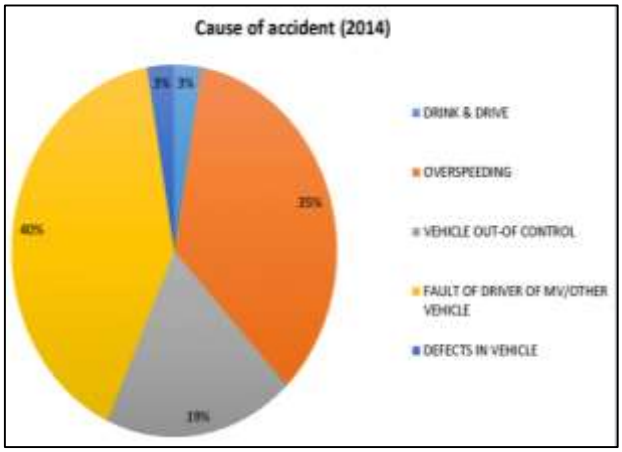
The above given graphs shows the analysis of the nature of accident in respective years.
Similarly causes of accident were classified giving the following results:



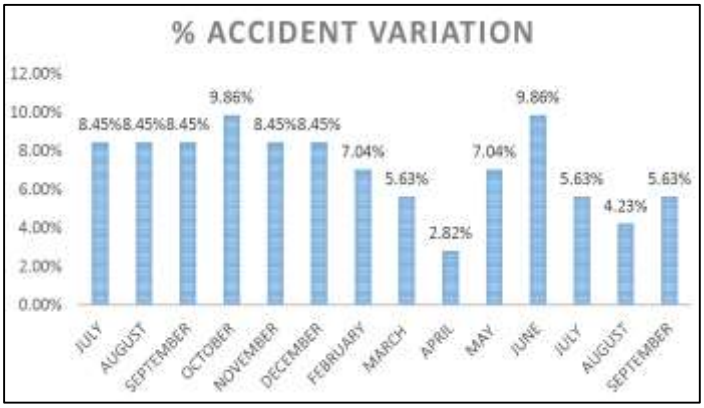


Causes of accidents were analysed as given below:

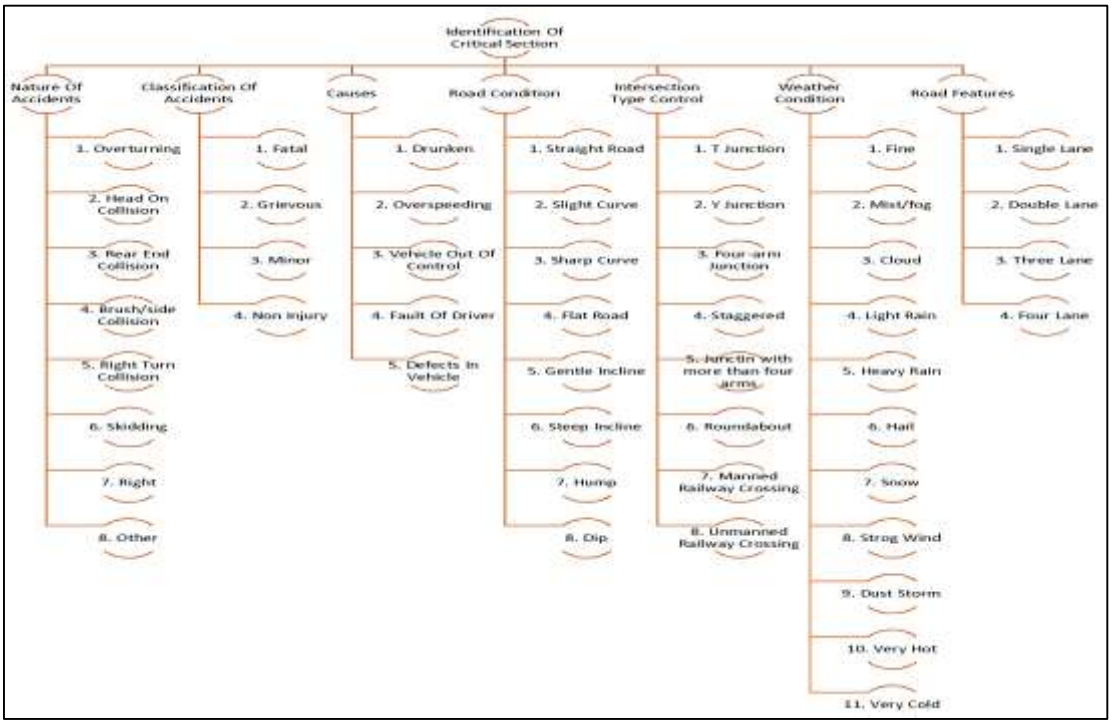




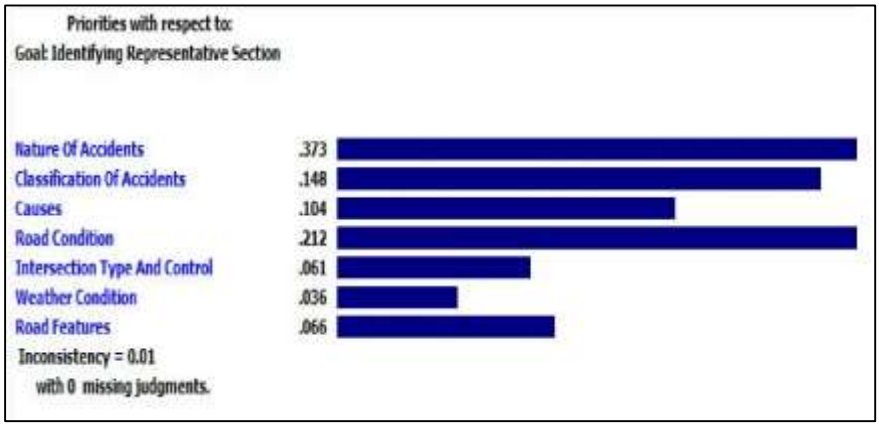
This was the monthly variation in accidents from January 2012 to December 2015 as given below:

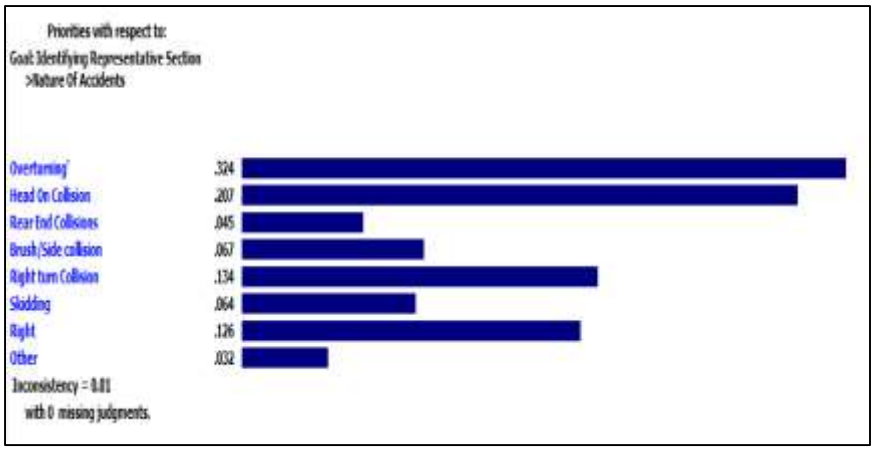


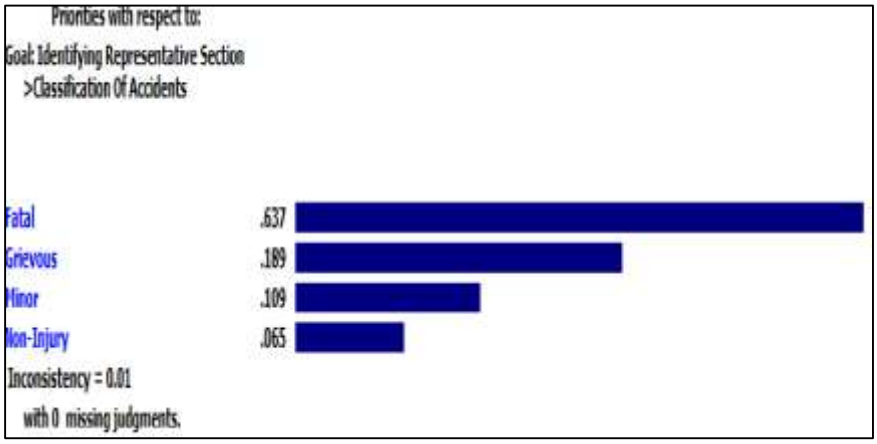
V. SAFETY ANAYSIS USING ANALYTICAL HIERARCHY PROCESS



Synthesis of Relative Weights in Expert Choice 2.04 Software
Prioritization of sub criteria's was carried out by comparative analysis of existing accident data and their grievousness.



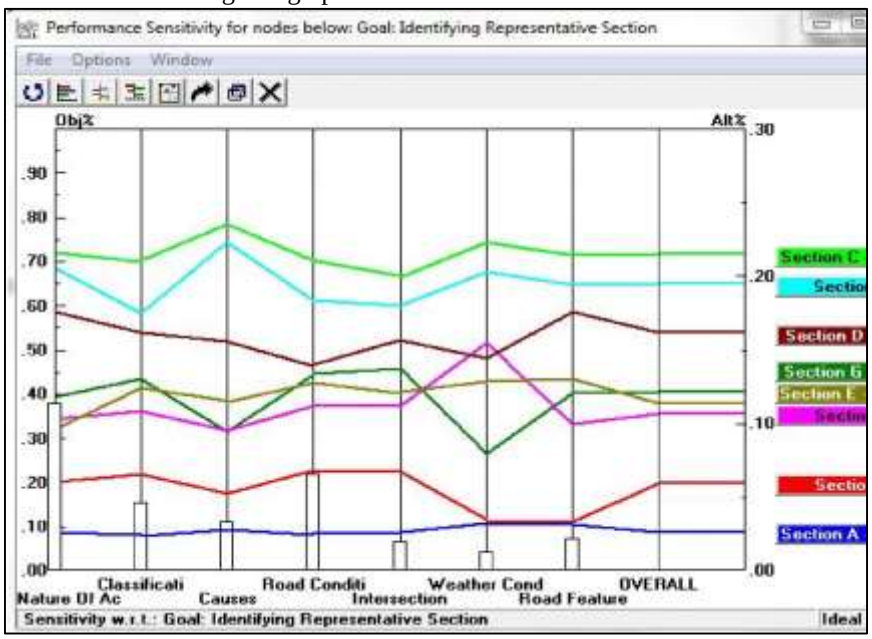




All seven criteria's and their 49 sub criteria's were subjected to pair wise comparison based on their relative importance.

Divided Sections	No Accidents	Length Of Section (KM)	Double lane accidents	Single Lane accidents	Four Lane Accidents	Straight Roads	Slight Curves	Sharp Curves	Flat Roads	Over Speeding	Drunken Driving	Visibility Issues (Night Time)
A	3	6	3	0	0	2	0	1	0	2	0	1
B	4	6.5	4	0	0	2	2	0	0	3	1	0
C	23	7	23	0	0	10	7	2	4	14	2	7
D	17	9	14	1	2	9	5	0	3	8	3	6
E	8	11	8	0	0	4	1	2	1	2	1	5
F	11	6	10	0	1	6	4	0	1	8	0	3
G	9	4.1	9	0	0	5	3	0	1	6	1	2
H	16	5	12	0	3	8	5	0	3	4	2	10

Critical sketch obtained was from the below given graph:



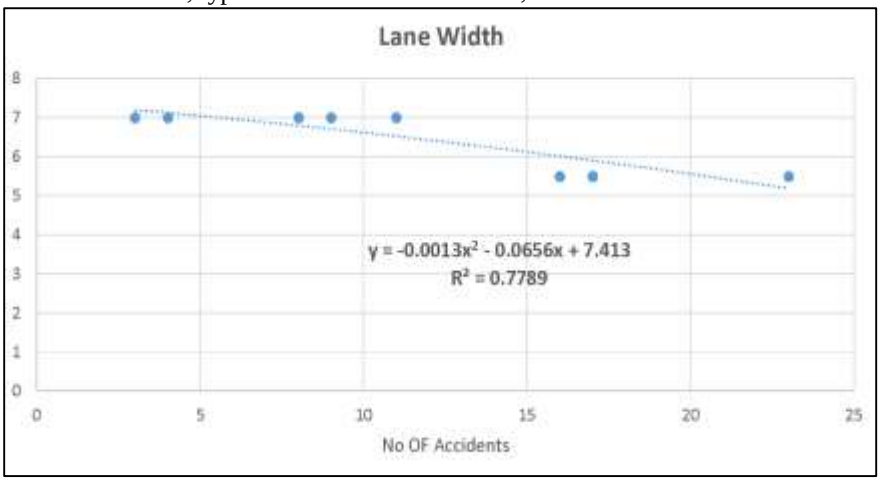
It can be seen that Section C is critical in all aspects of crash influencing factors and it would require further safety evaluation and applying corrections on factors like faulty highway geometrics, poor visibility during night, lack of information signs...etc.

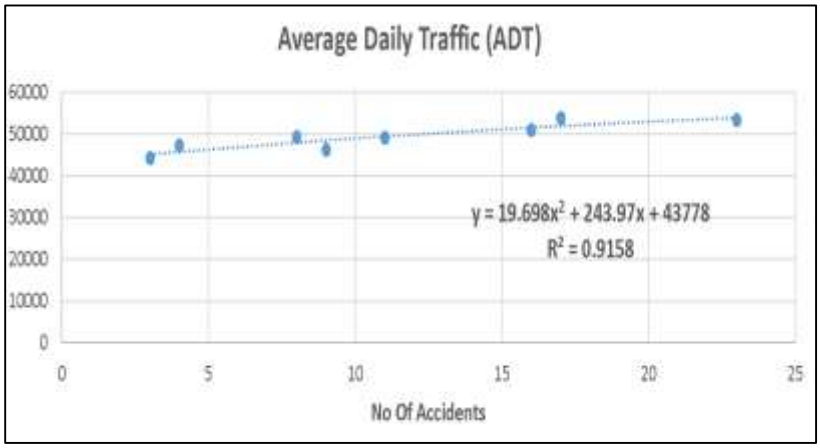
VI. CRASH PREDICTION MODEL DEVELOPMENT

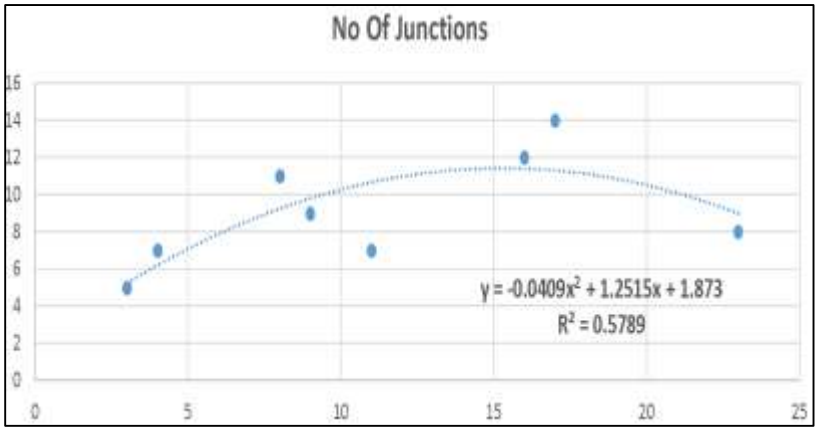
For the purpose of analysis the dependent variable was selected as the average of the total accidents that occurred in the past three years (Y) along the study stretch. Road characteristics and traffic volume details formed the independent variables for the analysis and summed up to a total of 4 independent variables. The best trend lines of each predictor variable and the dependent parameter were drawn using MS EXCEL 2007, to understand the. For further elimination of non-essential parameters, a correlation matrix was developed using MS EXCEL 2007. From the correlation matrix, Pearson's correlation of dependent variables were found to be ($p > 0.5$), showing the lack of inter-dependence among them. This shows that the data is fit for regression analysis. The individual trends were further used to conduct a mixed type of regression modeling.

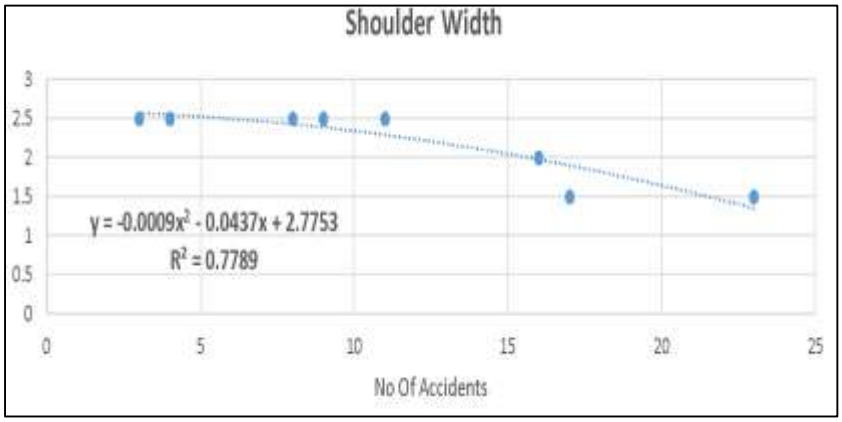
A. Influence Of Independent Parameters:

The various independent variables selected are lane width (LW), shoulder width (SW), average daily traffic (ADT), number of junctions (J). Trend lines were plotted describing the relationship these variables bear with the number of accidents in respective sections. The expression of the trend line, type of mathematical function, R2 values are articulated within each graphs.









Relationship of each individual parameter with the dependent variable

S. No	Independent Variable	Expression	Relationship	R2
1	Lane Width (LW)	y = -0.0013x2 - 0.0656x + 7.413	Polynomial	0.7789
2	Shoulder Width (SW)	y = -0.0009x2 - 0.0437x + 2.7753	Polynomial	0.7789
3	ADT	y = 19.698x2 + 243.97x + 43778	Polynomial	0.9158
4	No Of Junctions (J)	y = -0.0409x2 + 1.2515x + 1.873	Polynomial	0.5789

It could be inferred based on the R2 values from above table that some parameters have a high influence.

B. Multiple Linear Regression Model Development:

As we know, the following model was selected as the best fit model, satisfying both statistical (R2 value = 0.8867) as well as practical considerations. The coefficient of shoulder width was obtained to be zero as a result of regression analysis.

$$Y = -3.93\,(LW) + 0.00138\,(ADT) - 0.5364\,(J) - 26.77$$

Regression Statistics	
Multiple R	0.94168976
R Square	0.886779604
Adjusted R Square	0.551864307
Standard Error	3.055674153
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	292.5264219	73.13161	10.44311	0.041618375
Residual	4	37.34857812	9.337145		
Total	8	329.875			

R2 value of 88.6% indicate how much the independent variables has been able to explain the variation in dependent variable, which is the number of accidents. To explain the statistical significance of the model, we often rely upon the significance F value. Here it can be seen that the significance Of value = 0.0416 < 0.05 which means that the model is sufficiently significant at 95% confidence interval.

Parameters	*Coefficients*	*Standard Error*	*Lower 95%*	*Upper 95%*
Intercept	-26.77489235	48.37066265	-161.0733819	107.5236
Lane Width	-3.938883526	2.798460451	-11.70865535	3.830888
Shoulder Width	0	0	0	0
ADT	0.001385203	0.000698065	-0.000552935	0.003323
No Of Junctions	-0.536424844	0.53008907	-2.008188048	0.935338

Value of a coefficient indicate that for each 1 unit of increase in that parameter, how much would be the relative increase in the dependent variable. For example, for each one unit increase in the parameter of lane width, there would be a consequent decrease of 3.93 units in the number of accidents. Crash prediction models are developed to establish the relationship between the explanatory variables and crash frequency. It can be clearly seen that model successfully explains the crash variation to an extent of 88.6%.

VII. CONCLUSION

Aim of the study was to identify and analyze the various parameters responsible for accidents. Based on the literature review, the main factors responsible for accidents were identified. The study stretch was decided considering some important features such as feasibility for conducting surveys and availability of adequate accident data. Substantial amount of accident data was collected and segregated for further analyses. Mixed type of linear regression analysis was adopted and a best fit model was selected which was statistically and practically significant. This paper aimed to analyze, evaluate and identify effective road safety treatment measures for a rural national highway. model was developed in such a premise that it would relate the crash frequency to various geometric and traffic variables. The study area was defined as the national highway -06 connecting Nagpur to Kondhali. Accident data of 3 years were collected for the analysis.

REFERENCES

[1] Chatterjee, A., Everett, J.D., Reiff, B., Schwetz, T.B., Seaver, W.L., and Wegmann, F.J. (2003). "Tools for Assessing Safety Impact of Long-Range Transportation Plans in Urban Areas." Center for Transportation Research, The University of Tennessee, Knoxville, TN.
[2] Cheng Cheng, Yan Chen, Taoying Li (2011) "An AHP Method for Road Traffic Safety", 2011 Fourth International Joint Conference on Computational Sciences and optimization.
[3] Fajaruddin Mustakim and Motohiro Fujita, "Development of accident predictive model for rural roadway", World Academy of Science, Engineering and Technology, vol 58, 2011, pp 126-131.
[4] Fazio, J., Holden, J., and Rouphail, N. M. (1993). "Use of Freeway Conflict Rates as an Alternative to Crash Rates in Weaving Section Safety Analyses." In Transportation Research Record: Journal of the Transportation Research Board, No. 1401, TRB, National Research Council, Washington DC, 61-69s.
[5] Golob, T. F., Recker, W. W., and Alvarez, V. M. (2004). "Freeway safety as a function of traffic flow." Accident Analysis and Prevention, Volume 36, No. 6, 933-946.
[6] Kadiyali, L.R. and Venkatesan, S. (1984), "Traffic Accidents Forecast and Remedies" Indian Highways, Indian Roads Congress, Vol. 12, No.4, pp. 7-12.

[7] Kalaga, R.R and Silanda, S.N. (2002), "Accident Rate Prediction on Arterial Roads of Durban, South Africa", Indian Highways, Indian Roads Congress, Vol. 30, No.7, pp. 25.
[8] Khan, S., Shanmugam, R., and Hoeschen,B. (1999). "Injury, Fatal, and Property Damage Accident Models for Highway Corridors." In Transportation Research Record: Journal of the Transportation Research Board, No. 1665, TRB, National Research Council, Washington DC, 84-92.
[9] Kiattikomol, V. (2005). "Freeway Crash Prediction Models for Long-Range Urban Transportation Planning." Doctoral's Dissertation. The University of Tennessee, Knoxville, Tennessee, Augus.
[10] Murthy, S.r., Gunashekar, T.K. and Thyagaraja, T.N. (1991), "Analysis of Accident Rates and Black spots in Bangalore city", Indian Highways, Indian Roads congress.