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EFFECTS OF ROAD GEOMETRICS ON ACCIDENTS: A CASE STUDY OF AH-45 THROUGH NELLORE TO KAVALI

Pranay Kumar G
M.Tech student, IV semester, Visvodaya Engineering college , Kavali, pranay1916@gmail.com,
Anvesh Kumar M
Assistant Professor, Department of Civil Engineering, Visvodaya Engineering college , Kavali, anveshbusy@gmail.com,
Dr.Suresh Babu T
Professor and Head , Department of Civil Engineering, Visvodaya Engineering College , Kavali, hodce.vec@gmail.com.
Manikanta K V
Research Coordinator , Department of Civil engineering, Visvodaya Engineering college, Kavali, myindia191@gmail.com

ABSTRACT

Accidents are not natural but they are caused is a common saying in the area of traffic safety. Thus, if accidents are caused by some factors, those can be identified and appropriate remedial measures can be developed and implemented to the extent feasible. It is strongly felt that most of the accidents, being a multi factor event, are not merely due to drivers fault on account of driver's negligence or ignorance of traffic rules and regulations, but also due to many other related factors such as abrupt changes in road conditions, flow characteristics, road user's behaviour, climatic conditions, visibility and absence of traffic guidance, control and management devices. In the present study, the accident data of the proposed stretch from the year 2010-2014 has been collected from concerned police stations in prepared data formats. The data sheet covers all the accident details. At each police station First Information Reports were referred to note down the accident particulars. The analysis work was carried out for the proposed stretch and black spots were identified. After this, the main data required is the geometrics of the road way which will be useful for the evaluation of the black spot locations. A model is built with the accident rate as dependent variable and road environment factors such as road width, shoulder width, curvatures, sight distances, radius, and number of cross roads or junctions, no of culverts etc as independent variables.

Key words : Crash Density, Super Elevation, Crash frequency , Sight distance, Crash rare, Accident rate.

1. INTRODUCTION

People, roads and vehicles form the same important combination all over the world that of being able to transfer themselves or goods from one place to the other. Road accidents became a serious problem throughout the world, in social, health and economic terms. Over twenty million people are injured and over one million are killed every year globally due to road traffic crashes. Developing countries account for up to 85% of all the fatalities. Traffic accidents in developing countries have been increasing rapidly and have in some cases become more deadly than the diseases that historically affected the population.

2. OBJECTIVES OF THE STUDY

The objectives of the present study are

- To identify the Blackspot locations
- To identify the road design elements that affect road safety
- To develop models to determine the appropriate balance between road design standards and road safety.

4. LITERATURE REVIEW

Accident prone locations on the roads are those places, where accidents often appear to cluster or concentrate. These stretches are termed as black spots . Studies conducted in the developed countries show that identification and improvement of black

spot locations reduces the occurrence of accident significantly. The broad techniques for the identification of black spot may be categorized as [Yulong PEI, Jianmei DING, 2005].

1. Statistical methods
2. Bio-medical engineering approach
3. Engineering methods
4. Subjective assessment techniques
5. Empirical Bayes Method

Research report number 57 of the Transport Research Group prepared by Silcock and Smith (1985) of The University of New Castle reviewed various methods of identifying accident black spots as prevalent in UK. US Federal Highway Administrative report No: FHWA-RD-77-81 compiled by Taylor and Thomson (1977) on identification of hazardous locations describes the situation in USA. The practices used in Russia for identification of black spot can be found by Bobkov (1975).

Stokes (1996) proposed a method which combines the Crash Severity and Crash Rate methods and has been considered to be the most meaningful method by various state and local agencies. In this method, an equivalent property damage only (EPDO) number is calculated and then divided by volume to obtain an EPDO rate for each location.

Lowa State University (2002) combined the Crash frequency, crash Rate and value loss method.

Past studies in finding out effect of Geometrics on Accidents

To find the effect of geometrics on accidents, so many authors have worked out and developed several models which will give the relationship between geometric features and accidents. A variety of traffic and design elements such as AADT, cross-section design, horizontal alignment, roadside features, access control, pavement conditions, speed limit, lane width, and median width, gives the future predicted accident rates as output.

Pasupathy et al (2000) and Davies (2000) have produced a range of multivariate models with quite different relationships. The authors believed that the reasons for these variations are that the relationship between road geometry and crash risk differs between regions and that the parameters that influence crash risk are difficult to characterize.

Davies (2000) looked at the relationship between road geometry and crash risk for all vehicle types. That study found significant effects due to the horizontal average curvature, difference between maximum and minimum horizontal curvature, and the minimum advisory speed. Small effects were also found for the gradient, direction, sealed carriageway width and annual average daily travel. There are possibly effects associated with surface age, surface type, wet or dry surface, and accident type. There were no significant effects due to cross section slope or vertical curvature.

A study that looked specifically at the relationship between road geometry and heavy vehicle crash risk was carried out by Milliken and de Pont (2000). That study used data for heavy vehicle crashes on the State Highway network in New Zealand. They estimated that heavy vehicle crash risk could be reduced by 8% per meter of widening for small increases in road width. This result is backed up by McLean (1997) who estimated a reduction in crash rate of 2% to 2.5% per 0.25 meters of widening. However, there were other predictors such as AADT that had a much stronger relationship with crash rate. These other predictors were not independent of seal width, so it was not possible to confidently attribute an increased crash rate to reduced seal width alone.

Relationships between heavy vehicle performance and heavy vehicle crash rate have been developed in studies such as Mueller et al. (1999). These relationships are fairly strong so it appears that the relationship between heavy vehicle crash rate and heavy vehicle performance is better understood than the relationship between heavy vehicle crash rate and road geometry. Therefore, a good understanding of how road geometry influences vehicle performance will enable a better understanding of the effect of road geometry on heavy vehicle crash risk.

Jacobs (1976) analyzed the accident data of Nairobi-Mombasa road in Kenya for the years 1972 and 1973. The road was divided into various sections and details such as accident data, length of each section, the average annual daily traffic flow, average road width, number of junctions, average horizontal curvature, and surface irregularity were collected for each section. The model developed was,

$$Y = 1.09 + 0.031\ X_3 + 0.62\ X_5 + 0.0003\ X_4 + 0.062\ X_2$$

The independent variables X_3, X_4, X_5considered were found significant at 10% level.

Where;

Y = accident rate per million vehicle kilometers

In the Road User Cost Study

(RUCS) report of 1982, an attempt was made to correlate road accident rate with variables such as horizontal curvature, vertical profile, and number of

junctions. The relationship developed for AH-45 through Nellore to Kavali road was

AR = -0.1526 + 0.0216 RF + 0.0031 CV + 0.4793 J

Where, RF = rise and fall; CV = curvature in the alignment; J= no of junctions

TRRL study has developed an equation, which gives relations between road width and accidents for a few developed countries [Sattertheathe, 1984]. The relationship is as follows

$$Y = 1 / (0.173B-0.21)$$

Where, Y = number of accidents per million vehicle km per year

B = road width in m

Shepherd et al (1982) gave an exponential mode correlating the number of accidents as the dependent variable and flow horizontal curvature, junction and land use as independent variables.Matthew G. Karlaftis and Ioannis Golias (2002) developed a Hierarchical tree based regression model (HTBR) or Binary recursive partitioning model based on the AADT data available, number of crashes, lane widths, median width, friction between tire and pavement, pavement serviceability index, pavement type etc.

4. METHODOLOGY AND INVESTIGATION

The First stage of the study includes preparation of accident data format to collect the accident data from the police stations. The forms are prepared as per IRC: 53 1982. These forms if filled properly provide the necessary information about the accidents like date of occurrence, day of occurrence, time of accident, type of area, chainage, weather condition, Classification of the accident, number of deaths, number of injured, nature of accident, accused vehicle driver gender and age, person driving vehicle, type of accused and victim vehicles, type of license, type of maneuver, responsibility of driver, type of junction, type of traffic control, cause of accident, and collision diagram. The formats of the forms have been designed to facilitate computer processing such that each data is divided into different sub categories and all those categories are given coding. For example type of area is divided into ten sub categories and given coding like near school or college, near a bus stop, near a temple, at pedestrian crossing etc.

4.1. Accident data collection from secondary sources

the accident data of ah45 through Nellore to kavali for five consecutive years i.e. 2010, 2011, 2012, 2013, and 2014 has to be collected from fir reports. In the fir reports the complete details about the accidents will be available, and whatever data is necessary to fill the accident data sheet that has to be noted down for each accident that was recorded in that police station. In the same way in all the police stations covering AH-45 through Nellore to kavali, the accident data has to be collected.

4.2 Tabulation and general analysis of accident data

the collected data has to be tabulated in ms-access and general analysis has to be carried out. General analysis includes finding out total number of accidents in police station regions, composition of vehicles involved in the accidents, nature of accidents occurred, based on type of area, type of accused and victim vehicles, type of manoeuvre, responsibility of driver etc. Then cross analysis has to be carried out for relating two or more categories at a time with the number of accidents occurred. In the cross analysis important categories like type of accused vehicle, type of victim vehicle, type of manoeuvre, responsibility of driver and compared in combinations.

4.3 Selection of black spot identification method

after the general analysis, depending up on data availability, two or more black spot identification methods are to be selected for comparison among them. For the present study crash density and crash frequency methods are considered. From the crash density method a stretch (section of road under a police station area) can be selected in which more number of accidents occurred when compared with length of the stretch. From the crash frequency method accident prone locations in that stretch can be identified.

4.4 Analysis and identification of black spots

black spots are to be identified according to crash density and crash frequency methods through the analysis of accident data collected. Critical crash density and critical crash frequency values are to be calculated for all the locations. The locations which are having the more crash frequency or crash density values than their critical values are said to be critical locations i.e, blackspot locations.

4.5 Selection of major black spots

from the identified black spots a few major black spots are to be selected which are having the highest crash frequency and crash density for the further continuation of work i.e collection of geometric features.

4.6 Collection of geometric features at selected black spot

in this section the geometric features of each selected black spot like cross-section details, camber, super elevation, signs and markings, drainage, sight distance, horizontal and vertical profiles and

encroachment details will be collected. The total station instrument is going to be used for the present study to collect the geometrical details. From the total station instrument north- east coordinates of different locations has to be recorded.

4.7 Tabulation and extraction of geometric details from the collected data

the geometric details like camber, super elevation, distances, gradients etc are to be extracted from the data collected in the field and tabulated to proceed for further analysis.

4.8 Modelling for accident prediction

statistical model has to be developed from the available data to give the predicted accident count when the geometric details of a particular section were known. For this, mini tab software is going to be used. Mini tab software is statistical software from which all types of statistics can be performed based on the data available. For the present study multiple regression equation is to be developed for the prediction of accidents for a section with known geometrical details. From the analysis and comparisons, the proposals for the accident reduction measures can be given.

5. ANALYSIS OF ACCIDENT DATA

AH 45 is a National Highway passing through the Nellore and Kavali, having a total length of 58 km, all with two lane bitumen surface.

The accident data was collected from the FIR reports in the police stations covering the AH45 through Nellore to Kavali. For this data recording, an accident data format was prepared and all the data was recorded on those sheets. A total number of 804 accidents were recorded in the entire stretch. A sample of the data sheet was shown in Appendix A. The collected data was tabulated in MS-Access and general analysis has been done like consolidating the total no accidents in each police station, severity wise, monthly distribution of accidents, type of accused and victim vehicle, nature of accident occurred, time wise distribution, type of area, responsibility of driver, etc. Accident data is summarized in Tables 4.1 and 4.8.

Table 4.1 shows the police station wise distribution of accidents throughout the AH45 through Nellore to Kavali. In the total accident data 9% accidents are recorded in Near Eenadu Press and next 18% of accidents are recorded in Gowravaram police station area.

From the below table it can be clearly observed that rear end collisions are occurring in maximum amount at near or inside a village. The main accused vehicle is lorry/truck and victim vehicle is two wheeler. The main reason for more number of accidents is exceeding lawful speed while crossing another vehicle.

From the Table 10 it can be observed that highest accidents were observed when the accused vehicle is a Lorry and the victim vehicle is a Two wheeler (11.5%) or a Lorry (10.5%).

From the Table 11 it was observed that more number of fatal accidents (15%) and minor accidents (30%) occurred during the crossing type of manoeuvre.

Table 1 Accidental Data

Name of the Police Station	**Total no of accidents in 5 years**
On AH-45 near Eenadu office Road	69
On AH-45 near Ayyappagudi Circle	17
On AH-45 Near Kanuparthipadu	64
On AH-45 Near Saakshi office	47
On AH-45 Near Narayana Engineering College	24
On AH-45 Near Prashanthi nagar	27
On AH-45 Near Bhagat Singh Colony	25
On AH-45 Near Simhapuri Hospitals	41
On AH-45 Near Maipadu Road	28
On AH-45 Near Penna Bridge	14
On AH-45 Near Jammipalem Road	8
On AH-45 Near Inamadugu Road	23
On AH-45 Near Chowdary Petrol Bunk Near Kovur Main Road	17
On AH-45 Near Maneguntapadu Road	19
On AH-45 Near North Rajupalem	29
On AH-45 Near Yallayapalem, Bucchi Road	21
On AH-45 Near North Rajupalem Entrance	7
On AH-45 Near B.v Palem Road	13
On AH-45 Near Kothapalle	15
On AH-45 Near Sunnambathi Village	31
On AH-45 Near Damavara Main Road	24
On AH-45 Near Alluru Road	29
On AH-45 Near Anantharam Road	9
On AH-45 Near Tellagunta circle	10
On AH-45 Near Bitragunta Main Road	8
On AH-45 Near Gowravaram Village	67
On AH-45 Near Chenchugoddu Palem Road	24
On AH-45 Near Musunuru Village	61
On AH-45 Near Thummalapenta Road	29
On AH-45 Near Bainatipalem Road	16

Table 2 : Nature of accident

Nature of accident	**No of accidents**	**% of accidents**
Over turning	56	7
Head on collision	118	14.46
Rear end collision	216	26.5
Collision brush / Side swipe	86	10.5
Right angled collision	54	6.25
Skidding	76	9.3
Right turn collision	125	15.31
Others	85	10.41

Table 3: Accident details based on Type of area

Type of Area	No of accidents	% of accidents
Near school or college	74	9.06
Near or inside a village	85	10.4
Near a factory / Industrial area	126	15.4
Near a religious place	201	24.6
In Bazaar	173	21.2
Near office complex	98	12.0
Residential areas	35	4.28
Open area	24	2.9

Table 4: Accident details based on Type of accused vehicle

Type of accused vehicle	No of accidents	% of accidents
Unknown	136	16.66
2W	124	15.19
3W / AUTO	100	12.25
Lorry / DCM / Tractor / Truck	239	29.28
Car / Van /Jeep	123	15.07
Bus / Ambulance	94	11.51

Table 5: Accident details based on Type of victim vehicle

Type of victim vehicle	No of accidents	% of accidents
Unknown	77	9.43
2W	133	16.29
3W / AUTO	129	15.80
Lorry / DCM / Tractor / Truck	167	20.46
Car / Van /Jeep	94	11.5
Bus / Ambulance	101	12.37
Cycle	49	6.00
ADV	66	8.08

Table 6: Accident details based on Type of manoeuvre

Type of maneuver	No of accidents	% of accidents
Unknown	99	12.13
Diverging	127	15.56
Merging	166	20.34
Crossing	146	17.89
Stationary	111	13.6
Temporary held up	100	12.25
Parked	67	8.21

Table 7: Accident details based on Responsibility of Driver

Responsibility of Driver	No of accidents	% of accidents
Consumption of Alcohol or Drugged	155	18.99
Exceeding lawful speed	96	11.76
Did not give right of way to vehicle	54	6.617
Did not give right of way to pedestrian	66	8.08
Improper overtaking	129	15.80
On wrong side of road	35	4.28
Failed to give signal	33	4.04
Gave improper signal	56	6.86
Improper turn	81	9.92
Attention diverted	74	9.06
Others	37	4.53

Table 8: Accident details based on Classification of Accident

Classification of accident	No of accidents	% of accidents
Fatal	303	37.13
Grievous injury	346	42.40
Minor injury	167	20.47

Table 9: Characteristic wise peak accident records out of 816 accidents

Characteristic	Type of Characteristic with max number of Accidents	No of accidents
Nature of accident	Rear end collision	216
Type of area	Near or inside a village	85
Type of accused vehicle	Lorry/DCM/Tractor/Truck	167
Type of victim vehicle	Two wheeler	133
Type of maneuver	Crossing	146
Classification of accident	Minor injury	167

Table 10: Type of accused vehicle Vs Type of victim vehicle

Type of Accused Vehicle	Type of victim vehicle								Total
	Unknown	2W	3W / Auto	Lorry / Tractor	Car / Van	Bus	Cycle	ADV	
Unknown	12	21	12	10	15	18	15	9	112
2W	20	23	17	25	22	5	10	11	133
3W/Auto	9	15	20	45	10	15	5	10	129
Lorry/Tractor	67	10	25	12	3	17	13	20	167
Car/Van	42	10	20	30	23	15	2	3	145
Bus	50	5	5	15	13	17	10	14	130
Total	200	84	100	137	86	87	55	67	816

Table 11: Type of manoeuvre Vs Classification of accident

Type of maneuver	Classification of accident			Total
	Fatal	Grevious	Minor	
Diverging	23	24	21	68
Merging	22	15	23	60
Crossing	20	28	28	76
Stationary	15	24	29	68
Temporary held up	20	21	13	54
Parked	22	27	25	74
Stopping	25	25	39	89
Starting from near side	20	25	5	50
Starting from off side	17	38	15	70
Turning right	18	14	33	65
Going ahead overtaking	34	15	24	73
Unknown	34	18	17	69
Total	270	274	272	816

Table 12: Type of manoeuvre Vs Type of accused vehicle

Type of maneuver	Type of accused vehicle						Total
	Unknown	2W	3W / Auto	Lorry / Tractor	Car / Van	Bus	
Diverging	13	12	15	15	7	6	68
Merging	9	8	12	10	11	10	60
Crossing	13	12	9	6	18	18	76
Stationary	12	13	5	10	17	11	68
Temporary held up	10	12	18	5	6	3	54
Parked	12	15	15	8	16	8	74
Stopping	10	10	10	12	16	31	89
Starting from near side	13	9	8	7	7	6	50
Starting from off side	8	10	10	13	15	14	70
Turning right	11	15	9	11	10	9	65
Going ahead overtaking	9	13	9	18	15	9	73
Unknown	10	13	9	15	12	10	69
Total	130	142	129	130	150	135	816

From the Table 12 it can be observed that more no of accidents occurred when a Lorry (22%) / Car (12%) cross another vehicle

Table 13: Type of manoeuvre Vs Type of victim vehicle

Type of Maneuver	**Type of victim vehicle**								
	Unknown	2W	3W / Auto	Lorry / Tractor	Car / Van	Bus	Cycle	ADV	**Total**
Diverging	12	4	0	13	21	9	4	5	68
Merging	16	3	7	0	4	8	2	6	46
Crossing	19	11	20	23	9	16	2	14	114
Stationary	0	4	2	7	0	3	18	1	36
Temporary held up	21	19	17	5	68	4	2	3	139
Parked	4	10	11	0	21	7	8	10	73
Stopping	2	4	7	0	9	12	2	5	41
Starting from near Side	0	2	4	7	0	7	5	3	28
Starting from off Side	0	8	34	5	31	36	10	2	102
Turning right	1	2	11	0	17	11	2	3	56
Going ahead Overtaking	8	1	32	7	18	20	2	1	84
Unknown	3	6	6	1	4	3	1	5	29
Total	86	74	152	68	202	136	58	40	816

From the Table 13 it was observed that more no of accidents were occurred when a vehicle crosses a two wheeler (10.5%) / Lorry (10%).

Table 14: Responsibility of driver Vs Type of accused vehicle

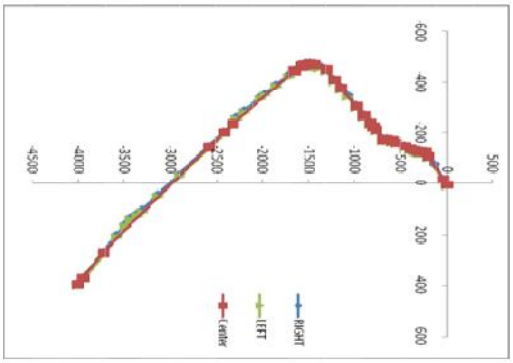
Responsibility of driver	**Type of accused vehicle**						**Total**
	Unknown	2W	3W / Auto	Lorry / Tractor	Car / Van	Bus	
Consumption of alcohol	10	15	40	23	22	20	130
Exceeding lawful speed	5	2	10	8	9	16	50
Did not give ROW to vehicle	15	35	8	3	3	4	68
Did not give ROW to pedestrian	17	18	5	20	7	7	74
Improper overtaking	5	8	1	10	30	0	54
On wrong side of road	17	2	2	15	22	0	58
Failed to give signal	3	10	37	8	13	3	74
Gave improper signal	9	1	4	27	1	8	50
Improper turn	2	8	11	4	8	7	40
Attention diverted	12	28	4	14	14	27	99
Others	25	18	8	4	14	50	119
Total	120	145	130	136	143	142	816

From the Table 14 it was observed that more no of accidents were occurred because of exceeding lawful
Average crash density = 4.71
Standard deviation of crash density = 2.41
Critical Crash Density = 4.71+2.41 = 7.12

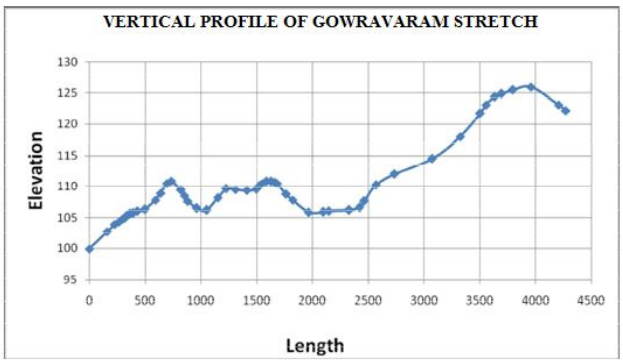
As per Crash frequency Method
Average Crash Frequency = 5.44
Standard Deviation of Crash Frequency = 3.51
Critical Crash Frequency = 5.44+3.51 = 8.95

6. GEOMETRIC DETAILS

6.1 Horizontal Profile



6.2 Vertical Profile



7 MODEL DEVELOPMENT

Since , CR = 0.006979X1 -0.0892 X2 + 0.011731 X3 + 0.3783 X4 - 5.3888
R square value = 1, Where X1 = Length of the curve
X2 = Degree of Curvature
X3 = Sight Distance X4 = Number of Crashes

8. CONCLUSIONS

From the analysis of the accident data it is clear that rear end collisions are occurring more (44%), accidents are occurring at near or inside a village (54%), while the major accused vehicle is a speed and the major lorry (44%) and major victim is vehicle (31%) is two wheeler. Crossing is the major type of maneuver (50%), and exceeding lawful speed (88%) is the major characteristic when responsibility of driver is considered. From the cross analysis of accident data it was observed that when the accused vehicle is a lorry and victim vehicle is a two wheeler (12%) more number of accidents have been taken place. In the same way, while crossing type of maneuver fatal accidents are recorded as 15% and minor accidents are recorded as 30%. And when lorry crosses any other vehicle, 22% of accidents were taken place. 10% of accidents occurred while some vehicle crosses two wheeler. While considering responsibility of driver, exceeding lawful speed is the major reason for which type of accused vehicle is lorry (38%), victim vehicle is two wheeler (28%), and type of maneuver is crossing (46%). From the crash density method Gowravaram Rural police station stretch was selected for analysis as its crash density is 17.25. From the model developed it was observed that the relation between crash rate with degrees of curvature and total rise is positive and with super elevation and sight distance is negative. From the field observation it was observed that at cross roads or junctions the chances of occurrence of an accident is more.

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