Effects of Highway Geometric Elements on Accident Rate

[1]RIFAT RASOOL, [2]Suhaib Firdous
[1]M Tech Scholar, Civil Engineering Department, Geeta Engineering College, Naultha, Panipat
[2]Assistant Professor, Civil Engineering Department, International Institute of Engineering And Technology Samani Kurukshetra Haryana

Abstract

The tremendous traffic growth generally observed in road transportation has led to a lot of negative consequences in the form of road accidents both in developed and developing countries. Studies focused on geometric design and safety aim to improve highway design and to eliminate hazardous locations. The effect of design elements such as horizontal and vertical curves, lane width, shoulder width,superelevation, median width, curve radius, sight distance, etc. on safety have been studied. The relationship between geometric design elements and accident ratesis complex and not fully understood. Relatively little information is available on relationships between geometric elements and accident rates. Although it has been clearly shown that very restrictive geometric elements such as sight distance, sharp horizontal curve result a considerably higher accident rates and that certain combination of elements cause an unusually severe accident problem. Data are collected for speed, super elevation, radius of curve and width of road at various points and at major black spots and explanations are given on how to which extent they affect highway safety. The results are being expected to help authorities in framing and prioritizing the improvement schemes.

Key words: Geometic elements, road design, accident modeling

1. Introduction

Road accident is a serious problem in our state J&K. From the year 2016 to 2017 there were 5172 road accidents that lead to approximately 869 fatalities (as per data collected from Awantipora, Saddar, Parimpora Police stations). Since then no efforts have been made by the government to improve road safety condition in order to achieve the target. Highway safety data analysts desire better quality data to meet a wide variety of needs. Many of the data elements currently collected are not of sufficient quality to meet the needs of data analysts. A primary source of highway safety data is crash data collected by police officers at the scene. Police are unique in their ability to collect on scene crash data shortly after the crash occurs, as well as the transient data that may erode (i.e., tire marks) or be removed from the scene. Although police are in a unique position to collect crash data, data collection is not their only responsibility. Their primary on scene responsibilities includes securing the crash site, caring for injured persons, and re-establishing traffic

flow. Therefore, on scene data collection systems must consider the officer's needs when implementing new technologies. Once a series of data collected, accident sites have are selected for possible treatment and before a decision can be made on which sites will be treated and the type of improvement work necessary, further information is usually needed. This extra data, obtained through site visits, should relate to both the site accident data and to the other factors that might help to determine what the problem at the site are. On site visit, data should include details of the road, its environment, vehicle features and road user characteristics Signs and Marking, Lighting, Width, Poles, posts, etc. Divided/undivided ,Legibility, Height, Horizontal railings, Number of lanes, Conspicuity Intensity, Rocks, trees, other Cross fall Comprehensibly Obstruction hazards, Gradient Credibility, Parked Vehicles , Safety barriers, fences, Shoulder , Lane, centre On street parking ,Side slopes, Verge And edge lines , Culverts Median and Other markings, Off-street parking and Bridge abutments, access openings Pavement markers , Visibility ,Footpath, Post mounted Clearway hours, Kerbs, pram ramps , delineators ,Parking controls On intersection approach, Drainage Hazard markers , Loading facilities Of side road Combination of Chevron alignment, Bus stops , Of traffic control devices , factors Markers Taxi rank Of pedestrians , Physical obstruction Of parked vehicles ,Type Primary/secondary/ speed of bus stops, Roughness Tertiary Safe speed Over crests, Friction Intensity ,Subliminal delineation, Service access, Speed limit ,Super elevation Controller type Land uses , Damaged road furniture, Sag at foot of hill ,Channelization, crossing facilities Pedestrian barriers, Turning radius. Having identified dominant accident types at a location or area under study will, hopefully, give an indication of an appropriate remedial measure. This involves selecting a package of possible countermeasures for a site and prioritizing the potential treatments. This is done by deciding on appropriate objectives of the various safety strategies based on achieving satisfactory accident reductions. It is desirable to consider a number of alternative proposals for each site. For every proposal it should be checked that:

- The measures are likely to decrease the type of Potential Countermeasures accident at which they are aimed.
- No further increase in other types of accident is likely to occur as a result of the selected measure.
- No adverse effect on environment
- Cost effective or economical.

1.1 CAUSES OF ACCIDENTS

The various causes of road accidents are:

- **Road Users** - Excessive speed and rash driving, violation of traffic rules, failure to perceive traffic situation or sign or signal in adequate time, carelessness, fatigue, alcohol, sleep etc.
- **Vehicle** - Defects such as failure of brakes, steering system, tyre burst, lighting system.
- **Road Condition** - Skidding road surface, pot holes, ruts.
- **Road design** - Defective geometric design like inadequate sight distance, inadequate width of shoulders, improper curve design, improper traffic control devices and improper lighting,.

- **Environmental factors** -unfavourable weather conditions like mist, snow, smoke and heavy rainfall which restrict normal visibility and makes driving unsafe.
- **Other causes** -improper location of advertisement boards, gate of level crossing not closed when required etc.

1.2 METHODOLOGY

The methodology of the project work is classified into three major steps. The first one is the accident data collection, the second one is the data analysis and last step is to recommend countermeasures. The overall methodology involves:

I. Data collection of various accident records from Police stations that comes under the jurisdiction of this road stretch (reference FIR records).

II. Data collection from onsite visit.

III. Identification of black spots

This methodology requires a map of the desired road network and certain specified road attributes to carry out prioritization. The analysis then identifies accident black spots on the given road network. While carrying out the analysis the method incorporates the road related factors such as road geometries and accident severity data collected from P.S which leads to accidents.The factors considered for evaluating accident prone locations road are as follows:

- Road width
- Number of lanes
- Approximate number of vehicles per day
- Type of road
- Drainage facilities
- Surface condition of the pavement
- Frequent vehicle type
- Presence of shoulders, edge obstructions, median barriers and ribbon development
- Radius of horizontal curve

Primary data collection involve the following parameters which is collected after site visit

1. Design Speed
2. Horizontal Curves
3. Super elevation
4. Carriageway width

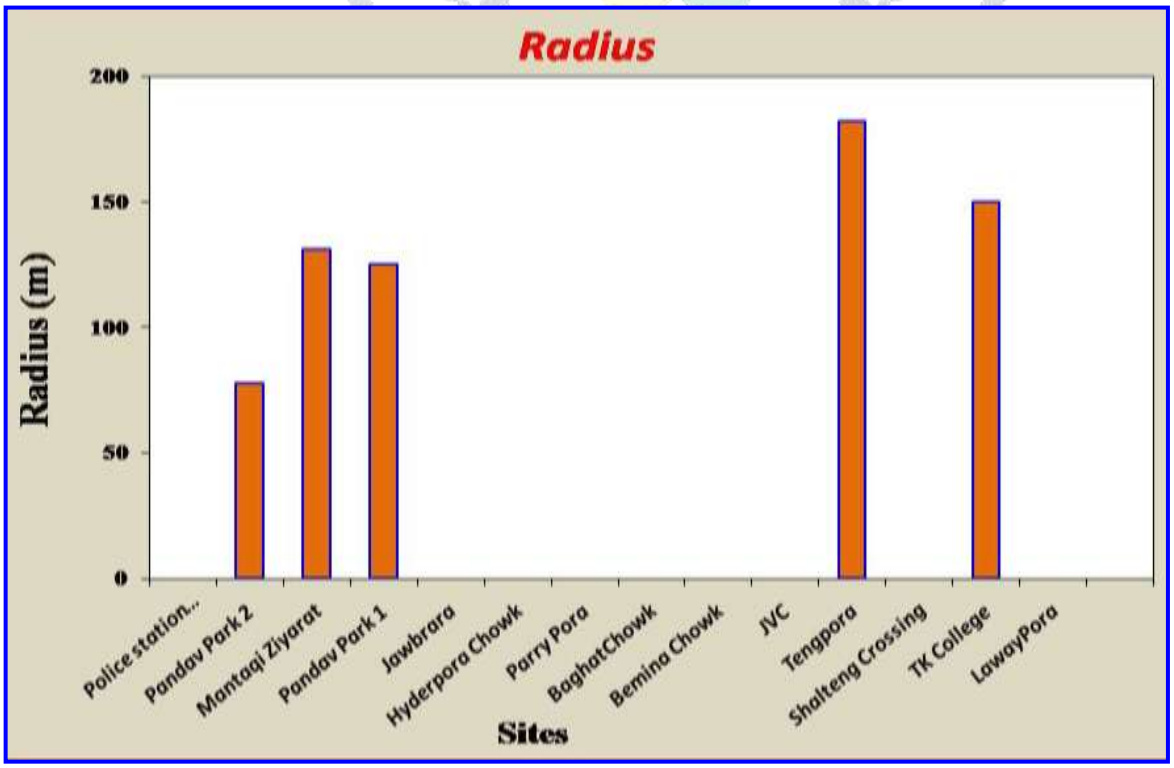
TABLE : Data collected from various accident prone stretch or Sites

S. No	Place	Radius	Super	Carriage way

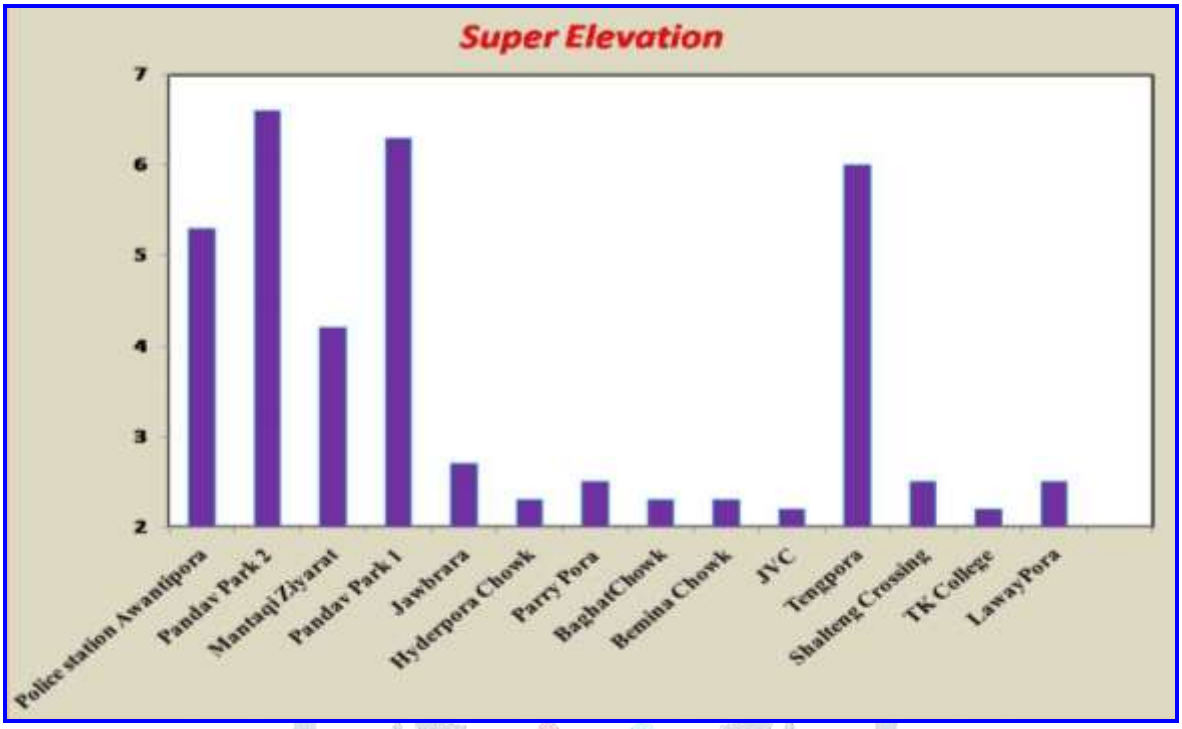
			Elevation	width
1	Police station Awantipora	0	5.3	7.1
2	Pandav Park 2	78	6.6	7.45
3	Mantaqi Ziyarat	131	4.2	6.9
4	Pandav Park 1	125	6.3	7.3
5	Jawbrara	0	2.7	6.7
6	Hyderpora Chowk	0	2.3	7
7	Parry Pora	0	2.5	6.25
8	BaghatChowk	0	2.3	6.8
9	Bemina Chowk	0	2.3	8.25
10	JVC	0	2.2	8.3
11	Tengpora	182	6	8.2
12	Shalteng Crossing	0	2.5	9.4
13	TK College	150	2.2	7.3
14	LawayPora	0	2.5	5

Analysis and Results

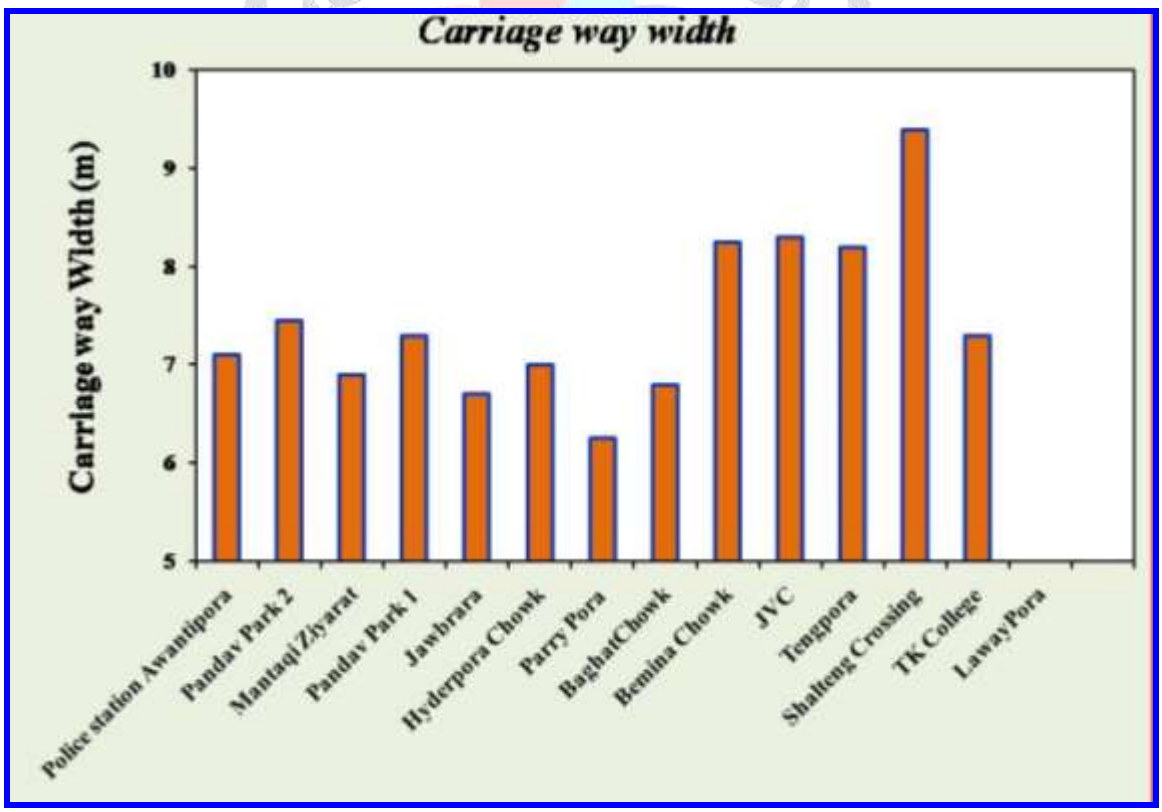
RESULTS



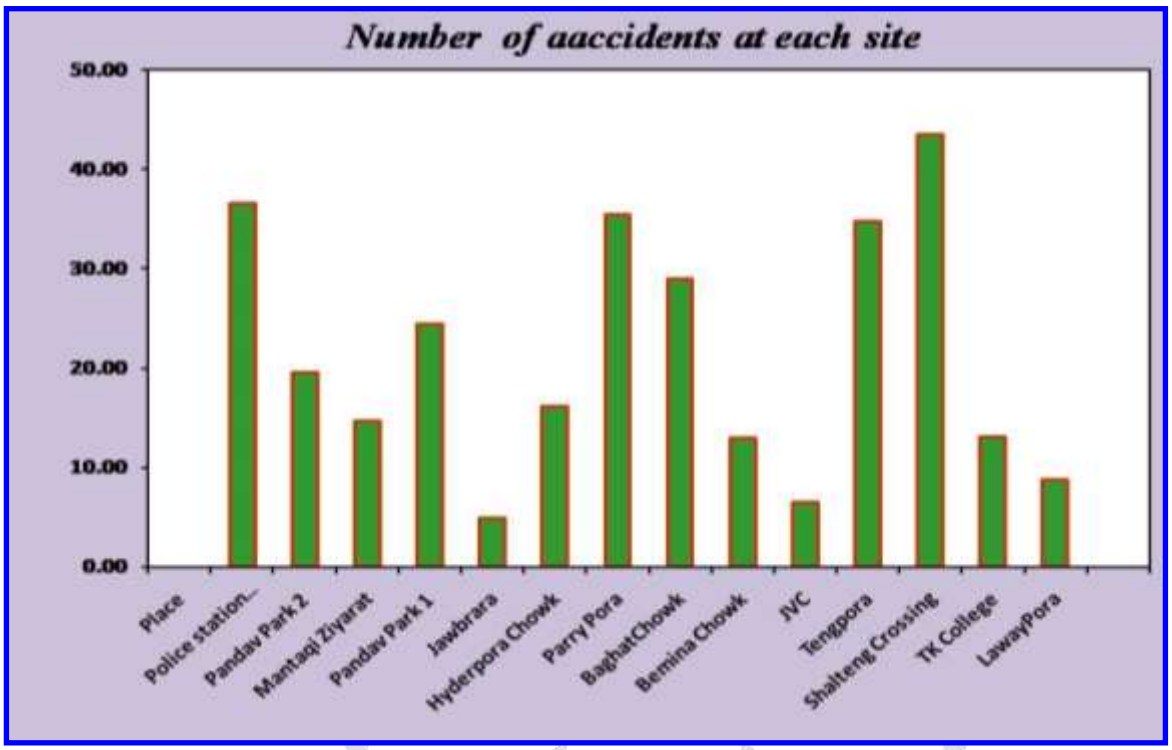
Change in radius of curve from Awantipora to Lawaypora.



Change in Super elevation from Awantipora to Lawaypora

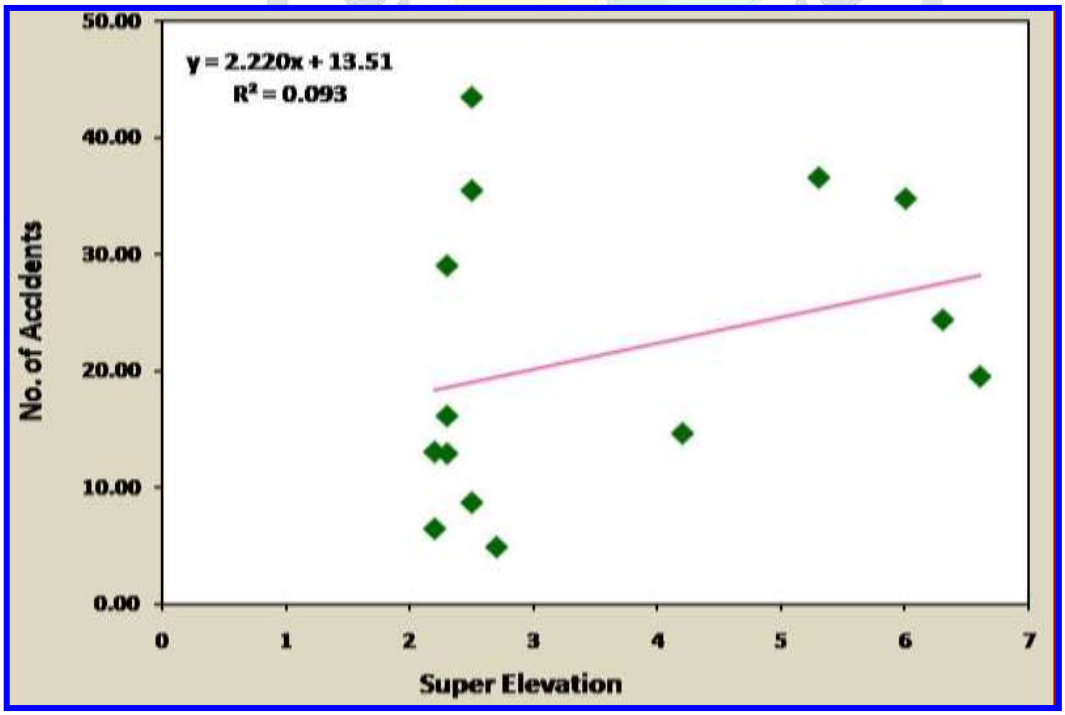


Change in carriageway width from Awantipora to Lawaypora

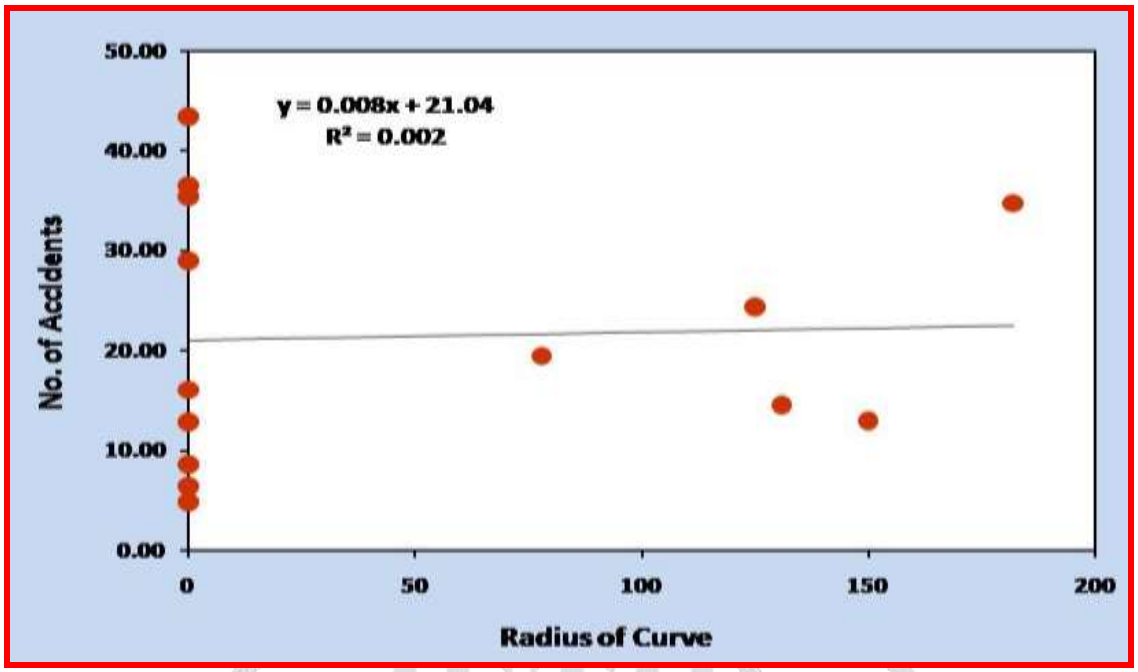


Number of accidents that occurred at the selected sites during the period of study.

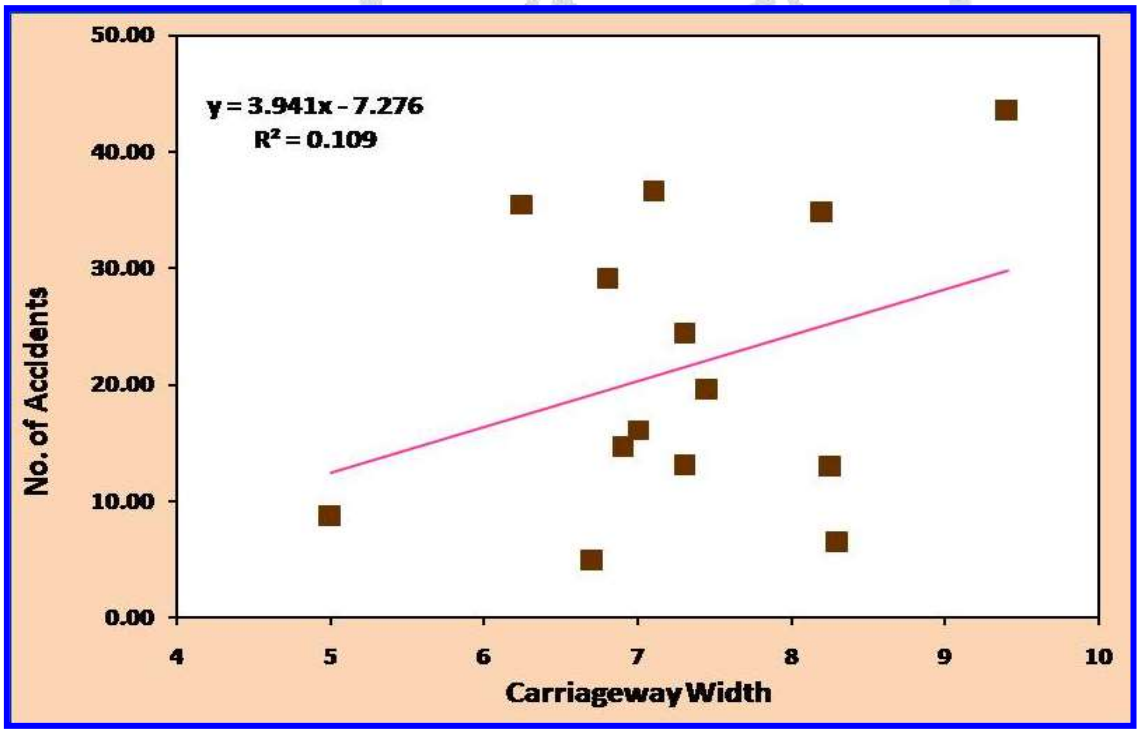
SINGLE REGRESSION ANALYSIS



Relation of number of accidents to the radius of curve at the selected sites.



Relation of number of accidents to the superelevation at the selected sites.



Relation of number of accidents to the carriageway width at the selected sites.

CONCLUSIONS

The study shows that the main causes, effects and locations of accidents on National Highways are:

- ✓ Occurring on straight stretches due to high speed.

- ✓ Occurring at four-arm junctions due to insufficient sight distance, lack of traffic guidance, and absence of markings and poor road geometries.
- ✓ Head-on collisions due to high speed and bad overtaking practice.
- ✓ Pedestrians are most vulnerable due to insufficient pedestrian facilities, poor knowledge of traffic rules and making errors.

The main recorded cause of accidents is driver error.

- Negligence and over speeding is as high as 90%.

Countermeasures are problem oriented and the choice of measures for a particular set of contributory factors must be aimed at resolving problems. Potential solution and the basis for countermeasures are of three types:

Recommendations

a. Remove the conflict

- Prevent pedestrian crossing
- Prevent hazardous vehicle maneuver

b. Improve visibility

- Move the hill or obstruction
- Move the crossing

c. Reduce speeds

- Reduce speed limits
- Provide speed breaker or other physical devices

Maximum casualties are in cars, followed by pedestrians and trucks

Following parameters are to be improved to increase the safety in the national highway

- Improving Driver Expectancy.
- Improving Safety at Junction.
- Provision of Overtaking Zones.
- Use of Traffic Control Device.
- Speed Control and Reduction
- Pedestrian Safety
- Countermeasures for Specific type of Collisions.

References

✓ Aram, A. (2010). Effective safety factors on horizontal curves of two-lane highways. Journal of Applied Sciences, 10(22), pp. 2814-2822.

- ✓ Bayata, H. F., Hattatoglu, F., & Karsli, N. (2011). Modeling of monthly traffic accidents with the artificial neural network method. International Journal of the Physical Sciences, 6(2), pp. 244-254.
- ✓ Binglei, X., Zheng, H., & Hongwei, M. (2008). Fuzzy-logic-based traffic incident detection algorithm for freeway. In Machine Learning and Cybernetics, 2008 International Conference on (Vol. 3, pp. 1254-1259). IEEE.
- ✓ Cansiz, Omer F., Easa, Said M. (2011). Using Artificial Neural Network to Predict Collisions on Horizontal Tangents of 3D Two-Lane Highways. International Journal of Engineering and Applied Sciences, pp. 47-56.
- ✓ Chang, I., & Kim, S. W. (2012). Modelling for identifying accident-prone spots: Bayesian approach with a Poisson mixture model. KSCE Journal of Civil Engineering, 16(3), pp. 441-449.
- ✓ Chattaraj, U. & Panda, M. (2010). Some Applications of Fuzzy Logic in Transportation Engineering, Proceedings of International Conference on Challenges and Applications of Mathematics in Science and Technology (CAMIST), pp. 139-148.
- ✓ Choi, J., Kim, S., Heo, T. Y., & Lee, J. (2011). Safety effects of highway terrain types in vehicle crash model of major rural roads. KSCE Journal of Civil Engineering, 15(2), pp. 405-412.
- ✓ Daigavane, P., & Bajaj, P. (2009). Analysis of selective parameters contributing to road accidents on highways for establishing suggestive precautionary strategies. In Emerging Trends in Engineering and Technology (ICETET), 2009 2nd International Conference on (pp. 576-580). IEEE.
- ✓ Donnell, E. T., Gross, F., Stodart, B. P., & Opiela, K. S. (2009). Appraisal of the interactive highway safety design model's crash prediction and design consistency modules: case studies from Pennsylvania. Journal of Transportation Engineering, 135(2), pp. 62-73.
- ✓ Driss, M., Saint-Gerand, T., Bensaid, A., Benabdeli, K. and Hamadouche, M.A. (2013). A fuzzy logic model for identifying spatial degrees of exposure to the risk of road accidents (Case study of the Wilaya of Mascara, Northwest of Algeria). International Conference on dvanced Logistics and Transport (ICALT), pp. 69-74
- ✓ Figueroa Medina, A. M., & Tarko, A. P. (2007). Speed changes in the vicinity of horizontal curves on two-lane rural roads. Journal of transportation engineering, 133(4), pp. 215- 222.
- ✓ Fitzpatrick, K., Lord, D., & Park, B. J. (2010). Horizontal curve accident modification factor with consideration of driveway density on rural four-lane highways in texas. Journal of Transportation Engineering, 136(9), pp. 827-835.
- ✓ Geometric Design Standards for Rural (Non-Urban) Highways, IRC:73-1980, The Indian Road Congress, New Delhi, 1980 Gibreel, G. M., Easa, S. M., & El-Dimeery, I. A. (2001). Prediction of operating speed on
- ✓ three-dimensional highway alignments. Journal of Transportation Engineering, 127(1), pp. 21-30.

- ✓ Glennon, J., (1987). Effect of alignment on highway safety: Relationship between safety and key highway features: state of the art report 6. Transportation Research Board, Washington, DC.
- ✓ Guidelines for Design of Horizontal Curve for Highway and Design Tables, IRC:38-1988, The Indian Road Congress, New Delhi, 1988.
- ✓ Harwood, D. W., Council, F. M., Hauer, E., Hughes, W. E., and Vogt, A. (2000). Prediction of the expected safety performance of rural two-lane highways. FHWA-RD-99–207, Federal Highway Administration, Washington, D.C.
- ✓ Hassan, Y., Sayed, T., & Tabernero, V. (2001). Establishing practical approach for design consistency evaluation. Journal of transportation Engineering, 127(4), pp. 295-302.
- ✓ Hassan, Y., & Easa, S. M. (2003). Effect of vertical alignment on driver perception of horizontal curves. Journal of transportation engineering, 129(4), pp. 399-407.
- ✓ Iyinam, A. F., Iyinam, S., & Ergun, M. (1997). Analysis of relationship between highway safety and road geometric design elements: Turkish case. Technical University of Istanbul, Faculty of Civil Engineering, Turkey.
- ✓ Kanellaidis, G., & Vardaki, S. (2011). Highway geometric design from the perspective of recent safety developments. Journal of Transportation Engineering, 137(12), pp. 841-844.
- ✓ Lin, F. B. (1990). Flattening of horizontal curves on rural two-lane highways. Journal of transportation engineering, 116(2), 181-186.
- ✓ Mehdi Hosseinpour, Ahmad Shukri Yahaya, Seyed Mohammadreza Ghadiri, Joewono Prasetijo (2013). Application of Adaptive Neuro-fuzzy Inference System for road accident prediction. KSCE Journal of Civil Engineering, Volume 17, Issue 7, pp. 1761-1772.
- ✓ Milton, J., & Mannering, F. (1998). The relationship among highway geometrics, trafficrelated elements and motor-vehicle accident frequencies. Transportation, 25(4), pp. 395- 413.
- ✓ Mustakim, F., & Fujita, M. (2011). Development of Accident Predictive Model for Rural Roadway. World Academy of Science, Engineering and Technology, 58, pp. 126-131.
- ✓ Polus, A., & Mattar-Habib, C. (2004). New consistency model for rural highways and its relationship to safety. Journal of Transportation Engineering, 130(3), pp. 286-293.
- ✓ Recommendations About the Alignment Survey and Geometric Design of Hill Roads, IRC:52-2001, The Indian Road Congress, New Delhi, 2001.
- ✓ Seneviratne, P. N., & Islam, M. N. (1994). Optimum curvature for simple horizontal curves. Journal of Transportation Engineering, 120(5), pp. 773-786.
- ✓ Shen, J., and Gan, A. (2003). Development of crash reduction factors: Methods, problems, and research needs. Transportation Research Record. 1840, Transportation Research Board, Washington, D.C., pp. 50–56.

- ✓ Stamatiadis, N., Lord, D., Pigman, J., Sacksteder, J., & Ruff, W. (2010). Safety Impacts of Design Element Trade-Offs for Multilane Rural Highways. Journal of Transportation Engineering, 137(5), pp. 333-340.
- ✓ Taiganidis, I., & Kanellaidis, G. (1999). Approximate perspective design of roads. Journal of Transportation Engineering, 125(4), pp. 314-323.
- ✓ Yi, P., Xiao, Y., Ciccolini, A., Frommer, G., & Zhang, D. (2001). Rule-based model for traffic accident visualization and analysis. Journal of computing in civil engineering, 15(2), pp. 129-136.
- ✓ Zadeh, L.A. (1975).The concept of a linguistic variable and its applications to approximate reasoning-I, Information Sciences, Vol. 8, pp. 199-249.
- ✓ Zegeer, C. V., Deen, R. C., and Mayes, J. G. (1981). Effect of lane and shoulder widths on accident reduction on rural, two-lane roads. Transportation Research Record. 806, Transportation Research Board, Washington, D.C., pp. 33–42.