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PEDESTRIAN CRASH PREDICTION MODEL FOR URBAN ROAD FROM VIJAY NAGAR TO BHAWARKUAN (A.B. ROAD), INDORE

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Abstract: Pedestrians are the most vulnerable and neglected road users in India. Vehicle crashes with pedestrian are almost inevitable and cause injury or death to pedestrian. In India, annually, around one-third of road accidents involve pedestrians as victims. The pedestrian accident prone urban road stretch A.B. road in Indore city was selected as the study stretch. A statistical model for predicting the number of pedestrian accidents from Vijay Nagar to Bhawarkuan (A.B. Road) was developed using simple linear regression analysis on SPSS version 26 software. Several variables such as vehicular volume, pedestrian volume, length of cross-walk, width of cross-walk, width of footpath, lane width, pedestrian signals, pedestrian crossing sign board, number of lanes were found to considerably affect the pedestrian accidents.

Index terms: Pedestrian accident, SPSS software, Regression analysis, Pedestrian accident modelling, Mathematical modelling.

I. INTRODUCTION

Due to the large number of pedestrians and vehicular activity, pedestrians are at greater risk in urban areas.
As per the World Health Organization (WHO) Global status report on road safety 2018, In every 1 minute and 41 seconds, there is a Pedestrian death around the world, every hour there is 36 pedestrians died, every day there is 854 Pedestrians died, every month there is 25,968 Pedestrians died and every year around 311,614 Pedestrians died.
As per MORTH, road accidents in India killed around 1.5 lakh people annually. India accounts for almost 11% of the accident related deaths around the World. In 2016 nearly 15,800, in 2017 nearly 20,457 and in 2018 nearly 24,861 pedestrians were killed in India. Pedestrian accounts for almost 15% of the Accident related death in India. Now If we mention Madhya Pradesh (State in India) around 1504 Pedestrians were killed in road accidents in 2018. Indore was third in the list of number of road accidents, persons killed & injured in Million-Plus Cities in 2017 which felled to fifth in 2018(Road Accident in India, 2018).

II. LITERATURE REVIEW

S. Binil Sundar (2016) et al., aims to analyse the pedestrian safety on Thiruvanmiyur to Sriuseri in Chennai (22 km stretch) through accident analysis. Data collected by them such as severity of accident, location, time, date and type of vehicle involved in accident. They analyse the data and find out that the key risk for pedestrian accidents were driver behaviour such as speeding and lack of infrastructure such as sidewalk and raised crosswalk. They further gave the measures to reduce the pedestrian accidents such as improvement in cross walk, restriction of heavy vehicle in peak hours etc.

Charles V. Zegeer (2005) et al., study to create a better understanding of the characteristics and cause of vehicular crashes in which older pedestrian is involved, to reduce the problem. Pedestrian age was carried out on around 26,000 pedestrian crashes in 11 years all over the North Carolina. According to them when an older age group pedestrian (65 or older) struck an accident they have much more likelihood of being killed i.e 20%, compared with 5-10% for younger age group. They recommended variety of educational, enforcement and roadway improvements to reduce the injuries and fatalities to older pedestrians.

Loreta Levulyte (2015) reviews the pedestrian-motor vehicle collision and road safety management. Paper also examines the pedestrian safety in order to determine which factors is responsible for pedestrian-vehicle conflict to know the reasons behind accident raising. Some factors which are studied are transport infrastructure, vehicle technical parameters, pedestrian behaviour, pedestrian crossing, crossing design and waiting time present. Technical information found by this paper gives the opportunity to

improve accident reconstruction cases and technical parameters and also, it let to understand road infrastructure problems and pedestrian behaviour on road.

Srinivas S. Pulugurtha (2010) work in two approach, first one is to examine the non-linear relationship between pedestrian crashes and predictor variables and second one is to developed generalized liner pedestrian crash estimation model. Data of 176 signalized intersections within the city of Charlotte, North Carolina were collected and used it to look at the non-linear relationship and develop the pedestrian crash estimation model. The number of pedestrian crashes per year was considered as dependent variable whereas land use characteristics, road network characteristics, demographic characteristics, socio-economic characteristics and number of transit shop were considered as predictor variable. In this paper Pearson correlation coefficient was used. Models were developed separately for all signalized intersection.

Pegah Jafari Haghighatpour (2014) describes the Prediction models for pedestrian crash in future, by this we can predict the pedestrian crash so it can be useful in reducing the pedestrian crashes. This paper shows models which may specify the safety indicators, indicated with existing information by differentiated parametric and non-parametric variables for signalized intersection. Methodology adopted in this paper is identify, the study intersections, data elements, number of pedestrian crashes as predicted variable which depend on other characteristics, extracting incoming vehicle volume, the number of transit shops, number of lanes, correlation between predictor variables and develop pedestrian crash estimation models. Three models including Regression, Poisson, Negative binomial with defined variables have been determined. T and chi square tests, calibration and comparison of variables has done by cure fitting. Future recommendations in this study is parameters such as demographic, land use, socio-economic characteristics that have an impact on relation between pedestrian crash, vehicles and pedestrian volume etc., optimization of traffic signals phase.

III. STUDY AREA

Indore is 200 km west from Bhopal and having a population of around 30 lakhs. Therefore, it is the 14th most populous city in India and 1st in Madhya Pradesh. The total road network length in Indore is almost 1710 km. The main road covers around 234 km, while intermediated road length accounts for 211 km and city road covers a length of 936 km. The National Highway and State Highway accounts for quite 50% of the incoming and outgoing traffic within the city. Now if we talk about Agra-Bombay Road (AB Road) which lies in the center of the city, and also the life line of the city transport. It covers around 49km in Indore city. My study stretch starts from Vijay Nagar square and terminate at Bhawarkuan Square which is 7.8 km in length. As Shown in Fig 1.

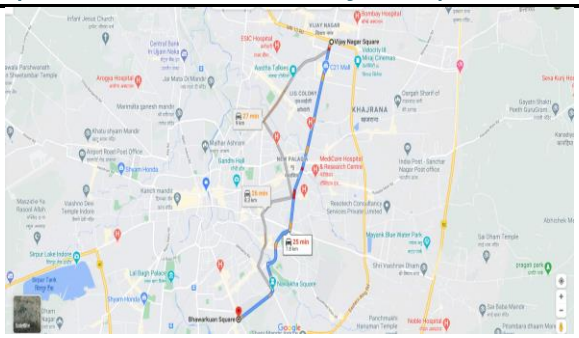

Figure 1: Road Map of Study Stretch from Vijay Nagar to Bhawarkuan

The 7.8 Km stretch is further divided into 10 sections starting from Vijay Nagar Square, LIG Square, Guitar Square, Palasia Square, Geeta Bhavan Square, Chhatrapati Shivaji Square, GPO Square, Indra Gandhi Square, Navlakha Square and end at Bhawarkuan Square.

IV. METHODOLOGY

Methodology adopted in this study is, Identification of factors affecting pedestrian crashes, Selection of the Road segment, Selection of the Road segment, Collection of accidents data through traffic police station, Selection of tool for analysis, Selection of variables, Development of pedestrian crash prediction model, Validation of model. Pedestrian characteristics such as pedestrian age, gender, behavior, Geometric characteristics such as availability of footpath, condition of cross-walk, number of lanes, Traffic characteristics such as pedestrian signals, pedestrian crossing sign board, median, Environmental characteristics such as lighting condition on road as well as on footpath, rain, snow, fog, smoke, smog, dust, strong winds are the factors responsible for pedestrian crashes. Through field survey, pedestrian count, vehicular count is collected. Length and width of the cross-walk, width of the footpath, number of lanes, width of the road, whether pedestrian signals are there or not, pedestrian sign board. All these data are collected from field survey. Pedestrian accident data was collected on my study stretch from ASP Office Traffic Indore. IPC section, Age of the pedestrian, gender of pedestrian, location of accident, time of the accident, vehicle by which accident occurred are collected. The Statistical Package for the Social Sciences (SPSS) software is used in statistical analysis of data. SPSS is a computer based quantitative analysis package developed by SPSS Incorporation. Using SPSS data management and statistical analysis tasks are often performed.

Selection of Variables:

In our study we have selected number of area and to develop model we have selected variables. These variables are in two category i.e,

- Dependent Variable (Number of Accident)
- Independent variable (Vehicle Volume, Pedestrian Volume, Length of cross-walk, Width of cross-walk, Pedestrian signal, Pedestrian sign board, width of footpath, Number of lanes, Lane width).

Development of pedestrian crash prediction model:

Crash prediction model have been useful tool for transport Engineers and Planners. Through crash prediction Engineers and Planners can predict the number of pedestrian accidents, by using this model it can help them to reduce in the number of pedestrian accidents.

The model was developed for pedestrian crashes occurring on my study stretch in the region over the five-year period 2015-2019.

Validation of model:

When any model has developed, we have to check the statistical validity of that model whether it is valid or not. To check the statistical validity of model we have to perform some test, these tests are as follow:

1. Anova Test
2. F-Test
3. T-Test

V. DATA COLLECTION

In order to pick the locations for the study, a couple of locations were selected. The locations best suited for the survey were chosen. At these locations, video graphic survey was conducted through which the number of pedestrians and number of vehicles in those particular locations were examined. The Locations which were selected are {location (

Number of pedestrian counts in peak hours, total vehicular traffic in terms of PCU in peak hours)} Vijay Nagar Square (2197, 3970), LIG Square (2179, 5170), Guitar Square (1694, 5652), Palasia Square (1665, 4270), Geeta Bhavan Square (2287, 4105), Chhatrapati Shivaji Square (1650, 4171), GPO Square (1397, 3895), Indra Gandhi Square (1864, 3722), Navlakha Square (2107, 4560) and Bhawarkuan Square (2455, 4642).

The Accident data on study stretch is collected from the ASP Office Traffic East Central kotwali, MTH Compund, Indore. Last Five-year Accident data is collected i.e, 2015, 2016, 2017, 2018, 2019 as shown in Table 1, 2, 3, 4 and 5 respectively.

Table 1: Number of Accidents in 2015

ACCIDENT DATA ON A.B. ROAD (VIJAY NAGAR TO BHAWARKUAN) 2019				
S.No	Name of Police Station	Death	Fatal Injuries	Minor Injuries
1	Vijay Nagar	0	3	13
2	MIG	0	6	21
3	Lasudia	1	1	7
4	Palasia	0	1	10
5	Tukoganj	1	2	12
6	Sanyogitaganj	1	6	23
7	Bhawarkuan	0	8	30

Table 2: Number of Accidents in 2016

ACCIDENT DATA ON A.B. ROAD (VIJAY NAGAR TO BHAWARKUAN) 2016				
S.No	Name of Police Station	Death	Fatal Injuries	Minor Injuries
1	Vijay Nagar	1	2	19
2	MIG	0	4	23
3	Lasudia	3	5	16
4	Palasia	0	6	16
5	Tukoganj	0	2	22
6	Sanyogitaganj	1	12	39
7	Bhawarkuan	1	17	43

Table 3: Number of Accidents in 2017

ACCIDENT DATA ON A.B. ROAD (VIJAY NAGAR TO BHAWARKUAN) 2015				
S.No	Name of Police Station	Death	Fatal Injuries	Minor Injuries
1	Vijay Nagar	1	6	26
2	MIG	1	3	23
3	Lasudia	2	4	21
4	Palasia	1	6	25
5	Tukoganj	0	2	26
6	Sanyogitaganj	2	18	55
7	Bhawarkuan	2	21	56

Table 4: Number of Accidents in 2018

ACCIDENT DATA ON A.B. ROAD (VIJAY NAGAR TO BHAWARKUAN) 2018				
S.No	Name of Police Station	Death	Fatal Injuries	Minor Injuries
1	Vijay Nagar	1	7	15
2	MIG	0	3	23
3	Lasudia	1	1	9
4	Palasia	0	6	10
5	Tukoganj	1	4	19
6	Sanyogitaganj	1	1	16
7	Bhawarkuan	1	8	34

Table 5: Number of Accidents in 2019

ACCIDENT DATA ON A.B. ROAD (VIJAY NAGAR TO BHAWARKUAN) 2017				
S.No	Name of Police Station	Death	Fatal Injuries	Minor Injuries
1	Vijay Nagar	1	4	22
2	MIG	0	1	20
3	Lasudia	2	3	19
4	Palasia	0	2	19
5	Tukoganj	0	2	21
6	Sanyogitaganj	1	7	52
7	Bhawarkuan	2	1	43

VI. ANALYSIS AND RESULTS

The Sections is further divided into 39 segments. At these segments Number of accidents, Vehicle Volume, Pedestrian Volume, Length of cross-walk, Width of cross-walk, Pedestrian signal, Pedestrian sign board, width of footpath, Number of lanes, Lane width are analyze. The data obtained from various sources is analyze in SPSS version 26 software.

Regression Analysis:

A transport planner generally faces the problem of predicting whether any kind of relationship can be established between two or more variables. The technique of predicting the number in future data (called dependent variable) from measurements of the other independent variables data is called regression analysis. In this study linear regression analysis is used to develop the pedestrian crash prediction model. Any relation between the both variable i.e, dependent and independent variable is linear, then it is called as linear regression analysis. If the independent variable is two or more than two, then the analysis is called as multiple linear regression analysis.

Results and Discuss:

As the regression analysis is applied on the data entered in SPSS software version 26, results are shown in Table 6, 7 and 8.

Table 6

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.874[a]	.764	.668	5.491

a. Predictors: (Constant), Pedestrian Signboard, Pedestrian length in m, Footpath Width, Vehicular Volume, Width of cross-walk, Pedestrain Signal, Pedestrian Volume, Length of cross-walk, ID, Number of Lanes, Width of lane

Table 7

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8937.791	11	812.526	7.957	.000[b]
	Residual	2757.132	27	102.116		
	Total	11694.923	38			

a. Dependent Variable: Number of Accident

b. Predictors: (Constant), Pedestrian crossing Signboard, Pedestrian length in M, Footpath Width, Vehicular Volume, Width of cross-walk, Pedestrian Signal, Pedestrian Volume, Length of cross-walk, ID, Number of Lanes, Width of lane

Table 8

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	56.948	27.689		2.057	.049
	Vehicular Volume	.013	.004	.397	2.805	.009
	Pedestrian Volume	-.005	.002	-.370	-2.788	.010
	Segment length in m	-.018	.020	-.108	-.912	.034
	Length of cross-walk	-19.787	2.928	-2.529	-6.758	.000
	Width of cross-walk	-24.926	5.520	-.502	-4.516	.000
	Number of Lanes	25.534	5.762	1.361	4.432	.000
	Width of lane	10.006	2.504	1.810	3.996	.000
	Footpath Width	3.669	1.622	.255	2.262	.032
	Pedestrain Signal	-9.366	3.746	-.255	-2.500	.019
	Pedestrian crossing Signboard	10.254	3.954	.273	2.594	.015

a. Dependent Variable: Number of Accident

Formulation of Model Equation:

The Coefficients of the result output gives us the value which is needed to write the regression equation. The pedestrian accident crash prediction model for study stretch using multiple linear regression analysis is shown in the equation given below:

Y=56.948+0.013*X1-0.005*X2-0.018*X3- 19.787*X4-24.926*X5+25.534*X6+ 10.006*X7+3.669*X8-9.366*X9+10.254*X10

Here, Y= Dependent variable i.e, Pedestrian accident
X1= Vehicular volume,
X2= Pedestrian volume,
X3= Segment length,
X4= Length of Cross-walk,
X5= Width of Cross-walk,
X6= Number of lanes,
X7= Width of Lane,
X8= Footpath Width,
X9= Pedestrian Signal,
X10= Pedestrian Crossing sign board.

CONCLUSIONS

- Using accident analysis, it is found that Bhawarkuan police station has maximum number of accident and Tukoganj police station has lowest number of accidents.
- Pedestrian crash has positive correlation (i.e. any change in independent variables results in positive change in dependent variable, i.e. number of crash) with vehicle volume, number of lanes, length of the cross-walk, width of the lane, footpath width and pedestrian crossing sign board.
- Pedestrian crash has negative correlation (i.e. any change in independent variables results in negative change in dependent variable, i.e. number of crash) with Pedestrian volume, segment length, width of the cross-walk and pedestrian signals.
- Result of the study found that as number of pedestrian signals increases the crash rate is decreases.
- R-square obtained from the developed predicted model is 0.764, this shows that 76.4% of the variation in pedestrian crashes is explained by the variation in vehicular volume, Pedestrian volume, Segment length, Length of Cross-walk, Width of Cross-walk, Number of lanes, Width of Lane, Footpath Width, Pedestrian Signal, Pedestrian Crossing sign board while 23.6% influence by other factors.

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