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A Review on Evaluation of Safety at Highway Intersection

Vishwas Malik
Department of Civil Engineering UIET, MDU Rohtak
Email id-vishu.malik73@yahoo.com

Abstract

Road accidents are one of the most important factor for the untimely deaths of human beings. What specifically cause road accidents is debatable but there is an agreement on some of the reasons like excess number of vehicles on the roads and not following the traffic rules. The way the accidents rate are increasing have forced the stakeholders to think for the safety measures. In the present paper we will try to examine the road safety measures undertaken and will evaluate it.

Key words: Road accidents, deaths, vehicles, intersection, safety

I. INTRODUCTION

About 40% of motor vehicle crashes occur at crossing points. In recent years, the number of crashes at traffic signals has increased considerably. Zhou et al. [1] looking into this aspect tried to do some research to measure the safety at the crossing points in china. It is important to note here that china ranks first in death toll caused by road accidents and almost 30 % of the deaths are happening at intersection point in urban areas. Crossing points are those points where roads from at least two different sides are connecting.is an area shared by two or more roads. A little mistake in judgment can cause extreme mischances. Overall traffic flow relies upon the execution of the convergences. Contrasted and other urban convergences, for the most part, produce more car accidents as a result of impressive clashes in mechanized rush-hour gridlock and additionally clashes among mechanized activity, non-mechanized movement, and people on foot. As indicated by past insights, roughly 55% of aggregate car accidents and 23% of accidents with fatalities in urban zones in the USA happen at crossing points. In India, roughly 32% of urban car accidents occur at convergences. These measurable information demonstrate that crossing points are spots of critical security concern. Consequently, the security assessment of a crossing point is a determinant issue so as to set up a connection for upkeep and to settle on right outline decisions for the improvement of new foundations. Crossing points that have mishap potential or have high quantities of mischances called unsafe convergences. A point by point factual examination ought to be completed keeping in mind the end goal to discover best measures to lessen seriousness and number of car crashes. By distinguishing the reasons that make the convergence unsafe it is conceivable to enhance its security all the more successfully. Security is plainly a standout amongst the most vital measures.

II. STUDY AREA

In any road network, urban road crossing forms an important part and are in general more complex due to heavy traffic merging from different ends. Road intersections that have accident potential or have high numbers of accidents called hazardous intersections thus safety evaluation of a road intersection is a determinant problem. Urban road crossing is a special form of at-grade intersection where vehicles from the conversing legs are forced to move round a central island in one direction either clockwise (India) or counter clock-wise in organized manner and move/weave out of the roundabout into their desired direction. In conventional urban road crossing, traffic flow at entry seek suitable gap in the circulating stream to negotiate at the roundabout. The self-regulating form of at grade intersection is safe and smooth because of less crossing conflict points and aesthetically pleasing in nature. Roundabout also may be described as an enlarged road intersection, where all entering vehicles shall yield and find suitable gaps to move around in an urban areas in one direction before they move out of the traffic flow into their respective directions radiating from the island. Urban road crossing are further classified according to size and environment to facilitate analysis of specific performance. Since this is the point where vehicles change their directions and speed very rapidly, hence urban road crossing becomes more important issue in the perspective of severity of road accidents. Though a four legged Central Island Intersection have eight conflict points that is less than conflict point at signalized intersection, are not free from road accidents. Heavy traffic, and lack of awareness of road user makes it more accident prone area. Hence it is necessary to evaluate the road safety at urban road crossing to reduce the accidents and to make Intersections more safe and smooth.

III. REVIEW OF THE LITERATURE

This paper presents the review of literature relevant to the problem considered in this study Literature review related to Intersection safety and evaluation of safety at urban road crossing in different parameters. The major aspects that are required to solve the problem in this study are: a review on identification of safety hazardous components and reviews on evaluation of Intersections safety.

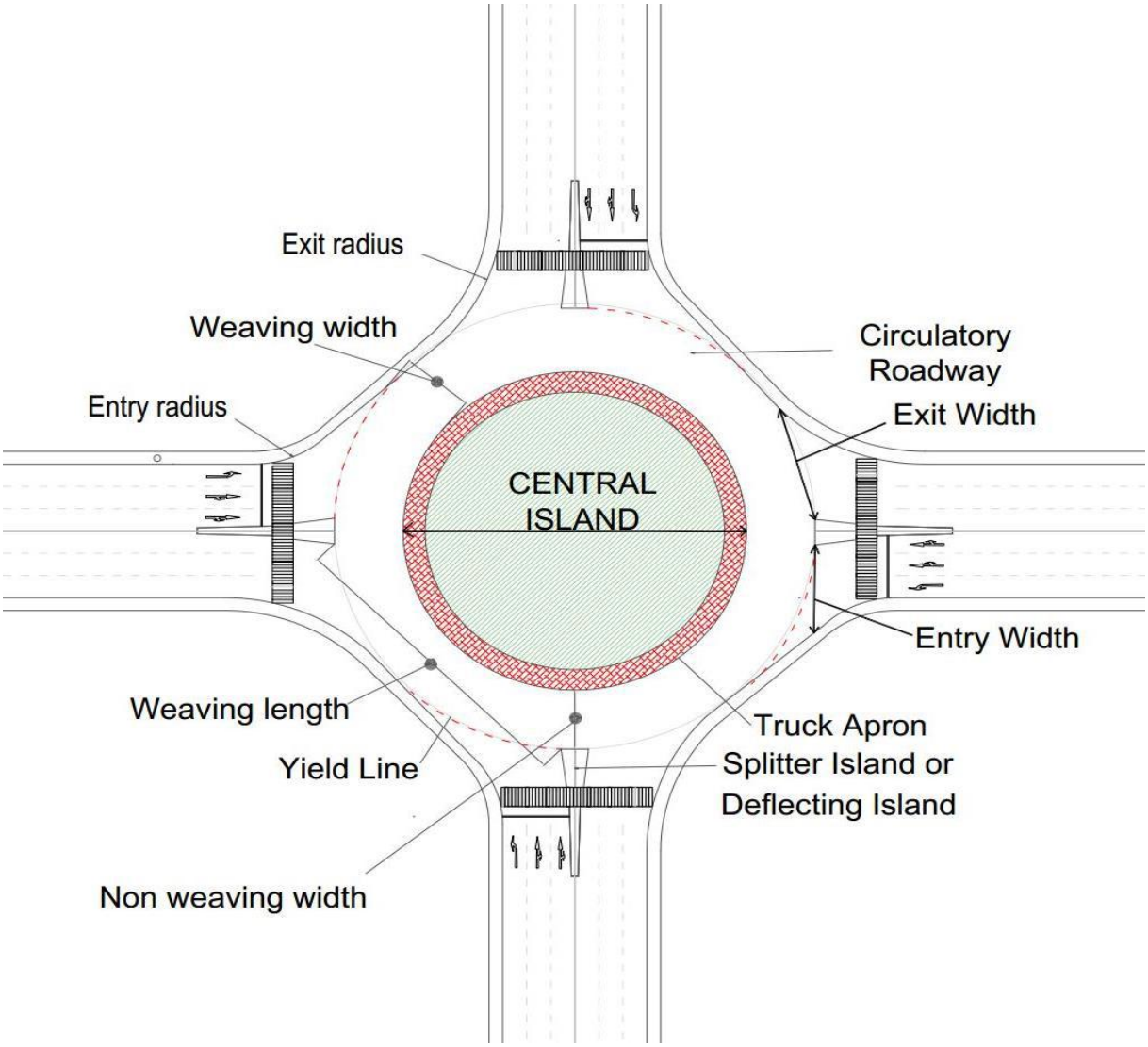

Figure 1 Geometrical Elements of Roundabouts (Source: IRC Guidelines for Roundabout-Draft, 2017)

Reviews on Evaluation of Safety at Roundabouts

Ahmed et al. (2014) collected the accidents data from MIROS (Malaysian Institute of Road Safety Research) which contain various type of data, such as accident information which includes number of accidents, accident severity and vehicle type, field information such as major/minor road width, lane marking, control type, geometry and location, and miscellaneous information such as weather, time of accident, and Average Annual Daily Traffic (AADT) of intersection. The raw data collected from MIROS contains various attributes such as driver characteristics, vehicle Characteristics, intersection characteristics, traffic control, land use and environmental characteristics. It was reduced to four specific attributes related to the context of intersection geometry for analysis. These are road width, locale, lane marking and control.

The analysis of the data has shown the effect of road width, locale, lane marking and traffic control on the accident scenario of unsignalized intersections in Malaysia. Only 8% of the total accidents that happened in the city while remaining were in town, small town and rural areas. 70% accidents occurred at intersections with single lane and only 2% and 4% took place on intersections with one way traffic and divider respectively. 93% of the accidents that occurred were on intersections with no control on minor road. Analysis of the data shows that almost 40% of the accidents that occurred on unsignalized intersections with major road widths between 9 to 12 meters. In general the numbers of accidents were observed to be normally distributed over the width of the major road. The results thus obtained will be highly relevant and will highlight the major cause of accidents that makes an intersection more prone to accidents. Hence, the necessary action taken in response will be effective and will greatly reduce the accident occurrence. Thus, improves the overall safety performance of the road network.

Murthy et al. (2015) analysed the factors influencing road accidents using regression analysis in SPSS model. Area of study is part of Hyderabad. The objective of the paper was to review relation between accident per year and intersection Parameters, to develop prediction models, to test their validity, to suggest improvement measures to prevent road accidents and to derive a model for accident parameters. They categorized the factors influencing road accidents in four groups. These are; (a) Vehicle related factors (b) Road related factors (c) Road user related factors (d) Environment related factors. A data of 1-3 year was observed for moderate to heavy Traffic locations. Sections of minimum 0.15 km in region of accident prone locations were taken for analysis. Detailed analysis carried out through monthly, annual and hourly data. There are 6 selected intersections is selected. The data collected from police records in accidents/year, traffic volume (major and minor road), turning traffic volume in vehicles/day, pedestrian volume etc. Primary and secondary data was collected for Hyderabad city, from state police department and national crime records bureau. It contains number of vehicles involved, time, severity etc., in the year of 2007 to 2011.

Rahman et al. (2012) collected data to analysis the severity of accident in Bangladesh at Intersection. She collected the data of accidents & rearranged these with respect to the various parameters like weather, collision type, day of week etc. She collected the data of accident from 2005 to 2009. Her main concerns were the intersections of Dhaka city. She then selected twenty five specific intersections and collect data of road width and number of legs. Then she developed a model of accident prediction with the collected data. Various factors have been studied for their relationship with accidents which are not possible to give a complete discussion in this review. Statistics from the Road Safety Cell (RSC) of the Bangladesh Road Transport Authority (BRTA) shows that annual fatality rate in road accident in Bangladesh is 85.6 per 10,000 vehicles which compares to rates of below 3 per 10,000 vehicles in most developed countries. In general, it can be said that overloaded or less roadworthy vehicles, lack of awareness of safe road use, poor traffic management and law enforcement and poor driver training are the various reasons for the high levels of road traffic accidents in Bangladesh.

Arndt et al. (2000) defined relationship between Roundabout Geometry and accidents rates for 100 Roundabouts in Queensland, Australia. Regression Analysis is done on 'single vehicle', 'approaching rear end' and 'entering and circulating' accident categories. After various observations, it was found that accident model incorporate appropriate explanatory variables. The models here were defined based on the concept of exposure and propensity and observed driver behaviour. This model explained the importance of limiting the difference between the expected drivers speed through successive geometric elements. This model also explained the need to minimize the relative speed between entering and circulating vehicles. The accident rate is a function of the propensity of an accident. Single vehicle accident rate at Roundabout is dependent upon the speed that drivers chose on the previous geometric elements. The relative speed of the vehicles is expected to be a parameter at merge and diverge points of interchange and at intersections controlled by traffic light, stop signs or give way sign. To minimize accidents rate on Roundabouts, it is important to limit the relative speed between entering and circulating vehicles around 35 kmph. Minimizing the entry width, radius of approach curve, better positioning of entry and departure legs and increasing the central island diameter will decrease the relative speed between entering and circulating vehicles. The relative speed between any streams should be minimized for optimum safety.

Ahemad et al. (2015) analyzed the four parameter namely Road width, traffic control, lane marking, land use with respect the road accident. Accident data in Malaysia is recorded by Police on standard forms known as POL 27. It is then transferred to MIROS (Malaysian Institute of Road Safety Research) for the development of accident database. The data recorded contains several attributes such as number of accidents, accident severity, vehicle type, road width, shoulder width, lane marking, control type, geometry, land use, weather and time of accident. They analyzed 442 unsignalized intersections in the northern part of West Malaysia.

The geometric parameters that affect accident severity are observed and their results are discussed. The data was analyzed separately for each parameter. The effect of each subtype on the overall behavior of accident occurrence was studied. Since, the parameter of road width did not contain any subclass; it was divided into three different ranges. The first range represents intersections with major road width between 0 to 9 meters. The second range represents intersections with major road width between 9.1 to 15 meters. The third range represents intersections with major road width greater than 15 meters. It is a simple technique in which the "Severity Index" of each sub-type falling into each parameter is calculated and the results are compared. Severity Index can be defined as the number of deaths per 100 accidents occurring at an intersection. It is a measure of the seriousness of accidents occurring at any intersection. It can be calculated by the following formula:

$$\text{Severity Index} = \frac{FatalAccidents}{AllAccidents} \times 100$$

Harper et al. (2003) developed more advanced prediction models that enable more accurate evaluation of urban roundabout accidents. These models were developed to predict vehicle accidents on urban roundabouts in relation to traffic volumes and geometric parameters. They found that entering and circulating accidents are the most common crash type. (Haycock and Hall 1984) found that at 4-arm roundabouts in the UK, the risk of single vehicle accidents increased with wider entries and with greater entry path curvature, but decreased where there was greater approach curvature.

Al-Suleiman et al (2006) inspected traffic accidents problem at roundabouts in Jordan, and observed possible relationships between traffic accidents and traffic geometric and planning variables.30 roundabouts were selected from different cities as a case study. Traffic and geometric variables were measured from field survey. The main objectives of this research effort were to inspect possible relationship between traffic accidents and traffic, geometric and planning characteristics of roundabouts in Jordan based upon the available accident data and to develop regression models that can be used further to predict traffic accidents at roundabouts in urban areas. To fulfil the need of this research, data have been collected for 30 major roundabouts in Jordan. The selected locations were observed during different periods to calculate peak-hours of traffic flow and traffic operational conditions. Data on traffic accidents were collected from Traffic Directorates and Public Security Headquarter in the related cities. After inspecting accidents reports for three years (2003-2005) with a total of 2620 accidents, the influence areas of roundabouts were found based on accidents reports. Roundabout accidents can be classified into vehicle-vehicle collision, pedestrians-vehicle accidents, and collision with fixed obstruction. The analysis showed that the most of the accidents were vehicle-vehicle collisions (94.21%), followed by pedestrian-vehicle collisions (3.84%), and the rest of the accidents were collisions with fixed objects (1.85%). They also observed the effect of operational, geometric and planning variables on traffic safety at roundabouts, and concluded the possible relationships between these variables and traffic accidents. The variables included in this study are operational variables (peak hour volume and pedestrian volume level), geometric variables (number of roundabout legs, central island diameter, circulating lane width, average entry width, and entry angle), planning variables (land uses), presence of traffic calming measures. General linear regression analysis was conducted to develop an accident prediction model for accident rate and number of accidents at roundabouts. Step wise regression analysis is the most suitable technique to develop the best prediction models when the number of independent variables is relatively high. Based on linear regression analysis, two prediction models were developed using accidents rate and number of accidents as dependent variables.

Mohammad et al. (2012) introduced an approach to evaluate and improve unsignalized intersection safety performance. This method was fully based on the existing conditions of unsignalized intersection, including geometric design, sight distance, pavement surface conditions, traffic control devices, and lighting, etc. This approach is a non-crash and non-conflict based analysis method. In this approach, a safety index is developed to give a diagnostic summary of the safety performance level of unsignalized intersections. Suitable countermeasures are prioritized and recommended based on the cost benefit analysis. Therefore, there is a need to prioritize the safety problems at these intersections caused by existing traffic conditions and rank the possible safety countermeasures. Field engineers used the survey forms in the fields to perform diagnostic process by filling the survey forms (also called safety diagnostic forms) with information collected from each intersection. The basic information (elements) in the form covers intersection existing conditions that have direct relationships to traffic safety at intersections. The category of "significance" indicates whether the particular condition (such as lighting) at the intersection has significant safety problem. A score of "0" indicates not significant and "5" very significant. Category of "severity" indicates whether the particular safety problem associated with the particular condition (such as lighting) would result in a severe traffic crash with a score of "0" indicating not severe and "5" very severe.

IV CONCLUSIONS

The main objective of this paper is to develop a review to evaluate the safety at Roundabout. The following important conclusions may be drawn based on this study:

Roundabouts in any road network are most identified accident prone location. Numbers of accidents are significantly more at road intersection in comparison of mid-block section. Hence to improve the road safety, it is necessary to improve the roundabout safety performance. But all roundabout cannot be improved. So there is need to evaluate the safety at roundabout so that we can prioritize the roundabout on the basis of safety performance.

Further, critical reviews of literature shows that there are few studies are available to evaluate the safety at roundabout. A number of hazardous components like design of Central Island, design of approach, circulatory stream characteristics, safety furniture deficiency etc. direct affect the safety at roundabouts. Therefore, this study presents a review to evaluate the safety at roundabout and prioritize the more safety hazardous roundabouts.

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