Evaluation of Road Safety for Roundabout and Signalized Intersection

Daya Shankar Pandey, P.K. Agarwal

Abstract: Traditional intersections have always caused accidents. There are numerous geometric intersection designs that best fit each situation. This study performed an operational and safety comparison with different intersection like signalized, unsignalized and roundabout to decrease the overall travel delay & collision at intersection and increase the safety using case study. This dissertation describes the application of the traffic conflict technique to estimate, traffic safety at intersections. Using data collected from surveys, traffic frequency and severity standards for signalized and roundabout have been established. The methodologies are developed incorporating the relative importance of different severity of different safety indices at intersection. The relative importance (weights) of very low, low, medium and high severity condition is developed using data collection and expert opinions experience people which have knowledge in development/safety development at intersection were obtained by conducting a survey. A questionnaire was prepared to obtain the relative importance of different severity of different parameter performance. The weights are developed in such a way that their values lie between 0 and 1. In proposed work design safety parameter for intersection for enhancement of safety at intersections and all safety design is implemented on MATLAB and analysis of the geometrical design for vehicle system in the intersection by MATLAB, analyses, the status of confliction and desired value obtained by comparison of actual value with available geometric designs and to enhance the safety at intersection and explores methods to solve the problem of collision at intersections. In this paper evaluate safety parameter of roundabout.

Keywords: Road safety, Roundabout Intersection, Signalized Intersection, Traffic Survey

I. INTRODUCTION

Road accidents are clearly the most frequent and major cause of damage to human lives. The severity of road accidents, measured in terms of number of persons killed per 100 accidents has increased from 28.5 in 2014, to 29.1 in 2015 (MORTH, 2015). India has only 1% of total vehicles and 3.5% of total deaths (Times of India 2012). The reason behind this scenario is extremely dense road traffic, lack of planning and implementation in accordance to safety factors (proper geometric design, environmental conditions and traffic rules). More than half of road accidents occur at Roundabout. This has given a thrust to redesigning of the existing Roundabout. In a recent study in America (by FHWA) it was found that out of total fatal and injury crashes 56.7% of it took place at intersections, and on an average 53.5% crashes of all crashes took place at Roundabout only. In India this data ranges between 30%-35%. And in Australia 43% of urban crashes and 11% of rural crashes are at intersections.

Vehicles moving in different directions, as well as pedestrians (wanting to cross the road) might try to occupy same space at the same time. Hence, to avoid accidents and improve overall efficiency, it is necessary to reduce this conflict for space. The conflict can be reduced by intelligent design of intersections based on evaluation of safety factors. Implementation and continued success of road-intersections depend on improved understanding of major safety factors. These factors include- traffic control devices, road and Roundabout geometry, driver behaviour, light and heavy vehicle characteristics, behaviour and requirements of other road users, traffic flow characteristics and operation of traffic control to resolve vehicle to vehicle conflicts (as well as vehicle to pedestrian conflicts). Optimization of above mentioned factors improve traffic and pedestrian safety, operational performance, environment and aesthetics.

II. METHODOLOGY BASED FRAMEWORK FOR ROUNDABOUT

In this section, framework for roundabouts based on the above methodology is presented in brief (similar process, applied to un-signalized intersection, is already discussed in more detail). As per the methodology, the framework is developed in four stages.

Stage I: Development of a Hierarchical Structure to Identify Safety Factors Affecting Safety at Roundabout.

For roundabouts, twelve safety factors have been identified and classified. This has been done through questionnaires answered by experts and road users.

Stage II: Determination of Relative Importance of Identified Safety Factors

In case of roundabout, it has been found that the following safety factors have higher impact on the overall safety index-height of central-island, speed of moving vehicles, and non-motorized transport compositions. This has been determined through study of literature, observation and inputs from experts and ordinary road users.

Stage III: Developing Assessment Tool (SIEM) For Evaluation of Overall Safety of Roundabout.

Formula for computing safety index values for each of the twelve safety factors is developed. These safety indices are used to compute the overall safety factor of the roundabout. The formula for the overall safety factor of roundabout is as follows:

\[
RSI = \sum_{i=1}^{n} w_i \cdot RSFi_i
\]

Where:

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RSI = Overall safety index for the given roundabout
RSFI = Roundabout safety factor index for ith safety factor

Stage IV: Evaluation of Overall Safety Index, Safety Optimization and Ranking of Roundabouts using SIEM

For the given roundabout case-study, SIEM is used to evaluate the safety indices to identify following safety factors to be modified to bring the overall safety factor value to acceptable range- adequate approach width, traffic signs, approach sight distance, and absence of cross-walk. Safety factors identified for modification, by SIEM varies from one case to another.

Table 1: List of identified Roundabout Safety Hazardous Components

| S. No. | Safety Component ID | Safety Component Notation |
|--------|---------------------|---------------------------|
| 1.     | RSFI-1              | Diameter of Central Island |
| 2.     | RSFI-2              | Height of Central Island  |
| 3.     | RSFI-3              | Approach Width            |
| 4.     | RSFI-4              | Entry Angle               |
| 5.     | RSFI-5              | Entry Radius              |
| 6.     | RSFI-6              | Approach Sight Distance   |
| 7.     | RSFI-7              | Splitter Island           |
| 8.     | RSFI-8              | Relative speed of Entering and Circulating Vehicles |
| 9.     | RSFI-9              | Slow Moving Vehicle Composition |
| 10.    | RSFI-10             | Non-Motorized Transport Composition |
| 11.    | RSFI-11             | Traffic Signs             |
| 12.    | RSFI-12             | Cross Walk                |
| 13.    | RSFI-13             | Minimum Width of Pedestrian Island |
| 14.    | RSFI-14             | Pedestrian Volume         |
| 15.    | RSFI-15             | Lighting                  |

III. ANALYSIS OF THREE DIFFERENT ROUNDABOUTS

Figure 1: Methodology based framework for evaluation of overall safety index at roundabout

Traffic operational safety hazardous condition includes circulatory stream characteristics and safety furniture deficiency. In which circulatory stream characteristics is decomposed in two factors i.e. Relative speeds of entering and circulating vehicles and traffic composition. And also safety furniture deficiency is classified in 3 factors i.e. inadequate pedestrian’s facilities, traffic signs and poor lighting. In this level, factor related to pedestrian safety is further categorized in 3 factors i.e. Absence of cross walk, minimum width of Pedestrian Island, and pedestrian volume.
Table 2 Input data for identified roundabout intersections RAI<sub>1</sub>, RAI<sub>2</sub>, RAI<sub>3</sub>

| S. No. | Safety Component ID | Safety Component | Notation | Ploy.(weight) | Mata Man.(weight) | P&T.(weight) |
|-------|---------------------|------------------|----------|---------------|------------------|--------------|
| 1.    | RSFI-1              | Diameter of Central Island | IDC      | 0.275         | 0.947            | 0.2 333      |
| 2.    | RSFI-2              | Height of Central Island | IH CI    | 0.10          | 0.35             | 0.2 5        |
| 3.    | RSFI-3              | Approach Width     | IA W     | 0.528         | 0.714            | 0.3 143      |
| 4.    | RSFI-4              | Entry Angle        | IEA      | 0.33          | 0.566            | 1.4 5        |
| 5.    | RSFI-5              | Entry Radius       | IER      | 0.15          | 0.0              | 0.0 5        |
| 6.    | RSFI-6              | Approach Sight Distance | ASD     | 0.53          | 0.366            | 0.7          |
| 7.    | RSFI-7              | Splitter Island    | ASI      | 0             | 0.25             | 0.2 5        |
| 8.    | RSFI-8              | Relative speed of Entering and Circulating Vehicles | RSECV | 2.833         | 2.27             | 1.7 857      |
| 9.    | RSFI-11             | Traffic Signs      | TS       | 0.625         | 1                | 0.7 5        |
| 10.   | RSFI-12             | Cross Walk         | AC W     | 1             | 1                | 1            |
| 11.   | RSFI-13             | Minimum Width of Pedestrian Island | MWPI | 0.166        | 0.416            | 0.2 917      |
| 12.   | RSFI-14             | Poor Lighting      | PL       | 0.312         | 0.062            | 0.3 125      |

Figure 2 Comparison of different values of various safety indices between RAI<sub>1</sub>, RAI<sub>2</sub>, and RAI<sub>3</sub>.

This section presents the comparison of the results of level of safety at identified roundabout intersections based on the overall safety Indices determined in pervious section. Table 1 shows the results obtained using developed methodology and figure 2 presents the rank of three identified roundabout intersections on the basis of result obtained using developed methodology.

Figure 3 Bar chart Representation of different values of various safety indices between RSA<sub>1</sub>, RSA<sub>2</sub>, and RSA<sub>3</sub>.

Above Figure presents the bar chart comparison of the results of level of safety at identified roundabout intersections based on the overall safety index determined in pervious section. Table 1 shows the results obtained using developed methodology and figure 3 presents the rank of three identified roundabout intersections on the basis of result obtained using developed methodology.

Figure 4 Representation of Available values of various safety parameter of Polytechnique Square (RSA<sub>2</sub>),
Figure 4 presents the Available value of safety parameter identified roundabout intersections on the basis of result obtained using developed methodology for the Polytechnique square.

Figure 5 presents the Available value of safety parameter identified roundabout intersections on the basis of result obtained using developed methodology for the Mata Mandir Square.

Figure 6 presents the Available value of safety parameter identified roundabout intersections on the basis of result obtained using developed methodology for the P&T Square.

Figure 7 presents the Comparison of different values of various Available safety indices between RAI1, & RAI2.

Table 3 Input data for identified roundabout intersections RAI1, RAI2, RAI and change data

| S. No. | Safety Component ID | Notation | Play. | Change | Mata Mandir | Change | P&T | Change |
|-------|---------------------|----------|-------|--------|-------------|--------|-----|--------|
| 1.    | RSFI -1             | ID CI    | 0. 72 | 41     | 0. 0526     | 0. 73  | 0. 7 | 667    |
| 2.    | RSFI -2             | IH CI    | 0. 9  | 41     | 0. 65       | 0. 65  | 0. 7 | 5      |
| 3.    | RSFI -3             | IA W     | 0. 47 | 14     | 0. 2857     | 0. 85  | 0. 7 | 571 (8) |
| 4.    | RSFI -4             | IE A     | 0. 6  | 7      | 0. 4533     | 0. 72  | 0   | 0. 8   |
In this paper, the process of development of framework for roundabout intersections have been given. The development of framework is based on the methodology described earlier. The framework is implemented over MATLAB to give Safety Index Evaluation Method (SIEM) software. SIEM improves the overall safety of intersections optimally and ranks the intersections on the basis of their overall safety index. Same process will follow on signalized intersection and compare it.

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