# Risk Assessment of Road Intersections in Colombo Suburban

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**Abstract**: Intersections have been described as one of the most complex traffic conflict points for motorists, pedestrians, cyclists, and other road users. In this research the primary focus is on different methods of risk assessment at road intersections. Twelve intersections from Malabe to Battaramulla on New Kandy Road, Sri Lanka roadway were chosen to conduct the research. Traffic accident data required for the research were collected from the Police accident records while Annual Average Daily Traffic (AADT) data were collected from road development authority of Sri Lanka. Risk metrics method was used for the analysis. It was found that intersections at Malabe, Koswatta, Thalawathugoda, and Robert Gunawardana Mawatha require medium cost intersection improvements work such as right turn bays, visibility improvements and signal upgrades. The rest of the intersections were categorized as low risk intersections and safety measures are needed for those intersections.

*Keywords*: Intersection Crashes; Intersection Safety; Risk Metrics Analysis

## 1. INTRODUCTION

Road intersection can be defined as a place where two or more roads meet that is a point of potential vehicle conflict. Road intersections consist of different designs, configurations, and sizes such as T-intersection, four-leg intersection, and multi-leg intersection. Risk assessment can be considered as the combined effort of identifying and analyzing events which has a negative impact: and making judgments on the type of risk. Intersection crashes are one of the most commonly type of crashes (USDOT, 2020; NHTSA 2010).

Accidents which occur at road intersections account to over 40% of the total number of crashes occurring at roads. Analyzing and producing countermeasures has been a major challenge for traffic engineers and traffic safety officials. Due to the number of accidents occurring at road intersections more demand for traffic safety at road intersections has been noted. There are many reasons for road intersection crashes. Most common reasons for road intersection crashes are negligence and carelessness of the driver (USDOT, 2020). According to safety studies, 89% of intersection crashes were due to driver errors (USDOT, 2020). The most common causes can be termed as perception failure, misunderstanding the situation, wrong decisions, lack of intersection visibility, high approach speeds at intersections, poor road surface condition, faulty traffic lights/signals/intersections, and complex intersection layout. Road intersections are dangerous due to constant traffic flow at most times. To enforce road safety, intersection safety is the most important area. According to Sri Lankan police records, intersection-related crashes have increased during the past five years. With proper risk assessment and awareness many crashes at road intersections could be prevented. Risk assessment should always be carried out. Risk assessment is a method used to identify hazards, analyze risk, evaluate risk, and control risk. By conducting proper risk assessment and adhering to its terms, causes for collisions at intersections can be minimized ensuring safety to motorists, cyclists, and pedestrians. The objective of this study was to assess urban intersections Sri Lanka and find the cause for the intersection accidents and to investigate the possible control measures.

## 2. LITERATURE REVIEW

Signalized intersections are expected to ensure safety, but it does not promise pedestrian safety due to traffic violation and unsafe signal phasing (Hamidun, 2015). Therefore, an alternative method to access pedestrian crossing risk at signalized intersection was investigated. The study was conducted in Sydney in 2013. Data collected for this study included human, engineering and environmental factors which relate to the sequence of events which occur in pedestrian-vehicle conflict. Petri net Modelling approach was used to analysis the data. Pedestrian accident occurs when a pedestrian and vehicle arrive at the same point simultaneously at the same time and place. Through the petri net model application, the integration of human, engineering and environmental can be seen directly. Petri net modelling approach is capable of modelling complex event sequence for risk analysis.

Traffic crashes at intersections in urban areas take majority of the accident toll therefore developing a risk assessment model of immense importance according to the Korea transport institute (Kim and Sul, 2009). Analyzing and introducing counter measures for traffic accidents at intersections was the main objective of this research. The study has been conducted in Sungnam city in Korea at three intersections namely Soojin, Shinhung and Woori Bank Intersections in 2009. Data on accident type, accident time of day, major accident causation were collected. Micro-simulation-based method called the Surrogate safety assessment model was used for finding countermeasures. The results showed that, when the speed limit was decreased from 70kph to 60kph, the minimum time to collision was reduced from 0.46s to 0.36s. Also, the initial deceleration rate also decreases which means at lower speeds driver can apply breaks smoothly because when speed changed from 70kph to 60kph, initial deceleration rate decreased from -1.04 to -0.4. Even though micro-simulation can be used to represent traffic, it does not account individual behavior of each vehicle therefore it is not sufficient for safety analysis.

Road Infrastructure Safety Assessment is an operational device-based procedure that links infrastructure features to crash rates and provides crash ratings (Apleton et al, 2009). Objective of this research was to find the road user advantages due to improved road safety infrastructure. The study was conducted in Wellington, New Zealand in 2009. Width of lanes, street lighting, and visibility of turning paths at intersections were among the collected data. Survey method based on research and risk rating method were used as the methodology. According to the results, safety at intersections depend on the type of intersection, traffic volume, and turning movements and collected data were not sufficient to build a risk model for intersections. Therefore, assessments were conducted considering design issues and maintenance issues. Road Infrastructure Safety Assessment model allowed to monitor a road controlling authority's performance with time considering road safety.

New Zealand Road Assessment Program (RAP) called KiwiRAP conducted by New Zealand Transport Agency (NZTA), applies road risk statistics to major urban road networks for several cities in New Zealand. Brodie et al. (2013) applied road risk ratings to urban road network collecting necessary data to calculate collective risk at intersections and midblock sections. Estimated Death and Serious Injury (DSI) casualty equivalent approach was used. According to the results, 8.3% of the network was classified as high risk and these corridors were responsible for 63.1% of all injury crashes. The obtained results exceeded international road assessment programs target. After analyzing the risk mapping outputs, refinements required for the assessment framework was found. The two refinements found out were, the need for different risk thresholds in urban and rural speed environments and to have a threshold that vary as a function of corridor length. Both the probability of a person being seriously injured or killed in a road accident varies on crash movement type, the speed environment, and the form of road where it occurs.

Many traffic safety research was conducted on crash data, but that data contains only a limited amount of data on driver behavior. Therefore, Cano et al. (2009) proposed a method to detect accidents by processing data using ground-based observations in Sweden. Data collected for this research includes geometric layout of the intersection and vehicle information which are position, size, speed, acceleration, and orientation. The incident detection method constituted with the core of a video-based automatic incident detection at intersections. Incident classification was a global estimation of the quantified combination of the 5 risk contributing factors called post encroachment time, time to collision, distance between vehicles, acceleration rate and deceleration rate. Incident classification was undisturbed passage, potential conflict, slight conflicts, and serious conflicts. The proposed method was verified using driver simulator and real traffic conditions. With use of automatic analysis tools manual work could be redirected to conduct a better focused investigation to gain a better understanding of the dynamics of the events.

Accident prediction functions are tools which used to calculate average frequency of accidents at road entities such as road intersections. Costescu et al. (2016) developed accident prediction functions appropriate to peculiarities of Bucharest urban environment in Bucharest in 2012. Accident Data from 350 intersections at Bucharest were collected. The data collected included 1360 road accidents. GIS system was used for the selection and classification of network features by structural characteristics. The accident prediction models were developed, and the models were evaluated using the correlation coefficient of R-square. For unsignalized intersection, the correlation coefficient of R-square was 0.76 and adjusted correlation coefficient R-square was 0.71. For signalized intersections, correlation coefficient R-square was 0.74 and that of the adjusted correlation coefficient R-square was 0.70. According to the values obtained, it was concluded that the developed functions were accurate and acceptable. Accident prediction functions were defined and calibrated for intersections, but further efforts are needed to include risk assessment as a criterion for urban planning and evaluation.

## 3. METHODS

The study area selected to conduct the research was from Battaramulla to Malabe roadways which is shown in Figure 1. The roadway is two-way two-lane asphalt paved road with AADT of 50,000. This is one of the main corridors which can be used to enter Colombo city. Accident data were collected from the Thalangama Police Department. Investigating the accident data, twelve most risky intersections were selected for this study. About 103 intersection-related traffic accidents were recorded during 2014 and 2019 in these intersections.

### 3.1 Risk Metrics Method

Risk Metrics approach for intersections is a tool used to identify risks at intersections and develop countermeasures for the risks identified (NZTA 2013). The proposed method consists of four steps. The four steps are identifying the intersection and strategic context, crash priorities and strategic context, understanding the issues and proposing remedial measures. The remedial measures were suggested based on the issued identified as mentioned in NZTA (2013).

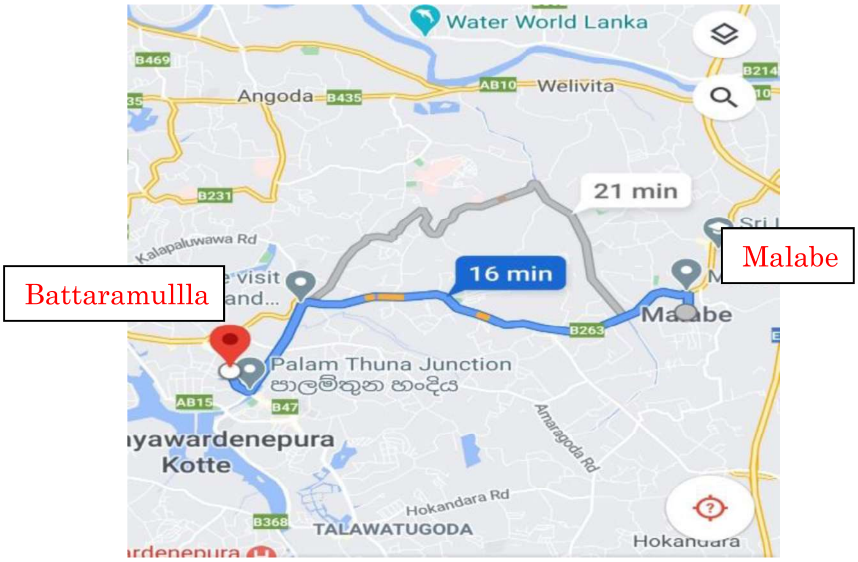


Figure 1. Study Area from Battaramulla to Malabe

Intersections selected to conduct this research were the intersections between Malabe junction and the Battaramulla junction. The existing safety measures imposed by the government was recorded such as safety sign boards, speed limitations, presence of intersection signal lights etc. Data collection includes collecting detailed crash statistics from the Police traffic administration and road safety division. Obtained crash statistics were summarized. Collective risk and personal risk metrics were used to categorize the two intersections where, collective risk was defined as the total number of deaths and serious crashes per intersection in a crash period and personal risk is defined as the risk of a serious injury or death to all vehicles entering the intersection (NZTA, 2013). Personal risk was calculated by dividing the collective risk by traffic volume.

### 3.1.1 Collective Risk

After obtaining the values of the number of deaths and serious crashes, fatal and serious crash equivalents are used to categorize the collective risk level. Weightage of fatal accidents to serious injury accidents was taken as 4:1 (Sugiyanto 2017). DSI crashes equivalents were categorized by comparing with the thresholds as in Table 1 as determined by the NZTA (2013).

Table 1. Deaths and Serious Injury crash collective risk equivalents (Source: NZTA 2013)

| Collective risk level | Number of deaths and series crashes equivalents |
|---|---|
| High | >= 11.2 |
| Medium High | 7.7 – <11.2 |
| Medium | 4.2– <7.7 |
| Low Medium | 2.1 – <4.2 |
| low | < 2.1 |

### 3.1.2 Personal Risk

Personal risk determines the risk to each individual entering the intersection. The personal risk is determined by the value obtained when the collective risk divided by the traffic volume. In order to calculate the traffic volume, the AADT data are required for each leg of two intersections. According to the NZTA, traditional traffic exposure measure that has been used in road safety analysis is crashes per 100 million Vehicle Kilometers Travelled (VKT). Therefore, the personal risk metric used in this methodology was adjusted to be equivalent to deaths and serious crashes per 100 million VKT. The personal risk was adjusted to the same time period as the crash history. This was done by multiplying the number of years by the number of days in a year. The reported DSI crashes are per five years, and 1.7 is a conversion factor to make the exposure equivalent to VKT through the intersection. The conversion factor is used because it takes account of the distance travelled by each vehicle using the junction of 100 meters, DSI crash equivalents was used to categorize the personal risk level. DSI crash equivalents are categorized by comparing with the thresholds in Table 2 (NZTA 2013).

Table 2. Deaths and serious crashes personal risk equivalents (Source: NZTA 2013)

| Personal risk level | Estimated DSI per 100 million vehicle kms |
|---|---|
| High | > 224 |
| Medium High | 112 – <224 |
| Medium | 70 – <112 |
| Low Medium | 42 - <70 |
| low | < 42 |

### 3.1.3 Remedial Safety Measures

Collective risk and Personal risk were compared according to Figure 2 (NZTA 2013).

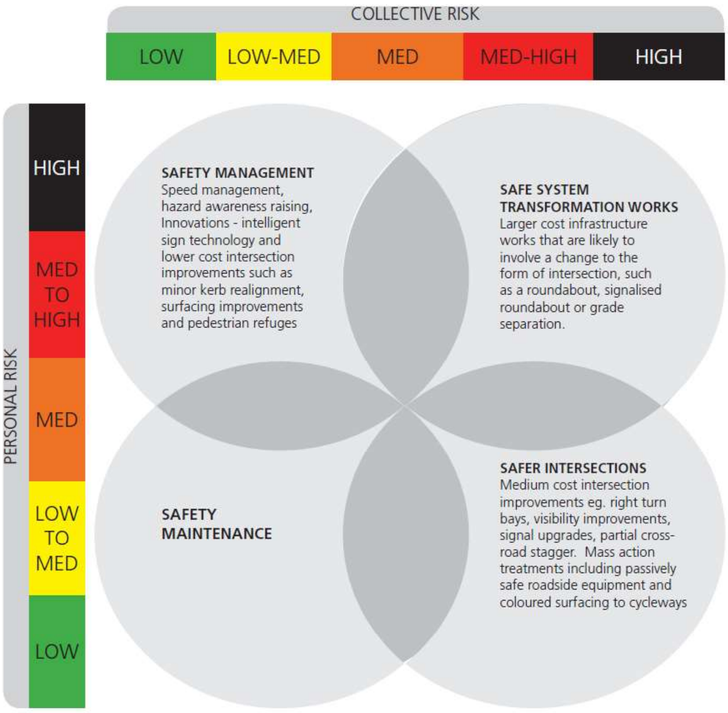


Figure 2. Remedial safety measures (Source: NZTA2013)

In the Figure 2, collective risk level is mentioned in the x-axis, from low risk to high risk and personal risk level is indicated in the y axis, from high to low risk. Suitable remedial safety measures were found for the intersection considering the risk levels of collective and personal risk.

## 4. RESULTS AND DISCUSSION

Collective risk and Personal risk were calculated according to the methodology mentioned in Section 3. Afterwards the remedial safety measures were found according to the personal risk and collective risk level. Table 3 indicates the summary of the results of the risk metrics analysis. According to the risk metrics analysis none of the intersections were classified as high-risk intersections. Due to this reason larger cost infrastructure work to the intersections are not required. The suggested solutions were safety maintenance and safer intersection. Safer intersection can be done by visibility improvements, signal upgrades and safe roadside equipment.

Table 3. Risk Metrics results and proposed remedial measures

| Intersection | Collective risk | Personal risk | Remedial Safety Measure |
|---|---|---|---|
| Malabe Intersection | 19 | 15.52 | Safer Intersection |
| Koswatta Intersection | 15 | 10.78 | Safer Intersection |
| Thalawathugoda Intersection | 18 | 23.8 | Safer Intersection |
| Battaramulla Intersection | 12 | 9.8 | Safety Maintenance |
| Parliament Intersection | 6 | 8.11 | Safety Maintenance |
| Potuwarama Intersection | 6 | 7.02 | Safety Maintenance |
| RobertGunawardana Intersection | 15 | 16.13 | Safer Intersection |
| Chadriaka Kumarathunge Mawatha Intersection | 4 | 11.11 | Safety Maintenance |
| Thalahena Intersection | 8 | 42.8 | Safety Maintenance |
| Pipe Road Intersection | 6 | 7.28 | Safety Maintenance |
| Udumulla Intersection | 11 | 23.6 | Safety Maintenance |
| Ekamuthu Mawatha Intersection | 4 | 22.42 | Safety Maintenance |

## 5. CONCLUSIONS

This study assesses the risk at road intersections at Thalangama Police division. Accident crash details of 12 intersections was collected from 2014 to 2019. According to the risk metrics analysis the intersections Malabe, Koswatta, Thalawathugoda and Robert Gunawardana Mawatha requires safer intersection work such as medium cost intersection improvements such as right turn bays, visibility improvements and signal upgrades. The rest of the intersections were categorized as low risk intersections and the remedial safety measure was to maintain safety at those intersections. Evaluation and monitoring after implementation of the remedial safety measures should be conducted to calculate the effectiveness of the remedial safety measures. Risk assessment of road intersections is very important to prevent injuries and deaths occurring at road intersections.

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