# Analysis of Signalized Intersection Crashes

**Nasima Bhuiyan, EmelindaM. Parentela and Venkata S. Inapuri**

## Abstract

The goals of providing high levels of mobility and intersection efficiency while simultaneously ensuring the highest level of safety result in competing interests at signalized intersections. Road fatalities and injuries generated by accidents represent a major challenge especially in the field of transportation. The Federal Highway Administration (FHWA) reported in the year 2013 that the highest number of vehicle crashes in the United States happens at intersections. Over 2.8 million intersection-related crashes occur each year and these account for about forty percent of all types of reported crashes. These crashes had a detrimental effect on loss of about 8500 lives and more than a million injuries. A comprehensive analysis of accidents at intersection would help find viable solutions to reduce the probability and severity of crashes.

This paper presents an analysis of accidents at signalized intersections based on a proactive approach using signalized intersection characteristics, including the the types of left turn controls. An analysis of five-year accident data at selected signalized intersections in the City of Los Angeles and the City of Long Beach indicate that signalized intersection crashes and others are caused by controllable factors. Factors such as the traffic condition, number of lanes, presence of medians, pedestrian crossings, speed limit, and the type of left turn protection have been used in the analysis. The result shows a correlation between the types of left turn control and the average number of crashes. The study concentrates on finding whether any particular type of accident is influenced by the type of left turn. Statistical theory is adopted in this analysis.

## Introduction

Signalized intersections are where most vehicle accidents happen. According to the Federal Highway Administration (FHWA) report, over 2.8 million intersection-related crashes occur each year in the United States of America. It accounts for over 40 percent of all reported crashes.

Vehicle movements at signalized intersections have many distinct conflicting patterns which contribute to the number of crashes. At signalized intersections, differences exist in traffic volumes, travel speeds, traffic signal operations, intersection geometry, and vehicle-bicycle-pedestrian interactions which affect the safety performance on various approaches.

Modeling the total number of crashes at intersections may obscure the real relationship between the crash causes and their effects. Three different types (i.e. protected, permissive and protected-permissive) of left turning phases at a signalized intersection are considered.

In this paper, a framework for modeling signalized intersection crashes is presented using regression analysis. Various factors such as traffic volumes expressed in terms of Annual

Average Daily Traffic (AADT), intersection geometry, pedestrian crosswalk, type of left turn control, and number of lanes are considered in the analysis. This could help understand factors that significantly contribute to signalized intersection crashes.

## Literature Review

Traffic conflicts that take place at a signalized intersection can be significantly reduced by studying the factors such as the geometry design and the signal timing which is calculated according to the number of lanes and the annual average daily traffic. Srinivasan et al (2008) evaluated the urban signalized intersection safety effectiveness of engineering improvements and found that changing from permissive or protective-permissive phasing to protected phasing could lead to an elimination of left-turn crashes but other types of crashes such as rear-end may increase.

There are many ways to analyze the correlation of various factors to the frequency and the number of accidents at a signalized intersection. For instance, using generalizing estimating equation with negative binomials as functions can be used to correlate the left turn crashes with various factors. In this paper, the left turning signal efficiency does not only depend on the width of the left turn lane but also on various other conflicts such as signal timing. (Wang et al., 2007).

Signal timing is not the only factor that affects the left turn crashes but also the type of left turn signal like the protective or permissive. Based on accident data shows, the number of accidents at an intersection with permissive left turn signal is more than the protected type, which can happen due to the presence of pedestrians or the opposing through lane traffic. Therefore, when considering the safety of signalized intersections, turning vehicles play a major role in ensuring the effectiveness of the intersection. Also, the effect of pedestrians has to be considered for the turning vehicles which influence the safety and there may be conflicts due to the pedestrian factor. The correlation between pedestrians and turning vehicles has to be considered as a major factor in accident analysis. (Li and Sun, 2016).

## Methodology

The study has been conducted on seventeen signalized intersections in the city of Long Beach and Los Angeles. The data collected on these intersections are the Annual Average Daily Traffic (AADT), the pedestrian volume, the number of accidents, speed at the intersections, and other intersection data. Linear regression model is developed so as to study the effect of various factors on the left turning accidents at these signalized intersections. Finally, a detailed analysis is made considering the regression model developed which can ultimately give some solutions for the left turning collisions and also give some basis for future research so as to reduce the left turning collisions.

## Analysis and Discussion

### Intersection Characteristics.

Table 1 shows the intersection data, the AADT and average number of accidents for these intersections. The average number of crashes represents the five-year average of the annual total number of crashes.

## Table1: Intersection Information

| No. | Intersection | Street Direction | Speed Limit (mph) | No. of Lane (EB) | No. of Lane (WB) | Intersection | Street Direction | Speed Limit (mph) | No. of Lane (NB) | No. of Lane (SB) | Type of Signal[1] | | AADT | Average Number of Crashes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | NB/ SB | EB/ WB | | |
| 1 | 1st St | E/W | 30 | 3 | 3 | Main St | N/S | 30 | 4 | - | Pr | - | 23671 | 4.8 |
| 2 | 108th St | E/W | 30 | 2 | 2 | Main St | N/S | 30 | 3 | 2 | P | P | 11596 | 3 |
| 3 | 104th St | E/W | 30 | 1 | 1 | Main St | N/S | 30 | 2 | 2 | P | P | 13310 | 2.6 |
| 4 | Colden Ave | E/W | 30 | 1 | 1 | Main St | N/S | 30 | 2 | 2 | P | P | 9142 | 4.8 |
| 5 | 120th St | E/W | 30 | 2 | 2 | Main St | N/S | 30 | 3 | 2 | P | P | 7631 | 3.2 |
| 6 | Center Dr | E/W | 35 | 4 | 4 | Sepulveda Blvd | N/S | 35 | 4 | 3 | Pr/ P | Pr | 55049 | 3.8 |
| 7 | Venice Blvd | E/W | 35 | 2 | 2 | Sepulveda Blvd | N/S | 35 | 4 | 4 | Pr/ P | Pr | 41051 | 6.6 |
| 8 | Westchester Pkwy | E/W | 35 | 2 | 3 | Sepulveda blvd | N/S | 35 | 3 | 3 | Pr/ P | Pr/ P | 17618 | 3.4 |
| 9 | Bellflower Blvd | E/W | 40 | 4 | 4 | Atherton St | N/S | 40 | 3 | 3 | Pr | Pr | 20200 | 4.8 |
| 10 | Palo Verde Ave | E/W | 35 | 3 | 2 | Atherton St | N/S | 40 | 3 | 3 | P | Pr/ P | 10100 | 5.8 |
| 11 | Anaheim St | E/W | | 3 | 3 | Long Beach Blvd | N/S | | 3 | 3 | LP | Pr | 20100 | 16 |
| 12 | Pacific Coast Hwy | E/W | | 3 | 3 | Long Beach Blvd | N/S | | 3 | 3 | Pr | Pr | 17800 | 15.4 |
| 13 | Willow St | E/W | | 3 | 3 | Long Beach Blvd | N/S | | 3 | 3 | Pr | Pr | 29700 | 8.4 |
| 14 | 10th St | E/W | | 2 | 2 | Long Beach Blvd | N/S | | 2 | 2 | P | P | 10900 | 7 |
| 15 | 7th St | E/W | | - | 3 | Long Beach Blvd | N/S | | 2 | 2 | P | Pr | 13100 | 5.8 |
| 16 | Hill St | E/W | | 2 | 2 | Long Beach Blvd | N/S | | 2 | 2 | P | Pr | 6500 | 3.6 |
| 17 | Burnett St | E/W | | 2 | 2 | Long Beach Blvd | N/S | | 3 | 3 | P | Pr | 6700 | 1.8 |

[1] P = Permissive; Pr = Protective; LP = Left turn prohibited

## AADT vs Average Number of Intersection Crashes

Data on intersection crashes, AADT and intersection geometry were collected from the Public Works Department of the corresponding city. Traffic count, which is measured in terms of AADT is adjusted based on a one percent growth of traffic each year. Figure 1 shows the relationship between the average number of crashes and AADT. The plot shows that the average total number of crashes is not solely influenced by the existing traffic and the type of left turn signal control.

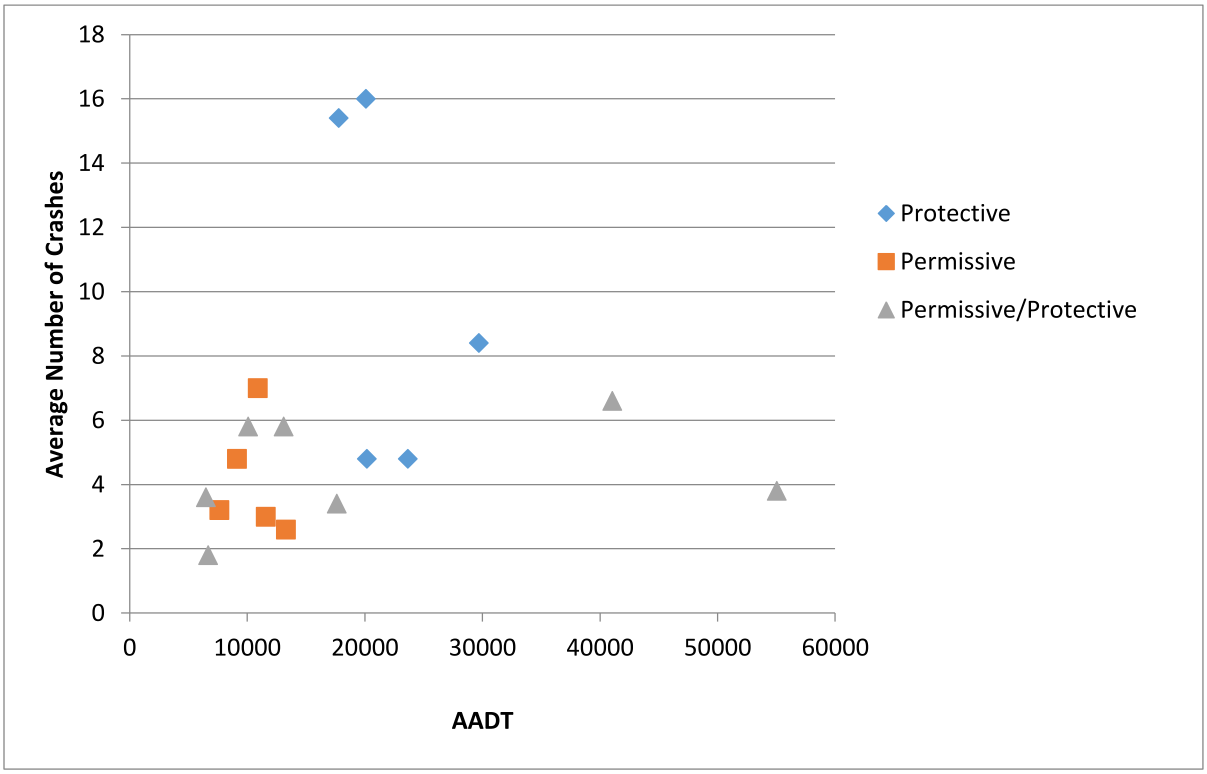


Figure 1. Average Number of Intersection Crashes vs. AADT

## Crash Prediction Analysis

A regression analysis is performed using the average accident data for five years as a dependent variable and establishing the relationship with independent variables such as AADT, travel speed, average number of lanes, presence of medians, pedestrian crossings, types of left turn control, and travel speed. The type of left turn signal control is evaluated by introducing dummy variable where 0 represents protected control and 1 represents permissive or a combination of protective-permissive control. The resulting relationship is expressed as follows:

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$$Acc = 1.52 \ln(AADT) - 4.64L + 1.57MDN - 2.51PED + 6.57LTSGNAL + 0.34SPD - 5.81$$

Where:

Acc = average number of crashes
AADT = annual average daily traffic
L = total number of lanes at the intersection
MDN = total number of medians at the intersection
PED = total number of pedestrians at the intersection
LTSGNAL = type of left turn signal control
SPD = travel speed

The resulting regression model shows a coefficient of determination ($R^2$) value of 0.645. The average number of crashes at signalized intersection seems to be strongly correlated to the number of lanes and the type of left turn control. Interestingly, AADT, which is the most commonly used predictor of traffic accidents, does not seem to highly influence the average number of crashes. Similarly, the presence of pedestrian crossings does not seem to highly influence the average number of crashes at a signalized intersection.

It should be noted that the number of samples used in the analysis is very limited and the model is intended to show only the effects of various variables on signalized intersection crashes

## Conclusion

The study attempted to determine a relationship between intersection crashes and various factors such as AADT, speed, type of signal phasing pedestrian data, and other intersection geometric data. While a correlation was established, it should be noted that the number of samples used in the analysis is very limited. Data on each road changes were collected for five to six years. Performing regression analysis at 10% significance level brought some correlation between the AADT and average number of accidents. The analysis shows that traffic accidents other have a relationship that could be useful for traffic engineers and the planners. Further studies may be needed to suggest different types of signals at the intersections.

## References

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