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Identification of Pedestrian Crash Prone Locations and Mitigation Measures

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ABSTRACT: In India, road crashes are one of the most important causes of death and health loss. Identifying and ranking high pedestrian crash prone locations plays a key role in developing efficient and effective strategies to enhance the pedestrian safety. The study discusses the present state of pedestrian accident information on National Highway (NH – 66) – a road stretches of 18.5 km which extends from North Paravur to Edappally. It includes collection of primary data and secondary data. Primary data collection includes road geometric data, traffic volume count and spot speed data. The safety analysis of the pedestrian and vehicular conflict at the Edappally Junction is done by Pedestrian – Vehicular Volume (PV²) analysis. Secondary data collection includes collecting the accident data from 2017 – 2021 from the various police department and prioritizing the crash prone locations by using Crash Severity Index (CSI) method. CSI method follows a system of assigning scores based on the severity of crashes in that particular location. Then, provide remedial measures at the identified locations to reduce the road crashes and enhance the safety of pedestrians.

KEYWORDS: Crash Severity Index, Pedestrian safety, Pedestrian – Vehicular Volume, Remedial measures

I. INTRODUCTION

Walking is one of the most important travel modes in every country. Transportation system that encourages walking, it can reduce traffic congestion and improve the safety of motorist. Pedestrians are one of the vulnerable road users, have become more susceptible to traffic crashes with the rapid growth of motor vehicle in India. Pedestrian deaths in India have gone up from 13,894 in 2015 to 23,483 in 2020, as per Union Ministry of Road Transport and Highways. Rapidly increasing road crashes in India have an adverse impact on the social and economic development of the country. Road facilities in urban areas are still a significant source of harm to pedestrians. Every year, a large number of pedestrians are killed or seriously injured in crashes involving motor vehicles. Pedestrian safety is an issue in many urbanized areas throughout the world. To reduce the crash rates effectively, it is essential to concentrate on measures which improve the road safety and hence reduce the number of road crashes and its severity in particular. The pedestrian road crash is influenced by several human and environmental factors, roadway characteristics and vehicular characteristics.

The identification, analysis and treatment of crash prone locations are widely regarded as one of the most effective approaches to road crash prevention. Providing suitable remedial measures helps to improve the pedestrian safety at the identified locations. Pedestrian – Vehicular Volume analysis helps to check the safety of pedestrians at the selected location. The study was carried out on NH – 66, starting from North Paravur to Edappally. The road stretch is 18.5 km. This work also includes the study of identification and prioritization of pedestrian crash prone locations using Crash Severity Index (CSI) method.

II. LITERATURE REVIEW

S Tawar et al. [1] studies deal with the identification and analysis of crash clusters using Crash Severity Index (CSI) method. The study stretch is 48km on NH – 48 from Ambience Mall to Kapdiwas in Bilaspur Kalan. FIR data was collected for the past three years from 2015 to 2017 from the various police department. Prioritize and ranked the crash clusters for pedestrians based on the CSI method. Total 11 crash prone locations were identified and prioritized using CSI equation. This method is used in this work to prioritize and identify the pedestrian crash prone locations. Five pedestrian crash prone locations are identified and prioritized using this method. Srinivas S Pulgurtha et al. [2] identified high pedestrian crash zones. To rank high crash zones, techniques like crash frequency, crash density, crash rate, and composite methods have been employed frequently.

Greeshma et al. [3] studied pedestrian vehicular conflict at Vytilla Junction and PV² analysis were carried out. For cross movement analysis of pedestrians, the value of PV² has to be computed so as to identify the necessary pedestrian



facilities. The permissible PV^2 value is 1×10^8 to 2×10^8 in general cases. But the obtained value is much higher than the permissible limit confirming that the junction is not safe for pedestrian cross movement. Pedestrian vehicular volume analysis was done at Edappally junction in this study. The number of pedestrians and vehicles are more at this junction and the junction is not safe for the pedestrian movement.

Faisal Mehraj Wani et al. [4] designed traffic signal according to Indian Road Congress (IRC: 93 – 1985) method at Kundahalli Junction. The traffic signal is already provided at this intersection which is to be upgraded as the cycle length provided is more than the optimum cycle length. The traffic volume of cars, two wheelers, buses and trucks are collected for a period of 12 hours (7:00-19:00). At these hours traffic congestion on road is at its highest. This method was used to design traffic signal in KMK Junction as a remedial measure. IRC: SP 41 – 1994 [5] gives the guidelines for the design of at grade intersection in rural and urban areas. Passenger Car Unit used in design and analysis of signalized intersection in Kerala as well as in India are based on the values given in this code. PCU are used to access traffic flow rate or volume on a heterogeneous traffic highway. PCU values for different vehicles are obtained from this guideline for this study.

Shafna Shukoor and Sangeet K [6] discusses the issues currently affecting the pedestrian environment in Kollam by using various traffic surveys. The study focuses on pedestrians and methods for creating walking sculpture, pedestrian routes, and pedestrian – friendly locations in the city. It offers recommendations and principles for pedestrian planning in Kollam city. The pedestrian plan suggests creating a network of pedestrian paths along all major locations in the city centre. IRC: 103 – 2012 [7] provides the guidelines for pedestrian facilities. This guideline cover engineering design and planning aspects of pedestrian facilities. The main aim is to minimize the pedestrian conflicts with the vehicular traffic to the minimum. Solutions to improve the quality of the pedestrian network should take children, elderly persons and persons with disabilities into account. In this work, provided suitable pedestrian facilities at the identified pedestrian crash prone locations.

III. OBJECTIVES

- Identification and prioritization of pedestrian crash prone locations using Crash Severity Index method
- To identify various traffic and road geometric factors causing crashes
- To suggest best suitable measures at the identified locations

IV. METHODOLOGY

The primary data includes road geometric data, spot speed and traffic volume count. The secondary data (accident data from 2017 to 2021) was collected from respective police stations. The secondary data was then analyzed using CSI method. Crash prone locations with more than 5 road crashes involving fatalities/grievous injuries or 10 fatalities were extracted for the prioritization and identification. Suitable remedial measures are suggested to the identified locations. Fig.1 shows the flow chart of methodology.

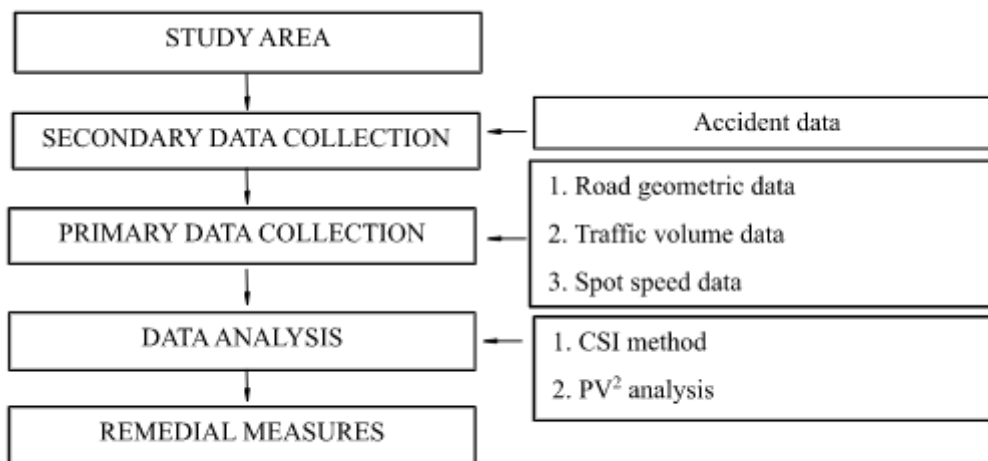


Fig.1 Flow chart of the methodology



4.1 Collection and Analysis of Secondary Data

The pedestrian accident data of the road stretch from 2017 to 2021 are collected from various police stations: North Paravur, Varappuzha, Cheranalloor and Edappally. Detailed analysis of secondary data is to be carried out using CSI method. The data is collected from FIR. The identified crash prone locations on the road stretch were ranked and prioritized into three orders based on Crash Severity Index (CSI) values. The formula given below is used for obtaining pedestrian crash prone locations using CSI method.

$$CSI = 7 \times FA + 3 \times GA \tag{1}$$

Where CSI, FA, GA is the Crash Severity Index, number of fatal crashes and number of grievous crashes. Crash Severity Index for each crash prone locations were calculated by using this equation. For estimation of CSI, the weightage to fatal crash was assigned as 7 and to grievous injury crash as 3, as per terms of reference for the appointment of Safety Consultants on DBFO basis, National Highways Authority of India (NHAI). Total 5 crash prone locations were identified and prioritized as shown below.

Table 1. Ranking of pedestrian crash prone locations

Rank	Place	Grievous Crashes	Fatal Crashes	Crash Severity Index
I	Edappally	37	6	153
II	Kunnumpuram	14	2	56
III	KMK Junction	10	3	51
IV	Thaikkavu	13	1	46
V	Cheranalloor Signal	12	-	36

4.2 Collection and Analysis of Primary Data

Primary data collection includes road geometric data, traffic volume count and spot speed data. Road geometric data were collected from National Highway department at North Paravur Mini Civil Station and National Highway department in Aluva. Road geometric data includes drainage type and its condition, shoulder type and its condition, land use type, light post number, carriageway details, median details, and the terrain type. Median is only in Kunnumpuram and Edappally having width 1m and 3m. Width of median at Kunnumpuram is not adequate as per IRC. Footpath is only at Edappally having width 2m.

Vehicular count was taken at KMK junction and Edappally. It is done with the help of a mobile application and converted to Passenger Car Unit (PCU) equivalent. Peak period (4pm to 6pm) traffic volume was taken at KMK junction and at Edappally both traffic volume and pedestrian count was taken during 8am to 10am. PCU currently used in the design and analysis of signalized intersections in Kerala as well as in India are based on the values given in the Indian Road Congress code, IRC: SP 41 – 1994.

PV² analysis were carried out at Edappally junction. Peak period (8am to 10am) working day traffic volume count and pedestrian count was taken. For cross movement analysis of pedestrians, the value of PV² has to be computed so as to identify the necessary pedestrian facilities. Where P is the number of pedestrians crossing and V is the Vehicular traffic volume in PCU per lane per hour. From the data collected, determined the peak hour volumes of vehicles for each road. The PV² analysis was conducted for each stretch of road joining the junction. Table 2 shows the obtained PV² value for each stretch in Edappally junction.

Table 2. Pedestrian – Vehicular volume analysis

Place	P	V	PV ² × 10 ⁸
Edappally – Vytilla Stretch	756	2460	46
Edappally Paravur Stretch	650	3321.5	72
Aluva Road	206	3309	23
Kaloor Road	130	2227.5	7

Spot speed survey is taken at Thaikkavu and Kunnumpuram to determine the speed that driver select, unaffected by the existence of congestion. The trap length which is taken for both locations Thaikkavu and Kunnumpuram is 30m. Generate a frequency distribution table by finding out spot speed of each free flow vehicle. Frequency distribution curve and cumulative frequency distribution curve was generated using EXCEL. Then, finally determined the speed percentile such as 15th, 85th and 98th percentile speed. Fig.2 to Fig.5 shows the frequency distribution curve and cumulative frequency distribution curve.

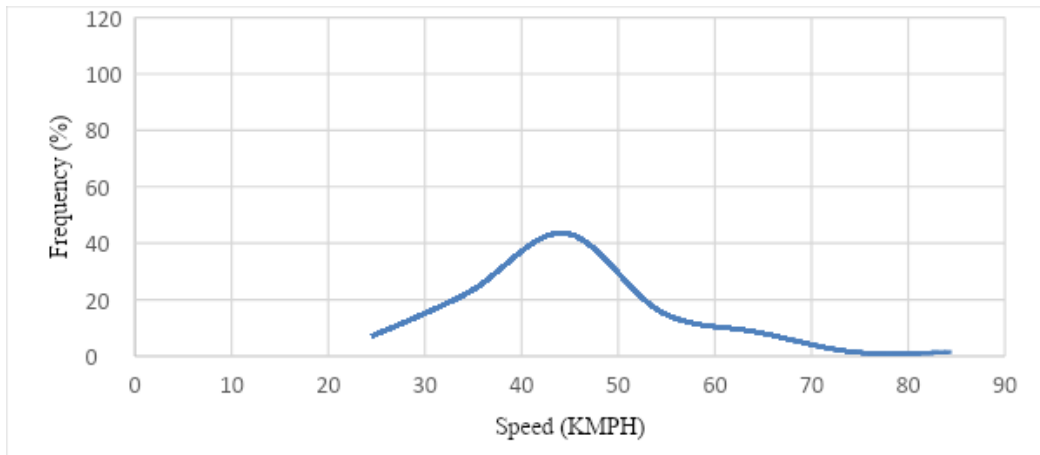


Fig.2 Frequency distribution curve at Thaikkavu

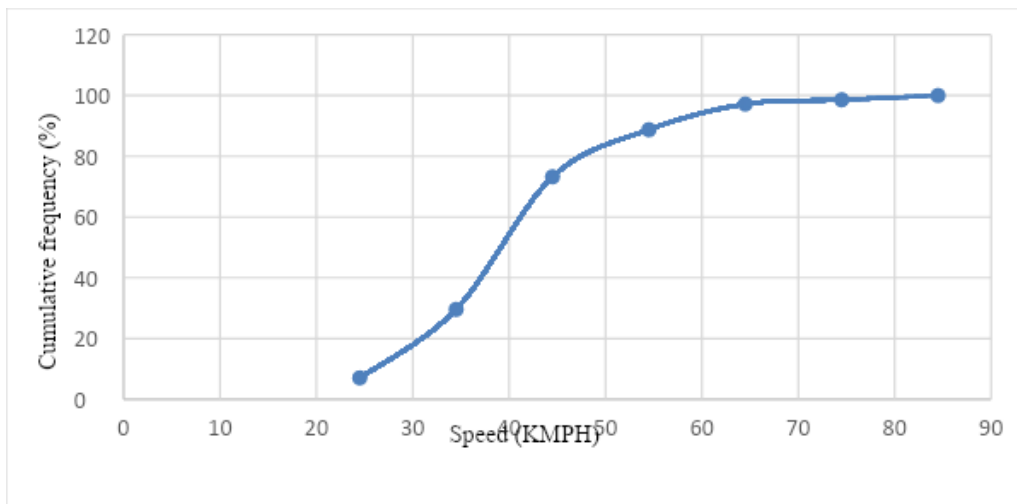


Fig.3 Cumulative frequency distribution curve at Thaikkavu

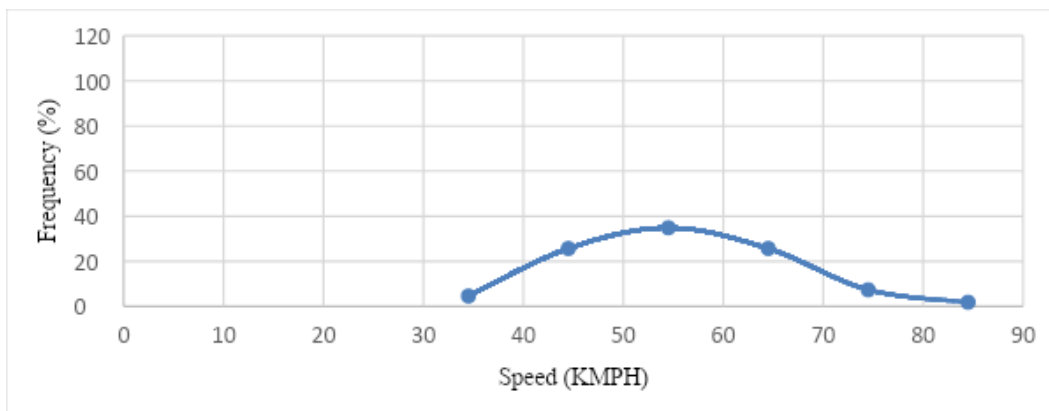


Fig.4 Frequency distribution curve at Kunnumpuram

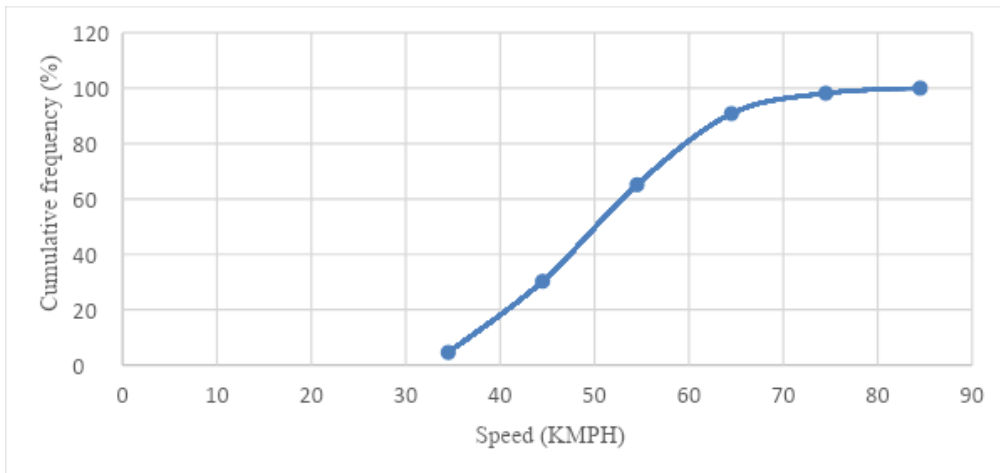


Fig.5 Cumulative frequency distribution curve at Kunnumparam

V. REMEDIAL MEASURES

It is essential to develop certain measures to mitigate the circumstances leading to the accidents in future from detailed observations and analysis of each pedestrian crash prone location. This work helped in identifying major reason of the pedestrian accidents in this stretch. Based on the study, it is suggested to provide remedial measures at identified locations. The measures suggested to reduce the rate of accidents for the study area are explained below.

KMK Junction: The road from Municipal junction to KMK junction is a congested road connected with hospitals, schools, petrol pump, shops etc. There is no traffic signal designed at this junction; as a remedial measure, it is suggested to design a traffic signal to reduce accident rate and ensure pedestrian safety. To reduce accident rate, provide hump and proper pedestrian crossing before the junction. Pedestrian crossing should be provided with a minimum of 2m wide. These observations are based on the road geometric data, volume count taken and referred guidelines for the pedestrian facilities. Fig.6 shows the image of KMK Junction.



Fig.6 KMK Junction

Traffic signal design based on IRC method. The details of the signal timing are given below:

Road	Green (sec)	Amber (sec)	Red (sec)	Cycle Time (sec)
Road 1	20	2	17+2	41
Road 2	13	2	24+2	41

Road 1				
Green	Amber	Red	All Red	Amber
20 sec	2 sec	15 sec	2 sec	2 sec

Road 2				
Red	Amber Red	Green	Amber	Initial Delay
20 sec	2 sec	13 sec	2 sec	4 sec

Road	Green (sec)	Amber (sec)	Red (sec)	Cycle Time (sec)
Road 3	31	2	17+2	52
Road 4	13	2	35+2	52

Road 3				
Green	Amber	Red	All Red	Amber
31 sec	2 sec	15 sec	2 sec	2 sec

Road 4				
Red	Amber Red	Green	Amber	Initial Delay
31 sec	2 sec	13 sec	2 sec	4 sec

Kunnumpuram Junction: Four – legged intersection having signal at this junction. NH – 66 has adequate width but the road connected to Manjummel road has to be widened. Condition of Shoulder is poor, provide minimum of 1.5m of shoulder width as per IRC. Bus stop, shops and hospitals make this area a busy junction. The pedestrian and vehicular traffic is high at this junction. There is no traffic signal is designed for pedestrian crossing; as a remedial measure, it is suggested to redesign a traffic signal to reduce accident rate. Provide proper lane marking and minimum of 2.5m median width as per IRC. Fig.7 shows the image of Kunnumpuram.



Fig.7 Kunnumpuram Junction

Cheranallor Signal: This junction is a signalized intersection and it is connected with container road. Heavy trucks and container vehicles are pass through this route. Speed of the vehicles are high at this location. While pedestrians are walk on the side of the road mainly hitting of pedestrian causes due to over speed of vehicle. Provide footpath for the pedestrians to walk safely. Instead of signal, design roundabout. It helps the drivers to reduce the speed while entering and exit of the junction. The provision of pedestrian refuges and traffic islands is a useful traffic management technique on pedestrian routes junctions enabling the pedestrian to deal with one lane particular direction of traffic at a time. Fig.8 shows the image of Cheranallor Signal.



Fig.8 Cheranallor Signal

Thaikkavu: Pedestrian accidents are more in this area so as a remedial provide footpath at both side of the road. Speed of the vehicle is also the main reason, install sign boards indicating speed limit. Provide pedestrian crossing with STOP line and width of the crossing should be in the range of 2 to 4m. Zebra crossing is a clearly specified pedestrian track across the carriageway and is delineated with the help of alternate black and white strips, which should have embossed texture for easy detection by person with vision impairment. Fig.9 shows the image of Thaikkavu.



Fig.9 Thaikkavu

Edappally: It is the major pedestrian crash prone location identified from the study area. Accidents are increasing day by day. Fatal accidents are also more in this location, Major reason for increasing accident rates are over speed. At this junction, there is no proper traffic signal for pedestrians. Edappally is a busy street connected with metro, lulu mall, flyover, toll, bridge and so on. Provide Educational Measures such as Education of road users and Safety drive. The passengers and pedestrians should be taught the rules of the road, correct manner of crossing and so on. Posters exhibiting the serious results due to carelessness of road users may be useful. Pedestrian crossing should be 4m wide. Proper marking on center lines, lane lines and edge lines. Provide sign boards indicating speed limits and no overtaking signs in order to warn and alert the drivers. Avoid street parking and park the vehicle in parking spaces. Increase the signal timing by twice to avoid the accumulation of vehicles to reduce the jam lengths. Provide skywalk which protect pedestrians from the weather. Skywalk with proper sitting arrangement helps the pedestrians to take rest from the busy junction. Fig.10 shows the image of Edappally.

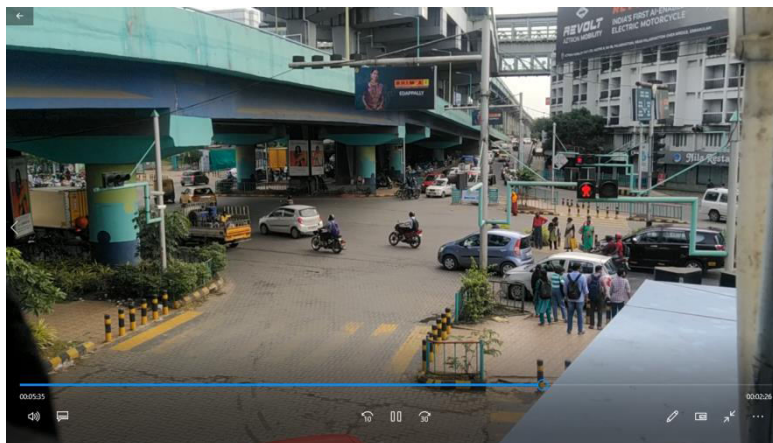


Fig.10 Edappally

VI. RESULTS AND DISCUSSION

- Edappally, Kunnumpuram, KMK Junction, Thaikkavu and Cheranalloor are the five pedestrian crash prone locations. Crash Severity Index method is used to prioritize the location by assigning weights. Edappally is the high pedestrian crash prone locations having CSI value 153. Kunnumpuram, KMK Junction, Thaikkavu and Cheranalloor Signal having the CSI value as 51, 46 and 36. Cheranalloor signal having fewer pedestrian crashes compared to other locations. Based on the CSI value the locations are prioritized.

- The Pedestrian - Vehicular volume analysis was done for cross movement analysis of pedestrian at Edappally junction. Pedestrian vehicular volume value obtained at Edappally-Vytilla stretch is 46, Edappally-Paravur stretch is 72, Aluva road is 23 and Kaloor road is 7. The permissible PV² value is $1 \times 10^8 - 2 \times 10^8$ in general cases. But the obtained value is much higher than the permissible limit confirming that the junction is not safe for pedestrian cross movement. NH – 66 stretch was found as the major travel corridor for pedestrian movement and the junction has poor condition for pedestrian.
- Spot speed at Thaikkavu and Kunnumpuram is found out. 15th, 85th and 98th percentile of vehicle speed at Thaikkavu is 28kmph, 51kmph and 74kmph. At kunnumpuram, 15th, 85th and 98th percentile of vehicle speed is 37kmph, 62kmph and 70kmph.

VII. CONCLUSION

The study was aimed to identify, evaluate and improve the pedestrian crash prone locations in Ernakulam district for a road stretch of 18.5 km on NH – 66 using Crash Severity Index method and Geographic Information System. Identifying crash prone location is an effective approach to reduce the accident rates of a place. The accident data from North paravur, Varappuzha, Cheranalloor, and Edappally police departments for five years were collected. The identified locations were prioritized by using Crash Severity Index method. CSI Value of a place represents hazardous spot. KMK junction, Cheranalloor signal, Thaikkavu, Kunnumpuram and Edappally are the five pedestrian crash prone locations with highest value of CSI which is chosen for the study. Most of the fatal and grievous injury crashes are caused due to ‘Hit Pedestrian’. Road geometric data from north paravur to Edappally were collected. Traffic volume count was taken at Edappally and KMK Junction. Traffic signal is designed at KMK Junction as a remedial measure by following IRC guidelines. Pedestrian count and traffic volume count was taken at Edappally Junction. PV² analysis were done at Edappally and the value obtained is higher than the permissible limit. The pedestrians are not safe for crossing at this junction. The pedestrian vehicle interaction is very high at this place. Spot speed data were taken at Thaikkavu and Kunnumpuram. Possible suggestions will help to improve the safety of pedestrians.

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