Pedestrian Management at an Urban Intersection: A Case Study

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Abstract

Each and every city would be enhanced with word "Smart". Various problems like traffic congestion, pollution and high accident rate are mainly due to rapid urbanization and motorization which are the major issues in achieving goal to make a city "Smart". The problem can be overcome to a great extent with optimization of signal cycle length which takes pedestrian crossing time into consideration. This paper mainly focuses on pedestrian crossing which is the most dangerous component in transport field. The behaviour of pedestrian crossing under mix traffic condition at signalized intersection is needed to be considered while optimizing signal cycle and designing crosswalks. The pedestrian clearance time is affected by various pedestrian characteristics and surrounding environment under mixed traffic condition. Pedestrian behaviour need to be analysed for safe and efficient traffic management. This paper considers presents the behaviour of pedestrians at an urban signalized intersection with an objective to suggest factors to be considered for traffic safety at intersections.

Keyword- Traffic Management, Pedestrian Signal, Pedestrian Clearance Time, Intersection Characteristics, Smart City

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I. INTRODUCTION

A developing country faces many problems regarding traffic and this kind of hazard is mainly concerned in traffic engineering. The problems which are of major concern are traffic congestions, air and noise pollution, high accident rates and lack of proper facilities and these are mainly due to high growth in population and rapid motorization. The term 'Traffic' is highly related to traffic intersection as an important part of urban road networks. Operation of traffic plays a key role in the vehicle speed and overall efficiency of entire road networks.

Most of the traffic research work has been focused on study related to vehicles. The safety, comfort and convenience of pedestrian mostly get overlooked. Walking is our first and essential means of transport. As every trip begins and ends with walking, each person is a pedestrian during some part of his/her trip. Not only vehicle's drivers but pedestrian also experience delays at signalized intersection. Pedestrians are considered as the most vulnerable road user involved in large number of accidents due to the complexity in evaluating their behaviours under different conditions of traffic and driver behaviour.

According to the National Crime Records Bureau 12,385 pedestrian deaths were reported for the year 2013 in India. The precise number of pedestrians injured and killed is difficult to estimate and could be approximately more than 40,000 deaths annually in India. More than half of injured and killed pedestrians were young men in the age group of 16-45. Probable causes of pedestrian accidents at intersections are inadequate protection provided for pedestrians, unwarranted signals, inadequate signal phasing and restricted sight distance.

The pedestrian crossing speed is used in signal timing arrangements. If the crossing speed is overestimated then pedestrians will not be able to complete their crossings within the given time. On the other hand if it is underestimated then the vehicles will have delays at the intersections. Thus, the need of optimization of signal cycle length for improving safety and also for effective traffic management of any signalized intersection is arising. Pedestrian clearance time should be taken in consideration during this optimization. Pedestrian clearance time is evaluated from pedestrian crossing speed and length of cross-walks. Pedestrian crossing speed is important design parameter in designing of signalized intersection and it is affected by many factors like age group, gender, crossing pattern, numbers of pedestrian and risk taking ability.

Different studies have been done on pedestrian behaviour influencing pedestrian crossing speed and it has been found that the value varies largely from the estimated walking speed at crosswalks of 1.2 m/s according to manual of 'Indian Road Congress' (IRC). This constant value is not applicable for mix traffic conditions prevailing at signalized intersections.

Wu et al. (2015) collected traffic data from 50 signalized intersections under mixed flow condition in Xi'an, China. The key objective of study was to develop an optimization traffic signal cycle length model for signalized intersections. The vehicle delay time, pedestrian crossing time as lower boundary and drivers' anxiety as upper boundary were taken into consideration in Optimization cycle length model. When traffic volume is low, pedestrian crossing time should be given more weightage rather than vehicle, while designing signal cycle.

Laxman et al. (2010) examined the pedestrian characteristics in sideways and walkways. Pedestrian behaviour analyses have great implications for transportation and urban planning policies and design practices. They conducted study in two different cities of India; one is Roorkee and second is Delhi. Based on land use, width of carriageway and shoulder, and available space between shoulder and shops these locations were selected. 4-5 pedestrians were randomly chosen from the total count and the time taken by them to travel particular distance was noted with an accuracy of 0.1 second for speed measurement. Variation in speed of pedestrians with respect to various pedestrian characteristics like age and gender, and movement (individual or in group, with or without baggage were analysed. The crossing speed was observed to be 80 m/min which is higher than that reported for China and Singapore but lesser than that of Germany. They observed that many of the pedestrians were using carriageway for travelling one place to another or for crossing the road. This resulted in conflict between pedestrian and motorized vehicle. These locations have lowest width of carriageway and the available space between shoulder and shops occupied by the shop owners for the display of their material and the rest by the parked vehicles. Thus pedestrian faced more friction, but due to free movement of pedestrian on the road their speed increased. With increase in age, energy level decreases and thus speed also decreases. Walking together also reduced speed of individual. Carrying baggage increase in friction, thus reduce speed of pedestrian. Females walk faster than males, e.g., subways.

Marisamynathan and Vedagiri (2014) analysed 775 pedestrian samples observed from three signalized intersections in Mumbai, India for their crossing behaviour like crossing speed, compliance with signal, and pedestrian-vehicular interaction under mixed traffic conditions. Factors influencing pedestrian crossing speed like pedestrian crossing volumes, crossing time, pedestrian appearance (like gender and age group), crossing behaviour (such as walking or running, alone or in groups and crossing speed variations), crossing locations (whether using the crosswalk or not using), pedestrian crossing phase time (whether pedestrian crossing during green phase or non-green phase) and pedestrian-vehicle interaction at crosswalk have been studied and a design crossing speed was determined for old and adult pedestrians as 0.95 m/s and 1.12 m/s respectively. Average crossing speed varies between 1.2 m/s to 1.4 m/s. The field average crossing speed of 1.34 m/s matches well with field value of 1.33 m/s measured in China which is also a highly populous region. The crossing speed variation is defined as the difference between the 85th and 15th percentile speed obtained from cumulative frequency graph. A new factor termed as crossing speed deviation factor (CSDF) is established and defined as the ratio of the crossing speed variation and average crossing speed as given in eq (1).

$$\mathrm{CSDF} = \frac{(v_{85} - v_{15})}{v_{50}} \qquad (1)$$

The result of analysis indicates that pedestrians were interested in walk rather than running during crossing. Around 44% pedestrians were complying with traffic signals and at highly populous region, rate of noncompliance was higher during peak hours. Only 78% pedestrian utilized the crosswalks. Male pedestrian crossing speed was more than the female. Crossing speed is affected by age of pedestrian, and adult pedestrian have faster crossing speed than the child and old pedestrian. Pedestrian crossing speed of group was less than that of a single pedestrian. The pedestrian crossing speed is more during non-green phase than the green phase. Increase in waiting time deceased rate of compliance of pedestrian. Study showed that the existing models failed to provide necessary accuracy of pedestrian delay estimation at signalized intersections in India because those models did not consider all possible pedestrian crossing behaviours under mixed traffic conditions.

Varsha and Bindhu (2016) assessed pedestrian crossing behaviour according to the demographic characteristics like age, gender and crossing patterns which differ from person to person. Also they tend to violate the green phase in absence of separate pedestrian green phase provided for crossing, they usually cross during red phase (when vehicles stops) in order to reduce their delay keeping themselves at risk at a signalized intersection. They also analysed the pedestrian characteristics like age, gender and crossing patterns (One step crossing, two step crossing and combined one step and zigzag crossing) at Pattom Junction, Trivandrum, Kerala. Pedestrian walking speed at a crossing was found to be varying from the assumed constant value 1.2 m/s recommended by IRC (1985). Average crossing speed varies between 1.58 m/s to 1.91 m/s. The average crossing speed of male (1.5m/s) more than that of the female (1.4 m/s) pedestrian. It is also observed that most of the pedestrians were not using crosswalks and they follow two type of crossing pattern (One step crossing and two step crossing). The study also focused on the need of enhancing traffic measures and implementing traffic management for the pedestrian safety.

Alver and Onelcin (2017) carried out investigation for the pedestrian's crossing speeds, delays and gap perceptions at 6 signalized intersections in Izmir, Turkey. From each intersection, crosswalk having highest pedestrian density was selected for observation. By videography method, data were collected from each intersection during peak hours. The average crossing speed of 1.31 m/s and the average 15th percentile crossing speed of 1.07 m/s were founded from 2694 observed pedestrians and compared with design crossing speed of 1.4 m/s in Turkish Standards Institute (TSI, 2012). At locations, where traffic volume is high pedestrian crossing speed is low and vice-versa. Pedestrian who moved individually; without items; male and younger have high crossing speed than that of moved in group; with items; female and old, respectively. Pedestrian also experience delays during green signal in Turkey and existing models in developed countries do not take these delays into account.

II. STUDY AREA

Pedestrian study was carried out in the Surat city of Gujarat, India. The total population of Surat city is about 44.6 lakhs (2011) (which is forecasted to be 6.2 million by 2021).

Fig. 1: Study Area-Majura Gate intersection

Present study was conducted at Majura Gate intersection on Ring Road (Figure 1), based on land use, continuous and significant pedestrian traffic and available width of road for crossing. Study was conducted on 28th December, 2018 between 10:00 am to12:00 pm and 4:00 pm to 6:00 pm.

III. METHODOLOGY

Pedestrian data was collected by direct observation method at intersection. A team of 2 members was positioned at 3 different locations of intersection. 1 person in team recorded time, using stop watch, and second person recorded pedestrian data in prescribe data format sheet. The time required by a pedestrian to cross particular stretch of land (measured lane width) was recorded.

Pedestrian behaviour like, crossing type (running or walking), using crosswalk or not, compliance with signal, crossing pattern (perpendicular or oblique) and crossing in group or single were monitored. The characteristics of pedestrian, like age and gender, having an influence on pedestrian crossing behaviour were also observed.

IV. DATA COLLECTION

Total 507 samples were collected from the field. Out of which 289 are males and 218 are females. The observed pedestrian composition is shown in Figure 2.

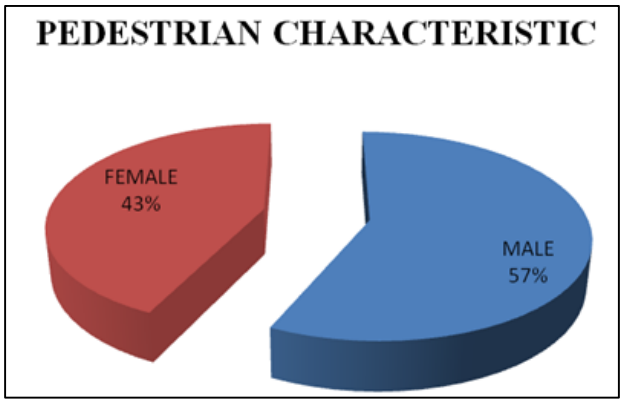

Fig. 2: Pedestrian Composition

The behaviour classification of pedestrians is given in Table 1. As observed, majority of pedestrian are adult (80.68%).

OBSERVED PARAMETERS			*NUMBER OF OBSERVATION*	*%*
CHARACTERISTICS	*GENDER*	*MALE*	*289*	*57*
		FEMALE	*218*	*43*
	AGE GROUP	*CHILD*	*20*	*3.94*

		ADULT	409	80.68
		OLD	78	15.38
BEHAVIOUR	CROSSING TYPE	WALK	491	96.84
		RUN	16	3.16
	NO. OF PEDESTRIAN	SINGLE	277	54.64
		GROUP	230	45.36
	CROSSWALK UTILIZATION	YES	150	29.59
		NO	357	70.41
	CROSSING PATTERN	PERPENDICULAR	323	63.7
		OBLIQUE	184	36.3
	COMPLIANCE WITH SIGNAL PHASE	YES	361	71.2
		NO	146	28.8

Table 1: Behavioural classification

V. DATA ANALYSIS AND RESULTS

The collected data is analysed to find field average crossing speed as 1.27 m/s, which is not matches with field value of 1.33 m/s measured in China (Marisamynathan and Vedagiri, 2014). However, this value is higher than the constant value of 1.2 m/s mentioned in Indian Road Congress (IRC 093-1985). The calculated V15, V50 and V85 speeds are 0.9, 1.2 and 1.6 respectively. The analysis of data is given in Table 2.

The mean crossing speed of male is 1.33 m/s and that of female is 1.15 m/s which is less than the crossing speed of male. The average crossing speed of old pedestrian is found to be 1.13 m/s and that of young adult is 1.30 m/s, which proves that adult pedestrian cross the road faster than the old.

Only 29.59% pedestrian utilize crosswalk. The rest 70.41% pedestrian do not use crosswalks for different reasons like, crosswalks are occupied by vehicles during the wait time at signal, sidewalks are sometimes occupied by small shop keepers for display of their commodity, handcarts (food stalls) and irregular parking of vehicles, etc. From analysis of crossing pattern of pedestrian, it is found that 63.7% pedestrian cross road parallel to the crosswalk (showing straight movement) and 36.3% pedestrian follow oblique pattern.

LOCATION	1	2	3
TIME OF SURVEY	10:00 am to 12:00 pm / 4:00 pm to 6:00 pm		
CROSSWALK WIDTH (m)	15	12	10
NO. OF SAMPLE	172	148	187
DIRECTION	TWO	TWO	TWO
MEAN SPEED (m/s)	1.3284	1.2188	1.225
STANDARD DEVIATION	0.4694	0.4521	0.2926
V_{15}	1	0.8	0.945
V_{50}	1.2	1.2	1.2
V_{85}	1.6	1.6	1.555
CSDF	0.5	0.666666667	0.508333333

Table 2: Analysis of collected data of crossing speed

The total amount of pedestrians complying with traffic signal is about 71.2%, indicating high compliance behaviour of pedestrian. Rest of 28.8% pedestrians shows noncompliance behaviour. One reason for this could be that pedestrians are unaware of traffic signals provided for them. Occasionally some of these signals are not suitably designed. The noncompliance behaviour of pedestrian is also due to longer waiting period. As waiting period for pedestrian is equal to the discharge time (green spilt) for the vehicles, pedestrian become impatient and tend to cross during no-walk time.

VI. CONCLUSION

From the above studies it can be concluded that for safe and efficient traffic management at any signalized intersection, optimization of signal cycle is required. And pedestrian crossing time must be taken into consideration during optimization to ensure pedestrian safety. Various pedestrian behaviours like crossing speed, compliance with signal and pedestrian- vehicular interaction under mix traffic condition need to be analysed as pedestrian crossing time is a function of pedestrian crossing speed and travel distance. Different pedestrian characteristics like age group, gender, crossing pattern, crossing type and numbers of pedestrians affect crossing speed of pedestrian. Geometric factors like crosswalk length and land-use are to be analysed.

Age and gender have significant effect on crossing speed. Young pedestrians have high crossing speed than old. Male pedestrian crosses the crosswalks faster than female. Pedestrian crossing individually has high speed than moving in group. Pedestrians walked fastest during don't walk phase, faster during flashing phase, and with average speed during walk phase.

It is clear that the actual pedestrian crossing speed largely vary from standards or constant design crossing speed 1.2 m/s (IRC 093-1985). IRC should revise the present crossing speed and recommend a more realistic crossing speed value. Not only in India, crossing speed vary from standard values in different countries. Also in India, driver have tendency to occupies crosswalk

space during red interval, due to which pedestrians are unable to use crosswalks effectively and these may result in hazardous condition. Sidewalks are also often occupied by the shop owners for the display of their material.

In India, pedestrian crossing is regulated by green and red indication while countries like Japan, US, etc. use additional clearance indication so that the pedestrian who are in crosswalk can move to the kerb side before green indication for vehicle start and arrive to the point of safety. In India, pedestrian signals must be optimised with consideration of green, flashing green and red intervals for better pedestrian movement and to reduce accidents rates, likely to occur by pedestrian noncompliance behaviour. Concept of Pedestrian plaza may be adopted in India.

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