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Pedestrians Crossing and Walking Behaviour - A Review

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Abstract— Present traffic condition is not suitable according to the needs of pedestrians. Unfortunately, a less amount of road users is aware about the crossing and walking behaviour at signalized intersection. Various studies were conducted on pedestrian behaviour while crossing and walking. The studies suggested that around 70% of the accidents involve pedestrians and it happened because of their non-compliance behaviour while walking. Also, talking on a mobile phone is associated with cognitive distraction that may undermine pedestrian safety. So, there is a special need to analyze the crossing and walking behaviour of pedestrians to ensure their safety. The walking speed of pedestrians at crossing has been found to be varying from the assumed constant value of 1.2m/s, as recommended by Indian Road Congress (1985). Pedestrians crossing behaviour is a complex phenomenon for traffic engineers to analyze as they differ from person to person. Various analysis and methods have been adopted by researchers to study the pedestrian behaviour. The present paper provides an overview of the past works that have been done regarding the walking and crossing behaviour of pedestrians at signalized intersection, by manipulating and quantifying the pedestrians perceived overall satisfaction level.

Keywords— crossing and walking behavior, Indian Road Congress, non-compliance, pedestrians, safety, signalized intersection.

I. INTRODUCTION

In today's world, the main problem which people are facing is the growth in road accidents. Currently, the major concern of research is safety, comfort, and convenience of pedestrians. In highly populated cities, the pedestrians travelling are very high with least amount of safety. Significant purposes behind passer-by's noncompliance with traffic signals are low quality administration, high traffic volume and longer traffic cycle. Indian Road Congress (IRC: 1985) have been proposed the walking speed of pedestrians as 1.2 m/s at crosswalks. But this speed is not maintained at every intersection in every situation. So the risks involved in crossing the road are very high. Among the various factors which are influencing the awareness of hazard and minimizing the risk include age of pedestrians, slipperiness of roads, and volume of traffic passing through the signalized intersection. Practices that would reduce the likelihood of pedestrian's accidents include, looking on both the sides and checking the traffic.

Signalized Intersection

Signalised intersections are generally installed at intersections of major roads. It usually involves several approach lanes on each leg. People on foot are sensitive road users and regardless of their definite description in traffic events, pedestrian involved harm and death are overrepresented in traffic accidents. The essential point of transport road safety policy is the pedestrians' safety, especially in urban areas. In order to minimize the accidents and raise the road level for both pedestrians and drivers, intersections with high traffic flows should be signalized.

The major verifiable truth in road safety issue is the pedestrian's illegitimate crossing behaviour. The main concern includes the following:

- Usually the pedestrians cross the streets without taking care of the incoming traffic, because their concentration is disturbed.
- Main mistake that pedestrians make is that of traffic gaps.
- Sometimes due to the inadequacy of space on sidewalks, pedestrians walk across the street.
- Moreover, the crosser-bye's sometimes do not follow the traffic light indications.

There are various factors that affect the pedestrians walking and crossing behaviour at signalized intersection. It includes; the physical environment (e.g., road width, type of street), road user variables (e.g., demographic characteristics) and social factors (e.g. the number of pedestrians in the group who are trying to cross).

Several studies have inspected differences in pedestrian behaviour by gender and age. It has been observed that male pedestrians tend to violate traffic rules more frequently than females and are more likely to cross in risky situations. Similarly, youths and adolescent pedestrians commit violations more than older road users, who express greater cautiousness and appreciation for the traffic signals at controlled pedestrian crossings. Another perspective that influences the crossing behaviour of pedestrians is their motives for compliance with road safety laws. In addition, fewer studies have focused on the factors affecting the compliance rate.

II. OBJECTIVES OF THE STUDY

The objectives of the present study are: -

1) To investigate whether different demographic groups (based on age and sex) and social elements (number of people on foot endeavoring to cross) vary in their crossing behaviour or not.
2) To identify various aspects that basically affects pedestrian crossing speed in the crosswalks at signalized intersections.
3) To determine why pedestrians violate the laws at signalized intersections.

III. LITERATURE REVIEW

Effect of mobile phones on pedestrians walking and crossing behaviour:-

1. Thompson, L. et al. (2014) conducted a survey on pedestrians at 20 high risk intersections. Demographic and behavioural information including the use of mobile phones (talking on phone, text messaging and listening to music) was recorded. The crossing behaviour of 1102 pedestrians was observed. Around one-third (29.8%) of total pedestrians performed distracting activity during crossing. Distractions included use of handheld phone (6.2%), text messaging (7.3%), listening to music (11.2%). Distracted pedestrians took longer time to cross the road. Across the average intersection length of 3.4 lanes, individuals using a handheld or hands-free phone took an additional 0.75 and 1.29 s to cross the road. Pedestrians who were text messaging took over half a second more to cross each lane and the pedestrians listening to music walked faster by an average of 0.16s per lane than undistracted pedestrians. Only text messaging and gender had a significant effect on optimal crossing behaviour. This compulsive use of mobile phones was also associated with higher rates of crashes.

2. Alejalil N. and Davoodi SR. (2017) conducted survey concerned with aspects of mobile phone usage and pedestrian distraction. It is reported that pedestrians are distracted by many interferences such as smoking and listening to music, but the most common distractor is the inappropriate use of a cell phones. There is a rapid increase in the number of pedestrians who use cell phones for talking or text messaging while crossing the street. It is documented that there is a direct correlation between the number of cell phone users and injuries. More usage of cell phones results in more injuries. Talking on cell phone considerably reduces attention to the unusual surroundings. The findings of the present study suggest that cell phone usage while walking can decrease the perceptual visual field, make pedestrians less aware of the surroundings and put them at the risk of having an accident, getting injured or death.

3. Alsaleh, R. et al. (2018) conducted study on the effect of distraction states and distraction types such as texting/ reading and auditory, such as talking/listening on parameters of pedestrians at crosswalks. Experiments were performed on a video data set near a college campus in the city of Kamloops, British Columbia. Results show that pedestrians distracted by texting/reading (visually) or talking/listening (auditory) while walking tend to reduce and control their walking speed by adjusting the step length or step frequency. Compared with non-distracted pedestrians, distracted pedestrians tend to have a statistically significant slower average walking speed. Distracted pedestrians differ in the way they control their walking speed based on the type of distraction (e.g., talking/listening or texting/reading).Moreover using cell phones while walking limits the visual sensory of pedestrians required for controlling gait balance, resulting in abnormal walking function, and this may lead to problems such as falling.

Effect of countdown timers on pedestrians walking and crossing behaviour:-

4. Huang C. and MA W. (2010) carried out the research on speed distribution of pedestrians and the impact of countdown pedestrian's signal on the crossing speed of pedestrians. The walking speed of passer-bye was determined at the two similar intersections of the road having different signal intervals. From the studies it was concluded that the average walking speed of females is lower than that of males while as the average walking speed of young people is effectively more than the older citizens. It was observed that the walking speed followed a normal distribution irrespective of the gender and age. CPS change the walking speed distribution of pedestrians and these effect are more dramatically at the last time span of signal change interval.

5. Long, K. et al. (2011) have studied the effect of countdown timers at signalized intersections in China by videotaping the signal phasing and traffic operations at 4 comparable signalized intersections under normal conditions. For comparable intersections with and without countdown timers, driver behaviour measured by driver decision (stop or go) and vehicle entry time (when the vehicle crosses the stop line) were analysed using binary logistical regression (BLR) and a nonparametric test, respectively. The results suggest that countdown timers can indeed influence driver behaviours, in terms of decisions to stop or cross the intersection. Results of the study suggest that when countdown timers are present, drivers are more likely to cross the intersection after the onset of yellow. It was also found that the presence of countdown timers contribute to the late entry into intersections and results to dangerous red light running behaviours. The countdown timers may also lead to increased entrance into the intersection during the later portions of the yellow and even the red.

6. Campbell A. (2014) analyzed pedestrian walking speed at signalized intersection. The data was collected after the installation of PCS devices. A total of 26,439 older and younger pedestrian speeds were analyzed to understand the effect

of PCS devices on a pedestrian's crossing walking speed. After installation the data were compared to the data collected by Arango's, which determined the normal and crossing walking speed of pedestrians on a segment of sidewalk and at signalized intersections without PCS devices installed respectively. From the conclusions it was clear that; older pedestrians walk slower than younger pedestrians regardless of whether a PCS device is present. The installation of PCS devices decreases the younger pedestrian's average crossing walking speed from 1.61 m/s to 1.27 m/s ,whereas the 15th percentile decreased from 1.33 m/s to as low as 1.05 m/s. The installation of PCS devices affects the crossing walking speed of pedestrians, by allowing pedestrians to slow their crossing walking speed. Moreover the average and 15th percentile of older pedestrians at all sites after installation were 1.19 m/s and 0.97 m/s respectively.

7. Xiong, H. et al. (2014) collected data by means of questionnaire and video recording at two signalized intersections; one with pedestrian countdown signal and the other was with traditional signal. Questionnaire shows the pedestrians' preference to countdown signals. It reveals that 91.8% of pedestrians believe that countdown signals are helpful in determining the time to enter crosswalk, and 72.6% of pedestrians think that countdown signals are more comfortable for crossing. Four measures of effectiveness were applied to evaluate effects of countdown signals, which include; proportion of compliers, adventurers, violators, and trapped pedestrians. The results show that countdown signals can significantly increase proportions of compliers and reduce proportions of violators and trapped pedestrians compared with traditional signal. However, countdown signals have weak impact on adventurers since many pedestrians do not understand the meaning of flashing signal.

8. Biswas, S. et al. (2017) evaluated the effect of the digital timers on pedestrian crossing speeds, and the pedestrian speed values were estimated from the video data both in the presence and absence of SCT. In order to examine the effect of SCT on age, the pedestrians were broadly classified as an adult-middle aged (21–60 years) and old (above 60years). The variations in the pedestrian walking speed data were analyzed. It was observed that male pedestrians had significantly higher walking speed (average walking speed 1.45 and 1.41 m/s at intersection 1 and 2 respectively) compared to female pedestrians speed (average walking speed 1.37 and 1.32 m/s at intersection 1 and 2 respectively) when SCT was on. Similar trend was observed in the absence of countdown timer. An adult middle aged male pedestrians walking speed (1.48 m/s) was significantly higher than that of old male pedestrian (1.25 m/s) in the presence of timer display, but the difference was not significant when SCT was switched off and the same pattern was observed at the other intersection. The present study observed that the presence of these timers can detrimentally affect the safety and efficiency of pedestrian crossings along zebra crossing by making them complex and unsafe.

9. Sobota, A. et al. (2017) compared behaviour of pedestrians and drivers in two periods of research for a week with enabled and disabled countdown timers. According to the results, countdown timers for pedestrians improve safety in the initial period of displaying red signal while significantly worsen at the end of the signal. Analyzing the flashing green signal the countdown timers improve safety. The entrance on the road at the last second of green light is allowed under Polish law but from a safety perspective this phenomenon is not desirable, that may result in a collision with road traffic. According to the results displays indicating the duration of individual signals at crossroads, equipped with traffic lights, reducing the number of entries at the red light at the beginning of the signal display.

Effect of violation of laws on pedestrians walking and crossing behaviour:-

10. Jiang N. et al. (2011) have carried out questionnaire survey in China based on the effects of pedestrian's character on violating the laws. Total feedbacks obtained were 675 out of which 535 were the valid samples. The study was based on the hypothesis that pedestrian personality was one of the major factors affecting pedestrian crossing behaviours. The results showed that the psychological and cognitive measures played the principal role in pedestrian safety. Also, this study showed that agreeableness had more effect on pedestrian violation in China; consciousness also had effect on violation. However this study showed that in china, the most pedestrian's violation were caused due to agreeableness.

11. Galanis A. and Nikolaos E. (2012) have examined the pedestrians crossing behaviour in signalized crosswalks. The study was carried out during the peak hours in summer of 2010, in Volos city (Greece). The main goal of this study was to calculate pedestrians crossing time, crosswalk velocity and illegal pedestrian crossing with red traffic light.85% of the pedestrians crossed the streets with green traffic light and only 15% with red traffic light. More pedestrians crossed the streets illegally where the traffic flow and speed are lower. The most illegal crossing behavior was noticed in women and pedestrians 20-50 years old. Older pedestrians crossed the street with lower walking speed (1,18m/sec) than pedestrians 20-50 years old (1,30m/sec) or under 20 years old (1,31m/sec). The highest illegal crossing behavior was noticed in collector streets (8%-28%) and the lowest in main arterials (4%-16%).

12. Harell W. (2014) carried out an observational study on the cautiousness and behaviour of risk, of 571 pedestrians on the signal controlled intersection in Edmonton, Alberta, Canada. From the studies it was observed that females and older citizens were more cognizant of traffic hazards and perceptive of risks. More care was observed when the temperature outside was warm instead of cold, when crosswalks were covered with ice rather than dry and when the volume of pedestrian was less. It was also analysed that crosswalk width and time of the day had not significant impact on the cautiousness. Moreover, the cautiousness was greater for low traffic volume.

Effect of age, gender and speed on pedestrians walking and crossing behaviour:-

13. Knoblauch R. et al. (1996) carried out the field study to measure the walking speed and start up time of various pedestrians under different age groups. The study was carried out on 16 crosswalks in 4 urban areas. Various parameters were included while collecting the data such as: crosswalk type, curb height, curbs width, signal cycle length, pedestrian-signal type. The results showed that the walking rates were influenced by variety of factors including; weather condition, street width, crossing speeds, signal cycle length. Also the walking speed of wider range of pedestrians was analyzed. The 15th-percentile walking speed for younger pedestrians (ages14 to 64) was 1.25 m/sec (4.09 ft. /sec); for older pedestrians (ages 65and over) it was 0.97 m/sec (3.19 ft. /sec). For design purposes values of 1.22 m/sec (4 ft. /sec) for younger pedestrians and 0.91 m/sec (3 ft. /sec) for older pedestrians are appropriate. The mean start-up times for younger pedestrians varied from 1.83 sec for males to 2.01 sec for females, with an overall mean value of 1.93 sec. For older pedestrians the mean values ranged from 2.39sec for males to 2.57 sec for females, with an overall mean value of 2.48 sec.

14. Jain A. et al. (2014) has done the analysis of pedestrians crossing behaviour conducted in Roorkee city (Uttrakhand). Depending on the crossing speed and waiting time, the study is based on certain characteristics namely: Age, gender, carrying baggage and luggage handling condition, crossing pattern of pedestrians, Volume and composition of traffic etc. In present study pedestrian safety and crossing patterns for different age groups and genders were observed. It has also been observed that majority of pedestrians cross the road in perpendicular direction while as only few cross in stages. In the present study the majority of pedestrians were not willing to take risk because of less safety margin and time gaps. There was a safety margin of zero (sec) for 1 out of 5 pedestrian's movement. The crossing speed for males was found to be 1.85 m/sec and that of females was 1.67 m/sec. Among various categories of pedestrians children were found to cross at higher speeds than others .No significant variation was observed in pedestrians crossing speeds due to handling of baggage. Among various categories of pedestrians females and older people have higher accepted time gaps and safety margins. Hence they were inclined to take very less risks than others.

15. Ding T. et al. (2014) had developed two models namely Automatic-balance model and waiting-time threshold model by analyzing the methods by which pedestrians cross the street. It has been observed that the pedestrian's unsafe behaviour can be reduced by reducing the waiting time and by increasing the noticed risk degree. It was also found that the pedestrians' unsafe behavior can be effectively reduced by increasing the perceived risk degree and reducing the waiting time. The pedestrians' unsafe behavior was the result of the pedestrians' waiting time being beyond their psychological expectations. By using the traffic psychology, the unsafe behaviour of pedestrians was analyzed. Moreover it was concluded that the planners and transportation engineers should focus on people oriented road system so as to meet the psychological needs of pedestrians

16. Tabish S. and Kumar M. (2017) have studied the pedestrian crossing behaviour at intersection. The site chosen were located at Ambala Cant railway station and another site at Chandigarh bus stand sector 43. The authors found that the pedestrian traffic was quite high and flow was continuous. Pedestrian accidents occur in a variety of ways; the most common type involves pedestrian crossing or entering the street at or between intersections. The largest group of victims in pedestrians was children under 15 years of age group; they had more chances of injury also. Moreover during dusk and darkness motorists cannot see pedestrians clearly. The methods opted for data collection was manual count and Questionnaire survey. They have gathered the information of pedestrian facilities and established a methodology to deal with pedestrian optimization problem. The accidental data collections were also done in this study, where they found pedestrians are more affected in accidental circumstances. They have estimated that complete segregation from vehicles through space may solve the problem of pedestrian causalities at crosswalks.

IV. CONCLUSIONS

1) Pedestrians account for a large proportion of road casualties and pedestrian crashes are more likely to occur at signalized intersections.
2) Male pedestrians tend to violate traffic rules more frequently than females and are more likely to cross in risky situations.
3) Outside temperature has been shown to affect pedestrian walking speed while crossing the intersections.
4) Pedestrians crossing in groups tend to cross on red more often than individual pedestrians.
5) More pedestrians cross the road illegally where the traffic flow and speed were lower. The studies showed that 41% of the total pedestrian fatalities can be ascribed to illegal crossing behaviour.
6) Additionally, it was found that the walking speeds of those who decided to go and those who decided to stop differ significantly.
7) Sometimes pedestrians cross the streets without noticing the incoming traffic, usually because their attention is distracted.
8) Moreover it has been analyzed that group size and gender are significant factors affecting the pedestrian compliance behaviour.

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