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A Comprehensive Review on Pedestrian Gap Acceptance at Unsignalized Road

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***Abstract*—This research aims to review on pedestrians' traffic gap acceptance for unsignalized road in urban areas. Pedestrian crossing is a complex issue in present transportation system, especially in urban areas there is no control for pedestrian road crossing. Pedestrians select gaps in vehicular stream depending on roadway geometry, behavioral characteristic of crossing vehicles and pedestrian etc. Due to improper road geometry and insufficient designated crossing points on road, pedestrians are sometimes forced to cross the road and they create confusion and risk to themselves, as well as to the drivers. For road users the choice of where, when and how to cross unsignalized roads are more or less depend on available gaps in vehicular stream.**

The present study is proceeding with an experimental approach, from observations of pedestrian crossings to the statistical analysis. The findings from this research will play a major role in improving the pedestrian road crossing behavior at unsignalized road.

Keywords*— *Pedestrians, Gap acceptance, unsignalized road, critical gap.

I. INTRODUCTION

Making decision to cross the road safely in relation to available traffic gaps is a complex task for pedestrians. Due to high population density, rapid urbanization pedestrian crossing behaviour becomes a critical element in the traffic system from both pedestrian as well as traffic flow point of view. Approximately one-third of the total traffic accident fatalities are pedestrians at signalized and unsignalized road. For example, in 2006, 23,285 pedestrians in China were killed in motor vehicle crashes and 82,391 were injured, representing 26% of all traffic fatalities and 19% of all injuries (CRTASR, 2007). Worldwide, more than 270,000 pedestrians die in traffic accidents annually, a share of 22% of all traffic casualties. In some countries this rate is as high as 75% (World Health Organisation, 2013). The situation in India is no different. Higher rates were observed in urban areas; 54 % of all traffic fatalities in Delhi and 80% of all non motorized fatalities in Mumbai were pedestrians (Mohan, 2004; Grebert, 2008). The pedestrian and bicycle fatalities in India is 27.4% (MoRTH, 2010). In many cases, pedestrian-vehicle crashes are often the result of poor decisions or risky behaviors exhibited during road crossings. *Moore (1953)* observed that pedestrians are primarily concerned on small time-gaps not a distance-gap in the traffic. He found that pedestrians accepted gaps of less than 3s at a speed of 1.57 m/s and 7 s at 1.2 m/s. *Cohen et al. (195*5) also realised that the time gap was likely the most relevant measure. They observed that 92% pedestrians accepted gaps of 7 s at 7 m wide road and no one crossed the road when gaps were shorter than 1.5 s. There have been a considerable amount of research examining factors that influence pedestrians road crossing behaviour, including the physical environment (e.g. road width, type of street, signalized or unsignalized situation), road user variables (e.g. demographic characteristics), and social factors (e.g. the number of pedestrians in the group attempting to cross). It becomes imperative to study the crossing behaviour of the pedestrians which is vital in pedestrian vehicle interaction and increasing pedestrian risks. It should be studied in terms of gaps between two users to minimize the risk.

A. Defination of Gap

Gaps are defined by the characteristics of the site (referred to as adequate gaps and critical gaps) and gaps dependent on the conditions present at the time a pedestrian attempts to cross (referred to as available, accepted, and rejected gaps). The available gap is the gap present for a pedestrian. If the pedestrian accepts the available gap (i.e., crosses the street within that gap), then it is an accepted gap, otherwise it is a rejected gap. The adequate gap for a site is determined by dividing the crossing distance by the walking speed and adding an appropriate start-up time. The *Highway Capacity Manual* (HCM) defines the critical gap as "the time in seconds below which a pedestrian will not attempt to begin crossing the street. If the available gap is greater than the critical gap, it is assumed that the pedestrian will cross, but if the available gap is less than the critical gap, it is assumed that the pedestrian will not cross." The term adequate gap is used in the *Manual on Uniform Traffic Control Devices* (MUTCD) and is assumed to be the same as the critical gap in the HCM.

Type of gaps also defined as single stage, two stages and rolling. In the first case, the pedestrians cross the road, irrespective of its width, in one crossing maneuver. In the second case, they cross up to median in one go and subsequently cross the far side. The pedestrians keep searching for gaps between continuous flow of vehicles by adjusting speed and direction of movement in the third crossing pattern".

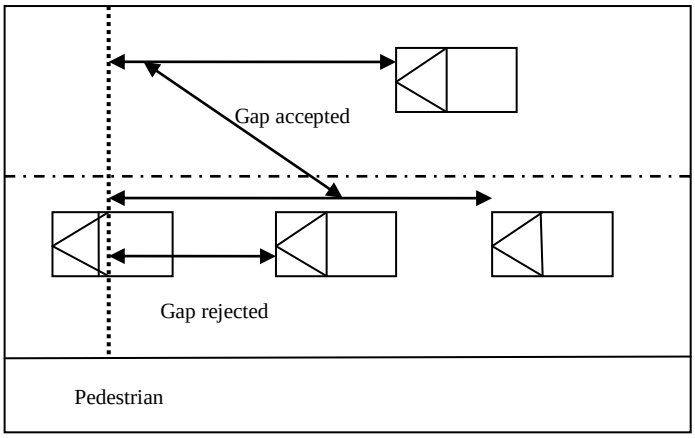

Fig 1: Gaps accepted or rejected

II. OBJECTIVES

The objectives of the research study reported in this paper are:

- To determine the characteristics of available and accepted gaps.
- To evaluate how age, gender and that of carrying luggage and baggage affects road crossing decisions as well as their crossing pattern.
- Pedestrian safety is also analyzed by evaluating 85th percentile gap acceptance and to compare the accepted gaps with the critical gap.

III. LITERATURE REVIEW

Various researchers have examined the effects of influencing factors on gap acceptance behaviour of pedestrians. These are discussed in the following paragraphs.

- Studied were conducted by *Oxely et al. (2005), Lobjois and Cavallo, (2006)* on effect of age difference in street crossing decisions. Experiments were conducted by considering vehicle distance, vehicle speed and time constraints. They concluded from their experimental results that older people accepted higher mean time gap than the younger one. *Oxley et al. (2005)* found a substantial increase in unsafe decision among pedestrians over 75 years old. *Das et al. (2005)* analyzed the collected data based on video recording of a crossing in India, and found that children and younger people accepts gap that were rejected by the older persons but found no difference in gaps accepted by two genders.
- Road crossing behaviour with respect to gender has also been observed in various studies. *Khan et al. (1999)* and *Tiwari et al. (2007)* concluded males have a tendency to show more hazardous road crossing behaviour than females due to less waiting time.
- The crossing patterns followed by pedestrians are observed in many studies. *Song et al. (1993)* examined the interaction of pedestrian and vehicle gaps at crossings which were at least 10m away from the designated crossing. In this study pedestrian crossing is divided into four categories namely, "two-gap", "risk-taking", "two-stage", and "walk and look". *Brewer et al (2006), Rastogi R.* and *Chandra S. (2013)* simplified the pedestrian crossing maneuvers into three different stages namely, "single stage", "two stages" and "rolling". It was observed that with one-way movement, more number of pedestrians looked for two stage gaps, whereas single stage crossing was prevalent on two-way roads. It was also observed that change in traffic operation affected rolling gaps more as compared to other gaps.
- Effects of vehicular lanes also have been studied. *Wilson and Grayson (1980)* analyzed that the few proportion of pedestrians accepting very small gaps (less than 2 s) at a crossing with two-way traffic flow. *Oxley et al. (1997)* reported that the average gap acceptance for younger pedestrian was found to be 51.3 m and for older pedestrian this value was 69.1 m for two-way road. For one-way road, the average gap accepted by younger and older pedestrians was 119.2 m and 134.1 m respectively. *Kadali and Vedagiri (2013)* concluded that in six lane divided road crossing, pedestrian gap acceptance behavior depends on type of gap (far lane or near lane) and behavioural characteristics instead of pedestrian demographic characteristics, like gender and age. From this study it is also found that pedestrian rolling gap makes pedestrian to accept small vehicular gaps instead of long waiting time. *Rastogi R.* and *Chandra S. (2013)* concluded that the average gap acceptance at two lane two way road is 24% lower as compared to the three lane two way road.

IV. DRAWBACK

There are some drawbacks in the above mentioned literature studies such as:

- *Oxely et al. (2005), Lobjois and Cavallo (2006)* concluded that pedestrians gap acceptance behaviour differ only on age of road users no difference found by two genders.
- *Khan et al. (1990), Tiwari et al. (2007)* found difference in road crossing behaviour between two gender. But they did the research only at signalized intersection.
- *Song et al. (1993), Brewer et al (2006), Rastogi R. and Chandra S. (2013)* described the crossing pattern of pedestrian crossing only for midblock location and 10m away from intersection. No pattern is described for unsignalized road and unsignalized intersection.

V. METHODOLOGY

A. Identification of study locations

The locations for carrying out the pedestrian study are decided based on the combination of land uses, width of the road, direction of traffic, traffic volume and intensity of pedestrian movement. Data are to be collected from the following locations at Silchar city, State- Assam, India:

- Infront of Green View Hospital, Link Road.
- Rangerkhadi Intersection.

- Premtala Intersection.
- Inter-state Bus Terminal, Ramnagar.
- Ambikapatti Intersection.
- Silchar Medical College Road.

The study locations chosen for the present study, satisfies the following criteria:

- The pedestrian traffic is enough.
- The traffic flow is continuous.
- The effective width of the road is uniform throughout the length considered.

For video recording of pedestrian flow, the road width considered should be easily accessed from vantage point.

A. *Data Collection Technique*

There are different methods for data collection. These are given below:

- Direct observation methods,
- Video observation methods,
- Time Lapse Photography,
- Pedestrian opinion surveys.

For this study, a video graphic survey is to be conducted that observed pedestrian crossing behaviour at selected location. The video camera is to be installed at the selected location in such a way that it captures the pedestrians crossing movement and approaching vehicles. It should be captured for an hour at each location.

B. *Analysis*

Recorded video is used to extract data. These data will be played on a monitor using a digital clock to extract the information regarding pedestrian crossing pattern, rejected gaps and accepted gaps. The approaching vehicle movement towards the pedestrian location will also be observed on the display unit. Based on the above recorded information statistical analysis is to be carried out.

By using SPSS package various statistical parameters like mean, standard deviation, skewness, kurtosis etc are to be determined. The analysis is to be done with respect to different pedestrian characteristics like age, gender and type of crossing etc. Statistical significance at 95% confidence level is to be examined by using F-Test at each location for both demographic behaviour (age, gender) and crossing pattern (single stage, two stage and rolling stage). The 85th percentile accepted gap is also to be finding out for safety margin analysis.

C. *Critical Gap*

Critical gaps are estimated from the distribution of gap acceptance and crossing time. The concept of critical gap is shown in Fig 2.

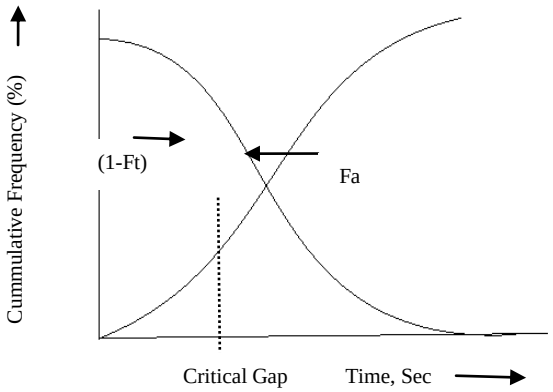

Fig 2: Cumulative distribution curve for gap acceptance (Fa) and pedestrian crossing time (Ft).

The intersection of the curves (Fa) and (1-Ft) gives the value of the gap which is just equal to the crossing time of a pedestrian. This is the critical gap. Critical gaps are to be finding out for each location with respect to pedestrian characteristics.

D. *Comparison of acceptance gaps and critical gaps*

. Comparison between the acceptance gaps and critical gaps are to be done for all the study locations and individual pedestrians' behaviour.

VI. CONCLUSIONS:

From literature study, the following conclusions can be made:

- Video observation method is simple technique for evaluating pedestrian gap analysis.
- Rolling gaps are more acceptable by pedestrians as compared to others on unsignalized road.
- Young participants generally used to take safe decision to cross the road with minimum time gap.
- Females and pedestrians with carrying luggage require more time gap to cross the road.
- The 85th percentile accepted gaps should be more than critical gap for safe road crossing.

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