Pedestrians' Gap Acceptance Behavior at Mid Block Location

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Abstract—**Walking is one of the main transport mode and more sustainable to human society. Pedestrian interaction with motor vehicles is found to be one of the major constraints to pedestrians' during road crossing. Traffic accidents involving pedestrians are a major safety problem throughout the world. The objective of this study is to investigate pedestrians' gap acceptance behaviour at mid block street crossings in urban arterial roads. In this study the size of vehicular gaps accepted by pedestrians and the decision making processes are mainly examined. For this purpose a suitable mid block section was selected in Hyderabad. Video graphic survey was conducted to collect pedestrians' characteristics, vehicular characteristics and flow characteristics. Pedestrian gap acceptance behavioral model was developed using regression technique. The study result shows that pedestrians' gap acceptance is better explained by the following variable attempts - pedestrian speed condition during crossing, crossing direction, rolling gap, vehicle speed and pedestrian age. The rolling gap plays a main role in pedestrians' decision making process.**

Index Terms—**Pedestrian, gap, behaviour etc.**

I. Introduction

Walking is one of the main transport modes and more sustainable to human society. Currently transportation planners are being encouraged to walk more, either by main mode of travel or as part of a multimodal trip. Walking plays an important role in connecting public transportation system. Mostly roads have been an obstacle to pedestrian movement by full flow of traffic. Pedestrian interaction with motor vehicles is found to be one of the major constraints to pedestrians' road crossing. Traffic accidents involving pedestrians are a major safety problem throughout the world. There are many studies done on pedestrian crossings. The major interests of these studies are: traffic accidents, traffic conflicts and pedestrian delays. Street crossing is a stimulating decision problem whose analysis may light shade on how humans value their time and their lives, how they perceive their environment, how their behavior changes during crossing, how they apply different tactics for crossing the road and how they interact with one another. A pedestrian who observes oncoming road traffic faces an optimal stopping problem. Walking carries a risk of accident, with possible injury or loss of life; where jaywalking ordinances are enforced, walking also may carry a risk of fine. Waiting entails a loss of time until a suitable future opportunity to walk arises. Most of the pedestrians' balance their time achieved by walking against the associated risks of accident and adequate by jaywalking. Then the risks of accident in different crossing environments are ready to face the pedestrians. Pedestrians interact with one another as they make their crossing decisions with group behavior. The practical consideration is that, relative to many other aspects of human behavior, street crossing is unusually amenable to empirical study. Videotaping makes it possible to observe independently and unobtrusively, the traffic conditions that pedestrians' face and the crossing decisions that they make.

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II. Background of the Study

Pedestrian gap acceptance behavior differs significantly from vehicular gap acceptance. This is because of motorists accepting smaller gaps when compared with pedestrians' as they have higher speed and hence move more quickly than pedestrians'. As pedestrians' need very few gaps, they lose their patience due to longer delays and decide to attempt small gap also, there by exposing themselves to the risk of being struck by a motor vehicle (Poulos, 1983). Many researches correlate the minimum gap from the vehicle that is accepted by pedestrians who intend to cross streets at mid-block (Yannis and Papadimitriou 2010). These parameters may be associated with traffic conditions and with vehicle and pedestrian characteristics. Pant and Balakrishnan (1994) studied the gap acceptance behavior of vehicles at stop controlled intersections. They used neural networks and a binary logit model for predicting accepted gaps at rural low volume stop-controlled intersections. Their model deals with vehicle gap acceptance without incorporating the pedestrians' gap acceptance. Tian et al. (1999) used a maximum likelihood methodology to measure the driver's gap acceptance. This gap acceptance study was done for the motorists and they considered the queue and vehicle type as the related parameters for defining the gap events. Oxley et al., (1997, 2005) conducted two different traffic simulated test on pedestrians to find out the age difference on gap selection process. From the results they could conclude that the distance between vehicles and pedestrians appear to be most important factor for the minimum gap. In addition, an increase in traffic density leads to smaller accepted gaps. These gaps are often described by means of probability distribution or estimated by means of linear regression model. Indicatively, it can be mentioned that the minimum accepted gap has been estimated at two seconds and the mean accepted gap at eight seconds (Das et al., 2005). Brewer et al. (2006) studied pedestrian behavioural analysis. It reveals that pedestrians do not wait always to cross the street till the lanes are completely clear. Instead of completely waiting for larger gaps; they get anticipated that the lanes would be clear and they use a "rolling gap" to cross the street.

Zeeger et al. (2001) conducted a detailed research on the safety effects of the marked versus unmarked crosswalks at uncontrolled locations. This research is more from a planning viewpoint, in deciding where to mark crosswalks. They observed that a marked crosswalk was associated with higher pedestrian crash rate compared with an unmarked crosswalk. Hamed (2001) studied pedestrian behaviour at pedestrian crossings, to understand the behavior of pedestrian while waiting for the crossing and number of crossing attempts at the curb side. David and Rice (1994) found that pedestrian accidents, especially child pedestrian accidents were likely to take place at mid-block in residential area under clear weather conditions. Macgregor et al. (2000) studied pedestrian behaviour at a midblock crossing. This was done primarily for the child pedestrian gap checking, which was important near schools. They conducted interviews from parents of children dominated area and they observed that children were less likely to search for traffic at signalized than at unsignalized intersections. Sun et al. (2003) studied the gap acceptance behaviour of pedestrian by developing probabilistic models and binary logit models. The study mainly aims towards finding pedestrian gap acceptance and motorist yield behaviour at mid block sections. It compares the result from both the models with the observed gap selection data. The logit model developed predicts the gap correctly among both. The study defines minimum average gap length which is accepted by most of the pedestrians to cross the street safely called as critical gap. The study also explains combined drivers behavior and pedestrian behavior during pedestrian crossing. It had been modeled to analyze how simultaneously pedestrian and driver behaviour influence the decision of crossing.

However, most of the above studies were carried out in developed countries, where transport systems and infrastructure correspond to improved levels of service of pedestrians, resulting in a generally compliant behaviour from the part of pedestrians as well as a consequence. The results of these researches can’t be transferred and used in developing countries like India. Indian roads and transport network have different characteristics and operational conditions. Road infrastructure and traffic control are often inadequate for pedestrians, but the behavior of pedestrians is also particularly non-compliant and often risk-taking. In this context, the aim of this research is to investigate pedestrians’ traffic gap acceptance for mid-block Street crossing in urban areas. In particular, the effect of several factors, such as pedestrians waiting time, the vehicular characteristics (speed. size) and finally pedestrians’ characteristics (gender, age) affect the traffic gap acceptance of pedestrians and their decision to cross or not. For this purpose, a field survey was carried out at an uncontrolled mid-block location. A regression model was then developed in order to examine the effect of various parameters on pedestrian gap acceptance, defined as the size of traffic gaps accepted by pedestrians.

III. Methodology

A field survey was carried on 21st December 2011 in Hyderabad at Ameerpet mid-block location. A considerable volume of pedestrians and vehicular flow was taken into account. In this survey, pedestrians crossing decisions were videotaped in real traffic conditions. Fig. 1 shows the survey location and critical data extracted from that video. At first, the video was captured and saved as several jpeg file format by a software tool named Video Snapshot Wizard to get a series of pictures. Thirty pictures can be obtained within 1 sec from that video. From each snapshot, data collected includes the size of gaps rejected or accepted by pedestrians, waiting time, number of crossing attempts, each vehicle’s speed, type of vehicle, near or far gaps, crossing direction, pedestrians’ speed condition, whether they using rolling or not, effect of baggage and individual pedestrians’ characteristics (gender, age etc.). The main objective of this study is to find out the required minimum gap with effect of above mentioned characteristics and capture the decision making process by regression model. To be more specific, it is important to note the pedestrians who actually crossed the street, either immediately or after several attempts, by rolling gap and by their speed changes were captured. Particular care was taken that data were recorded only during the flow of traffic and abandoned the jam condition, so that pedestrians would make an unprotected crossing by interacting with the incoming vehicles. The traffic gaps data was collected when the pedestrians were just ready to set foot on the street and head of the vehicle has just passed through gap accepted. The difference was calculated in milliseconds between the two time points from the captured files. At the same time, the speed of incoming vehicles was measured by length of vehicle travelled and divided with time difference.

Fig. 1. Survey location and Pedestrian crossing condition.

IV. Results and Analysis

It is a complex task for the pedestrian, to make decision while crossing the road. Pedestrian's gap selecting behaviour is supposed to be influenced by pedestrian's physical characteristics, pedestrian tactics, available gap sizes and vehicle's speed. For the analysis 2230 gaps were collected including accepted and rejected gaps. Out of these data 200 samples were accepted gaps. In this model, minimum gap required for pedestrians by regression technique is carried out by statistical analysis software SPSS16.0. A mathematical model was developed for the minimum pedestrians’ gap acceptance, a regression was selected. It is noted that lognormal regression assumes a normal distribution for the dependent variable. The final model is given in equation 1.

$$\text{Log Gap} = 1.283 - 0.081 * \text{Gen} - 0.093 * \text{Age} - 0.09 * \text{No.atmt} - 0.424 * \text{R.gap} + 0.17 * \text{VS} - 0.197 * \text{SC} + 0.383 * \text{DC} \quad (1)$$

where, Gen-Pedestrian gender; Age-Pedestrian age; No.atmt- number of attempts; R.gap- Rolling gap; VS-vehicle speed; SC-pedestrian speed condition during crossing; DC-pedestrian direction during crossing.

The goodness of fit measure R^2 is equal to 0.551 for present model whereas all the above variables were statistically significant at 95%. A residuals follows the normal distribution. Their mean value was almost zero and they had equal variances (homoscedasticity tests). It was also confirmed that the recorded log-gaps are normally distributed as well. The independent variables (discrete) were linearly independent to each other (multicolinearity test). A statistical t-test was conducted to test the significance of coefficient. For the coefficient, estimate was statistically significant from zero at 95% confidence interval. The validation part of model is shown in Fig 4, it shows predicted pedestrians, minimum gap versus observed gaps.

The rolling gap of the pedestrian has greater effect on the pedestrian gap acceptance. It is observed that pedestrians have less patience to wait for longer gaps and they use different tactics after some course of time after which they keep on attempting available gaps. Pedestrians keep on attempting the available gaps at some course of time and they start accepting the minimum gap also. The negative sign indicates that, if the pedestrians' use rolling gaps then they can accept very minimum gaps also. So in this case the gender, age, waiting time and group behaviour are not influenced on gap selection. The crossing direction condition is next affecting factor. In general pedestrians' are not ready to wait, after arrival on the curb for the reasonable gap. They keep on moving forward or change direction during rolling gap condition by attempting required gaps. The next factor is speed change; in this case younger men accept very small gaps also by increasing their speed at middle of the road. Most of the cases men appear ready to take risks than women. Pedestrian gender, age, number of attempts, speed condition and rolling gap are affected negatively. The main finding of the study indicates physical characteristics of pedestrian like gender, age and their behaviour like rolling, speed changes, crossing direction greatly affecting the minimum gap acceptance condition.

A. Gap Acceptance

The mean accepted gap was found as 4.149s and the mean rejected gap was identified as 1.769s shown in Fig 2. The minimum gap for pedestrians' crossing is more than the 1.769 sec while they use rolling gap; otherwise the minimum gap is 4.149 sec. It indicates that, for a pedestrian the minimum gap required to cross the road is 4.149s. The required accepted gap is varied from person to person by their physical characteristics, their tactical condition and particular environmental condition.

B. Pedestrian's Gender

The mean accepted gap for woman is 4.876s, obviously greater than that of man 3.422s is shown in Fig 3. It indicates that woman select larger gap than men. The percent of unsafe decision samples also reveals that men are more aggressive than woman.

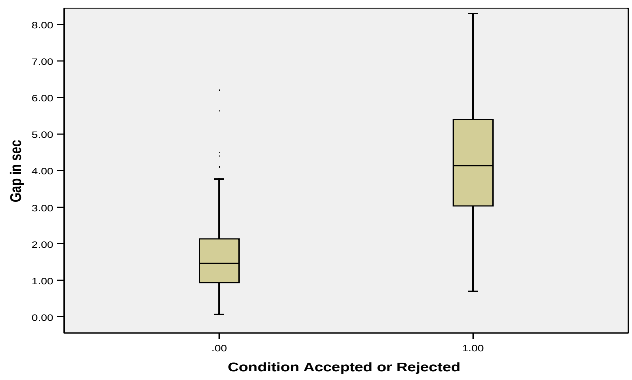

Fig. 2. Overall condition of accepted and rejected gap

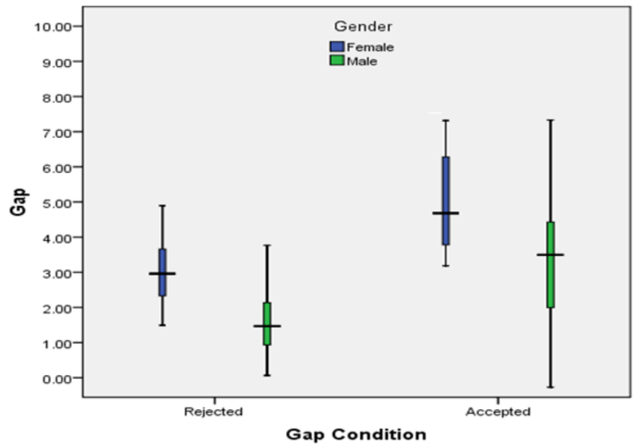

Fig. 3. Condition of accepted and rejected gap by gender

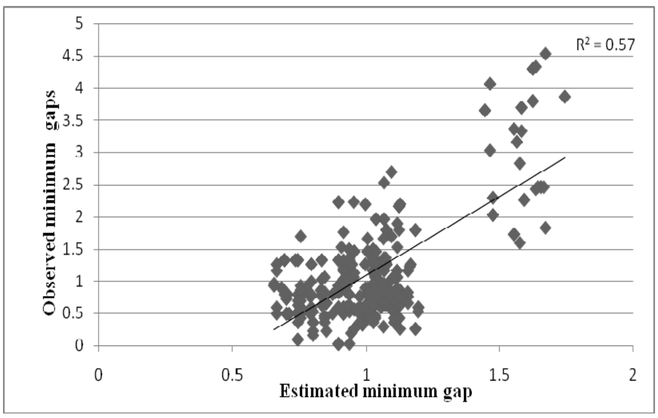

Fig. 4. Observed and predicted pedestrian gap

V. CONCLUSIONS

Most of the previous studies were carried to find out critical gaps for vehicular traffic and very few studies on pedestrians'. The previous studies are also not captured clear cut pedestrian behaviour during crossing. In this study, a field survey was conducted to observe the actual crossing behaviour. A lognormal regression analysis was implemented for modelling pedestrians' traffic gap acceptance. It was found that the accepted gaps depend on the rolling gap, vehicle speed, and pedestrian speed condition during crossing, direction of crossing, number of attempts, the gender of the pedestrians and age of the pedestrian. It is concluded that pedestrians select very minimum gaps when they use rolling gap and speed change condition during crossing. Pedestrians' individual characteristics were not that much affecting gap selection process when compared to the rolling gaps, speed change and crossing direction. It indicates that irrespective of their gender, age, waiting time and group behaviour they choosing gaps. Pedestrian's age was found to be more affected when compared to gender on gap acceptance. On the contrary, vehicle speed was found to be the most important determinants of crossing behaviour at the same time type of vehicle is not affecting on pedestrian gap acceptance. When the pedestrians use rolling gaps, then these gaps values are very less compared to the mean observed value. The minimum accepted gap observed for the male is less compared to the female, also less when compared to observed mean value of pedestrian.

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