

# A Review on Assessment of Vehicle Interference due to Pedestrian Crossing at Urban Midblock Section

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**ABSTRACT:** The 2010 highway capacity manual (HCM) provides an approach to estimate the mutual between pedestrians and automobiles at signalized intersections. However, the manual provides little guidance for capturing the interactions between pedestrians and automobiles at un-signalized midblock pedestrian crosswalks on urban street segments. The movements of vehicles on urban streets can be significantly impacted by midblock delays and stops. One of the performance measures in evaluating automobile performance on urban street segments is the travel speed. The manual computes the segment travel speed based on the segment length, the segment running time, and the control delay. Friction conditions, such as the midblock pedestrian crossings, interfere with the traffic flow on urban street segments and therefore increase the segment running time, which consequently lowers the travel speed and the level of service (LOS) of the segment. The frequency of the interference to vehicles is related to the frequency of the arrival of pedestrians and the flow of vehicles. This research develops and evaluates a model to estimate the frequency of midblock pedestrian interference to vehicles at un-signalized midblock crosswalks on urban street segments, using no of vehicle crossing, no of vehicle interfered, pedestrian crossing direction (curb-median),(median-curb), pedestrian gender, pedestrian age and travel speed as the independent variables.

**KEYWORDS:** pedestrian, regression, traffic volume, pedestrian volume.

## I. INTRODUCTION

The urban street division analysis of the HCM terms a methodology to assess the performance of urban street divisions to the automobiles traveling along the segments. These trade manual uses the term urban street to refer to the urban arterials and collectors that are sited in urban areas. As defined by the manual, an urban street is divided into individual elements that are really adjacent and operate as a single entity for the determination of helping travelers. Urban streets classically have pedestrian crosswalks at signalized intersections and/or at midblock locations. These crosswalks connect the pedestrian facilities across sections of the roadway. The delay suffered by pedestrians while they wait to use a crosswalk rest on the type of traffic control, the local laws, and drivers' devotion to those laws. Approaching vehicles also experience changing levels delay as pedestrians cross at marked midblock crosswalks, depending on the type of the control used at the midblock crosswalks, the pedestrian volume, and the pedestrian walking speeds. Walking is one of the dominant means of human movement .and so why pedestrian are one of the main element of transportation system.in earliest times, there was a huge pedestrian walking took place and walking was the only mode of transportation. for every time ,transportation is related to travel which consists walking as a must. So why, walking is considered to be an modern mode of transportation for first and last mile connectivity if it isn't too far. Walking is one of the major modes of transportation in Indian cities too.

Talking about pedestrian crosswalk, there were some cross walk like zebra crossing which are designed for a road, provide profitable work to assist the pedestrian to move from one side to the other side of the road and which plays a important role in the mobility and safety mode of signalized intersections.in some other places like where the busy traffic takes place, pedestrian chooses the need blocks to cross the road. But there is no safety as compared to signalized intersections. Even many pedestrian crosswalks are taking place in these midblock sections. In developing countries, due to partial available funds, the traffic organization facilities are lesser as compared to such facilities in developed countries. Recently in mega cities, efforts have been made to provide continual and safe facilities to road user. However, these infrastructures are designed for motorized vehicles and least focus on pedestrian facilities.

Pedestrians are most susceptible road users where death rate is very high in developing countries. In developed countries, sidewalks and midblock crosswalk are provided on an urban street segment as a part of the roadway segment where pedestrians are allowed to walk and cross the lanes. On other hand, in the developing countries, walking facilities for the pedestrians like footpaths or sidewalks are very restricted and in most of the cases these facilities like foot over bridge or under pass are very infrequent. Even though if such facilities are provided, pedestrian used to cross at grade in order to save time or insufficient facilities. During such crossing processes, pedestrian used force gap to cross the road and forced the upcoming vehicles to change the path or apply the brake to avoid conflict as shown in figure 1



Stoppage due to pedestrian crossing movement at urban midblock section would influence of performance of an urban street segment, such interruption cause delay to vehicular traffic. The present study attempted to estimate such delay due to crossing pedestrians at undesignated midblock locations. The present study is to develop and assess a model to estimate the frequency of midblock pedestrian interference to vehicles traveling along urban street segments using no of vehicle crossing, no of vehicle interfered, pedestrian crossing direction (kerb-median)(median-kerb), pedestrian gender, pedestrian age and travel speed.

## II. NEED OF THE STUDY

The rapid manufacturing growth, agriculture production coupled with rise in population over the past decade has subsidized in a large-scale increase in traffic in the city area. This increasing concentration of traffic has resulted, a number of problems like traffic congestion, delay, accidents, pollution etc. It is quite evident that, walking is fasten that holds our transportation system together. However, pedestrian crossing at mid-block is a common occurrence in developing countries. These crossings at undesignated locations have double effects. First, pedestrians put themselves at risk, and, second traffic speed and capacity are poorly affected. Such undesignated pedestrian crossing at mid-block complicates more the existing traffic problems. During pedestrian crossing operation, pedestrians force vehicles to change the path or reduce the speed. At such mid-block locations with pedestrian crossing, the quality of service is negatively affected. So the study seems quite necessary to be carried out at these locations so that the existing maneuvers can be explained and the effect of quality of service can be assessed.

## III. REVIEW OF LITERATURE

Indian urban cities are generally overcrowded which faces problems due to crossing activities. Activities are often going on or across the carriageway of the road which interacts with ongoing traffic flow and affects traffic flow parameters. These activities are also presented on a rural road but its severity is less. The studies conducted in the literature to assessment of vehicle interference due to crossing pedestrian on the urban roads and analyze the service performance of the roadways which are explained below.

### Literature review related to pedestrian pedestrian activity

**Forde et al. (2018)**The 2010 highway capacity manual (HCM) provides an method to estimate the mutual between pedestrians and automobiles at signalized intersections. However, the manual provides little guidance for taking the interactions between pedestrians and automobiles at un-signalized midblock pedestrian crosswalks on urban street segments. One of the performance measures in assessing automobile performance on urban street segments is the travel speed. The manual calculates the segment travel speed based on the segment length, the segment running time, and the

control delay. . The frequency of the interference to vehicles is related to the frequency of the entrance of pedestrians and the flow of vehicles. This paper develops and evaluates a model to estimate the frequency of midblock pedestrian interference to vehicles at un-signalized midblock crosswalks on urban street segments, using the traffic volume, the pedestrian volume, and the median type and posted speed limit as the independent variable.

**Laxman et al. (2010)** Data collected at four locations in a medium-sized city of India are analysed for pedestrians flow characteristics under mixed traffic conditions. The data are presented in the form of mathematical and graphical relationships between speed and volume, speed and density, flow and area module, and flow and density. The speed of the pedestrian was found to be unfair by the age and gender also. Male pedestrians move faster than female pedestrians. Pedestrians in the age group of 10–15 years had the highest speed, 82 m/min. the speed was reduced by about 85% when pedestrians move with their baggage or luggage.

**Conference and Infrastructure (2017)**A Law and Policy Method Despite a variety of acts and policies to legalize transport infrastructure and means of transport, pedestrian safety and rights remain obscure in India because the motorized road user remains the central object of statutory concern. We review current policies, statutes and jurisprudence correlated to pedestrian safety in India. Proportional analysis is done with relevant statute and policies from countries where pedestrian compliant guidelines have been mandated. This work will lead to a “Charter of pedestrian rights” as the first stage in enlisting legislation to implement pedestrian priority designs and traffic management approaches. We provide a preliminary framework of this Charter near the end of this paper.

**Avinash et al. (2018)**The present study is conducted to understand the naturalistic behavior of pedestrian at urban mid-block crosswalks due to contiguous factors under mixed traffic conditions in India. The research work reported here mainly examines the effect of individual characteristics replicated on crossing behavior at nine study locations in different cities of India. The selected study sections show a wide deviation due to city characteristics, roadway characteristics and geographical conditions. The study confirms that young pedestrians walk faster than the elder. Study results also indicate that city characteristics and geographical conditions considerably effects crossing behavior of pedestrian. The average crossing speed of pedestrian is measured to be higher (1.205 m/s) in Mega city as compared to Metro city (1.036 m/s), representative effect of city characteristics. . It was also found that with increase in number of traffic lanes and vehicular flow, pedestrian crossing time increases, which forces pedestrians to achieve stage- wise crossing. It is practical that delay at curb side is higher due to refusal of smaller gaps, but same gap can be accepted with increase in squad size. The outcome of this research work may be considered as a strong base in light of revising current practices dominant for designing pedestrian crossings at uncontrolled mid-block sections under mixed traffic condition.

**Connelly et al. (1998)** Investigated the gap acceptance behavior of three gender balanced groups (5-6 years, 8-9 years and 11-12 years) in crossing the road. The findings exposed that pre-adolescent school-age children, particularly those aged below 10 years, have relatively poor skills at reliably setting safe distance gap thresholds, and thus do not consistently make safe crossing decisions. Their capacity for making such decisions safely gradually declines as vehicle approach speeds exceed 55 kmph. The results also indicate that the children primarily relied upon distance in making judgments of safe street crossing gaps, irrespective of the speed of the upcoming vehicle, although about one-third of the children reported that they were taking into account both speed and distance.

**Das et al. (2005 )** examined the behavior of pedestrians wishing to cross a stream of traffic at signalized intersections and showed each pedestrian as making a isolated crossing choice by comparing the gaps between vehicles in traffic to an individual- specific 'critical gap' that characterizes the individual's nominal acceptable gap. Both parametric and nonparametric methods to estimate the distribution of critical gaps in the population of pedestrians as proposed. The model estimated provide information about heterogeneity in critical gaps across pedestrians and intersections, and permit simulation of the effect of changes in traffic light sequences on pedestrian crossing behavior and waiting times.

**Brewer et al. (2006)** observed that pedestrians cross a road in any of the three ways; single stage, two stages and rolling. .When a pedestrian accepts a gap which is large enough to cross the whole width of the road without stopping, it is called single stage crossing. In two stage crossing, the pedestrian will cross up to median of the road by accepting a gap and will wait there until a suitable gap becomes available. In rolling gap instead of waiting at curb till all the lanes are completely clear of traffic the pedestrian expects the gaps between the vehicles and crosses the lane while searching for rolling gap available to cross the road safely.

**Yang et al. (2006)** Found that in many Chinese cities, pedestrians' road crossing behavior is different from that in developed countries. Authors developed a micro- simulation model. The pedestrians were grouped into two: law-obeying ones and opportunistic ones. Opportunistic ones are those who violate traffic signal during Red Man and take decision depending on external factors like presence of policeman, vehicle flow and other factors. Questionnaire survey was conducted to determine the scopes of these two types of pedestrians under different circumstances. In addition, a time gap distribution, extracted from videotape, was used to determine the condition how pedestrians decide whether to walk or wait when met with vehicle flows. However, replication results deviated from the data extracted from the videotape. On adjusting the parameters, the simulation results agreed with the field results better. The model predicted high rate of pedestrians on red light running.

**Guangxin and Keping (2009)**

Analyzes the process of pedestrian's street-crossing and analyzes the psychological process of pedestrian's gap selecting. Also analyze pedestrian's time gap and safety margin, and explained the method to extract co-relative data from video. Finally, analysis was carried out about the influence factors of pedestrian's gap selecting, including pedestrian's gender, age, violating of traffic rules, crossing fellows, signal control, vehicle's distance and speed. The results showed that pedestrian's safety margin time is the vital factor that determine pedestrian's gap selecting behavior. Pedestrian's safety margin time is very useful to analyze the influence factor of their behavior. Results also indicated that children and the elderly need larger gaps than youth, and it is safer to cross street with fellows. The results also showed that it is more risky to cross street during red man and pedestrian's decision- making is decided by vehicle's speed rather than the distance to conflict while crossing none-signal-controlled crosswalk.

**Wang et al. (2010)**

Analyzed and modeled the pedestrians' gap acceptance behavior when they jaywalk outside crossing facilities, based on non-intrusive observations from real PVI scenarios, using binary logit technique. Three factors including near-side traffic gap time, pedestrian's age category and number of pedestrians in a crossing group, out of six proposed ones, are identified to be significant enough to be included into the binary logit model. A field study was conducted to collect the data of pedestrians' decisions and concurrent traffic status using a set of synchronized video cameras on a typical unsignalized urban road section. The data were used to develop and validate a pedestrian gap acceptance model based on discrete choice approach. The initial results with the model were appealing when considered in combination of simplicity and accuracy.

**Kadali and Vedagiri (2012)**

investigate pedestrians' gap acceptance behavior at midblock street crossings in urban arterial roads. Size of vehicular gaps accepted by pedestrians and the decision making processes are mainly examined. 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.

**Kadali and Vedagiri (2013)**

Investigated the pedestrian road crossing behavior at the uncontrolled midblock location in India under mixed traffic condition. Pedestrian road crossing behavior at uncontrolled midblock has been modeled by the size of vehicular gaps accepted by pedestrian using multiple linear regression (MLR) technique. Also choice model has been developed to capture the decision making process of pedestrian i.e, accepted or rejected vehicular gaps based on the discrete choice theory. Suitable study stretch, which a four lane divided urban arterial in Hyderabad, India, was selected for data collection. The collected data consists of 4198 gap data points which include both accepted and rejected vehicular gaps. Pedestrian's road crossing behavior has been explained in terms of minimum gap acceptance value by using a rolling gap (pedestrian roll over the small vehicular gaps). It has also been explained by the binary logit model with the help of vehicular gap size, frequency of attempt and rolling gap.

**Serag (2014)** investigated and modelled pedestrian road crossing behavior at uncontrolled mid-block in Egypt as one of the developing countries. Two aspects of pedestrian crossing behaviors at mid-block locations have been examined, namely the size of traffic gaps accepted by pedestrians and the decision or not to cross the street, as well as the related determinants. A lognormal regression model was developed in order to examine the effect of various parameters on the size of traffic gaps accepted by pedestrians. It was found that the accepted gaps depend on the speed of incoming vehicle, the pedestrian rolling gap, the frequency of attempts a pedestrian makes before crossing, the crossing width, and the age of the pedestrians. A binary Logit model was also developed in order to examine the effects of various parameters on the decision of pedestrians to cross the street or not. The results suggest that pedestrians' decision to

cross the street depends on the size of traffic gap, the vehicle speed, the pedestrian rolling gap, and the frequency of attempts before crossing.

**Mamidipalli et al. (2015)** Analyzed empirical observations collected at 27 sites in Alabama, Florida and north California and to develop pedestrian gap acceptance models at midblock crossing. Goodness-of-fit tests showed that a Probit based, single lane gap acceptance model, drawn from a non-controlled pedestrian crossing data set, yielded the best result (max rescaled  $R^2 = 0.69$ ). This model involved only two parameters: The size of the gap length in second and a binary variable that distinguish between gaps and lag events (first arriving vehicle, without a prior lead vehicle, to open gap). An would cross, where as a lag event had a negative coefficient, which meant that a pedestrian was less likely to accept a lag than a gap, given the same length in second. Other variables that described crosswalk characteristics as well as pedestrian and driver behavior did not emerge as significant factors in the model that can be used in traffic operational analysis. The model can be incorporated in to microsimulation packages and thus improved the accuracy of pedestrian behavior modeling at midblock crossings.

**Pawar and patil (2015)** investigated pedestrian temporal and spatial gap acceptance for midblock street crossing using field data of 1107 pedestrian gaps. Available gaps, pedestrian decision, traffic volume, etc. were extracted from the videos. While crossing a road with multiple lanes, rolling gap acceptance behavior was observed. Using binary logit analysis, six utility models were developed, three each for temporal and spatial gaps. The 50<sup>th</sup> percentile temporal and spatial gaps ranged from 4.1 to 4.8s and 67 to 79 m respectively, whereas the 85<sup>th</sup> percentile temporal and spatial ranged from 5 to 5.8 s and 82 to 95m respectively. These gap values were smaller than that reported in the studies in developed countries. The speed of conflicting vehicle was found to be significant in spatial gap but not in temporal gap acceptance. The gap acceptance decision was also found to be affected by the of conflicting vehicles.

**Pawar et al. (2016)** analyzed and quantified the dilemma zone for crossing pedestrians at high-speed uncontrolled midblock crossing. The dilemma zone was mathematically and graphically modeled and its location and length were determined by the empirical study based on gap acceptance and rejection background. Total of 1107 pedestrian lags/gaps were extracted and studied with consideration of both temporal and spatial lags/gaps for analysis. Dilemma zone was determined by using different methods such as the gap cumulative distribution method. For the selected midblock sections, dilemma zone started at 49m and ended at 62m upstream from marked pedestrian crossing. The upper and lower boundaries of dilemma zone can be further used to develop a pedestrian assistance system at midblock crossing for the safe movement of pedestrian.

**Pawar and patil (2016)** explored pedestrian temporal and spatial gap acceptance at uncontrolled midblock street crossing, where vehicle do not yield to pedestrian and pedestrian have to choose safe gap on their own. This results in complex interactions between pedestrians and vehicles. The paper reported the applicability and generality of driver's gap acceptance model to the pedestrian's gap acceptance. Temporal and spatial critical gaps are estimated using both deterministic (Raff's and Ashworth's Method) as well as probabilistic approaches (maximum likelihood method and logit method) using 1107 lag/gap observations. The analysis found that (a) temporal and spatial gaps follow lognormal distribution, (b) speed of conflicting vehicle has significant effect on the spatial gap acceptance, (c) critical gap values by deterministic methods are smaller than those by probabilistic method, (d) temporal and spatial critical gaps by different methods vary between 3.6-4.6s and 60-73m respectively. these values are much lower than the widely accepted values calculated using HCM 2010.

**Pawar et al. (2015)** used support vector machines (SVMs) in understanding and classifying gaps at uncontrolled intersections and pedestrian midblock crossing. The SVMs are supervised learning techniques originating from statistical learning theory and are widely used for classification and regression. In this paper, the feasibility of the SVM in analyzing gap acceptance is examined by comparing its results with existing statistical method. To accomplish that objectives, SVM performance was found to be comparable with that of the BLM in all cases and better in few. Also, the categorical statistics and skill scores used for validating gap acceptance data revealed that the SVM performed reasonably well. Thus, author derived that SVM technique can be used to classify and predict accepted and rejected gap values according to speed and distance of oncoming vehicle.

**(H. D. Golakiya and A. Dhamaniya, 2017)** Pedestrians are the most susceptible road users especially in mixed traffic condition with traffic infrastructure designed for motorized vehicles. Among 1.2 million death registered on world's road death rate of pedestrians, cyclist, and motorcyclist are almost half. In year 2015 every day around 1,374 accidents and 400 deaths taken place with 9.5 % of pedestrian involvement on Indian road. These situation forces traffic facility designer to rethink about the prevailing situation and design practice. In this study the 3D trajectory based approach is

used to determine pedestrian safety index using a surrogate safety measure (SSM). Post encroachment time (PET) has been adopted as SSM. Safety index threshold value has been developed for two separate cases namely, pedestrian pass first (PPF) and vehicle pass first (VPF) for different category of vehicles based on vehicle speed as a variable. The study will be useful for the safety of pedestrians in traffic facility design.

**(Fei SHENG)**The goal of this study is to research on pedestrians of mid-block crosswalks controlled by push-button signal. According to the psycholal analysis of the crossing pedestrians under the push-button signal, it was found that crossing psychology of pedestrians under this mode is different from the fixed-time and no signal mode. Data were collected from one typical mid-block crosswalk controlled by push-button signal. Analysis on the data showed that the demand of pedestrians when crossing the street from time and space is different. The statistics theory was used to get the arrival law of pedestrian. It demonstrated that the arrival law obeyed the negative binomial distribution. Based on the survey, we knew that pedestrian speed varied with the different time of pedestrian green lights. After analysis on the signal timing of the investigated crosswalk, we knew that the timing had great impacts on pedestrians' behavior.

**(Albert Forde, 2017)**This paper develops and validates a deterministic model that estimates the delay incurred by platoon vehicles due to pedestrian activity at midblock crosswalks on urban street segments. The developed model is validated using midblock delay data measured at an urban street segment in Newark, New Jersey. The model validation involves both quantitative and qualitative statistical analyses to compare the delay values measured in the field with those estimated using the developed model. The quantitative statistical analysis involves performing the t-tests using commercially available statistics software. The qualitative analysis involves the use of a diagonal plot to compare the measured and estimated delay data sets. Sensitivity analysis is performed to study the relationship between estimated midblock delay and the model's variables and parameters. The sensitivity analysis involves estimating the delay by increasing and decreasing the baseline values of the model variable and parameters by 50%. Results of the t-test show no statistically significant difference between the measured and estimated delays. Result of the sensitivity analysis shows pedestrian walking time significantly impacts vehicular delay.

#### IV. CONCLUSION

The present study is carried out with the objective of assessment of interference of vehicle due to crossing pedestrian at urban midblock section. Data for the present study has been collected from four fast developing cities namely Surat and Ahmedabad of Gujarat State, Mumbai of Maharashtra state and Jaipur of Rajasthan state. Video graphic survey has been conducted to achieve accuracy in data collection. The data related to vehicle interruption due to crossing pedestrians were extracted using Avidemux software. The data related to classified volume count, vehicle interrupted by crossing pedestrian, volume of crossing pedestrians, pedestrian and vehicle speed has been extracted from video tape and used further for detail analysis. Interference for individual category of vehicle has been worked separately to compare the impact of crossing pedestrians on different categories of vehicles. The variables like pedestrian age, pedestrian gender, pedestrian crossflow, vehicular flow, category of vehicles, pedestrian crossing direction and vehicle speed are taken as variables affecting interruption of vehicles. It was observed that interruption of vehicles affected by all these variables. The multilinear regression model is also developed to predict the interference of vehicles due to crossing pedestrians. The model is also validated using the data kept aside for this purpose. The present study may be useful for field engineering to predict the impact of crossing pedestrians on vehicles and will be useful in delay calculation for better travel time estimation

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