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Pedestrian Simulation in Congested Urban Area

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***Abstract*— Today due to the land limitation, lots of dense urban areas are facing pressures and problems, such as traffic congestion and lack of public open space. Two main occupants of urban roads are pedestrians and vehicles. The early stages of urban development people tended to focus on solving the problem of vehicular traffic, so now a large number of existing roadways are occupied by vehicles, triggering disputes and problems about pedestrian safety and comfort. For pedestrian safety and Convenience, elevated Skywalk is required. For a proper simulation of urban traffic scenarios, besides cars other road users, namely pedestrians, have to be modelled. This research paper focuses on identifying means to reduce pedestrian delay. Micro-simulation modelling has shown that reducing pedestrian delay at signalised intersections is possible. At what extent it is possible to capture traffic effects imposed by simulated pedestrians by providing Skywalk and then perform without simulations that is real situation. This work presents a real scenario for pedestrian movement through Skywalk without indulging it in the main traffic by using VISSIM software, therefore no delay will occur to the Pedestrian and provide comfortabiltiy in Urban Areas.**

***Index Terms*— Pedestrian Delay, Pedestrian Simulation, VISSIM, Skywalk.**

I. INTRODUCTION

Since the 1960s, skyway systems (also known as skywalk systems) have become a vital feature in many cities around the world. Ahmedabad is the largest city and former capital of the Indian state of Gujarat. With growing population, congestion, pollution and related issues, that are facing mobility accessibility problems, and the governments have become more supply oriented and thus preoccupied in building more roads, flyovers that they have completely neglected the most ancient mode of transport. Walking is a universal phenomenon but generally not considered as a transport mode because it does not employ vehicles as

modes. The term "Pedestrian" is used to recognize the fact that the approach to pedestrian pathway development must be
as scientific and systematic as the techniques which are applied to highway design and development. Hence safety of pedestrian is a basic step to create safer city. In metro cities, more than one mode of public transport is available now-a-days. Due to expansion of city boundary and urban sprawls, the single mode of transport is neither viable nor efficient as the spatial separation between commuters and work places has increased. Hence, public transport has become multi modal which combines two or more modes to provide comfort, rapid and environmentally compatible movement of the commuters. Hence, pedestrian safety is an integral part of overall transport system. Most central business districts are characterized by high intensity development within a small area with resultant congestion and conflicting pedestrian-vehicle movements, especially at signalized intersections. The downtown areas experience highest concentration of day-time population and diverse activities causing vehicle delays, air pollution, and accident hazards. In some cases the conflicting movements of vehicles and pedestrians have been segregated by implementing horizontal, and vertical separation like sidewalks, auto-restricted zones, partial and full malls, underground tunnels, and other innovative approaches. A few cities have diluted the complexity of the problem to some extent by the construction and operation of skywalk systems. A skywalk provides vertical separation of pedestrian and vehicular movements and, along with street level sidewalks, represents a unified system of pedestrian facilities in the central business districts. Pedestrian skywalk is, in practice, very much a transportation system management technique. Pedestrian modelling is a complex behavioural and engineering issue. Of interest to urban transport planners is both the behavioural side i.e., how pedestrians move in relation to other pedestrians, how they decide to cross the road, how they make route choice decisions and the engineering side, i.e., how traffic control measures affect pedestrian travel times [2]. Various modelling approaches have attempted to take into account these aspects, mostly independent of each other. Pedestrian specific micro-simulation techniques have been steadily improving over the last decade and have been increasingly applied to crowd movements and building evacuation scenarios with highly sophisticated behavioural algorithms.

With Pedestrian issues considering primarily from the safety point of view rather than Level of Service, amenity. At traffic signals, pedestrians are often accommodated in which least amount of interruption to motorised traffic, and signal cycle times can be long, leading to excessive pedestrian waiting times. This can result to frustration, causing pedestrians to violate the signals and use their own judgement to cross, resulting in safety risks [1]. At traffic signals, pedestrians are often accommodated in a way that causes the least amount of interruption to motorised traffic, and signal cycle times can be long, leading to

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excessive pedestrian waiting times. This can lead to frustration, causing pedestrians to violate the signals and use their own judgement to cross, resulting in safety risks.

Delay has been widely accepted as a key feature of designing or improving the existing facilities, or to carry out further studies which bring desire changes. Pedestrian delay is an important objective to optimize the effective delay usually carried by pedestrian either because of vehicle hindrance. The service measure is the average delay experienced by a pedestrian this average delay per pedestrian for a crosswalk is given in HCM 2000. Pedestrians obey certain speed-flow and speed-density relationships when pedestrian speeds fall below the desired speed due to higher volumes and densities. Pedestrian speed-flow relationships are well documented in the literature and any multimodal micro-simulation study that includes pedestrian movements should adhere to these relationships. VISSIM offers two different behaviours to model pedestrian flow. The first of these is to state no-interaction between pedestrians. With this constraint all pedestrian movements are independent of the presence of other pedestrians. Any speed-flow relationship is then essentially linear, with speed remaining equal to the desired pedestrian speed irrespective of the pedestrian flow and density. The second possible way to model pedestrian flow is to use the vehicle-following model specified in, which in VISSIM and based on Wiedemann (PTV AG, 2004). This means that pedestrians are defined as vehicles. In that situation pedestrians react to the presence of other pedestrians, under the rules developed for vehicles rather than pedestrians [2].

This paper is organized in four sections including this section. Section two discusses the background and the literature review on the Pedestrian facilities and simulation studies while discussion on the suitability of the important technique is made in section three. In section four one combined approach is suggested to estimate the pedestrian delay under mixed traffic condition and section five concludes the paper by presenting important conclusions, and pointing the directions for further research.

II. Background and Literature Review

Large number of studies have been reported on focusing to identifying the means to reduce pedestrian delay. Micro-simulation modelling has shown that reducing pedestrian delay. However, most of them have been conducted in developed countries. Several procedures have been developed in literature to reduce pedestrian delay and simulate using microsimulation software VISSIM. Researchers have differed in their opinions of how to reduce the delay caused to pedestrians. C Vallyon and S Turner [3] concluded that Micro-simulation modelling has shown that reducing pedestrian delay at signalized intersections is possible and beneficial during the middle of the day when pedestrian volumes are highest. Researcher looked at 'per-person' delay, which includes the delay of both pedestrians and vehicle occupants (assuming a vehicle occupancy of 1.3). Observation studies showed that pedestrian delays were substantially longer than 30 seconds. This provides an average delay experienced by people arriving at an intersection, irrespective of their mode of arrival. Jodie Y.S. Lee and William H.K. Lam [3] applied Pedestrian simulation (PS) for signalized crosswalks which estimates the variations of walking speed particularly on the effects of bi-directional pedestrian flows so as to determine the minimum required duration of pedestrian crossing time. Lu Wang, Shunqiang Ye, Min Tang [13] used simulation software VISSIM for microscopic traffic is used to simulate the behavior of the pedestrians and motor vehicles when they cross the intersection with no signal. They resulted and compare actual data with simulated one in which the difference between both of one is about 5%. So according to them VISSIM simulation system can simulate accurately real traffic phenomenon, and its errors are in an acceptable range. Ren-Yong Guo and Tie-Qiao Tang [11] developed a microscopic pedestrian model is developed for simulating pedestrian flow through walkways with not only perpendicular corners. They concluded that increasing the turning degree of corner has negative impact on the pedestrian queues; the effects of the pedestrian preference to inside routes on the pedestrian queues and flows are not still positive; the flow-density relation of pedestrian flow through walkways with corners, compared with that of pedestrian flow through bottleneck, is more complex. Manmohan K.jBhalla and Prahlad D.iPant [6] further described a method for estimating pedestrian trips on the sky walk system in the central business district of Cincinnati. The linear relationships between pedestrian trips (dependent variable) and land-use variables (independent variables) were tested at the 0.10 level of significance. The regression equation for estimating pedestrian trips during lunch peak revealed that restaurants (number of seats), office floor space area (sq ft or m2), and retail floor space area (sq ft or m2) are the most significant variables, explaining 75% of the variation in pedestrian trips.

Ronald G. Hughes and David Harkey [7] explores the feasibility of using a composite queuing system to reproduce the pedestrian crossing process at un-signalized crossing, and analyzes the pedestrian crossing process at roundabouts for typical demand volumes, geometric attributes and pedestrian behavior scenarios. They analyze pedestrian crossing capacity and delay using the Arena simulation model. Jen Te PAI and Jon-Jye CHENG [8] further noticed that the to build a sustainable skyway system, planners should pay much attention to the three critical strategies integrating with the public transit system, providing a pedestrian-friendly environment, and enhancing the urban image and landscapes—in their skyway plans. Benard Jacob FAIA and Catrol Morphew [9] built skyway systems to protect pedestrian from the elements. On August 27, 1962, the first skyway in Minneapolis was opened, which instantly became a local scenic spot and a major goal of building the skyway system to provide a climate controlled environment had shifted to spur the city's economy. Krsto Lipovac, Milan Vujanic, Bojan Maric and Miladin Nesic [2] define eventual differences in models of pedestrian behavior at signalized pedestrian crossings, with and without countdown displays and represent a contribution to the harmonization of

positions on the effect of a countdown display on pedestrian behavior. There was a statistically significant smaller total number of offenders at pedestrian crossings with a countdown display than at pedestrian crossings without a countdown display (23.9 and 27.3%, respectively). Muhammad M. ISHAQUE [6] highlight the pedestrian capabilities of traffic simulation tools an example of a modelling approach is presented in the VISSIM micro-simulation software. In this vehicle following model of VISSIM is used to simulate pedestrian flow characteristics.

As discussed above, many studies are found in literature conducted in developed country where Pedestrians simulation with use of software is addressed in any of the studies reported above except taking microscopic models approach. Under heavy traffic condition vehicle and pedestrian interaction becomes complex due to lack attentions given to pedestrians, no providence for pedestrians walkway. As it is provided zebra crossing but there is no uniform outline for the safe movement of pedestrians in the main traffic zone. The combine effect of all these factors makes the prudence of Skywalk with articulating simulation of pedestrians a more challenging task. This paper gives an overview of some of the important method to evaluate pedestrian delay and recommending prospective facilities for Pedestrian in urban area.

III. Criteria for finding pedestrian delay

Delay has been widely accepted as the key performance index for signalized intersections, thus it is necessary to estimate delays accurately for all kind of traffic participants at signalized intersection. Many research has been conducted for finding vehicle delays at signalized intersection under a broad range of conditions, but eventually research on pedestrian delay is much less. In Highway Capacity Manual (HCM), sophisticated models are provided to estimate vehicle delays at signalized intersection, but the provided pedestrian delay model is quite simple (Transportation Research Board, 2000)

A. At Signalized Intersections

The method of critical gap estimation should be simple and easy to implement. It should be applicable to all traffic conditions and should be generalized enough for its application to mixed as well as uniform traffic and similar it should be work for over saturated as well as under saturated traffic condition. The signalized intersection crossing is more complicated issue to analyse as compare to midblock crossing, because it involves pedestrians crossing the street, intersecting sidewalk flows, and others queued waiting for the signal to change. Research indicates that the average delay for pedestrians at signalized intersection crossings is not constrained by capacity, even when pedestrian flow rates reach 5,000 p/h [1]. The average delay per pedestrian for a crosswalk is given by

$$dp = \frac{0.5(C - g)^2}{C}$$

Where,

dp = average pedestrian delay (s),
g = effective green time (for pedestrians) (s), and
C = cycle length (s).

LOS criteria for pedestrians at signalized intersections, based on pedestrian delay. When pedestrians experience more than a 30-s delay, they become impatient, and engage in risk-taking behavior the time. The higher the delay, the poorer is the level of service. The pedestrian delays could be calculated using the 2010 Highway Capacity Manual (HCM 2010) (Transportation Research Board 2010 According to the 2010 HCM method, pedestrian delays while waiting to cross an intersection approach are computed as:

$$DELAYS_{PED;\ HCM} = \frac{(T_G + T_Y + T_R + - g_{WALK})^2}{2 \times (T_G + T_Y + T_R + 4)}$$

Where DELAYSPED, HCM = Average pedestrian delays per pedestrian per cycle computed using the 2010 HCM method, in s=ped=cycle; TG, TY, TR = Green, yellow, and red intervals of a cycle, in s; and gWALK = Effective green time for pedestrians to cross an intersection, in s.

B. At Unsignalized Intersections

Another aspects applicable to unsignalized intersection with a pedestrian crossing against a free flowing traffic stream or an approach which is not controlled by a stop sign. However crossing over a unsignalized intersection is more complicated to analyze than one at midblock, involving intersecting sidewalk flow, pedestrians crossing the street and pedestrian judgment of an acceptable gap. This critical gap is the time measured in seconds in which pedestrian will not attempt begin crossing the street. They made their own judgment to determine if the available gap is long enough for a safe crossing. If the available gap is more than the critical gap then pedestrian will cross, but if available gap is less than critical gap, it is assumed that the pedestrian will not cross. For a single pedestrian, critical gap is computed according to (HCM-2000).

$$tc = \frac{L}{Sp} + ts$$

Where,

tc = critical gap for a single pedestrian (s),
Sp = average pedestrian walking speed (m/s),
L = crosswalk length (m), and
ts = pedestrian start-up time and end clearance Time (s).

The estimation of delay is not an end in itself. Delay are used in models for capacities and design computation at signalized or unsignalized intersections and in midblock section. Delay estimated by different procedures could have different influences on the output of the model. It should be guaranteed that the reported value of delay, in conjunction with their estimation procedures, gives a realistic and reliable estimate of the capacity which should be irrespective

with the external parameters, especially the major street volume.

C. *Pedestrian Microsimulation*

Microsimulation traffic models have become widely accepted tools to analyze and identify solutions for vehicle traffic. Pedestrian microsimulation is still in its infancy, research into employing microsimlation for pedestrian analysis has flourished in the past decade. (Teknomo 2002; Daamen 2004; Klugl and Rindsfuser 2007; Kretz 2007) [12]. According to Schoon (2010), use of computerized methods for analysis and design of pedestrian facilities stems from the need to examine extensive amounts of data utilizing complex computational methods and to satisfy required design variables, inputs, and outputs. Among the more widely employed pedestrian circulation softwares are VISSIM, SimWalk, Legion and NoMad. VISSIM (PTV-AG) employing the social force model (Helbing and Molnar 1995) pedestrian behavior model was employed to evaluate the effects of pedestrian heterogeneity. VISSIM employs the social force model published by Helbing and Molnar (1995) designed to represent the stochastic behavior of pedestrian movements. Simulation in VISSIM is also the interaction between pedestrians and other traffic and hence how the vehicular traffic is influenced by the pedestrians (PTV Group, 2011). Such a simulation may help to improve current infrastructure in cities where the pedestrian volumes are significantly large. On a more detailed level, it can be helpful when it comes to planning the location of new pedestrian crossings or the width of a sidewalk.

IV. Data collection and Analysis

Selected area should be such that which represents the real traffic scenario that is a composition of vehicle and pedestrian flow. The site should comprises of intersection which will be in the following requirement:

- The site must have regular bus service routes.
- The site must have atleast one nearside bus stop.
- The intersection must be signalized for vehicular traffic.
- The intersection requisite of maximum pedestrians flow.
- There is no proper providence for pedestrian signal timing.

Conceiving this all situation the following survey is being scheduled for getting data which will be input in the VISSIM microsimulation software.

A. *Input data*

From the carried survey the peak hours data is being taken, which is in per hour phase (Pedestrian/hour, Vehicle/hour), Speed of Vehicle and Pedestrian, Road Inventory data, Pedestrian opinion survey data.

B. *Analysis*

Control measures at mid-block crossing may be warranted as one of the following as:

- Peak hours volume of Pedestrian (P) and Vehicle (V) are such that PV2>108 for undivided carriageways and PV2>2x 108 for undivided carriageway.
- Approach speeds of vehicles exceed 65 kph.
- Waiting time for Pedestrian/Vehicle becomes too long.
- Accident records indicates 5 or more injuries to pedestrian in a year due to collision with vehicles.

This control measures are should be adopted where there is traffic signal with exclusive pedestrian phase. In this, if one of the parameters are existing then proper traffic signal approach should be design for pedestrians [13].

Ensuring worthy movement for both vehicles and pedestrians alongside a signalized route could prove to be a difficult task. Among further factors, delays induced by the operation of traffic signals organize a significant proportion of the total travel time of pedestrians or vehicles on these routes. Traffic signal systems are established along urban areas or corridor to control and regulate the flow of traffic [14].

However during peak hours, a corridor may operate under moderate traffic flow with no serious congestion. But some time, travelers may experience excessive delay at intersections due to lack of signal coordination. Sometimes high flows of both pedestrians and vehicles along the corridor may create congestion problems. Traffic congestion on urban streets leads to widespread network delays.An estimation of the delay for pedestrian will recompense some amount of delay to vehicle. This will lead to improper management in Traffic. So from traffic observations with under- saturated conditions is highly complicated. For this situations one simple approach could be taken for design of Grade Separated Pedestrian Facilities which is either Subway or Providing Skywalk at junction. As Pedestrian Subway will be usually costlier than a Skywalk. Therefore use of Skywalk is to be considered at junction, and its design will be carried out in VISSIM Software. In VISSIM, by giving all inputs step wise simulation can be taken and total delay will be estimated through after the test simulation. According to the total delay observed to vehicle and pedestrian, new approach should be design by taking one of the Pedestrian Facility which is Skywalk.

V. Conclusion

This paper is attempted to obtain an overview of some of the important methods, developed by different literatures, with their characteristics and suitability to Indian conditions. Many estimations methods are available to estimate the delay, hence it is difficult to understand which procedure is reliable and which is not. Therefore, we formulated certain quality criteria which produces comparisons between all this. According to the criteria, identifying delay through VISSIM microsimulation software this approach is the best one. The investigation of the different theoretical concepts shows that principles of the various methods could also be combined. Limited number of studies have been conducted on the pedestrian delay in congested urban area. We just reviewed all important methods given by different literatures in this paper. Now data collection part will come and we planned to

collect the large samples size data and develop the models considering more realistic behaviors of pedestrians.

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