Method To Determine Pedestrian Level of Service At Kottayam Town

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***Abstract*—In India pedestrians usually cross the road at mid-block crosswalks due to ease of access to their destination or the development of adjacent land use types such as shopping, business areas, school and residential areas. The behaviour of pedestrian will change with respect to different land use type and this change in behaviour of pedestrian further reflects change in perceived level of service (LOS). In this framework, pedestrian perceived LOS were collected with respect to different land-use type such as shopping, residential and business areas. Because pedestrian crossing behaviour is significantly governed by traffic flow characteristics, pedestrian characteristics, land-use, road geometry, and sociodemographic characteristics.**

Pedestrian delay was one of the key performance indicators for pedestrian level of service. The main objective of this study is to identify the various factors affecting PLOS at intersections. Video graphic method was used for collection of field data. Questionnaire survey was conducted to know the perceived level of service of pedestrians. The correlation between PLOS and various factors affecting it were determined by using Pearson correlation in SPSS software. And by using the linear regression a model was created for determining the LOS at intersections. This study concludes that road width and traffic volume are the main factors affecting LOS ofcrosswalks at unsignalized intersection.

Keywords: PLOS, Level of service, Pedestrians

I. INTRODUCTION

Modelling of pedestrian LOS at intersections can provide an insight to intersection designs that better and more safely accommodate pedestrian mobility. Such a measure would enable pedestrian facility programming to be merged into the mainstream of transportation planning, design and construction. Intersections, by their very nature, are locations where there is considerable potential for conflict between different traffic streams and different users. At busy intersections motorists, cyclists, and pedestrians often have to deal with complex situations and be aware of the position, movement and intent of other users. Mixed traffic of motor vehicles and pedestrians are common in urban intersections. Efficiency of intersections greatly affects the entire network performance. The demand for the improvement of pedestrian facilities is raised due to the reasons such as difficulties in crossing heavily trafficked intersections, turning vehicles across their paths during the green signal, conflicts among pedestrians and cyclists, physical barriers, low visibility, improper design of handicapped accessible ramps and so on. Road designers have to investigate what kind of mechanism is necessary in order to promote walking. They need to analyse what kind of route adjustment is necessary and how to make walkways safe and comfortable so that pedestrians can travel with pleasant feeling. To represent an integrated picture of facilities for pedestrians, it is important to review, compile, and organize the current state of researches that assess level-of service (LOS). The first attempt on LOS study was made by Lautso and Murole to find out the influence of environmental factors on pedestrian facilities. This research was a milestone in pedestrian LOS research, and it was further expanded by later researchers to accommodate many important factors into the computation of pedestrian LOS (Lautso and Murole, 1974). Sarkar proposed a qualitative method to compute pedestrian LOS based on six factors: safety, security, convenience and comfort, continuity, system coherence, and attractiveness (Sarkar, 1993). Qualitative attributes of pedestrian environments are described, but not quantified, in Sarkar's work. Since it is a qualitative method, the measurement of each factor is not easy in reality and also most of the factors are linked with each other. Later Khisty developed a quantitative method to determine the pedestrian LOS based on almost same criteria proposed by Sarker (Khisty C. J, 1994). Although Khisty's method provides a quantitative measure of pedestrian LOS on a point scale, the results from this scale are not easy to interpret. A fundamental question remains as whether these scaling systems really address the pedestrian facilities, i.e., do pedestrians agree with these scaling systems. Miller et al (Miller et al, 2000) also proposed a scale method for pedestrian LOS assessment.

Alternatives were introduced to improve the existing conditions and the proposed model was calibrated by using 3-D visualization. Dixon proposed a pedestrian LOS evaluation criterion which involves the provision of basic facilities, conflicts, amenities, motor vehicle LOS, maintenance, and travel demand management, and multimodal provisions (Dixon, 1996). A study proposed “overall LOS” as an index that combines the factors and indicates an overall value for the pedestrian LOS. Conjoint technique was used to combine the factors affecting pedestrian LOS (Muraleetharan et al, 2004). A mathematical model was proposed by Landis et al based on five variables: lateral separation of pedestrians from motor vehicle traffic, presence of physical barriers and buffers, outside lane traffic volume, motor vehicle speed, and vehicle mix (Landis et al, 2001). Although this mathematical model evaluates a roadway segment, it does not include intersections. However, they believe that intersection conditions have a significant bearing on pedestrians and a measure must be developed that includes conditions at intersections. Also, this model is limited with environmental factors only and does not include other factors such as flow rate of path users, and space requirements. Some studies use pedestrian signal delay to define a pedestrian LOS (Joseph et al, 1999). The delay at intersection is an important indicator of the efficiency of an intersection. A pedestrian LOS criterion for signalized/unsignalized intersection is defined in terms of time delay in the Highway Capacity Manual 2000 (HCM, 2000). Although HCM describes LOS criteria for pedestrian at intersections based on pedestrian delay, it does not include the other factors such as crossing facilities, turning vehicles, and pedestrian- bicycle interactions at crosswalks, etc. Recent researches on pedestrian LOS indicate that there are also some other factors that affect pedestrian LOS. Therefore, a method is needed to include the factors into the computation of pedestrian LOS at intersection. Based on literature review, much of the works dealing with pedestrian is limited to pedestrian facilities on uninterrupted sidewalks. On the other hand, there are a few studies dealing with pedestrian facility issues at intersections. Usually, accidents in non-motorized transport modes occur when it is difficult for the user to cross an intersection (Fugger et al, 2000). This indicates that a reliable measure is needed to describe the pedestrian environment at intersections. Therefore, the attempt of this research is to solve intersection LOS issues connected with pedestrians. The research will provide a method to assess the degree of difficulty a user will experience crossing an intersection. Development of pedestrian LOS measure for intersection is intended to indicate the level of difficulty in crossing intersections.

II. METHOD

Midblock crosswalks include three types: signalized, marked (unsignalized), and unmarked. The walking environment of signalized midblock crosswalks is almost the same as that of signalized intersections, which already had great deal of researches, so this research attempted to model the quality of pedestrians’ crossing road segments only with marked and unmarked midblock crosswalks between two intersections through pedestrians’ perceptions of safety and convenience. The length of road segments in medium-sized urban areas is not too long, and the types of midblock crosswalks on the same road segment are generally the same, so a hypothesis was made: all of the midblock crosswalks on the same road segment are of the same type. Pedestrians might view the road segment as a whole when crossing; that is to say, the factors that might influence the pedestrians’ perceptions of safety and convenience are the conditions of all of the midblock crosswalks on the road segments, so another hypothesis was made: what influences pedestrians’ sense of safety and convenience was the overall crossing condition of the road segment. Based on the two hypotheses, the primary factors that possibly influenced pedestrians’ sense of safety and convenience when crossing were analysed firstly, and then survey on the characteristics of the primary factors and pedestrians’ real-time responses to the overall unsignalized midblock crossing environment of road segments was carried out simultaneously, based on which the significant influencing factors were identified, and a pedestrian LOS model was developed ultimately.

A) Factors Influencing Pedestrian LOS at Unsignalized Midblock Crosswalks.

In reference to Indian actual traffic conditions, factors influencing pedestrian LOS at unsignalized midblock crosswalks can be summarized as the following.

i. The Distance between Crosswalks.

The convenience of pedestrians’ crossing street from midblock crosswalks can influence pedestrian sense of convenience to a large extent. As shown in Figure 1, the distance between crosswalks is the distance between all of crosswalks on the road, including the crosswalks at intersections and midblock crosswalks. The convenience of pedestrians’ crossing street from midblock crosswalks is determined mainly by the distance between crosswalks and the location of the crosswalks; the larger distance between crosswalks or the more unreasonable location of the midblock crosswalks may contribute to larger distances, so that pedestrians must divert when he/she wants to reach a site across the street, which leads to the increase of resistance of pedestrians’ crossing and the decrease of pedestrian level of service. The rationality of the location of midblock crosswalks is difficult to measure, and the distance between crosswalks can reflect the convenience of pedestrians’ crossing to some extent, so the distance between crosswalks was selected as potential factors influencing pedestrian LOS.

ii. Crossing Facilities.

Crossing facilities can protect or hurt pedestrians and bring convenience or obstruction to pedestrians, so the conditions of crossing facilities were believed to influence pedestrians’ sense of safety and comfort. Crossing facilities factors include the waiting space, crossing distance, type of crossing markings, median type, and separate path for bicycles. See figure 1.

iii. Delay.

The total time spent by pedestrians waiting to cross the street is expressed as delay. Because some driver did not yield to pedestrians, pedestrians had to wait for the gap of the traffic to cross the street, which results in pedestrians' delay. The delay of pedestrians at unsignalized midblock crosswalks is determined by the gap distribution of the traffic which is difficult to obtain during design stage of the street, so factors influencing the gap distribution were studied. The gap distribution was determined by traffic volume and control pattern of the upstream and downstream intersections, and the control program is generally formulated according to traffic characteristics, so the pedestrians' delay at unsignalized midblock crosswalks can be represented by traffic characteristics of the street being crossed.

B) Site Selection

Most of the midblock crosswalks on the main roads in Kerala are unsignalized midblock crosswalks, so the survey of pedestrian LOS for the overall unsignalized midblock crossings of road segments was carried out in Kottayam, a medium-sized town. As shown in Figure 2, 6 road segments were selected as survey sites. The roadway cross sections included two to four lanes in undivided or divided forms. The width of sidewalks ranged from 1.3 m to 7 m. Some main road segments and inferior road segments had motor vehicle on-street parking. The study area covered almost full range of the build-up area of Kottayam, so the land use of it included the typical land use patterns of Indian medium-sized town, which is comprised of shops, offices, apartments,

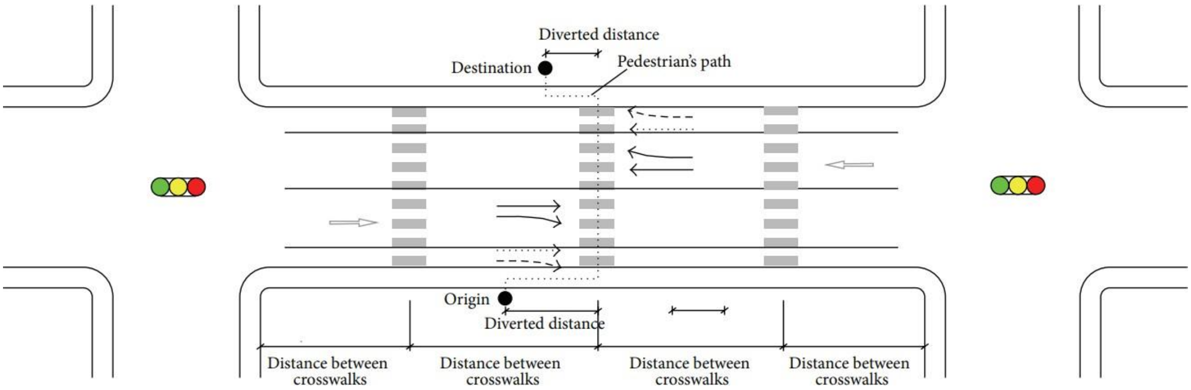

Figure 1 Elements of pedestrians' crossing system of road segment

parks, restaurants, banks, and so forth. Figure 2shows location.

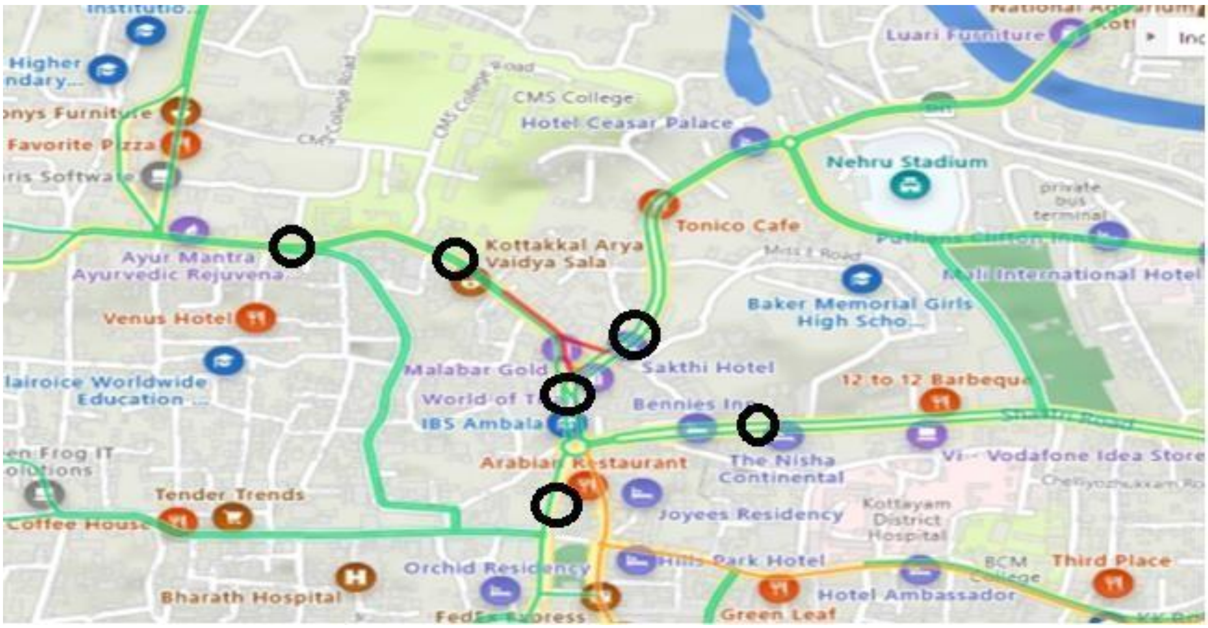

Figure 2 Site Location

C) Survey Time.

degree. The reason was that the change trends of convenience degree and safety degree when crossing

Data was collected from Monday to Saturday in Kottayam, Kerala, from 7:00 to 9:30 which coveredthe peak hour and off-peak hour. The weather was sunny and hot.

D) Questionnaire Design and Survey.

This study surveyed pedestrians crossing the unsignalized midblock crosswalks to get the participants' real-time responses on the pedestrian LOS of the overall unsignalized midblock crossings of road segments. Investigators stood on one side of the crosswalks to search for voluntary participants. The searching principle was that the participants should have different genders and diverse ages which were achieved by investigators' observation. Once the participants crossed the street, investigators started to talk with him/her. Investigators firstly explained the meaning of LOS to the respondents and then asked how they felt as they crossed the street. Furthermore, pedestrians' travel characteristics were also collected, including travel time, travel purpose, and walk frequency.

Unsignalized midblock crosswalk user survey form shows a sample questionnaire sheet used for the survey and the description of LOS given to the pedestrians. It is worth noting that pedestrians' perceptions were inquired from two respects separately: the convenience degree and the safety due to the same change of the unsignalized midblock crosswalks were not accordant; for example, the decrease of the distance between crosswalks may lead to the improvement of pedestrians' perceptions of convenience and the deterioration of pedestrians' perceptions of safety, so pedestrians' feeling of convenience and safety on unsignalized midblock crosswalks should be analysed separately. The survey was conducted in regional language for better understanding. Table 2 shows the sample.

കോട്ടയം റോഡിൻറെ പെഡസ്ട്രിൻ ലെവൽ ഓഫ് സർവീസ് വിലയിരുത്താൻ വേണ്ടി ഉള്ള ചോദ്യാവലി (✓ഉചിതമായ കോളത്തിൽ രേഖപ്പെടുത്തുക)

1.	റോഡിൻറെ വീതി മൂലം താങ്കൾക്ക് തടസ്സങ്ങൾ നേരുന്നു.	ശക്തമായി യോജിക്കുന്നു	യോജിക്കുന്നു	അഭിപ്രായമില്ല	വിയോജിക്കുന്നു	ശക്തമായി വിയോജിക്കുന്നു
2.	നിലവിലുള്ള റോഡിന്റെ വീതിയിൽ നിങ്ങള് തൃപ്തരാണ്	ശക്തമായി യോജിക്കുന്നു	യോജിക്കുന്നു	അഭിപ്രായമില്ല	വിയോജിക്കുന്നു	ശക്തമായി വിയോജിക്കുന്നു
3.	പെഡസ്ട്രിയൻസ് സിഗ്നൽസ് വന്നാൽ റോഡ് മറികടക്കുവാൻ ഉള്ള പ്രയത്നം എളുപ്പം ആകുന്നു	ശക്തമായി യോജിക്കുന്നു	യോജിക്കുന്നു	അഭിപ്രായമില്ല	വിയോജിക്കുന്നു	ശക്തമായി വിയോജിക്കുന്നു
4.	വാഹനങ്ങളുടെ നിരക്ക് വർധിക്കുമ്പോൾ റോഡ് മറി കടക്കാൻ ഉള്ള ബുദ്ധിമുട്ട് കൂടുന്നു	ശക്തമായി യോജിക്കുന്നു	യോജിക്കുന്നു	അഭിപ്രായമില്ല	വിയോജിക്കുന്നു	ശക്തമായി വിയോജിക്കുന്നു
5.	അമിത വേഗത മൂലം താങ്കൾക് റോഡ് മറികടക്കുവാൻ സാധിക്കാറുണ്ട്	ശക്തമായി യോജിക്കുന്നു	യോജിക്കുന്നു	അഭിപ്രായമില്ല	വിയോജിക്കുന്നു	ശക്തമായി വിയോജിക്കുന്നു
6.	ഭാരമേറിയ വാഹനങ്ങൾ പ്രവർത്തന സമയങ്ങളിൽ റോഡ് മറികടക്കുന്നതിൽ തടസ്സമുണ്ടാകാറുണ്ട്	ശക്തമായി യോജിക്കുന്നു	യോജിക്കുന്നു	അഭിപ്രായമില്ല	വിയോജിക്കുന്നു	ശക്തമായി വിയോജിക്കുന്നു
7.	സൈൻബോർഡുകൾ റോഡ് മറികടക്കുന്നതിൽ ഉപയോഗപ്രദമാണോ	ശക്തമായി യോജിക്കുന്നു	യോജിക്കുന്നു	അഭിപ്രായമില്ല	വിയോജിക്കുന്നു	ശക്തമായി വിയോജിക്കുന്നു
8.	സീബ്രാക്രോസിങ് ഇല്ലാത്തതിനാൽ റോഡ് അറികടക്കുവാൻ ബുദ്ധിമുട്ട് ഉണ്ടാകാറുണ്ടോ	ശക്തമായി യോജിക്കുന്നു	യോജിക്കുന്നു	അഭിപ്രായമില്ല	വിയോജിക്കുന്നു	ശക്തമായി വിയോജിക്കുന്നു

Table 1 Questionnaire

	Location	Land use	Total number of lanes	Divided	Median width in metre	Average crossing speed (m/s)	Averagetraffic speed (km/h)	Traffic volume (PCU/h)
1	KK road	Mixed type	Two	Yes	0.7m	1.440	38.34	3554
2	Central junction	Mixed type	Two	No	0	1.400	24.75	4225
3	Thirunakkara junction	Shopping	Two	No	0	1.030	32.07	2674
4	Bakery junction	Business	Two	No	0	1.200	23.63	4832
5	Shastri road	Business	Four	Yes	1m	1.210	29.61	2080
6	CMS collegejunction	Education	Two	No	0	1.070	32.71	3524

Table 1 Roadway characteristics at Kottayam Town

E) Field Survey

According to the potential factors influencing pedestrians LOS at unsignalized midblock crosswalks, the content of field survey was divided into two types, which were the static state data and dynamic state data. The static state data included the geometric characteristics of the street being crossed, the distance between crosswalks, and the condition of the unsignalized midblock crosswalks. The dynamic state data included the control characteristics of the upstream and downstream intersections and the traffic characteristics of the streets being crossed.

III. DATA ANALYSIS

Software analysis

With the help of SPSS software, we done factor analysis and reduce 5 components to 2 variables. First of all, we have 5 factors for our analysis. The purpose of factor analysis is to reduce our number of variables into a smaller number of components. The number of variables we input in our analysis, will always be equal to the number of components. Eigen values are shown in fig. the number of factors or components that have eigen values greater than one is taken. All other components with eigen values less than one, we do not keep. Since only 2 components had an eigenvalue greater than one, we only have 2 components in our solution. Some of eigenvalues will be always equal to the number of components.

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
Road width	1.4350	.51683	200
Volume	1.4000	.60151	200
Speed of vehicle	4.2800	.67370	200
Heavy Vehicles	1.4250	.69772	200
Sign Boards	4.0200	.76978	200

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.579
Bartlett's Test of Sphericity	Approx. Chi-Square	34.414
	df	10
	Sig.	.000

Factor Analysis

Table shows KMO and Bartlett's test values. the std value for KMO and Bartlett's test should be more than 0.5 and less than 0.05.it actually testing whether correlation matrix is related.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.490	29.801	29.801	1.490	29.801	29.801	1.490	29.798	29.798
2	1.057	21.136	50.937	1.057	21.136	50.937	1.057	21.139	50.937
3	.926	18.527	69.464						
4	.849	16.987	86.450						
5	.677	13.550	100.000						

Extraction Method: Principal Component Analysis.

The test result shows that variable 1 (Road width) affects the level of service. Volume of vehicles is variable 2 and it creates major traffic congestions.

IV. CONCLUSION

Pedestrians Level of Service is mostly affected byRoad width and traffic volume. Since these two factors are co-dependent changing one factor can affect the other inversely. Therefore, the location needs special setups like pedestrian beg button or pedestrian signals.

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