Study of Comfort Pedestrian Traffic Conditions

Vsevolod Prykhodko[1], Olexandr Zhytenko[2]

1. Mechanical Engineering and Transportation Technologies Department, Lviv Polytechnic National University, Ukraine, Lviv, Stepan Bandera street, 12, E-mail: satrapandfeller@gmail.com

2. Mechanical Engineering and Transportation Technologies Department, Lviv Polytechnic National University, Ukraine, Lviv, Stepan Bandera street, 12, E-mail: zhytenko@ukr.net

Abstract – A method is needed to assess the degree of difficulty a user will experience crossing an intersection. A field survey will be conducted to collect geometric, operational and traffic characteristics of crosswalks. A number of primary independent variables influencing pedestrian LOS (level of service) should be identified and tested in the stepwise regression analysis Development of pedestrian LOS measure for intersection are intended to indicate the level of difficulty in crossing intersections. This study explains a method for the estimation of pedest rian LOS at intersections and also identifies the factors affectingpedestrian level-of service LOS at intersections.

Keywords – pedestrian facilities, heavily trafficked intersections.

Introduction

Since the pedestrian environment is multi-dimensional, the pedestrian in the roadside environment is subjected to a set of several factors significantly affecting his or her perception of safety, comfort, and convenience. Measurement of these factors is necessary to evaluate the pedestrian facilities and evaluation methods are needed to understand how well a particular street accommodates pedestrian travel. In order to appropriately plan for more walkable environments, methods are required that allow planners and decision-makers to effectively identify and assess the elements of the built environment that support or detract from walking. The quality of the pedestrian environment has been measured for many years using the Level-of-Service (LOS) approach. The LOS for pedestrian facilities is influenced by a lot of factors and different pedestrians have different perceptions on the LOS.

Analysis of previous studies and publications

Dixon (1996) 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. There was no qualitative environmental assessment relating to walkability. This seems to be best suited to footpath assessments, applicability to intersections was uncertain.

Muraleetharan et al., (2004) used conjoint technique to combine the factors affecting pedestrian LOS. Total utility from the conjoint analysis represents an overall value, which specifies how much a user puts on a product or service. Even though this study proposed a method to determine overall LOS, it does not include all the factors affecting pedestrian LOS.

Muraleetharan et al., (2005) identified the factors affecting pedestrian level-of service at intersections and proposed a method for the estimation of pedestrian LOS at intersections. The study revealed that the factor turning vehicle has greater influence on pedestrian LOS than other factors. Furthermore, the factors delays at signals and pedestrian-bicycle interaction were also found to be significant factors in determining pedestrian LOS at intersections.

Hubbard et al., (2009) did a statistical analysis using a binary logit model that provides new insights into the factors that affect the likelihood that a pedestrian is compromised ,delayed, altered their travel path, or altered their travel speed, in response to traffic turning right on green

during concurrent vehicle/pedestrian signal timing. Application of a binary logit model of pedestrian compromises shows that the probability of a pedestrian compromise increases with increasing right-turn vehicle flow rate, and is higher for crosswalks outside the CBD compared to crosswalks in the CBD for the same right-turn flow rate.

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. This indicates that a reliable measure is needed to describe the pedestrian environment at intersections. Development of pedestrian LOS measure for intersection is therefore intended to indicate the level of difficulty in crossing intersections.

Formulation of the problem

Pedestrians constitute the largest group of users of the road network, and are also the most vulnerable road users. The pedestrian movement is not limited to lanes, as it is in the road transport, or specific routes, but limited only by the physical constraints around them, namely the presence of sidewalks or hiking trails. Therefore, pedestrian needs must be taken into account when designing a transport infrastructure. In order to know how the state of the road network provides a comfortable and safe pedestrian movement, there is a need to assess the conditions of pedestrian traffic and identify the main factors having a negative impact on the participants of the movement with the subsequent resolution of existing problems.

Main material

Comfort is a positive emotional reaction to the external environment or situation. The comfort of pedestrian traffic conditions can be considered as a certain emotional reaction to the external environment in different situations.

Separately distinguish the notion of physical, physiological and psychological comfort of pedestrian traffic. Under the physical comfort of the pedestrian movement, the minimum amount of effort spent traveling is understood, which is manifested in such parameters as adequacy, continuity and unimpeded design of the sidewalk, its convenience for certain categories of people, the state of coverage, and the availability of protection against adverse weather conditions. The psychological comfort is provided by the ability to maintain the desired speed of movement, as well as the ability to use the surrounding infrastructure. In addition, the level of noise and pollution determine the physiological state of pedestrians

All these types of comfort are interconnected and the overall feeling of comfort depends on the positive reactions of the pedestrian on all three levels.

Methods for estimating pedestrian traffic conditions can be divided into three types: 1 - those based on pedestrian flow characteristics; 2 - those based on the characteristics of the host environment; 3 - assessment based on the perception of pedestrians.

The assessment of pedestrian traffic according to HCM (Highway Capacity Manual) is determined by the LOS (Level-of-Service) level for sidewalks based on the results of calculating pedestrian velocity, available personal space and pedestrian flow intensity on the effective width of the sidewalk. That is, this method considers the pedestrian flow in the same way as the traffic flow, determining speed, density and intensity. Conditions are considered comfortable for movement when the pedestrian has a sufficiently individual space to choose the desired path and speed.

The various factors that can be considered in the development of the model can be grouped into three main categories, as follows:

1) Pedestrian Factors: Pedestrian Flow, Pedestrian Crossing Time, Pedestrian Delay, Pedestrian Sight Distance;

2) Crosswalk Factors: Pedestrian Holding Area, Crosswalk Width, Crosswalk Surface Condition, Crosswalk Marking, Roadway Factors, Number of Lanes, Roadway Width, Exclusive Left-Turn Lanes.

3) The various factors considered in the development of the present P-LOS model are as follows: Pedestrian Flow, Pedestrian Crossing Time, Pedestrian Delay Time, Crosswalk Surface Condition, Crosswalk width, Crosswalk Marking, Roadway width, Number of lanes.

The main objectives of this study are: 1) To identify factors which influence the level of service of crosswalks at signalized intersections; 2) To develop a regression model, this can be used to determine the pedestrian level of service of crosswalks at signalized intersections.

Methodology for development of P-LOS. The development of the P-LOS model involved:

- The collection of data by visual surveys and field surveys;
- A statistical analysis of the collected data using multiple linear regressions;
- A model validation process using several statistical tests.

For statistical analysis software SPSS is used. Originally it is called as “Statistical Package for Social Scientists” but now stands for “Statistical Product and Service Solutions”, one of the most popular statistical packages which can perform highly complex data manipulation and analysis with simple instructions.

Data analysis. The following are the assumptions made, prior to the development of the model using the multiple regression analysis method.

1) For each value of the independent variables (X), there is an array of possible values for the dependent variables (Y) which is normally distributed about the regression line;

2) The mean of the distribution of possible Y values is on the regression line, that is, the expected value of the error term is zero;

3) The standard deviation of the distribution of the possible Y values is constant regardless of the X values;

4) The error terms are statistically independent of each other, that is, there is no serial correlation;

5) The error terms are statistically independent of X values.

Data for the development and independent variables:

The P-LOS model consisted of a dependent variable and seven independent variables. The dependent variable was the P-LOS Score obtained through interviews and questionnaires. Pedestrians were asked to rate the crosswalks in terms of safety and comfort. The average rating of the pedestrians for each crosswalk is mentioned. Pedestrian flow (ped/hr), pedestrian crossing time (sec), pedestrian delay (sec), crosswalk surface condition (0- poor, 1 - moderate, 2 - good), crosswalk marking (0 - not visible, 1-slightly visible, 2 - highly visible), crosswalk width, and roadway width (m) were measured at the study locations. Comfort is a positive emotional reaction to the external environment or situation. The comfort of pedestrian traffic conditions can be considered as a certain emotional reaction to the external environment in different situations.

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From the analysis, the regression equation to determine the P-LOS Score took the form of equation is Eq. 1:

$$P - LOS = 7{,}443 - 0{,}002PFH - 0{,}061PCT + 0{,}679CSR \qquad (1)$$

where, CSR = crosswalk surface condition rating. (0 - poor, 1 - moderate, 2 - good) PCT = pedestrian crossing time (sec); PFH = pedestrian flow (ped/hr).

To aid in the determination of the P-LOS of the crosswalk, a LOS table, as shown in table 1, was developed as a basis for stratifying the model's numerical result into a level of service category.

Table 1

The range of values of P-Los

Pedest. level of service (P-Los)	P-Los score
A	8.5 < x < 10.0
B	7.0 < x < 8.5
C	6.0< x < 7.0
D	5.0 <x < 6.0
E	4.0 <x < 5.0
F	x <4.0

Conclusions

From this study, it was found that the following factors had a greater influence on the level of service of crosswalks at signalized intersections for the selected study site.

a) Pedestrian Flow;

b) Pedestrian Crossing Time;

c) Crosswalk Surface Condition.

This study also produced a P-LOS Model which can be used to determine the level of service of crosswalks at signalized intersections.

Significance of P-LOS models:

1) Pedestrian LOS model for crosswalk provides a measure of a crosswalk's performance with respect to pedestrians' safety and comfort.

2) Using the value of pedestrian LOS at crosswalk, roadway designers can determine how well a particular intersection accommodates pedestrian travel. In other words, pedestrian LOS measures can provide an easy understanding about the condition of a crosswalk. Such a measure would help in evaluating and prioritizing the needs for pedestrians on existing intersections.

3) Pedestrian LOS at crosswalk can be used to develop a minimum LOS standard which could prescribe the minimum acceptable LOS for the adequate accommodation of pedestrians. Crosswalks at urban intersections should be targeted to maintain a minimum pedestrian LOS in order to provide a minimum level of accommodation for pedestrians.

4) Pedestrian LOS models could also be used to support the development of pedestrian facility improvements.

From the model and the observations made, it can be recommended that in order to achieve high levels of service of crosswalks at signalized intersections, the following can be practiced in the planning and design of crosswalks at signalized intersections:

1) Shorten pedestrian crossing time by reducing crosswalk length and increasing crosswalk width.

2) Increase pedestrian flow by providing a longer pedestrian green time and providing larger walking space.

3) Reduce pedestrian delay by shortening cycle length of the traffic signal system.

4) Improve the condition of crosswalk surface through routine checks and maintenance.

5) Make sure that crosswalk markings at intersections are visible both day and night through routine checks and maintenance.

6) Provide adequate space for holding or accommodating pedestrians while waiting to cross.

7) Provide minimum required roadway width at the intersections in order to shorten crossing distance and time.

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