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# Evaluation of pedestrian crosswalk level of service (LOS) in perspective of type of land-use

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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). So, it is important to evaluate the quality of service of such crossing facilities with respect to different land-use type under mixed traffic conditions. In this framework, pedestrian perceived LOS were collected with respect to different land-use type such as shopping, residential and business areas. The ordered probit (OP) model was developed by using NLOGIT software package, with number of vehicles encountered, road crossing difficulty as well as safety considered as primary factors along with pedestrian individual factors (gender and age), land-use type and roadway geometry. From the model results, it has been concluded that perceived safety, crossing difficulty, land-use condition, number of vehicles encountered, median width and number of lanes have significant effect on pedestrian perceived LOS at unprotected (un-signalized) mid-block crosswalks in mixed traffic scenario. The inferences of these results highlights the importance of land use planning in designing a new set of pedestrian access facilities for unprotected mid-block crosswalks under mixed traffic conditions. Also the study results would be useful for evaluating pedestrian accessibility taking into account different land-use type and planning required degree of segregation with vehicular movement at unprotected mid-block crosswalk locations.



## 1. Introduction

Land use type has significant effect on pedestrian behaviour at crosswalk locations with increase in volume of vehicular flows. It is important, to understand the requirements and behavioural characteristics of pedestrians at different land-use types for design and evaluation of pedestrian facilities. In developing countries like India, people are from various income groups with wide variety of behavioural characteristics and different living standards. The traffic characteristics and roadway designs are also quite different when compared to the developed countries. It is a complex task for the traffic engineers, planners and policy makers to design comfortable, convenient and safe crosswalk facilities for pedestrian at proper location which is well connected to different land-use type, suitable for Indian context. Indian metropolitan cities have high population densities with mixed land-use type and pedestrian have more number of short trips. These trips may generate more

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crossings at different mid-block crosswalk locations to access their destinations. In general, pedestrian crosswalks are necessary along the roadway network to connect different land-use types such as residential areas, commercial, industrial, business and mixed land use. Also, it is important to avoid pedestrian-vehicular conflicts partially or fully at pedestrian friendly crosswalk locations. The pedestrian's safety, comfort and risk taking behaviour not only depends on vehicular flow and the roadway design elements, but also depends on the different land-use type (pedestrians are looking more comfort at shopping areas than the industrial areas) (Tiwari, 2001).

The land use planning needs to fulfill the requirements of pedestrian facilities to ensure continuous safe and comfortable pedestrian access by mixed land use (Buehler, 2011; Dumbaugh and Li, 2011). The inappropriate crossing facilities or increase in block length (distance between two intersections) with neighborhood area with different land use conditions may lead to increase in abrupt pedestrian behaviour and results in decrease in pedestrian safety. Further, these land-use types can explain the changes in pedestrian activities and exposure of pedestrians to different environments at sidewalk as well as crosswalk. The urban population in Indian metropolitan cities like Mumbai increases rapidly and it results in increase in the urban form. The increase in urban form further leads to increase in trip lengths of the passengers. It play a major role in circulating increased trip lengths with combination of different vehicular and non-vehicular modes of traffic, but the increased trip lengths of non-motorized trips leads to varied crossing distances with increased vehicular lanes and vehicular traffic. Hence, pedestrian has direct exposure with vehicular traffic at crosswalks and the safety of pedestrian may decline during these activities and the pedestrian quality of service decreases.

Generally, the risk taking factor, comfort and safety may vary with respect to vehicular flow, pedestrian trip purpose, time of the trip, length of walk trip and pedestrian individual characteristics (gender and age). Hence, the pedestrian trips with adjacent land-use type have significant effect on pedestrian level of service (LOS) along with pedestrian safety and crossing difficulty at unprotected (un-signalized) mid-block crosswalk locations. In India, the unprotected mid-block crossings are designated by median opening and these crosswalks rarely have the markings and other sign boards for controlling of vehicular traffic. However, the pedestrians are crossing the road at such crosswalk locations frequently because pedestrian have different activities considering adjacent land use facilities. Also, the pedestrian safety and comfort have been decreasing at such unprotected mid-block crosswalk locations. So, there is a need to evaluate the pedestrian perceived LOS at such crossings by considering pedestrian perceived safety and difficulty as well as vehicular flow as the measure of effectiveness with respect to different land-use types. Based on this objective the study was undertaken and the details are summarized in this paper. The paper is organized as follows. The back ground of the literature study is explained in Section 2. The methodology for the model development is described in Section 3. The empirical modeling results are presented in Section 4. The discussion of the estimated models is discussed in Section 5. Section 6 explains the conclusions from the study and future research scope.

## 2. Background

Availability of transportation facilities and land use type are the vital components for pedestrian accessibility. Hence, the accessibility of various transportation modes such as non-motorized (pedestrian and bicycle) and motorized (public transportation) should be taken care at planning and design stage with considerations of future land use developments. An improper pedestrian facility along with different land-use type has significant effects on behaviour of pedestrians in densely populated cities in India. The number of trips and walking behaviour of pedestrians can be influenced by distribution of population and land-use types of employment, shopping, and other residential activities (Krizek, 2006). Several researchers have focused on the relationship between urban form and travel patterns (Stead and Marshall, 2001). The highly dense area leads to more pedestrian trips within the neighborhood and increase in block length increases the walking outside of the neighborhood (Oakes et al., 2007).

The behaviour of pedestrians' trips is influenced by connectivity of sidewalk as well as crosswalk with their origin and destination of the trip within neighborhood area (Shay et al., 2006). An accurately planned, designed and well-placed crosswalk facility increases the mobility of pedestrians between their origin and desired destination (Sisiopiku and Akin, 2003). Inappropriate pedestrian crosswalk facilities (improper crosswalk location and lack of markings and lighting or ramp for wheel chair users) with respect to adjacent land use makes the pedestrian to cross the road at any location and it further reduces pedestrian safety. Evaluation of unprotected mid-block pedestrian crossing facilities with different land use types under mixed traffic condition is a complex task for traffic engineers in India. The performance evaluation of transportation infrastructure facilities for different modes is carried out by LOS. Assessment of any pedestrian facility is aimed at effectively improving the existing quality of service with better accessibility to the adjacent land-use type and it promotes more number of walk trips.

In general, the assessment of pedestrian LOS is usually carried by two scales. The first scale defines pedestrian LOS in terms of individual pedestrian and second one in terms of areal units (Gallagher, 2012). There are several studies which explored individual pedestrian LOS based on quantitative and qualitative parameters. In this line, Lautso and Murole (1974) studied pedestrian LOS with effect of environmental factors. Some studies have focused on both combined effect of quantitative and qualitative parameters on pedestrian LOS (Môri and Tsukaguchi, 1987). Researchers have explored the effect of different qualitative factors such as safety, security, convenience and comfort, continuity, system coherence, and attractiveness to assess the pedestrian LOS at sidewalk locations (Sarkar, 1993). Khisty (1994) evaluated pedestrian LOS by weighted parameter approach in educational area. Jensen (2007) studied the pedestrian and bicycle LOS with different parameters like motorized and non-motorized traffic volume, vehicle speed, urban land use, bus stops, trees and parked