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DETERMINATION OF PEDESTRIAN LEVEL OF SERVICE FOR CROSSWALKS AT URBAN INTERSECTIONS

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Abstract - Pedestrians form the largest single road user group and also are the most unguarded road users because walking has been the primary means of human locomotion. Pedestrians have their respected walkways commonly known as physical boundaries by which they are restricted. Pedestrians are allowed only to use pedestrian ways, but they are not shortened to a particular lane or specific routes. At urban intersections, there are various factors which are affecting PLOS "Pedestrian Level of Service". As of now, several methods are introduced for the computation of quality operations of facilities to the pedestrian by which PLOS is proposed. Generally, some of the mechanism uses the fundamentals of vehicular traffic flow to resolve the pedestrian traffic operations. Hence the primary equitable of this study is to define the various factors which are affecting PLOS at signalized intersections. This paper mainly deals with the entire picture of LOS determination methods for pedestrian facilities and to suggest a suitable procedure for guessing PLOS at signalized intersections. The study is implemented to develop a model for PLOS of signalized intersections in Secunderabad and Hyderabad cities based on pedestrian's perception of secure and comfort. The main factors considered for the improvement of the model were through traffic, left turning freight, right turning freight, a number of pedestrians, a number of lanes and pedestrian delay, among these factors pedestrian delay plays one of the key roles. From two cities total twelve crosswalks were considered for study purpose. Field data is collected by using video graphic method and to determine the perceived LOS of pedestrian's questionnaire survey was conducted. To diagnose the various factors influencing PLOS Pearson correlation analysis was implemented. By considering both perceived LOS and significant factors as a dependent variable and independent variables respectively, regression analysis was used to flourish a necessary model that is suitable for Indian urban conditions. The several factors which are affecting LOS are under contrasted traffic conditions only. Durability and deficiencies are examined & suggestions are given to get more satisfactory service level analysis of pedestrian facilities.

Keywords -

I. Introduction

A. General

With the increase in economic growth of the developing countries, urbanization and growth of urban traffic also increase. This automatically results in the growth of urban population, results in rapid usage of public transportation. Generally, public need traveling when they have to reach their destination point from their point of origin. This usually makes them connect trips either origin or destination or both. Hence traffic is a composition of vehicular flow, crosswalks, sidewalks, and pedestrians, signalized and unsignalized intersections. Vehicles move on the pavement surface, where as pedestrians move on respective walkways. Usually, in few situations pedestrians try to violate the traffic signals because of their urgency or value of time. For some time, transportation engineers and planners have paid attention primarily to the motorized transportation system. As of now, the motorized transportation system received an immense importance than the nonmotorized transportation systems. This is because day by day there is rapid growth in motor vehicles, predominantly total attention in transportation system turned for regulation of motor vehicles only and the pedestrian regulation is completely neglected. Generally, in any transportation networks

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intersections are the most censorious constituents. Even though there is rapid growth in population, every road user should use the same space provided on that of different circumstances. Due to this large number of conflicts occur because of different road user moving with certain speed to different directions.

B. Background

Previously countless investigationsare carried out for the estimation of the pedestrian LOS. From these past studies, it was known that some factors such as traffic signals, traffic operations, road markings, and vehicle operating conditions influence the pedestrian LOS. Highway capacity manual gave several methods for pedestrians LOS at intersections. But Highway capacity manual did not include several factors such as turning vehicles, crossing facilities, and bicycle movements at crosswalks and motorists behavior towards pedestrians. IRC-103-1988 describes that where ever the possibility is high crosswalks should be designed quadrate to the respective carriage ways. Then the markings are proposed with a clear view and this reduces the inconvenience of pedestrians. As per IRC crosswalks design should maintain the following standards- overpasses should not be for longer distances, there must be clean visibility without any obstructions and waiting area is adequate.

C. Statement Of The Problem

Indian urban streets constitute major part by pedestrians, but eventually, the planning, design, and management of pedestrians are neglected. The growth of pedestrians is enlarging day by day but the facilities to them are not provided up to their satisfaction. In this situation for developing models for metropolitan city conditions studies on pedestrian need to be facilitated highly, where PLOS indicates the representative quality of particular intersection in terms of perceived secure and convenience.As pedestrians are the major part of road users, they are prone to many injuries and deaths sometimes, mainly at intersections.

D. Objects And Possibility

- The leadingdetached of this study is to define several factors which control the pedestrian LOS in metropolitan signalized network settings. Some of the aspects such as a number of lanes, existing zebra crossing, through traffic signals are involved in the account of factors affecting PLOS.
- The secondary dispassionate is this study is to define the relationship between these factors and pedestrian LOS in the urban Indian context where each individual variable controls the pedestrian LOS.
- The prime motive of this exercise is to scrutinize the pedestrian suspension on pedestrian LOS at blended traffic circumstances at signalized intersections. Factors such as safety and convenience of pedestrians also indirectly depend on the pedestrian delays.
- To suggest the suitable methodology that is apt for developing the PLOS model and to define the relationship between each individual variables and pedestrian LOS.
- To flourish a model demonstrating the pedestrian LOS of urban Indian roads with mixed traffic condition and to define the restrictions of changed pedestrian LOS levels (A - F) for Indian road circumstances under mixed traffic.

II. Concept Of Pedestrian Level Of Service

Introduction

Generally, capacity and level of service are related to each other. Detailed analysis of capacity gives the clear picture of how much traffic can be accommodated for a given transportation facility. Further analysis of the LOS describes how good the current traffic situation on a given facility is. Therefore a LOS gives aapproximate measure of traffic, while capacity determines the perceptible quota of a expertness. Beginningwith numerous circumstances such as prevailing traffic conditions, road conditions and type of facility both capacity and LOS are varied.

Level Of Service

The term which is sharplyrelevant to capacity and frequently unbalanced with its service volume is widely known as level of service. The level of service gives anapproximate measure of traffic, while capacity determines the quantitative measure of traffic facility. A service volume is termed as the maximum no. of vehicles, pedestrians which are held by a given traffic facility.The actual flow varies for alternative days and disparate times on a peculiar day

itself, thus for a given traffic facility capacity could be constant. The main motive of LOS is for a given rate of flow of traffic should be related to the traffic service quality. This particular term can be designated as the range of operations on a peculiar type of traffic facility.

Traffic quality is mainly divided into six levels of services that range in a sequence from level A toF. Here level A represents the finest quality of traffic and the driver has the opportunity to drive with free flow speed. On the other hand level F represents poor traffic quality where the driver cannot move with free flow speed. So, the LOS is exemplified as MOE (Measure of Effectiveness). Especially criterions such as speed, density, and delay are measured under this service.

Various Levels Of Pedestrian Level Of Service

LOS A

At LOS A walkways, pedestrians move in the path choose by them without shifting their movement in response with other pedestrians. Clashes betwixt pedestrians are unlike but the speed of the pedestrians is freely selected.

LOS B

In LOS B, pedestrians can choose their own walking speed because there is sufficient area for pedestrians to move freely and to bypass other pedestrians. This also avoids the crossing conflicts. In LOS B pedestrians are aware of remaining pedestrians for giving their response to their presence when selecting a particular walking path.

LOS C

At LOS C the walking area is less compared to both levels A & B, as the number of pedestrian's movement is high in level C. Yet there is sufficient area for pedestrians with normal walking speeds. Here the speed and flow rate declines when pedestrians come from reverse-direction. Crossing movements cause minor conflicts.

LOS D

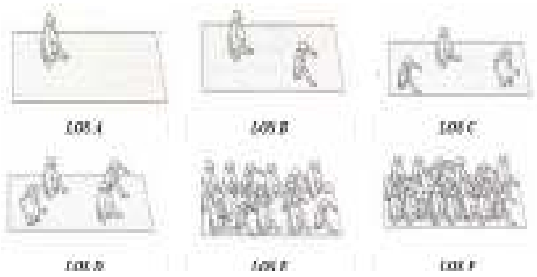
In LOS D, the freedom of walking or to select the individual walking speed is not allowed. Bypass of other pedestrians is blocked. Here crossing and reverse-flow movements have a major challenge of conflict, hence it is restricted. Parameters like speed and position of pedestrians alternatively change. Therefore LOS D provides reasonable fluid flow but the interaction among pedestrians lie same.

LOS E

In LOS E, the normal walking speed of all the pedestrians is restricted and frequently adjusted. Forward movement of pedestrians is only possible by shuffling, that too in fewer cases. The reverse flow of pedestrians is faced with extreme difficulties and area of walking is less for pedestrians moving with slower speed. Factors such as walkway capacity, stoppages, and interruptions are considered while designing.

LOS F

In LOS F, flow is unstable walking speeds are severely restricted and forward movement of pedestrians is only done by shuffling. Normal walking speed is very poor and reverse flow movement is highly impossible.



Overview

Generally, there is a significant proportion for every modal trip that is completed by walking. This results in the needs of the pedestrians, like the needs of motor vehicles that should be taken into account while designing the metropolitan environment and transportation facilities. Therefore there is some need to put an effort in directing towards the safe, accessible and convenient mobility for pedestrians. Residents are encouraged to make more trips of reasonable length. Evaluation of pedestrian facilities and walking conditions are carefully done with more complex than other vehicular roadways, due to occupants of automobiles are commonly separated in their wrap environment. Mean while the pedestrians are unprotected to a variety of diversified environment.

Signalized Intersections

At urban intersections, the traffic is guarded by traffic signs and systematic movement of vehicles is

allowed. There are chances of accidents and conflicts more as vehicles and pedestrians using the same road at the same time. As of now in India, the design of roadways is more concentrated as vehicles are the main users of roads. But in urban areas at intersections considerable amount of pedestrians using roads. So in order to design an intersection for better movement of pedestrians has to be considered in the design of roadways. The main problems that are faced by pedestrians during crossing the pavement are as follows

Pedestrian Delay

Delay is one of the important factors which influence the perceived LOS of pedestrians at signalized intersections. Delay is the term which is used to define (someone or something) late or slow. Here delay is time taken by the pedestrian to cross the pavement. Hence the total delay that is experienced by the pedestrian can be arranged into three types namely

1. Waiting time delay: Waiting time delay is the time taken by the pedestrian to wait for the occurrence of a gap to cross the road from arrival of him to given intersection.
2. Crossing time delay: Crossing time delay is termed as the delay caused by the pedestrian at the time of crossing the road. This mainly depends on the speed of pedestrian during movement onto another side of the road.
3. Vehicle interaction delay: Vehicle interaction delay is defined as delay caused by the pedestrian to interact with vehicles. This mainly depends on signal compliance.

Perceived Vehicle Conflicts

Pedestrians experience conflicts not only because of vehicles passing the crosswalk but also the vehicles moving close to the pedestrian movement and makes they feel unsafe. The vehicle movements that cause problems to pedestrian are as follows

Through traffic flow ,Left turning vehicles on red phase, Right turning movements permitted, Left turning traffic , Right turning traffic .

Perceived Exposure

The perceived exposure of the pedestrian crossing road depends upon time. Hence it depends on many other factors such as traffic control devices which influence the perceived exposure. The various factors influence perceived exposure of pedestrian such as the presence of side walk and presence of zebra crossing. The perceived exposure also extends to factors such as crossing distance and presence of channelizing islands.

Methodology

Let us know the methodology used to regulate the PLOS for urban intersections in a step by procedure format

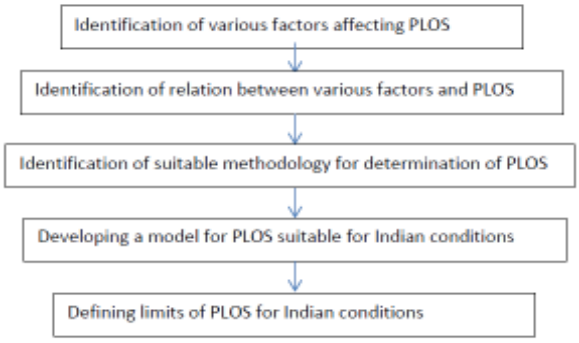


Figure 7 Methodology to determine PLOS.

Applications Of Pedestrian Level-Of-Service

The paper deals with the PLOS in urban India. In some cases, the intersections were similar to those present in urban and suburban areas of India. Finally, the main intention of this research is to develop a reliable, statistical model which represents urban Indian roads.Pedestrian level-of-service used to provide better facilities for pedestrians in terms of safety and comfort. PLOS is defined by operational efficiency of a given intersection in terms of pedestrian's perspective.

III. Review Of Literature

General

The level of service is a perceptible stratification of a conductpart or measures that represent the quality of service. Exploration on the pedestrian level-of-service started on by Laustro, Murole. The LOS usually described in six classes varying from LOS A to LOS F where A represents excellent conditions and F represents worst possible conditions.

Pedestrian LOS at signalized intersections is based on perceived comfort and safety; Landis et al. (2005) developed a model by considering perceived conflicts, perceived exposure and perceived delay, Landis concluded that the main reason behind the delay is due to vehicles turning right on red. To regulate the pedestrian LOS at urban intersections Muraleetharan et al.(2005) advanced a method by considering the factors such as areas at corners, turning vehicles, bicycle activities, turning delays and crossing facilities. This method also states that pedestrian LOS is greatly influenced by turning vehicles. In order to study for the improvement of PLOS at signalized intersections, Jensen in (2012) developed a model. This model says that some factors must be considered in order to improve the pedestrian LOS such as sidewalks and zebra crossings are to be situated before intersections. Shortest distances are considered for bicycle LOS at the intersection and other crossing facilities.

Pedestrian Level Of Service

Dixon (1996) announced several performance measures that affect the pedestrian LOS and bicycle level of service. They are probably discussed as facilities to be provided for pedestrians, motorized vehicle Level of service, conflicts, and amenities and finally gave some standard specifications for congestion management. Based on pedestrian vehicle system at intersection Lipinggao et al developed a delay model in (2012) and stated that two stage crossing is more efficient for urban streets. Paraskevi explained the scope for PLOS and their applicability at alternative prevailing conditions. Mean whileParaskevi&Magdalini in (2012) introduced some methodologies which are available for the computation of the pedestrian LOS.

Pedestrian Planning And Design

The PPDstudy is carried out by John Fruin. Many of the LOS assumptions and the concept of speed/density relationships and the body shape, dimensions of a pedestrian LOS are derived along with distinguishing between levels. Both approximate and perceptible analysis of evaluating sidewalks is introduced by Fruin.

The LOSpart is to be a safeguard that pedestrian facilities are tolerable for peak periods. Mean while there are some factors like street vendors and sidewalk cafes that may aggravate the criteria of LOS which are important to maintain the trait of pedestrian life. Fruin indicates that study of the bi-directional flow of pedestrian describes that flows of same frimness will not have much impact on one another. But in the case of a strong flow may get slow when it is subjected to an opposing flow. When the field work and analysis is going on we might be able to observe all these conditions. Measured width of sidewalks should be automatically decreased to 12-18” on each side. This is because it should account for some buffer area necessary by pedestrians to avoid sidewalk obstacles.

Pedestrian Field Studies, Walking Speed

Generally, the walking speed of pedestrians differs or varies from person to person. Richard L. Knoblauch and Marsha Nitzburg gave the mean speed of walk for pedestrians depending upon age factor. Pedestrians with 65 years of old and younger have a mean speed of 4.95ft/sec. Similarly, the mean speed for pedestrians above 65 age period is 4.11ft/sec. females with age 65years old and under walked 0.32ft/sec slower than males.

Obstacles In Pedestrian Simulations

Pascal Stucki and Christian Gloor announced that a person requires 0.3m lateral space on each side for having extra longitudinal space for deviates the speed. Based on this they proposed measured distance to obstacles as 0.45m for walls and 0.3m for poles respectively.

Walking Behavior In Bottleneck Situations And Its Implications For Capacity

Bottleneck situations occur when the pedestrians to be survived on a walkway or roadway are extremely high than designed. Serge P. Hoogendoorn says that for bottleneck conditions pedestrians make layer like trails due to lack of speed. Generally, they may be formed from inside neck or outside the neck. Commonly specified space between layers is 45cm. The distance should be less than the effective width of single pedestrian, thus it is known as **Zipper effect**.

Urban Space For Pedestrians

Boris S and Jeffrey Zupan method for urban area for pedestrians often quoted in highway capacity manual methodology. Based on the commensurate volumes of building floor space the standards for pedestrian

space is determined. Previously using special zoning districts pedestrian space was allocated in a case by case basis. In addition to it has found that the undisturbed walking speed varies between 150-350ft per min. The average of 270ft per min is taken into account. 40% of the speed is decreased by the pedestrians with older age.

IV. Methodology

Overall

The purpose of a pedestrian LOS at aurban intersection is a complex phenomenon involving many factors. This is mainly because vehicles in different directions and pedestrians are to attend the similar area at the same time. The methodology for determining the pedestrian LOS mainly includes determining the various factors which influence the pedestrians in terms of anticipatedsecure and comfort. The factors such as pedestrian delay, a sum of pedestrians, total lanes, through traffic, right turning vehicles, left turning vehicles, the speed of vehicles at the intersection, corner area etc. are the main influencing factors.

Details Of Data Collection And Extraction

Questionnaire Survey and video graphic survey was implemented, where they meet satisfaction level of each every individual pedestrian in terms of secure and convenience, and mathematical data and traffic inputs were possessed at crosswalks of urban intersections in all selected site locations. Nearly 25 pedestrians were interviewed at each site location at various crosswalks.QuestionnaireSurvey includes the details collected from different pedestrians to give their endemic information regarding that particular crosswalk, data is said to present in the form of percentages or ratings view. This process is continued for all the factors individually that affects crosswalks at signalized intersections.

Score for four elements such as crosswalk surface circumstances, crosswalk marking, crosswalk holding space and motorist's behavior was asked to pedestrian to give their personal rating. Sense and a full explanation of these factors have given to every pedestrian which was already noted on paper before asking their satisfaction level. It was emphasized to respondents that this thesis needs their perception of the level of difficulty if they were to use the separate crosswalk. For a better understanding of respondents, the factors explanation paper was prepared in both English as well as local language. Also, defendants were given enough time to answer. The overall satisfaction levels in percentage given by the pedestrians were considered as the dependent variables for the analysis. Traffic and Geometric data of particular signalized intersections crosswalk were collected video recording and field observation of signalized intersections crosswalk.

Factors Effecting Plos

Pedestrian delay:

At urban intersections pedestrian delay the major factors influencing the pedestrian LOS. The pedestrian delay is termed as the delay or time is taken for pedestrian to crosswalk. Generally, delay depends on existing traffic conditions and pedestrian crossing behavior. The pedestrian delay also occurs when the movement of pedestrians is high in quantity in particular walkways mainly at peak time.

Corner area:

Corner area is termed as the total area of the corner of the road. Typically corner area is categorized into two types as circular area and holding area. Holding area is known as the sufficient area to provide space for pedestrians to wait at the corner. Circulation area is known as the space required for the movement of the pedestrian.

Pedestrian flow:

Typically pedestrian flow is the no. of pedestrians passing a point per unit of time which is expressed in pedestrian per minute. Here point refers to the line of sight of a walkway is perpendicular to the movement across the width of a walkway. It is calculated by dividing the total no. of people crossing the given crosswalk with analysis period.

Vehicle flow rate:

Vehicle flow rate is termed as the no. of vehicles passing over the cross walks at a given time period. This is observed as the major obstacle for the free flow of pedestrians when they are allowed to pass the road. Hence during analysis period, the flow rate is calculated by observing the total no. of vehicles crossing a given crosswalk.

Mid-segment 85th percentile speed:

The speed of the vehicle which exceeds 15% of vehicles in the traffic flow defines eighty fifth percentile speeds. This should not influence the

intersection conditions when speed is measured at a distance from the intersection.

Left turn on red vehicle flow rate:

Left turn defines the no. of vehicles taking a left turn on the red signal during the analysis period.

Left turn vehicle flow rate:

The number of the vehicles turning left at the cross walks during the analysis period.

Crosswalk length:

Typically cross walk is termed as the curb to curb distance which is derived from the midpoint of the crosswalk. The cross walk must be consistent from curb to island in case of the channelized right turn island.

Presence of pedestrian head:

The pedestrian head is the green phase which is present at the pedestrian crosswalks. It helps to guide the pedestrian either to use the crosswalk or to wait until the further signal to cross.

Methods

For the determination of a PLOSvarious methods available are discussed below:

HCM (2010) method:

Highway capacity manual (2010) is applicable to all signalized intersections, the LOS is introduced by HCM which denotes the level of quality. This helps to derive the different local operation characteristics and traffic volume. Highway capacity manual designates the level of service as a letter which proposes a range of operating conditions to that respective facility. Typically there are six letters that are given by HCM as A, B, C, D, E and F. Here particular letter denotes the trait of pedestrian service, where A denotes the good quality of service and F denotes the poor trait of service.

Landis et al. model:

Landis et al. named the factors which give a significant effect on the pedestrian environment conditions under three perspectives.

- Side walk capacity.
- Quality aspects.
- Perceived safety or comfort.

This method also gave the guidance on design aspects of the walkways environment based on the three perspectives, motor vehicle speed, and volume. There are some other factors provided by this model which represents pedestrian's perceptions of crossing at urban intersections.

Muraleetharan et al. model:

This model was developed to consider the factors responsible for assessing the PLOS on a crosswalk: few factors are mentioned below

- The LOS at corners.
- The crossing facilities.
- The turning vehicles.
- The pedestrian delay.

Bian et al. model:

This method assessed a pedestrian level of service by analyzing the relationship in-between the quality of facilities and pedestrian perceptions. In order to investigate the true factors that affect PLOS, a pedestrian survey is conducted earlier. This is followed by step wise analysis of regression model. Typical factors which effect PLOS are the vehicle volume, pedestrian volume, distance between sidewalk & pedestrian lane and driveway access frequency. A provider based method is very useful instead of a user based method. This model was proposed on the basis of an actual perception of pedestrian comfort and safety. The LOS for a given intersection was calculated by using questionnaire survey. This survey gives the actual response of pedestrians. Essentially this model was introduced to determine the LOS by detecting the several factors that influence LOS with linear multiple regression analysis.

Vedagiri and Nagraj model:

This model is purely developed for pedestrian compliance behavior and arrival pattern. These terms are studied without any statistical evidence in order to develop the pedestrian delay at urban intersections. Statistical studies involve pedestrian noncompliance behavior. This is probed with limited frameworks like pedestrian age and gender. Crossing speed, compliance behavior, and pedestrian vehicular intersections are reviewed in this study.

V. Study Area And Data Collection

Study Area

The study area and data compilation for this research work are drawn from different site locations in Hyderabad &Secunderabad cities of Telangana state, India. These respective crosswalks will have a high number of pedestrian flow rates during the early and evening rush hours. The first location is Tarnaka. The second location was considered as the paradise cross roads. The third location was considered as the Begumpet junction. The final location is selected as N.T.R statue circle. All these selected site locations consist of sidewalks on both the sides of the road and will have considerable amount pedestrian flow rates. These roads are designed to give importance to pedestrians; they can cross the roads at any time without waiting. In order to collect the required data in our study area, video graphic survey and questionnaire survey are conducted at site locations with respective standards and equipment. As it is the live field area many different types of data compilation are provided from the field area. Observations are carried out by recording the pedestrians walking on crosswalks at different time intervals and noted. A digital video camera is used to transcript the data; the data recorded on crosswalks at various locations is taken at 15-minute time intervals. After completion of the specified time, the survey is stopped and the video clips were saved.

Data Collection

Data collection from the selected site locations is gathered by the closing session of the day or end of the survey. All the design aspects, geometric and viable aspects of the crosswalks were investigated by regulating the field surveys. All the characteristics of elements affecting the pedestrian LOS were gathered for each crosswalk within area of the site location. For easy identification, certain numbers or codes may be used at the time of collecting the information or recording the data. We should be able to introduce the measurement methods for each of the factors that are considered in the study in field measurement process. In some cases, these factors are not easy to identify and measure due to several reasons that exist at locations. But a considerable number of factors are clearly defined as per HCM. Ultimately HCM methods are used to define and measure the factors affecting PLOS. But we also included some of the factors which are not defined in HCM in previous research papers. In Hyderabad city there are many areas which show traffic congestions or pedestrian LOS. Few of them were selected in the study; signalized intersections where the pedestrian LOS is high are selected as site locations for this study. Six crosswalks are considered at signalized intersections, the first location is Punjagutta circle road, the second location is Jublie check post, the third location is Ameerpet junction, the fourth location is Khairatabad circle, the fifth location is Uppal ring road, and the sixth location is L.B nagar ring road, seventh location is Ramanthapur circle, and eighth location is Hi-tech city.

Questionnaire Survey

The name itself defines that a survey supervised by asking several questions suitable for the existing conditions. The pedestrian questionnaire survey is conducted with the intention to know the complete information about pedestrian's origin and destination points. The survey also includes gathering advices on what new dexterity or improvements should be replaced to existing facilities. The survey is mostly conducted at urban intersections and where the pedestrian flow is high. A detailed questionnaire is carried out by investigators present at the location on walkways and they survey the pedestrians passing the sidewalks or walkways. During this survey, no one will be forced to stop and answer the questions. In this survey, questionnaires are distributed to the pedestrians who are present on the selected crosswalks. In order to clear the doubts that arise in pedestrian mind, instructions, and explanations of LOS were given in the first few pages of the questionnaire data sheet. We clearly mention in the sheet what information we are expecting from them. It was highlighted to respondents that this study needs their perception of the level of difficulty. A scale ranging from 0-10 is provided in order to simplify the matter from assessment. Here scale 0 means the level of crossing is extremely difficult. Scale 10 indicates that the level of crossing is very comfortable.

Video Graphic Survey

Video graphic survey was conducted at signalized intersection locations. This helps to collect the data regarding the condition of traffic, crossing facilities and pedestrian delay. The movement of pedestrians, as well as vehicles, depends upon signals, this type of survey suits to record the data accurately. At peak hours in the morning and evening periods, this

method is adopted. A digital camera is arranged at the suitable place on the crosswalk and it is adjusted to record the PLOS to specified time intervals. Generally, time interval depends upon the location and duration period. The necessary time interval is set for recording data and the process is observed at regular intervals. The characteristics such as corner area, side walk width and width of the crosswalk are measured during the field survey. This survey mainly helps to determine the factors such as left turning vehicles, pedestrian flow, right turning vehicles and pedestrian delay. When certain obstructions occur on the walk ways it is also recorded in the video and it helps us to solve the problem and to take preventive measures.

Data Extraction And Analysis

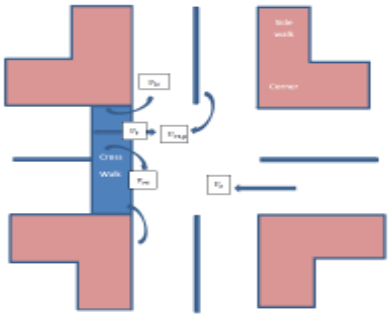


Figure 17 showing various movements of traffic through a crosswalk

- The above figure expresses various traffic movements that are possible through a crosswalk:
- Consider a signalized intersection where sidewalks and crosswalks are provided.
- Here the various factors which affect the pedestrian level of service such as corner walk left turnings, right turnings are represented as

Where vt = through traffic flow

vrt = right turning traffic

vlt = left turning traffic

vrt, = right turn permitted on red

$vltor$ = left turn on red

Data Extraction

The required data which is collected from different surveys and methods are put down here. As mentioned earlier, data extracted from various site locations are represented individually with respect to its characteristics. Firstly the sites Secunderabad station road, paradise cross roads, Begumpet circle and N.T.R statue circles are considered with the data extracted from the respective surveys.

VI. Results And Analysis

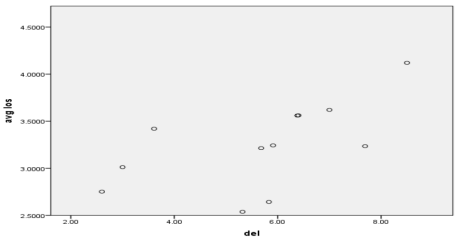
Introduction

Generally, surveys are conducted to get the data from various site locations in two cities. This process is carried out for all the crosswalks and complete data is obtained. In order to get the result from these collected data, Regression analysis is used to define PLOS. To identify the pedestrian LOS and factors affecting them at intersections regression analysis is used in step by step format. The pedestrians provided the data in a questionnaire survey in the form of scores. Hence these scores are used to calculate the pedestrian LOS and it is divided into six major categories.

Correlation BetweenPlos And Various Factors

Typically to bring out the relationship between pedestrian the LOS and various factors influencing it correlation is used. The main intention is to diagnose the liaison between the independent variable and the dependent variable, whether the variables are linear or exponential. Correlation among factors affecting Level of service and the average level of the service antiquated determined and presented in the table. A stepwise multi variable correlation scrutiny was implemented using the detected data of various types of intersections. This analysis also helps in transferring the defendant answers into numerical values. This multivariable analysis was used to express the mathematical equation for the pedestrian LOS. This is possible by the collection of factors with the statistical reliability which is used to form a mathematical expression. This measurement evaluates the circumstances of crosswalks at intersections.

Correlation Between Average Los And Delay

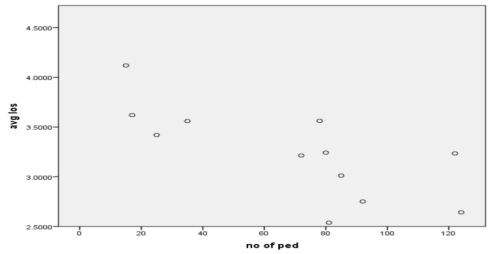


Graph 1 Showing correlation between average LOS &Delay

		Average LOS	Delay
Average LOS	Pearson Correlation	1	0.588
	Sig. (2-tailed)		0.045
	N	12	12
Delay	Pearson Correlation	0.588	1
	Sig. (2-tailed)	0.045	
	N	12	12

Table 8 Correlation between average LOS &Delay.

Correlation between average LOS and number of pedestrian

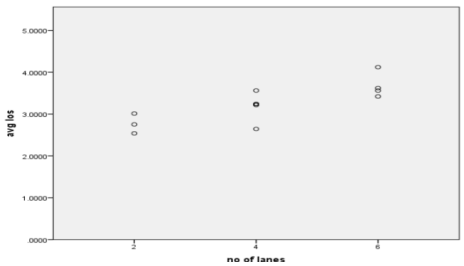


Graph 2 Showing correlations between average LOS & No. of Pedestrians

		Average LOS	No of Pedestrian
Average LOS	Pearson Correlation	1	-0.736
	Sig. (2-tailed)		0.006
	N	12	12
No of pedestrian	Pearson Correlation	-0.736	1
	Sig. (2-tailed)	0.006	
	N	12	12

Table 9 Correlation between average LOS & No. of Pedestrians

Correlation between average LOS and number of lanes

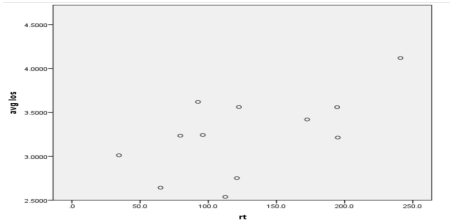


Graph 3 Showing correlations between average LOS & No. of Lanes

		Average LOS	No of Lanes
Average LOS	Pearson Correlation	1	0.796
	Sig. (2-tailed)		0.002
	N	12	12
No of Lanes	Pearson Correlation	0.796	1
	Sig. (2-tailed)	0.002	
	N	12	12

Table 10 Correlation between average LOS & No. of Lanes

Correlation between average LOS and right turn traffic

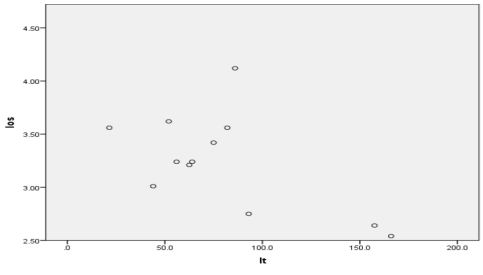


Graph 4 Showing correlations between average LOS & Right turning vehicles

		Right Turn traffic	Average LOS
Right Turn traffic	Pearson Correlation	1	0.601
	Sig. (2-tailed)		0.039
	N	12	12
Average LOS	Pearson Correlation	0.601	1
	Sig. (2-tailed)	0.039	
	N	12	12

Table 11 Correlation between average LOS & Right turning vehicles

Correlation between left turning traffic and average LOS



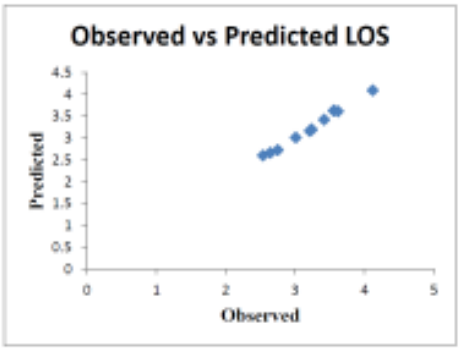
Graph 5 Showing correlations between average LOS & Left turning vehicles

		Left Turn traffic	Average LOS
Left Turn traffic	Pearson Correlation	1	-0.596
	Sig. (2-tailed)		0.041
	N	12	12
Average LOS	Pearson Correlation	-0.596	1
	Sig. (2-tailed)	0.041	
	N	12	12

Table 12 Correlation between average LOS & Left turning vehicles

PLOS model for crosswalks, validation, and comparison

From the available literature, the disparatecauses regulates the pedestrian LOS are considered. These factors are considered based on the urban Indian conditions. Based on these factors PLOS model was developed according to the conditions prevailing in urban Indian crosswalks. The slope of the best fitting line was found to be 42.44º for the developed model. The standard slope of a fitting line is 45º this model is applicable and hence validated.



Graph 6 Showing observed LOS vs. Predicted LOS

Connotation of Pedestrian LOSGrade

Actually, from previous observations, it is found that higher value of PLOS score indicates a low level of service. Our developed model gives PLOS score in the range of 1 to 6. Generally, LOS of many cities range from 2.5 to4.5, this represents PLOS Level C or D. Thus by comparing and analysis of previous data 3.5 values is selected and the following level of service ranges can be defined.

LOS A: PLOS≤ 1.5
LOS B: 1.5< PLOS ≤ 2.5
LOS C: 2.5< PLOS ≤3.5
LOS D: 3.5< PLOS ≤ 4.5
LOS E: 4.5< PLOS ≤5.5
LOS F: PLOS >5.5

Pedestrian LOS score for Hyderabad city

By using the new model PLOS of various intersections of Hyderabad city was determined. The intersections are classified as follows

Site	PLOS score	LOS
Punjagutta circle	2.643	C
Jublie Check post	3.235	C
Hi-tech city	2.752	C
Uppal Ring Road	3.214	C
Ameerpet	3.243	D
L.B Nagar	3.012	C
Ramanthapur	3.562	D
Khairatabad circle	2.538	C

Table 13 Pedestrian LOS at Signalized Intersections in Hyderabad City.

Above table shows the pedestrian LOS of various signalized intersections of Hyderabad city. Most of the intersections fall under the level of service category C and D.

Site	PLOS Score	LOS
Tarnaka	3.42	C
Paradise Circle	3.56	D
Begumpet Junction	3.62	D
N.T.R. Statue	4.12	D

Table 14 Pedestrian LOS at Signalized Intersections in Secunderabad City.

The above table shows the pedestrian LOS of signalized intersections of Secunderabad city. The pedestrian LOS of intersections was varying between C and D.

Summary

The developed model is possible only with the help of collected data by video graphic technique, perception and geometric. This in turn helps out for evaluating PLOS score in the urban Indian context. Hence on the basis of developed model PLOS score of other respective sites are calculated.

VII. Conclusions

- This study revealed that among all the factors 'turning vehicle' has a greater influence on the PLOS than other factors.
- When this type of system of vehicles increases, it results in a reciprocal decrease in the anticipated safety of the pedestrian.
- It is recommended that at intersections, the signal systems must be designed to reduce the pedestrian vehicle interaction because pedestrians feel discomfort due to these clashes with vehicles.
- At intersections, the remaining factors such as pedestrian bicycle interaction and delays at signals are organized to be symbolic factors in decisive the PLOS.
- The holding area and circulation area should be greater than the standard size. Pedestrians prefer an improvement in the case of design at crossings, like high visibility zebra crossing markings, an individual path for bicycles and good curb ramps.
- It was observed from the study that at crossings pedestrians do not encourage long delays at signalized intersections. Highway capacity standards also indicate that when pedestrians experience long delays they become impatient and they might engage in risk taking behaviors.
- A minimum level of service standard is developed by using PLOS at a crosswalk. Which in turn establish a minimum acceptable LOS for an adequate comfort of pedestrians?
- Therefore, to provide a minimum level of accommodation for pedestrians mainly urban crosswalks intersections undergo destination to maintain a minimum PLOS.
- This helped in defining the various factors affecting such as, through traffic, no of pedestrians, number of lanes and pedestrians delay on the level of service.
- This defined LOS model can be used by roadway designers to test alternative intersection designs. This can also be obtained by iteratively changing the independent variables beneficial to find the strong contribution of a factor to achieve the desired LOS.
- This study mainly helps in not only defining the PLOS at intersections but also determines the factors contributing to less correlation and more significance LOS values.

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