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Pedestrian Level of Service at Unsignalized Intersection and Junction Improvement

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Abstract:
This paper aims at developing a Level of Service (LOS) model for unsignalized intersection crosswalks for pedestrians from the perspective of the pedestrian's perception of comfort and safety in unsignalized intersection environment. Firstly, the potential primary factors influencing pedestrian LOS at crosswalk were summarized from three respects: traffic conflicts, crossing facilities and delay. Secondly, data for the model were collected, including 124 participants real-time sense of comfort and safety when they crossing the selected intersection crosswalks and the design and operational characteristics of the selected intersection. The above mentioned data's are obtained by conducting questionnaire and videographic survey in the selected intersection. The study area for research work is taken at Ernakulam district of Kerala, India which includes a two three legged intersection (Angamaly LF intersection and Mattor College Junction). Based on the survey data, Step-wise regression analysis were carried out to develop pedestrian LOS model for unsignalized intersections. A reliable, statistically calibrated pedestrian LOS model for unsignalized intersections was developed, suitable for application in the vast majority of Indian urban areas.

Key Word*: Pedestrian, Level of Service, Crosswalks, Unsignalized Intersection, Junction Improvement.*

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I. Introduction

Walking is one of the most important travel modes in Indian urban and sub- urban areas. Pedestrian is defined as a person whose mode of travelling is walking. So pedestrian plays an inevitable role in Indian traffic but they are the most vulnerable road user and are always neglected in transportation planning, construction and management. But it is a fact that at some point or the other every person is a pedestrian.Potential for conflict between different types of road users is very high at intersections it is because different traffic moving in different directions occupies the same area to cross. The nature of traffic in India is very heterogeneous so it is very hard for pedestrians to cope up with Indian traffic situation. So more care should begiven to improve pedestrian facilities, sidewalk, foot over-bridge, walkway etc. can be provided to increase the safety of pedestrian.The term LOS introduced by the highway capacity manual (HCM) represent the level of facilities a user can derive from road under various operating characteristics and traffic volume. HCM defines six LOS based on operational condition that is from LOS A to LOS F representing the best to worst level of services.Pedestrian level of service (P-LOS) expresses the degrees that the road facilities satisfy the pedestrian's demands of safety, comfort, continuum and celerity. Our study mainly focuses on effectiveness of crosswalks at the selected unsignalized intersections. The reason behind selecting unsignalized intersection was that compared to signalized intersections unsignalized intersections offer less safety to the pedestrians.

II. Pedestrian Level of Service

Pedestrian level of service indicates the environmental qualities offered to pedestrians at road traffic services and serves as a guide for development of standards of pedestrian facilities.

Objectives

1. To develop a regression model to determine the level of service of pedestrians (PLOS) at selected unsignalized intersections.
2. Validating the model using the statistical tests such as R square, T test and normality test.
3. Validating the obtained PLOS with an evaluation matrix.

Study Area: The study area for research work is taken at Ernakulam district of Kerala, India which includes two three legged intersection. Selected three legged intersections are Angamaly L.F junction and Mattoor college junction.

1. Three legs of Mattoor junction leads to Angamaly, Kalady and college road. To study the pedestrian LOS at this intersection we particularly chose Kalady Angamaly stretch (30.8 m) near the crosswalk where pedestrian flow is more compared to other stretches since bus stops are provided nearby.

Fig 1 Mattoor College Junction

2. Next study area taken is LF junction which leads to Angamaly, Kalady and Angamaly LF junction. Starting from the LF gate we particularly selected a stretch of length 42.3m since most of the pedestrians use this stretch to cross the intersection.

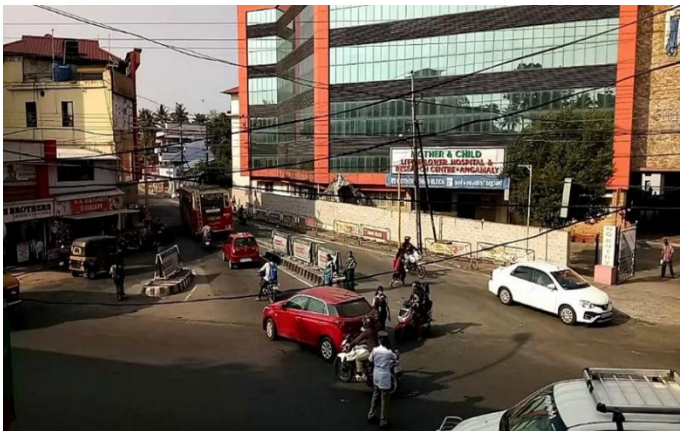

Fig 2 Angamaly LF Junction

III. Methodology

1. Conducting questionnaire survey and finding the values of dependent variable.
2. Conducting video graphic survey and finding the values of independent variables
3. A statistical analysis of the collected data using multiple regression analysis and the development of the regression model.
4. Validation of the model using T-test and R^2 Test.
5. Validation of the model using Evaluation Matrix.

Questionnaire Survey: Questions based on safety and comfort are asked to the pedestrians and ratings are given to the answers. The average P-LOS score is taken as the dependent variable to develop the model. The main questionnaire consist of seven multiple choice question. The survey was conducted among pedestrians and people near the bus stop. A total of fifty four people responded to the questionnaire survey in mattoor intersection and a total of seventy people responded to the questionnaire survey in Angamaly LF junction.

1. **Data Obtained from Questionnaire Survey:** Responses from pedestrians are evaluated by giving scores to the answers which are divided into four levels based on the performance of the intersections. A scale of 1 to 4 is sufficient to accurately cover the range of conformance. These scores were assigned entirely on the basis of literature studies. The scores can subsequently be aggregated and averaged to obtain an overall LOS. The scaling of LOS is taken as shown below:

LOS A: $X \leq 1.5$,
LOS B: $1.5 < X \leq 2.5$,
LOS C: $2.5 < X \leq 3.5$,
LOS D: $3.5 < X \leq 4.5$,
LOS E: $4.5 < X \leq 5.5$, and
LOS F: $X > 5.5$

TABLE 1: Responce from pedestrian

Mattoor	**Angamaly**
4.917	5.7608
4.29	3.618
4.998	4.4278
4.9614	5.2372
4.1384	4.7138
4.3696	5.6186
4.318	4.983
4.813	4.262
4.298	4.123
4.562	4.839

Videographic Survey: Pedestrian volume, pedestrian delay, pedestrian crossing time, through vehicle volume, through left turn vehicle volume, through right turn vehicle volume, side road left turn vehicle volume, side road right turn vehicle volume, vehicle speed are the main factors that identified by conducting interviews and proper literature studies. The values of all these factors are obtained from video graphic survey during the peak hours at selected unsignalised intersections. In order to achieve this cameras are fixed on either side of the both intersections namely mattoor and angamaly intersection. Usually videographic survey is conducted during the morning and evening peak hour.

1. **Data from Videographic Survey:**

Pedestrian score	**Pedestrian volume**	**Cross time**	**Pedestrian delay time**	**Through**	**Through left**	**Throug h right**	**side left**	**Side right**	**speed**
4.917	68	12	21.61	274	127	147	43	30	9.40
4.29	56	14.03	22.66	301	146	155	51	43	7.69
4.998	112	11	20	272	137	135	49	35	8.89
4.961	64	11.29	12	332	197	135	28	32	6.58
4.1384	95	13.73	29.47	302	142	160	39	31	4.13
4.3694	174	8.19	40.22	277	140	137	20	36	4.79
4.318	151	11.69	18.19	292	129	142	20	48	2.08
4.813	152	14.77	13.79	212	124	120	24	23	4.37
4.298	117	11.74	21.38	293	114	179	26	45	2.32
4.562	108	13.54	25.93	219	107	112	28	34	2.54

TABLE 3: Data from video at Mattoor junction

Table 3 denotes the values of traffic and pedestrian characteristics at mattoor junction which is extracted from videographic survey. The data were collected separately for each 5 minute interval.

TABLE 4: Data from video at Angamaly junction

Pedestrian score	**Pedestrian volume**	**Pedestrian delay time**	**Cross time**	**Through**	**Through right**	**Through left**	**Side left**	**Side right**	**Speed**
5.76	71	19.81	14.45	209	69	140	79	53	5.82
3.618	55	20.58	14.24	218	75	160	67	49	6.16
4.427	52	21.8	12.45	219	78	141	83	45	4.83
5.237	89	17.22	10.78	208	74	134	62	45	5.73
4.713	77	19.89	11.88	217	78	139	67	54	6.99

5.618	69	21.84	15.17	252	95	157	65	46	8.18
4.983	83	35.95	12.05	261	112	149	73	49	9.27
4.262	92	17.39	11.95	245	101	150	63	47	4.42
4.123	73	18.24	9.83	247	118	146	85	52	4.35
4.839	67	25.46	15.57	266	121	148	87	55	7.69

Table 4 denotes the values of traffic and pedestrian characteristics at Angamaly junction which is extracted from videographic survey. The data were collected separately for each 5 minute interval.

IV. Multiple Regression Model

Using various parameters of the intersections we can establish a traffic flow and pedestrian safety relationship model. Multiple regression is a statistical tool used to derive the value of a criterion from several other independent, or predictor, or variables. NCSS is a statistic package produced by NCSS, LLC.NCSS stands for Number Cruncher Statistical System. A statistical software named as NCSS 12 was used for multiple regression analysis. The NCSS package includes over 250 documented statistical and plot procedures. Multiple Regression is used to study the linear relationship between a dependent variables Y and independent variables X1, X2, X3…..

Used for two purposes: To determine which of the independent variables are significantly correlated with the dependent variable.

1. To estimate the parameters in a mathematical model of the relationship between Y and the X's.

Variables:

1. *Dependent Variable:* Pedestrian score
2. *Independent Variable :* Pedestrian volume, Pedestrian delay, Pedestrian crossing time ,Through vehicles, Through right vehicles, Through left vehicles, Side left vehicles, Side right vehicles , and speed.

Procedure:

1. Enter the data into the NCSS window sheet and then conduct data screening in order to predict the missing value if any.
2. After entering the detailed data into the software, multiple regression analysis is conducted in order to obtain a multiple regression model.
3. Before running the software the dependent variable and the independent variable are assigned to their respective boxes.
4. The pedestrian score is dependent variable expressed as Y. it is also known as dependent response or predicate variable.
5. The quantitative variable that is predicted from one or more X variables using regression model and the X variable is also known as independent variable. They are set of variable that used to predict Y. The Independent variables are pedestrian volume, pedestrian delay, crossing time, through traffic, through left vehicles, through right vehicle, side left vehicle, side right vehicles and speed.
6. The value of Y always depend upon the independent variable X.
7. After obtaining the final report accordingly we will reconduct regression analysis if necessary.
8. The equation for PLOS were obtained from this analysis report.
9. Through this analysis we will obtain the validation results of R-Square test, Normality test, and T test.
10. The same procedure is followed for another intersection also.

V. Result

Mattoor Junction: The estimated equation is ;

PLOS=5.7894 - 0.00201 * ped_vol + 0.00714*ped_delay-0.1879 * cross_time + 0.0105 * through_left - 0.00279 * Through_right + 0.0339 * side_left - 0.0534 * side_right + 0.0609 * speed

The average PLOS score from questionnaire survey is 4.566 and so it belongs to PLOS E.

1. **Validation test results:**

i. **R square** = 0.9621

ii. T test

- Pedestrian volume- 0.2043
- Pedestrian delay- 0.0013
- Pedestrian crossing time- 0.0131
- Through vehicles- 0.0124
- Through left vehicles- 0.0363
- Through right vehicles- 0.0623
- Side left vehicles- 0.0247
- Side right vehicles- 0.0157
- Speed- 0.0770

iii. Normality test

Shapiro wilk = No

Angamaly Junction: The estimated equation is:

PLOS =8.0298 + 0.0061 * side_right - 0.0060 * side_left + 0.408125 * cross_time - 0.09009 * through_left - 0.0012 * Ped_delay + 0.00049 * through_right + 0.0473 * speed + 0.014001 * ped_volume + 0.0153*through

The average PLOS score from questionnaire survey is 4.758 and so it belong to PLOS E

1. Validation test results :

i. R square = 0.8672

ii. T test

- Pedestrian volume- 0.02201
- Pedestrian delay- 1.0707
- Pedestrian crossing time- 0.0379
- Through vehicles- 0.06432
- Through left vehicles- 0.0298
- Through right vehicles- 0.2542
- Side left vehicles- 0.7265
- Side right vehicles- 0.3064
- Speed- 0.742

iii. Normality test

Shapiro wilk = No

Evaluation Matrix Results:

TABLE 2: Evaluation matrix results

Evaluation measures sites ↓ →	**Mattoor**	**Angamaly**
Safety	3	4
Comfort	5	5
Footpath surface	5	6
Obstructions	4	3
Crosswalk visibility	3	4
Provision of median	5	6
Average score	4.5	4.6
Overall LOS	E	E

VI. Junction Improvement

A junction is the general area where two or more roads join or cross. The importance of design of junction stems from the fact that efficiency of operation, safety, speed cost of operation and capacity are directly governed by the design. Since a junction involves conflict between traffic moving in different directions, its scientific design can control accidents and can lead to orderly movement of traffic reducing delays. Junctions represent potentially dangerous location from point of view of traffic safety. It is believed that well over half of the fatal and serious road accidents in built up area occur at junction.

Junction Improvement Methods:

1. Channelisation: Channelisation is the separation or regulation of conflicting traffic movements into definite paths of travel by the use of pavement markings or raised islands, to facilitate the safe and orderly movement of both vehicles and pedestrians.Channelisation serves separation of conflicts, Control of angle of conflict, Control of speed, Protection of vehicles leaving or crossing main traffic stream, Protection of pedestrians, Elimination of excessive intersectional areas, Blockage of prohibited movements, and Location of traffic control devices.

2. Traffic Signals: Traffic signals control vehicle and pedestrian traffic by assigning priorities to various traffic movements influence traffic flow. Traffic signals are designed to ensure an orderly flow of traffic, provide an opportunity for pedestrians or vehicles to cross an intersection and help reduce the number of conflicts between vehicles entering intersections from different directions.

3. Speed Hump and Speed Cushions: A speed hump is a raised portion of a road that creates a vertical motion for vehicles and discomfort that leads the driver to slow down. Its length is greater than the wheelbase of vehicles and the slope is gradual. These characteristics distinguish it from the speed bump which is more aggressive and not recommended for public roads. The Centre portion of a speed hump can be rounded or flat.

4. Zebra Crossings: Zebra crossings are located only on streets with low traffic volumes (less than 500 vehicles per peak hour in both directions) and never at signalized crossings. Zebra crossings are equipped with black-and-white poles topped by flashing orange globes. The zigzag lines before the crossing forbid parking and also overtaking a moving vehicle nearest the crossing or a vehicle which has stop- pad to give way to pedestrians.

VII. Conclusion

Mattoor Junction:

1. The average PLOS score from the questionnaire survey is 4.566 and it represents PLOS E
2. R square obtained is 0.95 that represents that the developed model fit the data well so our model is best fit.
3. T test p-values of all the factors are nearer to zero indicates that all the predictors are significant.
4. No value output for the Shapiro wilk represents that the model is valid.
5. Results from evaluation matrix also validates that the Mattoor junction falls in PLOS E category.

Angamaly Junction:

1. The average PLOS score from the questionnaire survey is 4.75816 and it represents PLOS E
2. R square obtained is 0.8382 that represents that the developed model fit the data well so our model is best fit.
3. T test p-values of all the factors are nearer to zero indicates that all the predictors are significant.
4. No value output for the Shapiro wilk represents that the model is valid.
5. Results from evaluation matrix also validates that the Mattoor junction falls in PLOS E category.

Significance of the Study:

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.

5. Roadway designers can use the pedestrian LOS model to test alternative intersection designs by iteratively changing the independent variables to find the best combination of factors to achieve the desired LOS

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