PEDESTRIAN LEVEL OF SERVICE AT INTERSECTIONS

A thesis submitted in partial fulfilment of requirements
for the degree of

BACHELOR OF TECHNOLOGY
IN
CIVIL ENGINEERING

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ROURKELA-769008
2015

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ROURKELA-769008

CERTIFICATE

This is to certify that project entitled, "**Pedestrian level of Service at intersections"** submitted by **Amrit Anushil Swain** in partial fulfillment of the requirement for the award of **Bachelor of Technology** Degree in **Civil Engineering** at National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance. To the best of my knowledge, the matter embodied in this Project review report has not been submitted to any other university/ institute for award of any Degree.

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ACKNOWLEDGEMENT

The study would not have been conceivable without the participation and direction of a few people who have contributed and provided their help in the fruition of the study. Most importantly I want to express my most profound feeling of appreciation to my guide Professor P.K.Bhuyan for his direction in the fulfillment of the undertaking.

The undertaking would not have been conceivable without his experiences and time that he has given inspite of his occupied timetable.

I likewise want to say thanks to Dr. S. Sarangi, Director, NIT, Rourkela for giving the vital facilities and chances to work in such a testing study environment. I am additionally appreciative to Dr.S.K.Sahoo, HOD, Department of Civil Engineering, NIT Rourkela for giving the important facilities to finish the undertaking.

In conclusion, I need to thank all the staff members from the Civil Engineering Department for their backing in the culmination of the task.

Amrit Anushil Swain

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ABBREVIATIONS AND SYMBOLS

HCM	Highway Capacity Manual
LOS	Level of service
PLOS	Pedestrian Level of Service
PCU	Passenger Car Units
V_{mra}	Right turning vehicle volume from the street parallel to the crosswalk
V_{mla}	Permissive left turning vehicle volume approaching to the crosswalk
V_{nra}	Right turning bicycle volume from the street parallel to the crosswalk
V_{nla}	Permissive left turning bicycle volume approaching to the crosswalk
V_{nta}	Through bicycle volume on the street parallel to the crosswalk
C	Constant
Bic/h	Bicycles per hour
Avg	Average
Pcu/h	Passenger Car Units per hour

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ABSTRACT

The study was aimed at improving the road conditions and designing roads in the future providing enhanced safety for pedestrians. In order to measure the safety of a pedestrian on a certain road , pedestrian level of service(PLOS) of that road was used as a parameter.

Highway Capacity Manual (HCM, 2000) has characterized LOS as "a quality measure depicting operational conditions inside an traffic stream, by and large as far as such administration measures, for example, speed and travel time, flexibility to move, movement interferences, and convenience and comfort.The HCM has defined six levels of service, A-F; describing operations from best to worst for each type of system.

A quantitative model based on the Chinese road intersections was used to determine the pedestrian level of service(PLOS).The factors affecting the safety of pedestrians that were considered in the model were right-turning vehicle volume from the street parallel to the crosswalk (pcu/h), permissive left-turning vehicle approaching from the street parallel to the crosswalk (pcu/h), right-turning bicycle volume from the street parallel to the crosswalk(bic/h), permissive left-turning bicycle approaching from the street parallel to the crosswalk (bic/h), through bicycle volume on the street parallel to the crosswalk (bic/h).The data were collected using a video camera.

After collecting the data, regression analysis was done in Microsoft excel to find the value of the coefficients of these factors. The range of the PLOS was also found using k-mean clustering in MATLAB. The pedestrian level of service were then calculated for the respective study areas and classified into A-F according to their values.

CHAPTER 1

INTRODUCTION

1.1 GENERAL

In the most recent decade India has seen a high development rate which has prompted the improvement of numerous metro-urban communities in the nation prompting a gigantic increment in activity. The vehicle business is expanding with a yearly creation rate of 4.6 million vehicles. As indicated by measurements given by the Ministry of Road Transport & Highways, Government of India, the yearly rate of development of engine vehicle populace in India has been around 10 percent amid the most recent decade

. This has led to increase in the number of accidents .The number of pedestrian fatalities has also been high. This has happened due to the increased conflict between the pedestrians and other vehicles at road intersections. In this way the needs of the pedestrian, similar to the needs of engine vehicles, ought to be considered in the outline of the urban communities and transportation frameworks. Endeavors ought to be made for safe , open and advantageous versatility for the pedestrians. Indian urban communities have generally been urban communities of walkers, and numerous urban occupants depend on strolling, cycling and open transport for their every day travel. In any case, with the fast increment in engine transport, restricted consideration has been paid to pedestrian and open transport offices. An adjustment in center is obliged which will permit individuals to recover the urban environment.

At present no proper methodology has been developed to evaluate the pedestrian level of service (PLOS) at Indian road intersections. Therefore an effort has been made in this study to use a

quantitative model proposed by the Transportation Research Board, Washington D.C. to evaluate the pedestrian level of service (PLOS).

1.2. STATEMENT OF THE PROBLEM

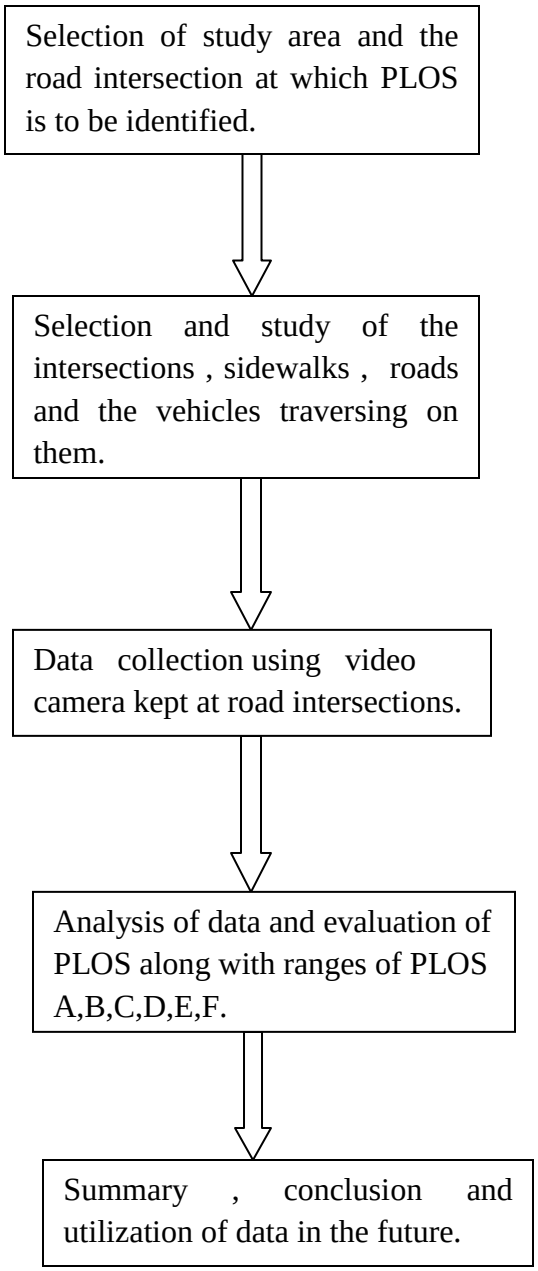
Fast urbanization has taken a toll on the Indian streets. The traffic engineers are confronting the intense undertaking of designing streets .In this procedure of giving better transportation facilities , they either neglect to give fitting pedestrian facilities or trade off the wellbeing of the pedestrians. With expanding populace, the lives of the pedestrians are as a rule continually imperiled. So the need of great importance is to give safe environment to the pedestrians with no contention with the other method of transportations.

PLOS examination is an imperative idea in characterizing the working state of a pedestrian office. A typical use of the level of administration investigation is to process the LOS of a present or changed facility for the close term or separation future. . Likewise, operational proficiency of urban street frameworks can be exceptionally all around judged by PLOS criteria.

Unlike the United States and other developed countries, no methodology has been developed in India to evaluate the pedestrian level of service (PLOS).Moreover, the traffic, roadway and environmental characteristics are different in the case of India than the other developed countries. Therefore the methodology needs to be modified according to the Indian context.

1.3. OBJECTIVE AND SCOPE OF THE STUDY

The study was aimed at improving the road conditions. The PLOS values which were calculated will help to classify the road intersections into different PLOS ranges A, B, C, D, E, F. These data will further help the traffic engineers to improve the road characteristics and conditions for the safety of the commuters. The overall framework of the project is depicted in the following figure-



1.4. ORGANIZATION OF THE REPORT

The report consists of seven chapters .The first chapter deals with the introduction of the project topic , the statement of the problem and the objectives and scopes of the project. The second chapter introduces the concept of Pedestrian level of service and explains the various factors on which it depends. The third chapter deals with the literature review of various research works that has been carried out on the topic of this project. The fourth chapter deals with the study area and the road characteristics of the study area. The fifth chapter deals with the data collection. It shows various data collected from the road intersections in the form of tables. The sixth chapter deals with the analysis of the data and the results obtained from the data collected. The report ends with the seventh chapter showcasing summary and conclusions. The reference is given in the end citing the names and works of the authors and researchers whose work has been discussed here.

CHAPTER 2

WHAT IS PEDESTRIAN LEVEL OF SERVICE?

2.1. GENERAL

The level of service is the yardstick which is used by the traffic engineers to evaluate the safety of the commuters. Level of Service idea initially developed from the idea of reasonable limit initially exhibited in the 1950 HCM. The level of administration was thought to be subject to various variables like pace, travel time, flexibility to move, intrusions in movement and working cost in the 1965 Highway Capacity Manual(HCM). This announcement of 1965 HCM was altered in the 1985 HCM by including two huge components impression of drivers and travelers and subjective measure of operational variables. The operation expense variable was however dropped. The HCM 1965 and 1985 has characterized six levels of level of administration A-F. The level of service is an element and steadily evolving wonder. The Highway Capacity Manual (HCM 2000) has characterized level of service as a " quality measure depicting operational conditions inside an traffic stream, by and large regarding such service measures as velocity and travel time, flexibility to move, movement interferences, and solace and comfort". The HCM has characterized six levels A-F for level of service taking into account best to most noticeably awful. The definition that is being taken after is the one given in the HCM(2010).

The level of service level A is viewed as unreasonable in urban regions .Urban territories for the most part have level of service changing between level C and level E. Different choices are utilized by traffic engineers to improve wellbeing at street convergences having more awful level of service. This is attained to by expanding the street width, restricting auto utilization to constrained territories, giving walkways and safe pedestrian and bicycle facilities.

The different PLOS levels are:

LOS A-This is the best level of service and will provide improved safety for pedestrians. The roadways will have adequate asphalt space, low traffic volume, low speed traffic, safe crossing point plan .Pedestrians will have low level of collaboration with engine vehicles. This kind of roadways can be found in school grounds, vacationer spots.

LOS B-These roadways provide some facilities of LOS A, yet do not have some pedestrian friendly plans. The pedestrians will face low to direct levels of conflicts with engine vehicles.

LOS C-These roadways do not have some pedestrian friendly convergence design and may have walkways on just one side of the road or may have high traffic stream. The pedestrians can expect moderate levels of connection with the engine vehicles.

LOS D- Pedestrians will have some trouble crossing the convergence .Certain insufficiency in pedestrian wellbeing and comfort features is liable to be there. Pedestrians can suspect moderate to abnormal state of cooperation with engine vehicles.

LOS E-These roadways are not suitable for pedestrian utilization and are sure to have a few inadequacies. The roadways could possibly give a pedestrian facility like walkways and pavements. These sorts of roadways are found in rustic zones, fringe regions of urban areas. The pedestrians can confront abnormal state of cooperation with engine vehicles.

LOS F-These roadways by and large have high volume of traffic stream and give slightest security to pedestrian travel. These roadways are described by fast traffic stream. The pedestrians are certain to face abnormal state of connection with engine vehicles

2.2.FACTORS AFFECTING PEDESTRIAN LEVEL OF SERVICE

1- SIDEWALK WIDTH-Sidewalks are given to upgrade the safety of the pedestrians. Subsequently more the width of the walkway, better is the PLOS.

2-ROADWAY WIDTH-The roadway width is contrarily relative to the safety of the pedestrians. The more the width of the roadway, there is less safety among pedestrians and subsequently less is the PLOS.

3-STREET PARKING-This has a positive impact on the view of safety among pedestrians. The vehicles in the city go about as a boundary and subsequently better is the PLOS.

4-TRAFFIC VOLUME-The PLOS diminishes with expansion in the traffic volume. With increment in the traffic volume, there is more risk of contentions between pedestrians and engine vehicles.

5-TRAFFIC FLOW SPEED-The recognition of safety of the pedestrians diminish with increment in the pace of the traffic stream. Thus the PLOS diminishes with increment in rate of traffic stream.

6-NUMBER OF LANES-The increment in number of lanes prompts increment in the width of the street. As the width of the street increments, there is abatement in view of safety among pedestrians and subsequently the PLOS diminishes.

CHAPTER 3

3.1. LITERATURE REVIEW

- **Muraleetharan and Hagiwara (2007)** concentrated on analyzing the impact of general LOS of walkways and crosswalks on walker course decision conduct and qualities influencing general LOS of walkways and crosswalks were characterized and weighted by relative significance through the expressed inclination study.
- **Smith (2009)** suggested that perceptions as well as objective assessment of the environment are significant in different ways in predicting walking conduct.
- **Muraleetharan et al. (2005)** uncovered that the element 'turning vehicle' has more prominent impact on pedestrian LOS than different variables and when the quantity of turning vehicles builds, a comparing reduction in the apparent security to the passerby. Accordingly the creators have suggested that at intersections the sign frameworks must be intended to minimize the pedestrian vehicle collaboration on the grounds that walkers feel inconvenience because of the contentions with vehicles.
- **Muraleetharan Thambiah, Takeo Adachi, Toru Hagiwara, Seiichi Kagaya, and Ken'etsu Uchida et al(2004)** proposed to re-design the computation of pedestrian levels of administration utilizing a factual technique. In their study, the conjoint examination system was utilized to decide how pedestrians organize the characteristics of walkways and how diverse levels of the above variables (or properties) influence their apparent level of administration on a walkway.

- **Hagiwara et. al. (2008)** explored clashes between the right-turning vehicle and the pedestrian originating from the right in the crosswalk in Japan and found that the time slack is continually reexamined amid the right turn by the driver, and the driver moderates and enters the crosswalk behind the pedestrian, if the time slack at the contention point is under 2 s. Additionally, the braking area of drivers who braked to maintain a strategic distance from clash with the pedestrian in the wake of beginning was 10.3 m before the conflict point.
- **Chen et. al. (2008)**have demonstrated that pedestrians have a solid effect on the right-turn limits at low pedestrian volumes and that the impacts of extra pedestrians diminish as the pedestrian volumes increment.
- **Bianet. al. (2009)** uncovered that the variables that essentially impact pedestrian LOS at signalized intersections included right turning vehicle and bike volume from the road parallel to the crosswalk amid pedestrian green time, tolerant left-turning vehicles and bikes drawing closer from the road parallel to the crosswalk, through bike volume on the street parallel to the crosswalk, and pedestrians' delay.
- **Venkata Chilukuri et al (2000)** tested the present mathematical statement utilized by the HCM to ascertain pedestrian postponement at signalized intersections. Chilukuri's factual examination of high and low stream rates on walkways between signalized intersections showed that the landing of pedestrians at those intersections had an essentially non-irregular example. Likewise, it is discovered that, in a composed sign system, (for example, those which exist in huge urban ranges), "pedestrians arriving arbitrarily at an intersection will move in a gathering after the sign turns green and may proceed as a noteworthy gathering towards the downstream signal." haphazardly at an intersection will

move in a gathering after the sign turns green and may proceed as a critical gathering towards the downstream signal."

- **The Turner-Fairbank Highway Research Center** report discovered that while figuring pedestrian velocity for crosswalks, the report recommends, the rate ought to be relied upon to be lower where "expansive quantities of older pedestrians" are available. In characterizing "expansive numbers," the report recommends that "extensive quantities of older pedestrians exist when the elderly extent starts to substantially influence the general pace circulation at the facility." For this situation, a material impact on the general velocity dissemination happens when the rate of elderly utilizing a crosswalk facility surpasses 20 percent.

CHAPTER 4

4.1. METHODOLOGY

The methodology is based on a quantitative method which was used in china. This methodology was chosen as China and India have large population and similar traffic characteristics. The traffic in both of these countries is heterogeneous in nature .The traffic generally consists of all types of vehicles ranging from cars, bicycles, motorcycles, small trucks etc. This methodology was proposed by the Transportation Research Board, Washington D.C.. The methodology is based on several influencing factors which will decide the value of the PLOS. The coefficients of these factors will vary from one region to another. Therefore the coefficients in this study will be found in accordance to the Indian road intersections .

The methodology is summarized as follows-

1. The road intersection to be studied was first selected. A brief idea of the type of vehicles on this road was obtained.

2. Significant influencing factors were then identified with the help of the model proposed by the Transportation Research Board, Washington D.C.

3. According to this model the PLOS is computed by the formula

$$PLOS= \alpha_1 V_{mra}+\alpha_2 V_{mla} + \alpha_3 V_{nra}+\alpha_4 V_{nla}+ \alpha_5 e^{0.0219 V_{nta}} + C$$ where,

Vmra = right-turning vehicle volume from the street parallel to the crosswalk (pcu/h)

Vmla = permissive left-turning vehicle approaching from the street parallel to the crosswalk (pcu/h)

Vnra = right-turning bicycle volume from the street parallel to the crosswalk(bic/h)

Vnla = permissive left-turning bicycle approaching from the street parallel to the crosswalk parallel to the crosswalk (bic/h),

Vnta = through bicycle volume on the street parallel to the crosswalk (bic/h),

and C = constant.

4. Then the intersection of the road was chosen. A video camera was fixed at this intersection during peak hours in the morning from 8 A.M – 11 A.M.

5. A total of six intersections were chosen .Three videos were taken at each intersection and the average values of the factors were obtained.

6. The coefficients of the Chinese road intersections are given in the table below. These coefficients have to be calibrated in accordance to Indian road intersections.

:

Table 1:

COEFFICIENTS	VALUES
α_1	0.039
α_2	0.160
α_3	0.031
α_4	-0.041
α_5	0.044
C	-0.484

7. After calibrating the coefficients according to the Indian road intersections , the PLOS of the chosen road intersections were found out.

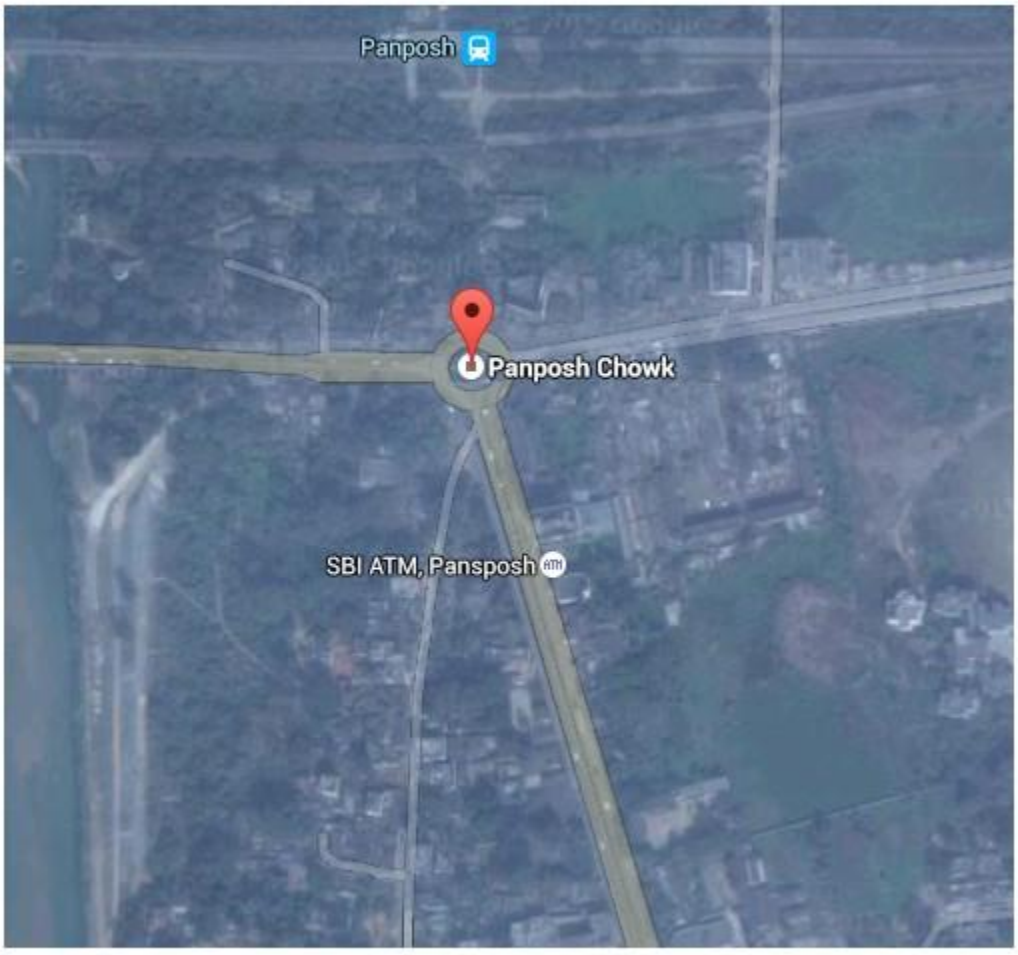
8. The range of the PLOS was defined by using K-mean clustering in the MATLAB.

9. Now the six road intersections were classified into their respective PLOS levels according to their values.

4.2. STUDY AREA

PANPOSH INTERSECTION:

Fig 1:



SECTOR 17 INTERSECTION:

Fig 2:

CHHEND CHOWK INTERSECTION:

Fig 3:

SECTOR 2 INTERSECTION:

Fig 4:

These four study areas were selected . The study areas provide a challenging environment as the traffic capacity of these roads is very high . These are the most used road intersections in Rourkela during peak hours.

CHAPTER 5

5.1. DATA COLLECTION

Panposh, Chennd, Sector-2 and Sector-17 were selected as the study area. Three videos were taken at each intersection at peak hours and the average data was collected. Two intersections of Panposh and Chennd were selected along with one intersection of Sector-2 and Sector-17 each.

PANPOSH INTERSECTION 1-

V_{mra} in pcu/h= 966

Cars	Trucks	Motorcycles	Bus	Auto
101	0	501	152.5	211.5

V_{mla} in pcu/h=954

Cars	Trucks	Motorcycles	Bus	Auto
105	301	450	50	48

V_{nra} in bic/h = 264, V_{nla} in bic/h = 90, V_{nta} in bic/h =324

PANPOSH INTERSECTION 2-

V_{mra} in pcu/h=1002

Cars	Trucks	Motorcycles	Bus	Auto
126	504	198	54	120

V_{mla} in pcu/h= 810

Cars	Trucks	Motorcycles	Bus	Auto
101	36	319	144	210

V_{nra} in bic/h= 90,V_{nla} in bic/h =114, V_{nta} in bic/h =300

SECTOR-2 INTERSECTION-

V_{mra} in pcu/h=372

Cars	Trucks	Motorcycles	Bus	Auto
72	0	177	0	123

V_{mla} in pcu/h=1224

Cars	Trucks	Motorcycles	Bus	Auto
204	108	708	18	186

V_{nra} in bic/h=174, V_{nla} in bic/h=448, V_{nta} in bic/h =200

SECTOR 17 INTERSECTION-

V_{mra} in pcu/h= 864

Cars	Trucks	Motorcycles	Bus	Auto
153	54	459	27	171

V_{mla} in pcu/h= 894

Cars	Trucks	Motorcycles	Bus	Auto
120	54	576	0	144

V_{nra} in bic/h= 120, V_{nla} in bic/h= 96, V_{nta} in bic/h= 150

CHENND INTERSECTION 1-

V_{mra} in pcu/h= 666

Cars	Trucks	Motorcycles	Bus	Auto
66	54	414	0	132

V_{mla} in pcu/h= 864

Cars	Trucks	Motorcycles	Bus	Auto
126	54	336	54	294

V_{nra} in bic/h= 90, V_{nla} in bic/h= 72, V_{nta} in bic/h= 306

CHENND INTERSECTION 2-

V_{mra} in pcu/h= 900

Cars	Trucks	Motorcycles	Bus	Auto
130	56	354	58	302

V_{mla} in pcu/h = 666

Cars	Trucks	Motorcycles	Bus	Auto
66	54	414	0	132

V_{nra} in bic/h= 72, V_{nla} in bic/h= 60, V_{nta} in bic/h =120

The conversion to pcu units was done with the help of the table given below-

CONVERSION TO PCU UNITS-

Table 2:

VEHICLE TYPE	PCU
MOTOR CYCLES AND SCOOTERS	0 .5
BICYCLES	0.5
CARS AND LIGHT COMMERCIAL VEHICLES	1
BUS, TRACTOR, TRUCK ETC.	3
3- WHEELERS	1

FINAL OBSERVATION TABLE-

Table 3:

S.no	SITE	Avg.V_{mra} in pcu/h	Avg.V_{mla} in pcu/h	Avg.V_{nra} in bic/h	Avg.V_{nla} in bic/h	Avg.V_{nta} in bic/h
1	Panposh	966	954	264	90	324
2	Panposh	1002	810	90	114	300
3	Sector-2	372	1224	174	448	200
4	Sector-17	864	894	120	96	150
5	Chennd	666	864	90	72	306
6	Chennd	900	666	72	60	120

CHAPTER 6

RESULTS AND ANALYSIS

6.1. CALCULATION OF VARIABLES:

The variables are-

$X_1 = V_{mra}$, $X_2 = V_{mla}$, $X_3 = V_{nra}$, $X_4 = V_{nla}$, $X_5 = e^{0.0219Vnta}$

Table 4:

S.no	SITE	X_1	X_2	X_3	X_4	X_5
1	Panposh	966	954	264	90	1107.65
2	Panposh	1002	810	90	114	713.37
3	Sector-2	372	1224	174	448	79.83
4	Sector-17	864	894	120	96	26.708
5	Chennd	666	864	90	72	813.21
6	Chennd	900	666	72	60	13.846

6.2. CALIBRATION OF COEFFICIENTS:

These variables were then used to find the coefficients of the model. This was done by regression in Microsoft Excel. The coefficients so obtained were thus calibrated according to Indian road intersections. The value of the coefficients are provided in the table below.

Table 5:

COEFFICIENTS	VALUES
α_1	0.006404
α_2	0.000690
α_3	0.001148
α_4	0.109880
α_5	0.001763
C	-5.38934

6.3. DEFINING THE PLOS RANGE:

The PLOS range was defined by K-mean clustering in MATLAB.

What is K-mean clustering?

K-mean clustering is a partitioning method. The function K-mean partitions data into *k* mutually exclusive clusters, and returns the index of the cluster to which it has assigned each observation. K-means treats each observation in our data as an object having a location in space. It finds a partition in which objects within each cluster are as close to each other as possible, and as far from objects in other clusters as possible.

After doing K-mean clustering, the range of the PLOS was defined which is given in the table below: Let the PLOS be Y.

Table 6:

PLOS	VALUE
A	Y<=1.5
B	1.5<Y<=2.5
C	2.5<Y<=3.5
D	3.5<Y<=4.5
E	4.5<Y<=5.5
F	Y>=5.5

6.4. CLASSIFICATION OF THE ROAD INTERSECTIONS:

Then the road intersections at different locations were classified into different PLOS levels according to the values obtained from the model.

Table 7:

S.No	SITE	PLOS LEVEL
1	PANPOSH	E
2	PANPOSH	D
3	SECTOR-2	C
4	SECTOR 17	B
5	CHENND	B
6	CHENND	B

CHAPTER 7

SUMMARY AND CONCLUSION

7.1. SUMMARY

This project was based on a quantitative model which was given by the Transportation Research. Board , Washington D.C. The quantitative model was based on certain significant factors which affected the pedestrian perception of safety while crossing the road intersections. These factors were therefore considered as variables in the PLOS formula along with their coefficients. The data regarding these factors was collected using a video camera kept at the required road intersection at peak hours. The data was then extracted from the video collected. After obtaining the variables, regression analysis was done in Microsoft Excel to find the value of the coefficients. These coefficients so obtained are in accordance with the Indian road intersections. The range of the PLOS was then defined in accordance to Indian roads by using K-mean clustering tool in MATLAB. After getting the ranges, the PLOS was calculated for the different study areas and then the study areas were classified according to this range into different PLOS levels.

7.2. CONCLUSION:

- The six road intersections were classified into different PLOS levels. The Panposh intersections1 and 2 were classified as PLOS levels E and D respectively. Normally urban road intersections have PLOS level varying between C and E . The classification shows that the road intersections at Panposh are not pedestrian friendly. There is probability of high level of conflict between pedestrians and other vehicles. The number of heavy vehicles plying on the road is very high. The width of the lanes are also high which leads to less perception of safety in the minds of the pedestrians. Thus this road intersection has a low degree of comfortability.
- The road intersection at Sector -2 was classified in the PLOS level C. This level is common in urban roads. The pedestrians face moderate level of conflict. The traffic flow speed as well as capacity is also moderate . More bicycles and motor vehicles travel by this road . The width is also comparatively less. The road intersection has a moderate degree of comfortability.
- The road intersection at Sector -17 was classified in the PLOS level B. The traffic flow is uniform . Very less number of heavy vehicles travel by this road. High incidence of bicycles and three wheelers was observed in this road. The width of the lanes is less . Thus the road is having a high degree of comfortability.
- The road intersections 1 and 2 of Chennd were classified in the PLOS level B. These intersections are pedestrian friendly. The pedestrians are prone to very less level of conflict. The traffic flow speed is less and the flow is uniform. Thus the road is having a high degree of comfortability.

- The results of this study can be used in the future by traffic engineers to enhance the pedestrian safety on these roads. The traffic engineers can decrease the width of the lanes, install pedestrian friendly sidewalks etc to increase the perception of safety among the pedestrians.

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