ANALYSIS AND DESIGN OF PEDESTRIAN LEVEL OF SERVICE ON NH-146 IN FRONT OF SATI VIDISHA (M.P.)

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Abstract : Walking is one of the most significant travel modes in urban & sub-urban areas. However, the concerns towards pedestrian comfort and safety are always skipped in transportation planning, designing, execution and management. Present study has concern for various factors affecting Pedestrian Level of Service (PLOS) at mid-block un-signalised intersection in front of SATI Main Gate on NH-146, Vidisha and to propose a suitable layout for pedestrian level of service at Midblock un-signalised intersection which is in between two intersections (L/s Durga Nagar, R/s Ahmadpur) in Vidisha District on NH-146 of Madhya Pradesh based on pedestrian's perception on safety and comfort. It is found that the factors influencing level of service under assorted traffic condition were turning traffic pattern, uninterrupted traffic, number of lanes, and number of pedestrian and pedestrian delay. The study was conducted during office hours (9:30 AM - 5:30 PM) From 23-07-2018 to 28-07-2018. Total 18,417 crosswalks from both directions were observed during this period. LOS, is determined in this study using IRC-103:2012 the intersection falls under Level of Service (LOS) – E. based on above study, it is recommended to provide the Pedestrian Facilities such as zebra crossing, rumble strips, proper signage's including speed restriction signboards considering the present space available.

***Index Terms* – Level Of Service, Midblock Intersection, Pedestrian Delay.**

I. INTRODUCTION

1.1 GENERAL

The Pedestrians are one of the main commuters on urban roads of India. In India, pedestrian safety and comfort is mostly neglected during transportation planning and management. As the number of pedestrians is increasing day by day, therefore, proper planning for providing good facilities to pedestrians are majorly required and development of new models regarding pedestrian facilities in view of Indian conditions needs to be assessed.

In India, urbanization began to accelerate exponentially which results major increment in urban population because interest towards live in cities & urban areas increasing. As per Census Survey-2011, the urban population is 31% i.e. 387 million of the total population of India. The urbanization in India is taking place at a very faster rate, therefore, better facilities should be provided to pedestrians from the beginning stage itself.

The performance of entire road network is totally depends on the good operation condition of junction/intersection. In India, many people are facing problems due to inappropriate planning and absence proper pedestrian facilities on intersections. The pedestrian volume has been increased considerably in large numbers on intersections in urban areas as compared to rural areas in India. Therefore, pedestrian importance, safety and comfort shall be considered while designing the intersections. In India, the risk of collision and accidents is more as vehicles & pedestrians use the same movement space at the same time. The proper safety and remedial measures shall be taken to improve the safety, comfort and quality of roads.

1.2 LOCATION OF STUDY

Vidisha is a city in the state of Madhya Pradesh, India. Vidisha district, is situated in the central part of the state and eastern part of the fertile Malwa region. It lies between latitude 23º20' and 24º22' North and longitude 77º15' and 78º18' East. The shape of this district is more or less elliptical and the longer axis lies from north-west to south-east with slight projections on the north, north-west, south and south-west. Its greatest length from north-west to south-east is about 133.6 km. And the greatest width from north-east to south-west is about 96 km.

Here, the location of the study is Mid-Block Un-signalised Intersection in front of SATI College on NH-146, Vidisha District. This study has been carried out for determining the Pedestrian Level of Service on Mid-Block Un-signalised Intersection. The Pedestrian count data of both directions have been collected. The various patterns of pedestrian crossings on the

intersection also measured. The basic aim of the study to reduce the pedestrian conflicts with the vehicular traffic to the minimum and providing solution to improve the quality of the pedestrian network should take children, elderly persons, persons with disabilities and people with heavy luggage into account.

Figure : Selected area for study (Google map)

1.3 NEED OF STUDY

There is lack of proper policies regarding pedestrians crossing facilities & safety in our country. Most of the studies which were carried out pertain to foreign conditions and the scenario on roads in India is totally different from there as we have mix and untidy traffic conditions.

1.4 CONCEPT OF PEDESTRIAN LEVEL OF SERVICE

The planning and design methods for the pedestrian suggested by many researchers are based primarily on vehicular flow traffic theory. Additional environmental factors that contributes to the walking experience and therefore to the perceived level of service, such as comfort, convenience, safety, security and attractiveness, should also be considered. Within the pedestrian level of service definition, SIX levels of service can be expressed as under:

(i) LOS A is a pedestrian environmental where ideal pedestrian conditions exist and the factor that negatively affect pedestrian LOS are minimal.

(ii) LOS B indicates that reasonable pedestrian conditions exist but a small number of factors impact on pedestrian safety and comfort. As LOS A is the ideal, LOS B is an acceptable standard.

(iii) LOS C indicates that basic pedestrian conditions exist but a significant number of factors impact on pedestrian safety and comfort.

(iv) LOS D indicates that poor pedestrian conditions exist and the factors that negatively affect pedestrian Level of service are wide-ranging or individually severe. Pedestrian comfort is minimal and safety concerns within the pedestrian environment and evident.

(v) LOS E indicates that the pedestrian environment is unsuitable. The situation occurs when all or almost all of the factors affecting pedestrian level of services are below acceptable standards.

(VI) LOS F, all walking speeds are severely restricted, and forward progress is made only by shuffling. There is frequent, unavoidable contact with other pedestrian. Cross and reverse-flow movement are virtually impossible. Flow is sporadic and unstable.

1.5 UNSIGNALISED INTERSECTION

Un-signalized intersections are the most common intersection type. However, the capacity of theses intersections may be lower as compare to other intersections; they do play a dominant role in controlling the traffic of a network. A poorly operating un-signalized intersection may affect a signalized network or the operation of an Intelligent Transportation System. The theory of the operation of un-signalized intersections is fundamental to many elements of the theory used for other intersections. For instance, queuing theory in traffic engineering used to analyze un-signalized intersections is also used to analyse other intersection types.

II. LITERATURE REVIEW

Ravishankar, (2018) conducted a study on Pedestrian Risk Analysis at Uncontrolled Mid-Block and Un-Signalised Intersection. Her research paper which was published in IJESRT (International Journal of Engineering Science and Technology) explained Transportation is defined as port to port transfer of person or goods by a medium which can be a vehicle or a person. Pedestrians being the most neglected mode of transportation in terms of safety and facility, face difficult situations while crossing near intersections and midblock crossings. It becomes more of a risk when the place of crossing is uncontrolled. But if behaviour of pedestrians while crossing is analysed in such conditions, it might be possible to create suitable solution to lessen the risk and ensure safety. In most of the cities, accepting suitable gaps between vehicles in uncontrolled midblock and intersection crossings pose threat to pedestrians' safety. The present study examines the safety of pedestrian crossing behaviour at midblock and un-signalised intersection crossings.

Wahane, (2017) This study aims to find out the factors influencing pedestrian level of service (PLOS) signalized intersections in Bhopal city based on pedestrian perception on safety and comfort. Pedestrian questionnaire survey was conducted to collect pedestrian overall satisfaction level in terms of safety, comfort and convenience for each crossing at signalized intersection based on pedestrian's experiences at the actual sites. Also video graphic method was used for Field survey of each crosswalk at selected five signalized intersection. A significant number of ratings were given by pedestrian for each intersection. Pearson correlation analysis was done to identify the various significant factors influencing pedestrian level of service. The factors such as Left turning traffic, Right turning traffic, number of pedestrians, number of lanes and pedestrian delay. Pedestrian delay was one of the key performance indicators for pedestrian level of service.

Vijayvargiya, (2017) conducted a study on Identification of Factors Affecting Pedestrian Level of Service of Crosswalk at Roundabouts. His research paper was published in IJESRT (International Journal of Engineering Science and Technology) explained Walking is the most basic mode of commute and is an essential part of transportation. Every trip essentially starts or ends with a walk trip. Over the years, it has been realized that in order to encourage walking and non-motorized transport and reduce the use of personal vehicles, pedestrian facilities need to be provided keeping in mind the requirements of the users and also improving the serviceability of the facilities. Roundabouts form an integral part of the road network and offer many advantages over conventional signalized and un-signalized intersections. Crosswalks are a critical element of pedestrian infrastructure at roundabouts. For improving the level of service of crosswalk facilities and enhancing the level of safety and comfort perceived by the users, identification of factors which significantly affect pedestrian level of service at crosswalks is very important. Only after the identification of these factors, measures can be taken to improve the facility. In this paper, review of existing literature on pedestrian level of service of crosswalks has been done and significant factors are identified.

Jain and Gupta, (2014) Pedestrian crossing behavior is analyzed for the provision of proper pedestrian facilities at desired locations, as well as to improve their safety while crossing the road. This paper presents the analysis of pedestrian crossing behavior from a study conducted at Roorkee city (Uttarakhand state in India). The effect of pedestrian characteristics like age, gender and that of carrying baggage and luggage as well as their crossing patterns were examined on pedestrian flow characteristics like crossing speed and waiting time. Pedestrian safety was also analyzed with respect to safety margins and gaps accepted by pedestrian in traffic stream. Crossing patterns were observed for different age group and gender.

Vedagiri and Marisamynathan, (2013) conducted a study on calculating pedestrian delay at signalized intersection for Indian conditions which can be used for calculation of pedestrian level of service. This study divided the total delay into waiting time delay, crossing time delay and pedestrian-vehicle interaction delay. Muraleetharan et al. (2005) presented different factors influencing pedestrian level of service along crosswalks and at intersection. The main factors are space at corner, crossing facilities, turning vehicles and delay and their extent of influence and also concluded that at intersection turning vehicle conflicts are the main influencing factor.

In past few years, due to rapid growth of city's population and modernization number of road users increases day by day. In olden days the city population was not that much and the roadways of that time was also not as much as busy today. One of the major reason behind the increasing rate of city is that, the city is located very near to the capital of the state Bhopal also buddist international tourism stupas are located at Sanchi with a distance of 12 km from Vidisha city. According to the census of the year 2011, the population of the only Vidisha city was 1,55,951 the population growth rate of the city is +2.2% per year. If population growth rate would be same as in the period 2001-2011, Vidisha's population in 2018 should be about 1,80,000.

The most deadly locations on our roads are the intersections. A study found that pedestrian accidents occurs due to irregular

crossing on intersections. Due to the high level of risk that has been present on our roads for decades, design of Zebra Crossing in intersection must be necessary not only for providing proper way for pedestrians but also for a safe journey. Although safety counter-measures can vary greatly depending on local issues and site issues.

III. METHODOLOGY

3.1 TWO WAY STOP CONTROL INTERSECTION METHODOLOGY

The TWSC intersection methodology for the pedestrian mode is applied through a series of steps requiring input data related to vehicle and pedestrian volumes, geometric conditions, and motorist yield rates to pedestrians. These data are used to calculate the average pedestrian delay associated with pedestrian crossings of un-signalize and non-STOP-controlled roadways. The methodology for calculating the pedestrian LOS of a pedestrian crossing of major street at TWSC intersection under the following circumstances: -

- **Scenario A:** Unmarked crosswalk, no median refuge island;
- **Scenario B:** Unmarked crosswalk, median refuge island; and
- **Scenario C:** Marked crosswalk with high-visibility treatments, median refuge island.

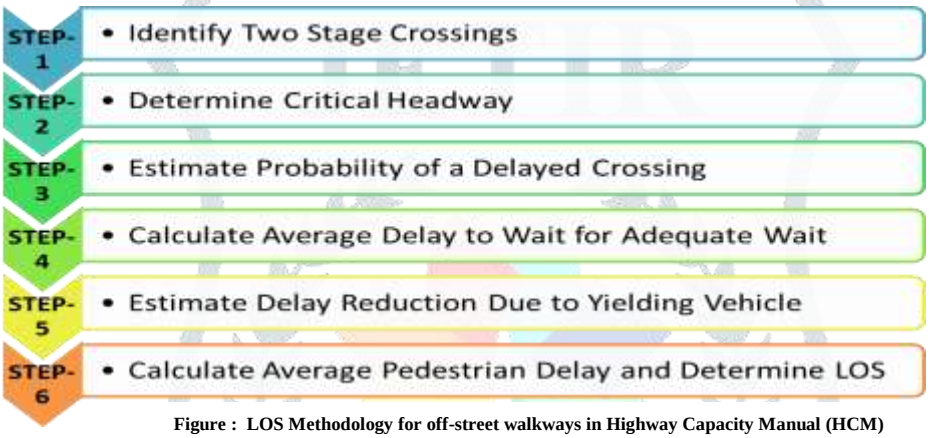


Figure : LOS Methodology for off-street walkways in Highway Capacity Manual (HCM) 2010

Step 1: Identify Two-Stage Crossings

When pedestrians cross in two stages, pedestrian delay should be estimated separately for each stage of the crossing by using the procedures described in Steps 2 to 6. To determine pedestrian LOS, the pedestrian delay for each stage should be summed to establish the average pedestrian delay associated with the entire crossing. This service measure is used to determine pedestrian LOS for a TWSC intersection with two-stage crossings.

Step 2: Determine Critical Headway

The procedure for estimating the critical headway is similar to that described for automobiles. The critical headway is the time in seconds below which a pedestrian will not attempt to begin crossing the street. Pedestrians use their judgment to determine whether the available headway between conflicting vehicles is long enough for a safe crossing. If the available headway is greater than the critical headway, it is assumed that the pedestrian will cross, but if the available headway is less than the critical headway, it is assumed that the pedestrian will not cross.
For a single pedestrian, critical headway is computed with Equation:-

$$t_c = \frac{L}{S_p} + t_s$$

Where,
tc = critical headway for a single pedestrian (s),
Sp = average pedestrian walking speed (ft/s),
L = crosswalk length (ft), and
ts = start-up & end clearance time of pedestrian (s).

Step 3: Estimate Probability of a Delayed Crossing

On the basis of calculation of the critical headway tc, the probability that a pedestrian will not incur any crossing delay is equal to the likelihood that a pedestrian will encounter a gap greater than or equal to the critical headway immediately upon arrival at the intersection.

Assuming random arrivals of vehicles on the Major Street, and equal distribution of vehicles among all through lanes on the major street, the probability of encountering a headway exceeding the critical headway in any given lane can be estimated by using a Poisson distribution. The likelihood that a gap in a given lane does not exceed the critical headway is thus the complement as shown in Equation below.

$$P_b = 1 - e^{\frac{-t_{c,G}v}{L}}$$

Because traffic is assumed to be distributed independently in each through lane, the below equation shows the probability that a pedestrian incurs non-zero delay at a TWSC crossing.

$$P_d = 1 - (1 - P_b)^L$$

Where,
Pb = probability of a blocked lane,
Pd = probability of a delayed crossing,
L = number of through lanes crossed,
tc,G = group critical headway (s), and
v = vehicular flow rate (veh/s).

Step 4: Calculate Average Delay to Wait for Adequate Gap

Research indicates that average delay to pedestrians at un-signalized crossings, assuming that no motor vehicles yield and the pedestrian is forced to wait for an adequate gap, depends on the critical headway, the vehicular flow rate of the subject crossing, and the mean vehicle headway. The average delay per pedestrian to wait for an adequate gap is given by Equation below.

$$d_g = \frac{1}{v}\left(e^{vt_{c,G}} - vt_{c,G} - 1\right)$$

Where,
dg = average pedestrian gap delay (s),
tc,G = group critical headway (s), and
v = vehicular flow rate (veh/s).

Step 5: Estimate Delay Reduction due to Yielding Vehicles

The study area comes under Scenario A and under Scenarios A and B, the motorist yield rates are approximately 0%. Therefore, there is no reduction in delay due to yielding vehicles, and average delay is the same as that shown in Step 4.

Step 6: Calculate Average Pedestrian Delay and Determine LOS

The delay experienced by a pedestrian is the service measure. The table given below shows the LOS criteria for pedestrians at TWSC intersections based on pedestrian delay. Pedestrian delay at TWSC intersections with two-stage crossings is equal to the sum of the delay for each stage of the crossing.

3.2 LEVEL OF SERVICE CRITERIA

Pedestrian LOS at intersections is defined for pedestrians crossing a traffic stream not controlled by a Stop sign; it also applies to midblock pedestrian crossings. LOS criteria for pedestrian are given in Table below.

Table 3.1: PLOS criteria in IRC:103-2012

LOS	Waiting time (Seconds)	Comments
A	≤3	Usually no confliction traffic
B	>3 and 13≤	Occasionally some delay due to conflicting traffic
C	>13 and 38≤	Delay noticeable to pedestrians, but not inconveniencing
D	>38 and 64≤	Delay noticeable and irritating, increased likelihood of risk taking
E	>64 and 90≤	Delay approaches tolerance level, risk-taking behaviour likely
F	≥90	Delay exceeds tolerance level, high likelihood of pedestrian risk taking

LOS F for pedestrians occurs when there are not enough gaps of suitable size to allow waiting pedestrians to cross through traffic on the major street safely. This situation is typically evident from extremely long control delays. The method is based on a constant critical headway. In the field, however, LOS F may also appear in the form of crossing pedestrians selecting smaller-than-usual gaps. In such cases, safety could be a concern that warrants further study.

IV. DATA COLLECTION

The data from primary & secondary sources have been utilized during study. However, as the research on pedestrian level of service in the study area is altogether a new study the study mainly depends on the primary sources for data & information.

4.1 Primary Data Collection

Manual method of data collection has been applied in this study. The data has been collected about the basic guidelines considered during the study. The study covers both morning and evening peak hour to analyse the existing movement pattern, pedestrian occupancy/crossing on the basis of traffic, crossing facilities and pedestrian delay at intersection. Mid-Block Crossing intersection was selected to count the amount of crossing for the period of 06 Days from 09:30 AM to 05:30 PM (08 hours) namely SATI Mid-Block Intersection on NH-146. The survey was conducted for the necessity of achieving the objective of considering exclusive pedestrian phasing. In this survey, direction wise amount of pedestrian crossing, number of pedestrians, Gender-wise occupancy, Age-wise occupancy, hourly variation of pedestrian, peak-hour pedestrian occupancy were surveyed. As the population of Vidisha city is high, therefore, large no. of pedestrian gather in most of the intersections of Vidisha city. For the lack of timing it could not possible to count pedestrian crossing at every un-signalized intersections of Vidisha city.

The characteristics for such study truly shows the requirement of side & cross walk, presence of road markings, signage requirement and safety assurance on intersection are measured during the field survey.

4.2 Data Extraction and Analysis

The survey was carried out to estimate the number of pedestrians crossing the street and for taking into account both the directional volume of pedestrians. The stretch namely National Highway No. 146 (L/s Bhopal & R/s Sagar) is a two lane road; the place consist buildings on either side along the stretch. The maximum pedestrian crossing was observed between 13:30 to 14:30 hours and the count was 3,667 pedestrians.

4.3 Day-wise Pedestrian Count

The Pedestrian Volume Count was carried out for 08 hours between 09.30 am to 05.30 pm in a period of 06 days from 23.07.2018 to 28.07.2018. The following data have been collected during pedestrian volume count: -

1. Hourly Variation of Pedestrian Volume
2. Gender-wise Pedestrian Volume
3. Age-wise categorization of Pedestrian Volume
4. Peak Hour density
5. Maximum Pedestrian Crossing

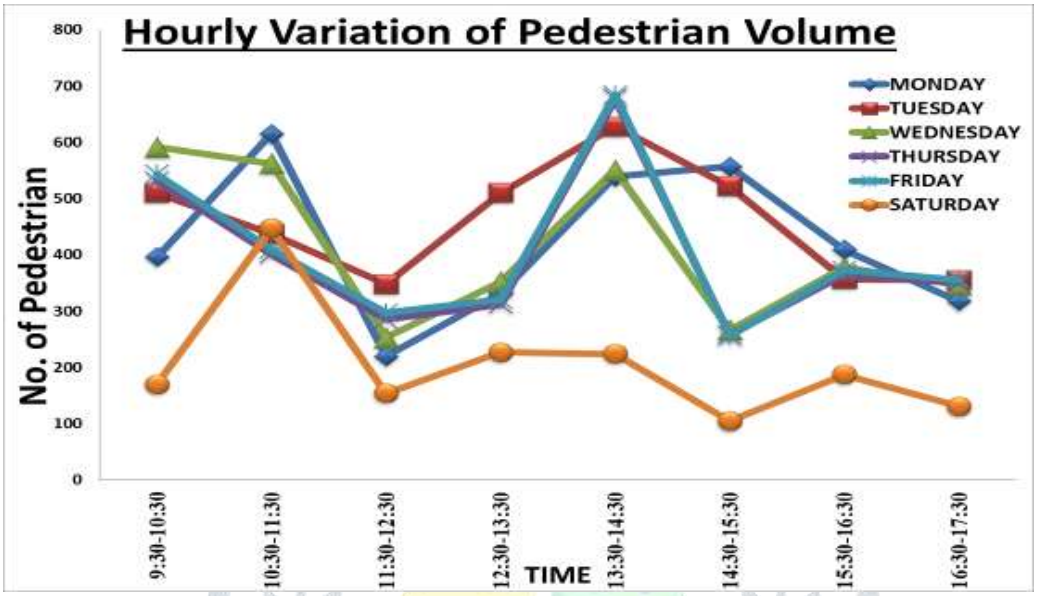
During volume count, it is observed that **3667 and 1645 number of** pedestrians crosses the study area on Tuesday and Saturday respectively. It is evident that large number of pedestrian crosses the road on Tuesday compared to other days.

Table 4.1 : Average Hourly Variation of Pedestrian Volume

	Date	23.07.18	24.07.18	25.07.18	26.07.18	27.07.18	28.07.18	Total	Average
Sr. No.	Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday		
1	**9:30-10:30**	396	510	591	531	543	170	**2741**	**457**
2	**10:30-11:30**	615	437	562	401	410	447	**2872**	**479**

Table 4.1 : Average Hourly Variation of Pedestrian Volume

Sr. No.	Date / Time	23.07.18 Monday	24.07.18 Tuesday	25.07.18 Wednesday	26.07.18 Thursday	27.07.18 Friday	28.07.18 Saturday	Total	Average
3	**11:30-12:30**	220	348	253	285	297	154	**1557**	**260**
4	**12:30-13:30**	332	510	352	312	321	227	**2054**	**342**
5	**13:30-14:30**	539	628	551	677	684	224	**3303**	**551**
6	**14:30-15:30**	557	522	267	258	256	105	**1965**	**328**
7	**15:30-16:30**	409	357	378	365	373	187	**2069**	**345**
8	**16:30-17:30**	318	355	347	349	356	131	**1856**	**309**



Graph 4.7: Daily Distribution Graph

4.4 Pedestrian Delay & Pedestrian Level of Service

The HCM-2010 pedestrian delay model is often utilized to calculate pedestrian delays. The pedestrian delay basically depends completely on the vehicle and pedestrian volume. The Level of Service (following LoS) is a measure used by traffic engineers to determine the effectiveness of elements of transportation infrastructure. The Highway Capacity Manual using letters 'A' to 'F', with 'A' being the best and 'F' being the worst. The Highway Capacity Manual 2010 (HCM 2010) also gives the LoS criteria for different pedestrian facilities. The basis of the pedestrian LoS the density (P/m^2), space (m^2/P) and the average speed (m/s). The LoS categories of waiting, standing and the moving pedestrian are different.

The Study area falls under Scenario - A (i.e. unmarked crosswalk, no median refuge island); the calculation of PLOS for a pedestrian crossing at Mid-block un-signalised intersection in study area is presented as below: -

4.5 Data Input

- Two lane with paved shoulders National Highway;
- 2,176 peak hour vehicles, bidirectional;
- Crosswalk length without median = 52.49ft (i.e. 16.0mt);
- Observed pedestrian walking speed = 4.10ft/s (i.e. 1.25 m/s);
- Pedestrian start-up & clearance time = 4.05 s; and
- No. of through lanes crossed = 2;

4.6 Data Analysis:

Step 1: Identify Two-Stage Crossings

Since the study area falls under 'Scenario-A' due to unmarked cross walk and as no median refuge is available. It is mentioned that study area comprises two lane configurations; therefore, it gives the two stage crossing opportunity to the pedestrians. In view of two stage crossing opportunity, two equidistant pedestrian crossings of 26.245 ft will complete the total cross length of study area. Hence, Cross walk length in this scenario would be 26.245 ft.

Step 2: Determine Critical Headway

Because there is no pedestrian platooning, the critical headway is determined by following equation: -

$$\mathbf{t}c = L/Sp + ts \Rightarrow 26.245/4.1+4.05 = \mathbf{10.45}\ \text{Sec} \quad \text{---------- (i)}$$

Where,

t_c = critical headway for a single pedestrian (s),
S_p = average pedestrian walking speed (ft/s),
L = crosswalk length (ft), and
t_s = start-up & end clearance time of pedestrian (s).

Step 3: Estimate Probability of a Delayed Crossing

The following equations are used to calculate P_b, the probability of a blocked lane, and P_d, the probability of a blocked crossing, respectively.

For the two-stage crossing, without any information on directional flows, one-half the volume is used i.e. (2176/2=> 1088) and v is therefore (1,088 veh/h)/(3,600 s/h) = 0.30 veh/s.

Scenerio-1: Calculation considering study area Three Lane i.e. Carriageway Width = 10mt, No. of through lane (L) = 3

$$\mathbf{P}b = 1 - \exp[(-tcg * v)/L)] \Rightarrow 1 - \exp((-10.45*0.30)/3) = \mathbf{0.65} \quad \text{---------- (ii)}$$

Scenerio-2: Calculation considering study area Two Lane i.e. Carriageway Width = 10mt, No. of through lane (L) = 2

$$\mathbf{P}b = 1 - \exp[(-tcg * v)/L)] \Rightarrow 1 - \exp((-10.45*0.30)/2) = \mathbf{0.79} \quad \text{---------- (iii)}$$

Scenerio-1: Calculation considering study area Three Lane i.e. Carriageway Width = 10mt, No. of through lane (L) = 3

$$\mathbf{P}d = 1 - [1-Pb]^{L} \Rightarrow 1 - (1-0.65)^{3} = \mathbf{0.95} \quad \text{---------- (iv)}$$

Scenerio-2: Calculation considering study area Two Lane i.e. Carriageway Width = 10mt, No. of through lane (L) = 2

$$\mathbf{P}d = 1 - [1-Pb]^{L} \Rightarrow 1 - (1-0.79)^{2} = \mathbf{0.99} \quad \text{---------- (v)}$$

Where,

$\mathbf{P_b}$ = probability of a blocked lane,
$\mathbf{P_d}$ = probability of a delayed crossing,

L = number of through lanes crossed,

$\mathbf{t_{c,G}}$ = group critical headway (s), and

v = vehicular flow rate (veh/s)

Step 4: Determination of Average Delay with respect to Wait for adequate Gap

The average gap delay d_g and average gap delay when delay is non-zero d_{gd} are calculated from following equation: -

$$\mathbf{d}g = 1/v((Exp(v*tc,G) - v* tc,G -1)) => 1/0.30*((EXP(10.45*0.30)-10.45*0.30-1)) = \mathbf{64.18\ Sec} \text{--- (vi)}$$

Where,

d_g = average pedestrian gap delay (s),

$t_{c,G}$ = group critical headway (s), and

v = vehicular flow rate (veh/s).

Step 5: Delay Reduction calculation with respect to motor vehicle yield

Under Scenarios A and B, the motorist yield rates are approximately 0%. Therefore, there is no reduction in delay due to yielding vehicles, and average delay is the same as that shown in Step 4. As the study area falls under Scenario A, therefore, motorist yield rates are approximately 0%.

Step 6: Calculate LOS

The Manual gives the LoS categories for un-signalized intersection as per Table given below for the whole crossing; at un-signalized intersection the delays can be moderate for pedestrians.

On Mid-Block un-signalised junctions, zebra crossing provision should be mandatorily followed because it allows the pedestrian to have sufficient right-of-way to move. Presently, it is observed that no zebra crossing exists in study area; therefore, improper pattern of pedestrian crossing has been seen throughout the survey.

LOS	Waiting time (Seconds)	Comments
A	≤3	Usually no confliction traffic
B	>3 and 13≤	Occasionally some delay due to conflicting traffic
C	>13 and 38≤	Delay noticeable to pedestrians, but not inconveniencing
D	>38 and 64≤	Delay noticeable and irritating, increased likelihood of risk taking
E	>64 and 90≤	Delay approaches tolerance level, risk-taking behaviour likely
F	≥90	Delay exceeds tolerance level, high likelihood of pedestrian risk taking

Table 4.2: Different Pedestrian Level of Service at Road Crossing based on Pedestrian Delay (s) (IRC: 103-2012)

VI. RESULTS

SR. NO.	ANALYSIS	RESULT	Comments
1.	Pedestrian crossing in peak hours	3,667 pedestrians	The maximum pedestrian crossing was observed between 13:30 to 14:30 hours
2.	Occupancy of Pedestrian	Younger Aged - 69%, Middle Aged - 24% Older Aged - 7%.	The occupancy of younger aged pedestrian is on a very higher side whereas occupancy of middle aged & older aged is comparatively very low

3.	Alertness of Pedestrian	Young Aged - 51%, Middle Aged - 71% Old Aged - 95%.	Older aged pedestrians are very alert compare to younger & middle aged pedestrian
4.	Impact of age	The traffic rules obey also depends on the age group of pedestrians. It is observed that, young people intend to violate the rules more frequently than the older ones.	
5.	Road crossing frequency	62% pedestrians are crossing this road every day for reaching SATI, Vidisha while 38% pedestrian crosses the road for other purposes	The maximum number of pedestrian crossing frequency is from students who are studying in the college.
6.	Pedestrian Waiting Time	As per above calculation, it is clearly evident that the average pedestrian waiting time is 69.43 Seconds	
7.	Pedestrian Level of Service	The Pedestrian LOS under Scenario A is LOS E in reference to the Table 1.2 of IRC: 103-2012.	

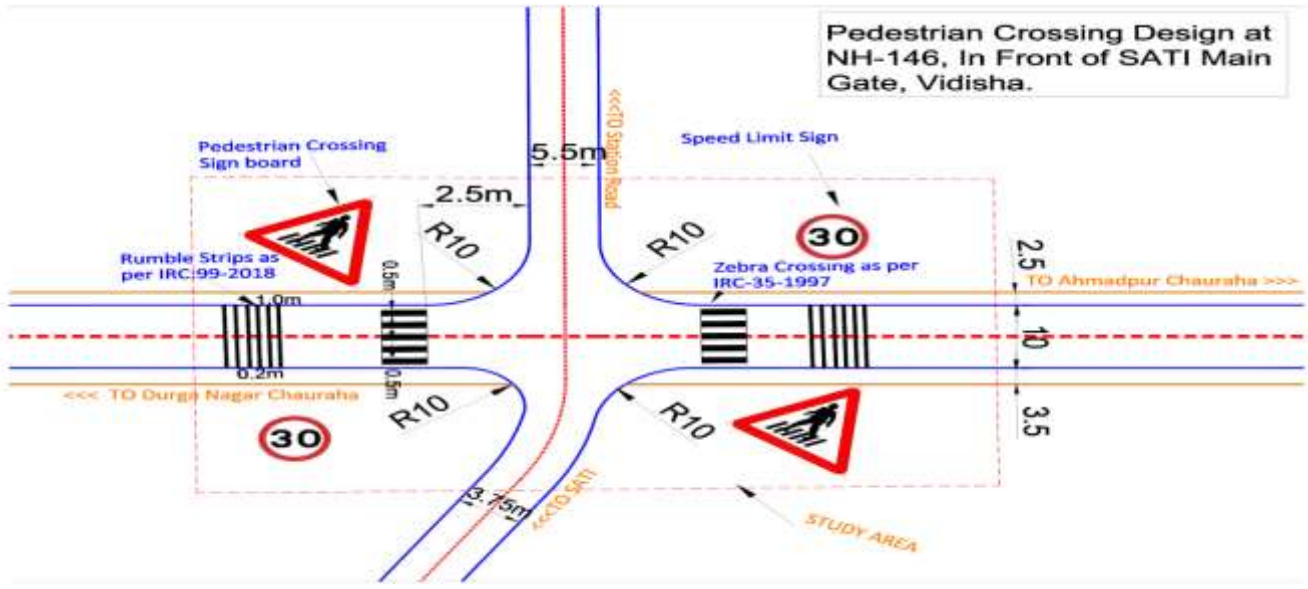
VII. CONCLUSIONS

On the basis of survey, it is clearly evident that the study area is a segment of National Highway No. 146; therefore, high volume traffic crosses the study area very frequently. In view of the above data analysis, it can be say that the study area falls under 'LOS-E' in reference to the Table 1.2 of IRC: 103-2012 and big pedestrian delay is happening in the absence of Zebra Crossing and proper signage's. At LOS category 'E' there is 64–90 seconds waiting time, which is big delay and many pedestrians' crosses irregularly. Further, it is concluded that provision of zebra crossing at road intersection is mandatory which enable pedestrians to cross with ease as vehicles are supposed to stop before 20-50 feet (6.0 – 16.0mt) the Stop Line marking.

VIII. RECOMMENDATION

- Mid-Block Crossing must be provided for pedestrian to cross the street safely from one direction to enter SATI College on opposite side of the street.
- At-grade pedestrian crossing both near intersection and mid-block should be made mandatory in view of heavy volume of vehicular traffic of National Highway.

Further, the following pedestrian facilities are hereby recommended to implement in the study area.



SCOPE FOR FUTURE WORK

The present study is conducted on mid-block un-signalised intersection. Therefore, it poses enormous potentials to be further studied and recommend best options such as:-

- Provision of refuge Island.

- In view of increasing rate of pedestrian crossings day by day, there will be a possibility of achieving the LOS-F in future.
- Design of Traffic Signal.
- Design of FOB (Foot Over Bridge).
- Design of Side walk.

Such research may enrich the quality of traffic management system for the worthy traffic congested area.

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