TRAFFIC FLOW CHARACTERISTICS IN MIXED TRAFFIC CONDITION DUE TO PEDESTRIAN CROSSING AT MID-BLOCK SECTION

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Abstract: In the developing countries like India the safety issue are very least for pedestrians, which is the most vulnerable road user in urban transportation system. The present study is conducted to measure the effect of pedestrian crossing at non signalized mid-block location in mix traffic condition at city Indore Madhya Pradesh.

The impact of pedestrian crossing on capacity and level of service of urban road, at designated or un-designated location at mid-block section is not present in the HCM nor in the IRC guidelines. Pedestrians crosses the road to save their time at undesignated section of the road which undesirably affects the movement of traffic. in the present study three mid-block location is selected in the city and traffic survey are done at base section i.e. where no pedestrian cross flow occurs and at friction section where pedestrian cross flow occurs. The speed-volume data are calculated from field survey data for finding out the capacity of base and friction section.

Then the basic model equation was generated for different class of vehicle at all selected mid-block location, also the mathematical relationship was developed showing the drop in capacity due to pedestrian cross flow. From the result it can be concluded that there is clear drop found in the mean speed of the vehicle, increase in the density and reduction in the traffic flow with the pedestrian crossing condition. Additionally, the pedestrian crossing facilities are recommended based on the traffic and flow analysis result outcome.

Index Terms - **Mid-block section, urban mid-block capacity, pedestrian flow, Traffic density, pedestrian crossing, passenger car unit.**

I. INTRODUCTION

Pedestrian are always considered as primary component in the urban Transportation system. In recent years the growth in urban traffic is major problem for every developing nation. Due to growth in the traffic, wellbeing of the pedestrian movement is not as safest as were in early times. Most of the casualties reported of the pedestrian while crossing the road either at intersection or mid-block section.

A mid-block section are locations between intersections where marked crosswalks have been provided. They provide designated location for pedestrian to cross the road when the distance between the two consequent intersection is more. The crosswalk may be signalized or unsignalized. A protected Mid-block crossing often include refuge islands with signalized crosswalk, which provide safety for pedestrians crossing two-way traffic. In the developing country like India where the mixed traffic condition exists ill legal midblock crossing rising by faster rate.

Pedestrian can safely use signalized crosswalk to cross the road, but due to pedestrian crossing through these invariably undesignated locations where there is no pedestrian crosswalk available two of the major problem arise first pedestrian put themselves at risk of accident and second it affects the traffic characteristics such as traffic flow, vehicle speed, capacity of section, travel time etc.

Crossing can be classified as of two types At-grade crossing and Grade separated crossing. In the grade separated crossing pedestrian are completely keep apart to the vehicular traffic by that there is no effect on traffic characteristics. For providing the grade separated facilities mainly these two-criteria traffic volume and pedestrian flow are considered, when the distance between the two-gap separated crosswalk is more therefore the travel time increases for pedestrian which sometimes enforced them for change their road crossing choice and they find use forced vehicle gaps at un-protected midblock to cross the road. However, it is very rare for pedestrians to identify appropriate vehicle spaces in heterogenous traffic conditions, which causes more interference between the vehicle and the pedestrians and that strictly affects the traffic flow characteristics at mid-block section of the road.

II. LITERATURE REVIEW

Bak, R., & Kiec, M. (2012) They stated when pedestrian volume is more than 400 ped/Hour semi actuated traffic signal should be considered. When higher percentage of driver give way to pedestrian thereafter the influence of pedestrian crossing on road capacity is stronger. **Dhamaniya A. Et Al. (2019)** They perceived that there is not much difference in the 85th percentile speed for different class of vehicle but there is significant drop in the 50th and 15th percentile speed. The Pedestrian Crossing Negatively Affects the Capacity of Friction Section and Drop in Traffic Capacity Calculated 14.37% Less as Of the Base Section. **Kadali B. Et Al. (2016)** Their study suggests that if the pv^2 is of 5×10^8 or greater requires a midblock crosswalk with zebra marking. They also concluded that selected adjustment factor for availability of footpath, signboard, safety margin, pedestrian behavior during road crossing have a significant impact on crosswalk facility design at multilane road crossing. **Sadrayi, A. Et Al. (2016)** They recommended that PRI should be installed in midblock whenever the traffic volume in each lane found to be less than 750 vehicle/Hour and PRI reduces the probability of fatal accident by less than 10%.In all pairs of vehicle volume and pedestrian PRI result in drop in the speed of vehicle additionally for PRI all volume pairs result in reducing fatal accident. **Chandra S. Et Al. (2003)** found out that the capacity of a 7.2 m wide road is estimated to be 2818 PCU/Hour which is slightly larger than the value specified in HCM-1994 but much lower than the value of 3200 PCU/Hour suggested in HCM-2000. **Zheng, C. Et Al. (2016)** concluded that when pedestrian crossing freely, error between model calculation and software simulation is within 2% when pedestrian flow is 1000 P/Hour. under uncontrolled pedestrian crossing error is within 5% when pedestrian flow is 800 P/.
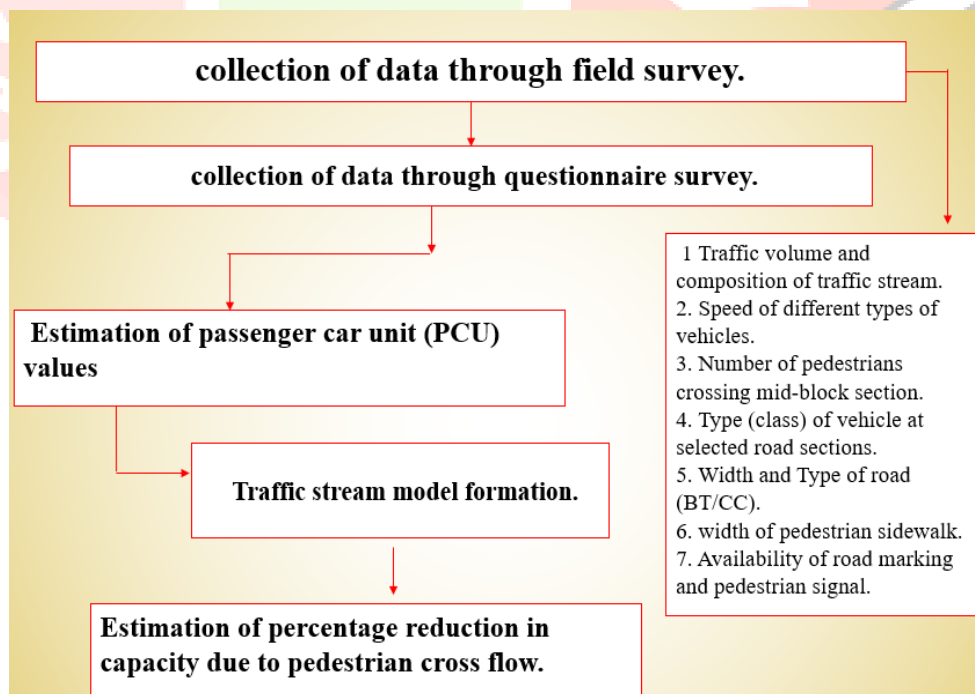
III. STUDY AREA

Indore is a city located in west-central India and it is 200 km west of capital city Bhopal of M.P. it's the highly populous city of the state with population of around 30 lakhs and area of about 530 km². Indore is defined as the industrial capital of state M.P. and it is home to the Madhya Pradesh stock exchange. The city has a literacy rate of 80.63%.

As Indore serves as an educational and industrial hub for the state with dense population approximately 5 lakh people travel inside the Indore city through public transport daily. Therefore, the number of pedestrians is also high who crosses the road and intersection also in the peak Hours there is traffic jam occurs at many intersections of the city.

In the present study the three mid-block locations are selected to find out the traffic flow characteristics on these three mid-block locations due to pedestrian crossing in mix traffic condition. In the existing study Madhu Milan square to Shivaji square is considered as Mid-Block Location No. 1. This mid-block is located in front of the MY government hospital. In the existing study Guitar square to Saket square is considered as Mid-Block Location No. 2. This mid- block is located at greater Kailash road in front of the public works department (PWD) office. And Bengali square to Medicare Hospital is considered as Mid-Block Location No. 3. This mid-block is located at kanadia road in opposite of the hanuman mandir.

IV. METHODOLOGY

V. DATA COLLECTION

a) Collection of Data Through Field Survey

To find out the effect of pedestrian crossing on traffic characteristics at midblock section data collection is done through traffic studies and traffic survey. Traffic studies were planned to determine the traffic volume, composition of traffic stream, and speed of different types of vehicles, number of pedestrians, type of vehicle at selected road sections. the data collected using video-graphic survey method at each section i.e. base section (where pedestrian cross flow occur) and friction section which is 300 meters away from base section (where no pedestrian crossflow occur) on typical weekday in peak Hours from 8 am to 12 am in morning and due to high pedestrian crossing at these sections.

A section of about 500 m that had uniform traffic operating circumstances was selected, and a longitudinal trap of 60 m was made in the central of this section for calculation of speed as well as flow. Thus, it was not conceivable to cover the full section of 500 m in the camera view, speed measured in this trap length was taken as the mean speed on the 500 m stretch.

b) Collection of Data Through Questionnaire Survey

Questionnaire survey data include 8 set of questions that were asked to people of different age group and gander. A google forms link was shared to each people and each question were clearly explained to them so that no point of confusion arises and exact data through survey can get done.

VI. RESULTS

The collected survey data i.e. vehicular flow, speed and density were figured for base section and friction section for all the three mid-blocks locations.by using the fundamental green shield relationship q= K*V from the speed-flow data of section speed- density plot was developed and model equation generated. then the field data of speed-flow curve were overlapped over green-shield flow curve to estimate capacity of section.

The capacity of mid-block friction section 1 location was estimated as 1583 (PCU/Hour/lane). The capacity of mid-block friction section 2 location was estimated as 1389(PCU/Hour/lane) and the capacity of mid-block friction section 3 location was estimated as 1632 (PCU/Hour/lane).

The pedestrian cross flow negatively affects the both capacity and stream speed of the friction section when compared to base section at all mid-block locations. Reduction in capacity due to pedestrian cross flow at friction section when compared to base section is found to be 30.47 %, 24.67%,17.78% for mid-block section 1,2 and 3 respectively.

Traffic Flow Characteristics Relations with Pedestrians and Without Pedestrian Crossing Condition at Madhu Milan Square to Shivaji Square Mid-Block Section 1

Table 1. Vehicle Speed Characteristics for Friction Section

Location	Type of vehicle	Speed in kmph			
		Minimum	Maximum	Mean	Standard Deviation
Location 1 (midblock with pedestrian crossing)	All vehicle	21.36	29.36	22.15	7.02
	Car	13.2	32.48	24.22	9.13
	Two-Wheeler	22.85	41.96	29.74	8.74
	Auto Rickshaw	9.25	26.63	16.54	10.49
	Heavy Vehicles	7.12	19.42	18.74	6.17

Table 2. Vehicle Speed Characteristics for Base Section

Location	Type of vehicle	Speed in kmph			
		Minimum	**Maximum**	**Mean**	**Standard Deviation**
Location 1 (Non-Pedestrian crossing Mid-block)	**All vehicle**	30.00	41.50	30.81	14.96
	Car	20.48	44.87	32.46	11.44
	Two-Wheeler	27.52	51.38	35.84	9.84
	Auto Rickshaw	14.33	32.15	23.49	8.72
	Heavy Vehicles	12.74	25.69	17.12	7.96

Speed-Density Relation for Mid-Block Section 1-

The relation between speed and density is linear. And speed is the elementary part for the Basic plot. Thus, in general it is not possible in all cases like zero density and free speed on the road.
One of the best procedures is Linear Regression Analysis, a well-known method for fitting a straight line between dependent and independent variables.

$$Y = a + bx \tag{1}$$

Where x and y denote,
x = k (density) and
y = v (speed)
Similarly speed and density are related in a linear form, i.e.
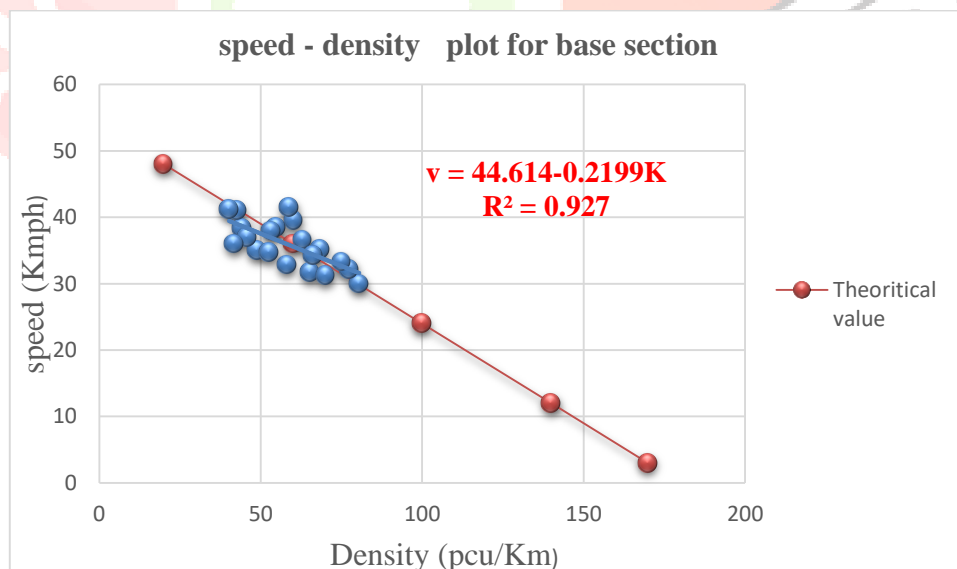
$$v = a + bk \tag{2}$$

speed - density   plot for base section

v = 44.614-0.2199K
R² = 0.927

Figure 1. Speed-Density Plot for Base Section at Mid-Block No. 1

speed density plot for friction section
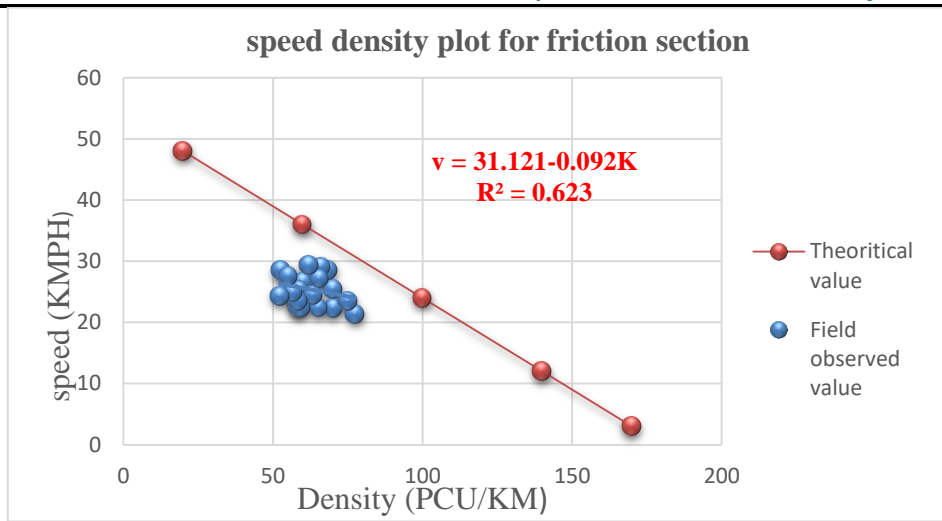
$$v = 31.121 - 0.092K$$
$$R^2 = 0.623$$

Figure 2. Speed-Density Plot for Friction Section at Mid-Block No. 1

Speed-Flow Relationship for Mid-Block Location 1

speed - flow plot for base section
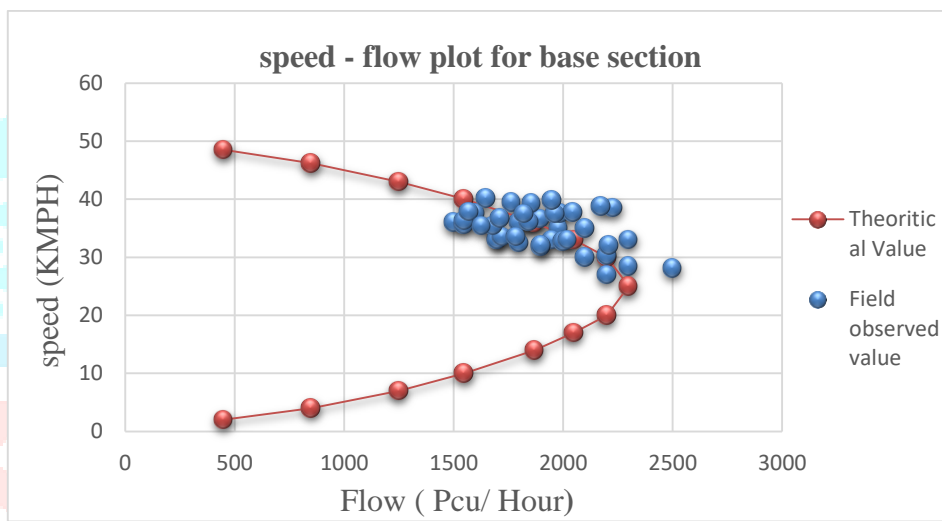
Figure 3. Speed-Flow Plot for Base Section at Mid-Block No. 1

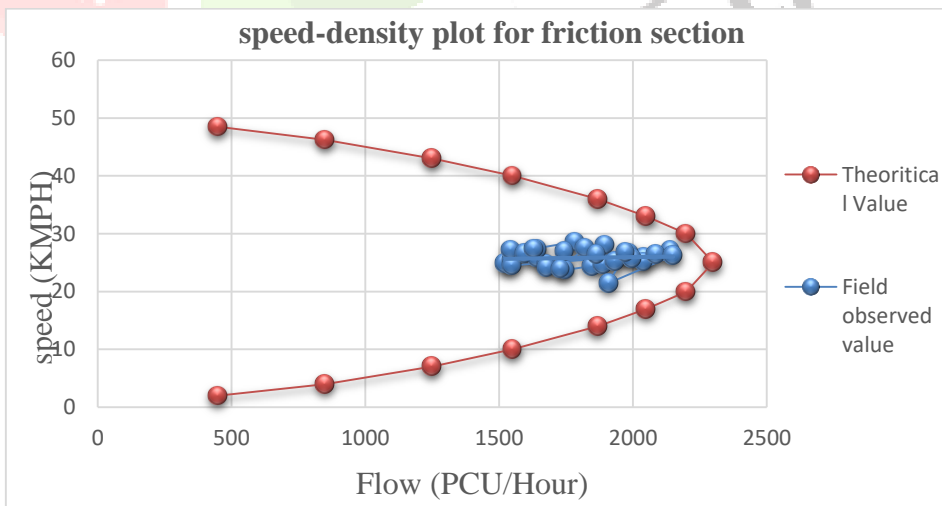**speed-density plot for friction section**

Figure 4. Speed-Flow Plot for Friction Section at Mid-Block No. 1

Model Equation Formation for Vehicular Flow Relationship with And Without Pedestrian Crossing for Mid-Block Location 1

with the purpose of study, the effect of pedestrian on different vehicle in which each type of vehicle picked distinctly on individual traffic flow, speed, density was also calculated from field data and association were also developed. The Formulated model relationship from the analysis of data of two study location i.e. base section and friction section are showed in table 3 & 4.

For friction section -

Table 3. Model Equation for Friction Section at Mid-Block Location No. 1

Vehicle type	Section type	Model Equation					
		Relation					
		Speed - Density	R^2	Flow – Speed	R^2	Flow - Density	R^2
All vehicle	Friction	V= 31.12 - 0.092*K	0.623	q=v (31.12-v)/0.092	0.356	q =k (31.12-0.092*K)	0.576
Car	Friction	V= 23.86 - 0.205*K	0.512	q=v (23.86-v)/0.205	0.412	q =k (23.86-0.205*K)	0.715
Two-wheeler	Friction	V= 41.45-0.161*K	0.621	q=v (41.45-v)/0.161	0.233	q =k (41.45-0.161*K)	0.414
Auto-rickshaw	Friction	V= 26.20-0.293*K	0.314	q=v (26.20-v)/0.293	0.278	q =k (26.20-0.293*K)	0.698

For base section-

Table 4. Model Equation for Base Section at Mid-Block Location No. 1

Vehicle type	Section type	Model Equation					
		Relation					
		Speed - Density	R^2	Flow – Speed	R^2	Flow - Density	R^2
All vehicle	Base	V= 44.614 - 0.219*K	0.927	q=v (44.614-v)/0.219	0.745	q =k (44.614-0.219*K)	0.517
Car	Base	V= 31.20 - 0.188*K	0.328	q=v (31.20-v)/0.188	0.212	q =k (31.20-0.188*K)	0.232
Two-wheeler	Base	V= 45.83-0.178*K	0.645	q=v (45.83-v)/0.178	0.185	q =k (45.83-0.178*K)	0.274
Auto-rickshaw	Base	V= 32.48-0.227*K	0.714	q=v (32.48-v)/0.227	0.275	q =k (32.48-0.227*K)	0.176

Estimation of Percentage Reduction in Capacity Due to Pedestrian Cross Flow

Figure no. 1 & 2 demonstrates the speed – density curve for mid-block section no 1. The data of plot follows the straight-line relationship Which was further used to grow Speed- flow relationship by using green shield model plotted in figure no. 3 & 4. The capacity of mid-block section 1 location was estimated as 1583 (PCU/Hour/lane). Likewise curves for the other two mid-block section location were plotted and capacity for each section was estimated.

Table 5. Capacity Reduction Percentage for Different Mid-Block Base and Friction Section

Mid- block Section no.	Lane capacity for friction section (PCU/Hour/lane)	Lane capacity for base section (PCU/Hour)	Pedestrian cross flow (PPH)	Reduction in capacity (%)
1	1583	2277	1280	30.47%
2	1389	1844	682	24.67%
3	1632	1985	335	17.78%

The pedestrian cross flow negatively distresses the stream speed and capacity of section also. Above table shows the reduction in capacity due to pedestrian cross flow at friction section when compared to base section.

$$y = 8.67 + 0.031 Q_{ped} - 1*10^{-05} Q^2_{ped}$$
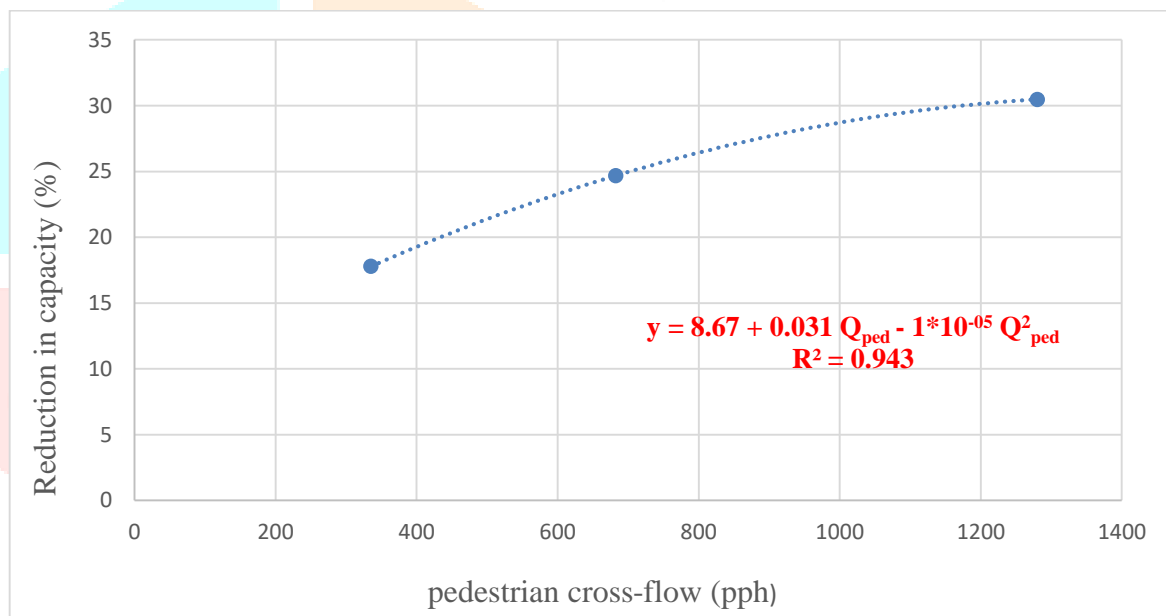$$R^2 = 0.943$$

Figure 5. Road Capacity Reduction with Respect to Pedestrian Cross Flow

Figure 5 expresses the reduction in capacity differences at different pedestrian cross-flow points. This curve follows a second-degree polynomial as shown in equation below-

percentage reduction in Capacity $= 8.67 + 0.031 Q_{ped} - 1*10^{-05} Q^2_{ped}$ .... ($R^2 = 0.943$)

Here Q_{ped} = pedestrian cross flow. And 8.67 represents intercept which shows reduction in capacity. Above equation is valid only when pedestrian cross flow is more than 250 pph.

VII. CONCLUSION AND SCOPE FOR FORTHCOMING STUDY

Based on the analysis of the collected data it can be concluded that there is clear drop found in the mean speed of the vehicle, increase in the density and reduction in the traffic flow with the pedestrian crossing condition at urban mid-block section location.

- The capacity of mid-block section 1 location was estimated as 1583 (PCU/Hour/lane) for friction section and 2277 (PCU/Hour) for base section. And the reduction in traffic capacity percentage registered as 30.47%.
- The capacity of mid-block section 2 location was estimated as 1389 (PCU/Hour/lane) for friction section and 1844 (PCU/Hour) for base section. And the reduction in traffic capacity percentage registered as 24.67%.
- The capacity of mid-block section 3 location was estimated as 1632 (PCU/Hour/lane) for friction section and 1985 (PCU/Hour) for base section. And the reduction in traffic capacity percentage registered as 17.78%.

Moreover, to the present study, traffic flow characteristic due to pedestrian crossing at mid-block section, can be extended and researched with the following –

- A proper study may be carried out in the future research project on the undivided urban road with the same geometric and site condition that are considered in the present study.
- This study does not include the safety of the pedestrian or vehicle therefore the pedestrian-vehicle interaction phenomenon can be studied. It's an important topic for further research.

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