Pedestrian-Vehicle Conflict Analysis for L-Turns at Signalised Intersections

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Abstract— Due to rapid increase in the traffic volumes and pedestrian volumes, traffic-pedestrian conflicts have increased manifolds in last few decades. For enhancing the pedestrian safety and for providing necessary infrastructure, a clear understanding of pedestrian crossing behaviour under mixed traffic conditions is needed.
Keywords: NHAI, SCI, PMGSY, CS, PET, TTC

I. INTRODUCTION

Traffic research on roadways has predominantly been on vehicles and convenience of pedestrian is often second while designing roadways. One of the major reasons is the complexity involved in modeling pedestrian behaviour. Complexity arises from multiple parameters which affect the pedestrian crossing behaviour and are very difficult to identify. Left turns at signalized intersections are mostly open for traffic, and pedestrian volume is very high with least amount of safety measures provided to them. Pedestrian crossing speed is one of the significant design parameters while designing signalized intersection infrastructures in traffic engineering. Pedestrian crossing speed has been found varying largely from the existing manual Indian Road Congress (IRC) estimated walking speed at crosswalks of 1.22 m/s. This constant value is not applicable for dynamic traffic conditions prevailing at intersections. Pedestrian crossing speed varies with regard to the pedestrian characteristics and behaviour. Accidents between vehicles and pedestrians represent an important safety issue for every country in the world. According to the World Health Organization around 270,000 pedestrians lose their lives on world's roads each year accounting for 22% of total 1.24 million road traffic deaths. Lars Leden [1] made a comparative study between the pedestrian safety at semi-protected schemes and normal non-channelized signalized approaches and reported that left-turning vehicles caused higher risks for pedestrians than right-turning vehicles. It is not surprising that pedestrian accidents are especially problematic in urban areas since pedestrian activity is much higher there. It is estimated that 40 percent of pedestrian accidents occur at intersections. This study examines pedestrian-vehicle conflict analysis at L-Turns of signalized intersections.

II. PROBLEM DEFINITION

As far as J&K is concerned, development of roads is taken up by various departments viz. Roads and Buildings Department (PWD), PMGSY, NHAI, Border Road Organization depending on the location and type of road. The road network developed decades ago in the urban areas and towns of J&K State. Traffic and pedestrian volumes have increased manifold during last couple of decades. Heavy traffic jams are being reported from urban areas as well as from towns. To mitigate the problem, the road network and the intersections needs to be analyzed and upgraded in order to accommodate the current as well as future traffic & pedestrian volumes. Up gradation of roads by way of increasing of the carriage way width is very difficult and time consuming and it involves huge financial implications and lot many people are affected due to relocation. Relief and Rehabilitation component of such projects is large in terms of money and also gives rise to number of litigations. Instead, the intersections could be developed and upgraded by way of advanced transportation engineering to accommodate large intersecting traffic and pedestrians. Usually, this approach is cost effective, involves less R&R and time. Due to improper road geometry and insufficient designated crossing points on road, pedestrians are sometimes forced to cross the road and they create confusion and risk to themselves, as well as to the drivers. This jaywalking behavior of pedestrians leads to severe conflicts and accidents.

III. TRAFFIC CONFLICT ANALYSES

Various techniques have been developed to analyses the traffic conflicts at intersections viz. U.S. traffic conflict technique; Classification by severity (CS); Post-encroachment time (PET); and Time-to-collision (TTC). Amongst the techniques, Time-to-Collision Technique (TTC) is one of reliable techniques. In Time-to-Collision approach it is analyzed if a vehicle and a pedestrian reach simultaneously the same spot at a same instant of time. Pedestrian-vehicle conflict is analyzed it can be identified three different phases:

1) Stopping phase: the vehicle is so far and with a speed that it can stop in safety in the possibility of pedestrian presence on walk side;
2) Conflict phase: the two road users' mutual positions and speed can lead to collision if conflict actors don't take an evasive manoeuvre (according conflict definition);
3) Passing phase: the vehicle is too close to pedestrian crossing that it can overtake the conflict area before the pedestrian reaches it.

From a safety point of view, the second phase has to be identified and analyzed to determine the physical and behavioral factors causing a potential accident.

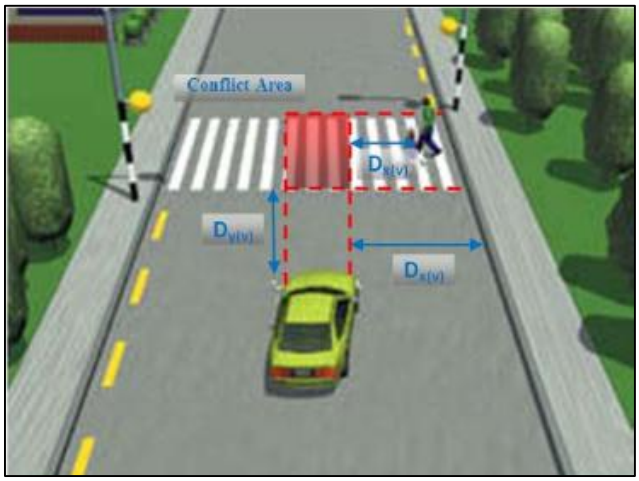

Fig. 1: Showing Position of Vehicle and Pedestrian with respect to Conflict Zone

The analysis is carried in three steps.

Step No. 1: Calculation of time to collision of Vehicle, which is given by:

$$TTC_{i\,(v)} = \frac{D_{y\,i\,(v)}}{V_{i\,(v)}}$$

TTCi(v) [sec] is the time that a vehicle takes to reach the pedestrian crossing or else the time to a potential collision with in crossing pedestrian (TTZ), at the time i.

Dyi(v) [m] is the longitudinal vehicle position or distance between the vehicle and the crossing at the time i.

Vi(v) [m/sec] is the vehicle speed at the same time i.

Step No. 2: Time to Collision of pedestrian is carried out in order to establish if a pedestrian can arrive at the conflict area in an appropriate time to collide with vehicle.

$$TTC_{i\,(p)} = \frac{D_{xi\,(v)} - D_{xi\,(p)}}{V_p}$$

Where,

TTCi(p) [sec] is the pedestrian time to reach conflict area, at the time i.

Dxi(v) [m] is the transversal vehicle position at the time i.

Dxi(p) [m] is the pedestrian position on crossing at the same time i.

Vp[m/sec] is the pedestrian speed.

Step No. 3: The third conflict parameter is the vehicle time to stopping (Ts), carried out using the following formula:

$$T_{(si)} = T_{(r)} - \frac{V_{i\,(v)}}{2a_{\,(b)}}$$

Where

$T_{(si)}$ [sec] is the stopping time at instant i.

$T_{(r)}$ [sec]is the reaction time of the driver. Standard value of Tr =1.2 s

$V_{i(v)}$ is the vehicle speed at the time i.

$a_{(b)}$ [m/sec2] is the braking deceleration.

These temporal parameters are utilized to define the time interval of conflict existence, identifying the above mentioned three phases. When $TTC_V > T_S$, it means that the vehicle can stop in safety before the conflict area (Stopping phase). At the same way, the pedestrian reaches the conflict area only after the vehicle has passed when $TTC_V > TTC_P$ (Passing phases). The potential conflict time (Conflict phase) is the so called $TTZ_{duration}$(Time to Zebra duration), i.e. the time during that the vehicle can't stop before to reach the conflict area ($TTC_V < T_S$) and the pedestrian is exposed to conflict with vehicle ($TTC_V < TTC_P$), as illustrated in Figure below.

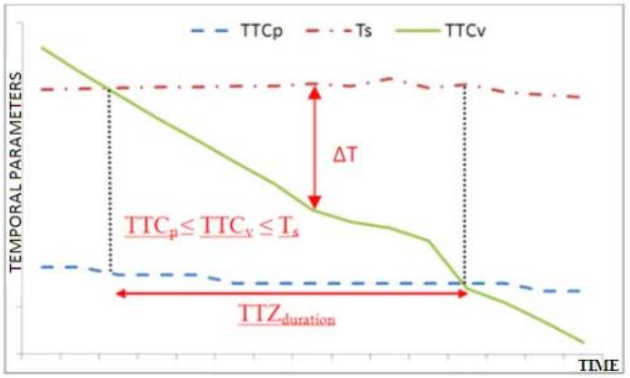

Fig. 2: Showing Potential Conflict Time (TTZ duration)

IV. RESULTS

The results are shown graphically below:

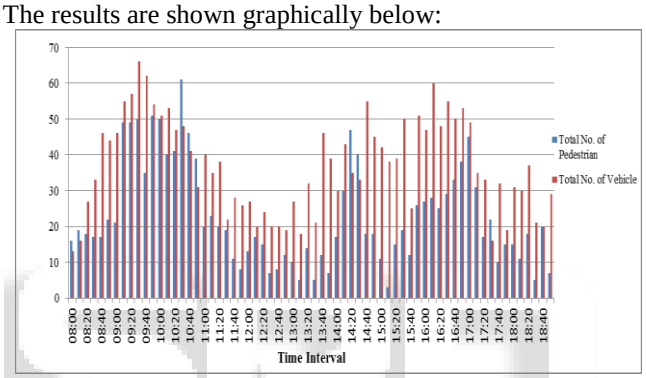

Fig. 3: L-turn 01 of Sanatnagar Byepass Intersection (Baghat to Chanapora)

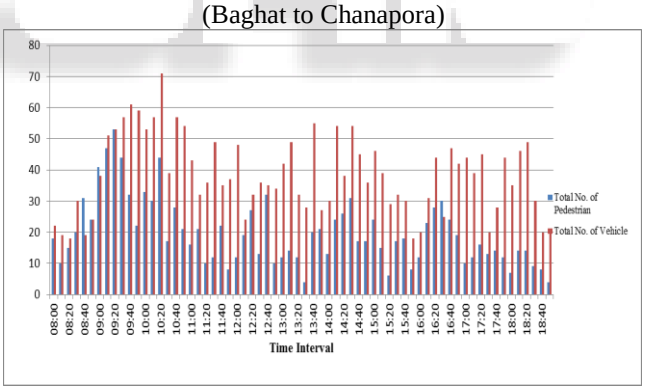

Fig. 4: L-turn 02 of Sanatnagar Byepass intersection (Chanapora to Rawalpora)

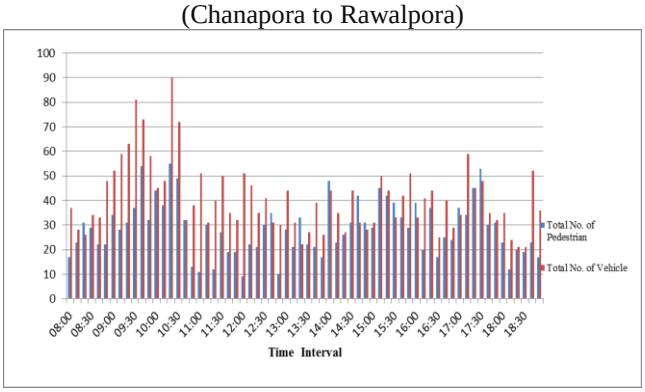

Fig. 5: L-Turn 03 of Sanatnagar Byepass intersection (Rawalpora to Hyderpora)

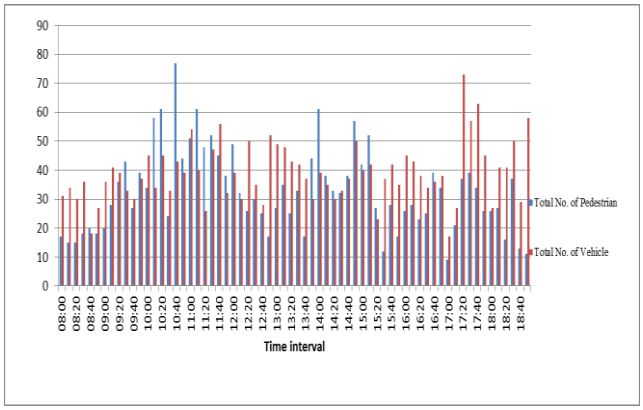

Fig. 6: L-turn 04 of Sanat Nagar Byepass intersection (Hyderpora to Baghat)

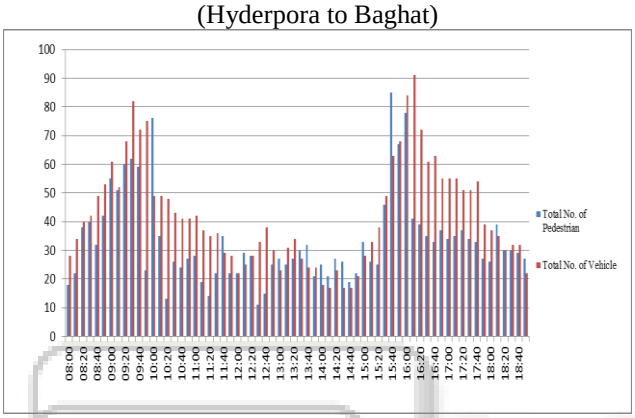

Fig. 7: L-turn 01 of Hyderpora Byepass intersection (Tengpora to Baghat)

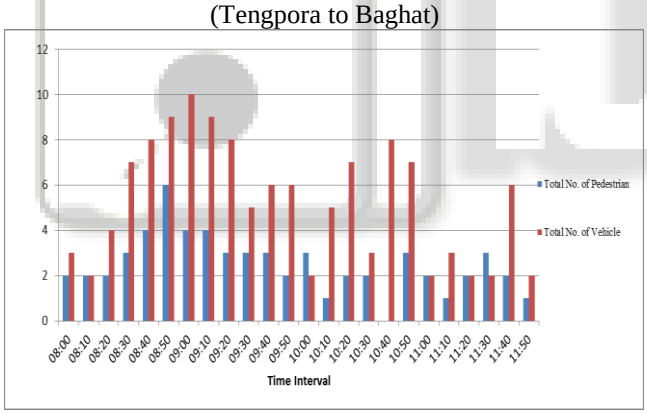

Fig. 8: L-turn 02 of Hyderpora Byepass intersection (Baghat to Sanat Nagar)

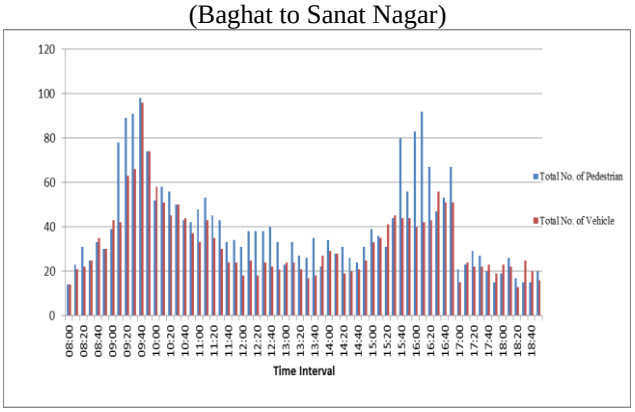

Fig. 9: L-Turn03 of Hyderpora Byepass Intersection (Sanat Nagar to Airport)

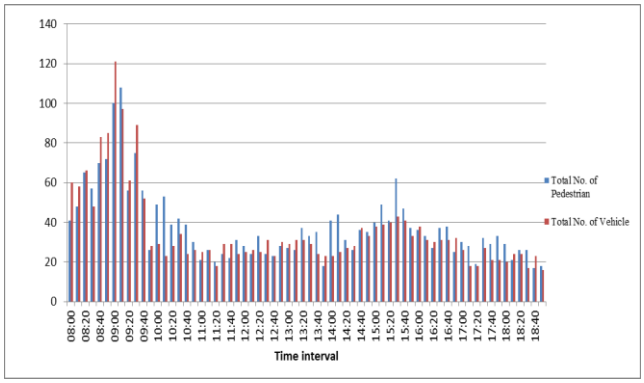

Fig. 10: L-Turn 04 of Hyderpora Byepass Intersection (Airport to Tengpora)

V. CONCLUSION

The research papers presents the conflict between left-turn vehicles and pedestrians at signalized intersections has increasingly become a safety threat to roadway traffic operation with the calculation of Pedestrian safety conflict index (SCI) based on conflict analysis of left-turn vehicles and pedestrians at signalized intersections. The paper also describes the time to collision method of Traffic Conflict Technique was used for estimating the probability of occurrence of conflicts between left turning vehicles and pedestrians.

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