Review Paper on Performance Evaluation & Capacity Estimation for Selected Undisciplined Intersections in Gurgaon City

Neelam[1], Mr. Nirmal Dhir[2]

[1]Master of Technology in Civil Engineering (Transportation Engg.), from World College of Technology and Management, Gurgaon
[2]Professor & HOD, Civil Engineering (Transportation Engg.), from World College of Technology and Management, Gurgaon

ABSTRACT

In this dissertation, the author aims to study and explore the Capacity Estimation for an Undisciplined Intersections/Junctions. Rotary intersections are particular form of at-grade intersections laid out for the movement of traffic in one route around a central traffic island. Basically all the major conflicts at an intersection namely the crash between through and right-turn movements are converted into milder conflicts namely merging and diverging. The vehicles entering the rotary are gently forced to move in a clockwise direction in orderly fashion. Rotary intersections are an effective intersection type which is also called as Roundabout which is provided for easier decision making than conventional intersections. These rotary intersections have a traffic calming effect by reducing vehicle speeds using geometric design. Rotaries require less maintenance than traffic signals. A well designed roundabout achieves a balance of safety and efficiency. Traffic rotaries reduce the complexity of crossing traffic by forcing them into weaving operations. The shape and size of the rotary are determined by the traffic volume and share of turning movements. Capacity assessment of a rotary is done by analyzing the section having the greatest proportion of weaving traffic. In the past years various models have been developed for analyzing the traffic flow on this intersection. These methods are classified in two groups. The first group consists of methods which are purely empirical and based on geometry of intersection. The second group consists of methods which are based on Gap acceptance process.

INTRODUCTION

In India carry different types of vehicles like high speed automobiles, low speed cycles, cycle rickshaws and animal drawn carts. This will lead to complex interaction between the vehicles and study of such traffic behaviour needs special attention. This will result in increased interactions between vehicles; then they tend to move in clusters rather than one after the other. Traffic consists on Indian roads of bi-directional freedom traffic such as two or three wheeled vehicles and uni-directional vehicles such as four wheelers while the above tends to overtake or turning or crossing or turn right even if a small gap is available. Hence, to determine the intersection capacity traffic engineer requires a clear understanding of gaps being accepted or rejected by various modes of traffic. Besides, in these mixed traffic conditions, users do not usually follow lane discipline and can occupy any lateral position on the road. To prevent traffic accidents, conflicting traffic streams are separated either in space or in time. Due to the increasing population of India, there is a growth in transportation demand, which results in increase in vehicular movement and hence increase in vehicular volume on roads. This increase in vehicular volume affects the level of service (Q, K & V) and safety of road especially at critical locations like intersection of two roads where vehicles moving in different directions compete for the use of same space.

Because of the pervasiveness of transport, solution to transport problems can have major influence upon people's lives. Transport engineering applies technological and scientific principle to the planning, functional design, operational and management of facilities for any mode of transport in order to provide for the safe, rapid, comfortable, convenient, economical and environmentally compatible movement of people and goods. Traffic engineer, a branch of transport

engineering, deals with the planning, geometric design, and traffic operation of roads, streets, and highways, their network, terminals, abutting land, and the relationship with other mode of transport [2].

Most developing country cities have been classified as ”low cost strategy” cities. In comparison with cities in the West, these cities consume less transport energy. Characteristics of these urban centers are high density, mixed land use, short trip distances, and high share of walking and non–motorized transport. Modes of heterogeneous traffic flow in developing countries consist of vehicles with varying dynamics and space requirements sharing the same road space.

At traditional junctions with stop signs or traffic lights, the most serious accidents are right-angle, left-turn, or head-on collisions that can be severe because vehicles may be moving fast and collide at high angles of impact. Roundabouts virtually eliminate those types of crashes because vehicles all travel in the same direction and most crashes are glancing blows at low angles of impact. Roundabouts can increase delays in locations where traffic would otherwise not be required to stop, however, for example, at the junction of a high-volume and a low-volume road, traffic on the busier road would normally not have to stop if the junction were signalized, because the traffic signals would provide a green signal to the busier road the majority of the time.

Merits and Demerits of Roundabouts

The key advantages of a rotary intersection are listed below:

- Traffic flow is regulated to only one direction of movement, thus eliminating severe conflicts between crossing movements.
- All the vehicles entering the rotary are gently forced to reduce the speed and continue to move at slower speed. Thus, none of the vehicles need to be stopped, unlike in a signalized intersection.
- Because of lower speed of negotiation and elimination of severe conflicts, accidents and their severity are much less in rotaries.
- Rotaries are self-governing and do not need practically any control by police or traffic signals.
- They are ideally suited for moderate traffic, especially with irregular geometry, or intersections with more than three or four approaches.
- Although rotaries offer some distinct advantages, there are few specific limitations for rotaries which are listed below.
- All the vehicles are forced to slow down and negotiate the intersection. Therefore, the cumulative delay will be much higher than channelized intersection.
- Even when there is relatively low traffic, the vehicles are forced to reduce their speed.
- Rotaries require large area of relatively at land making them costly at urban areas.
- The vehicles do no usually stop at a rotary. They accelerate and exit the rotary at relatively high speed. Therefore, they are not suitable when there is a high pedestrian movement.

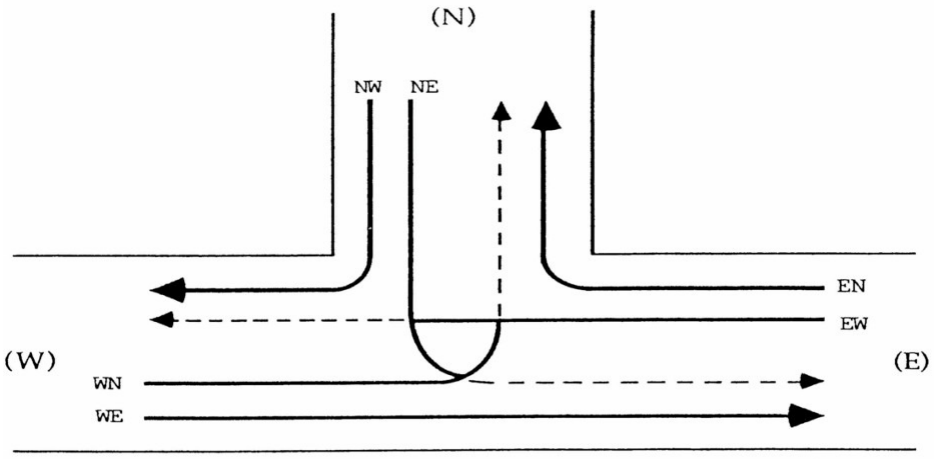

Fig 1: Hierarchy of the possible movements at three leg unsignalized intersection

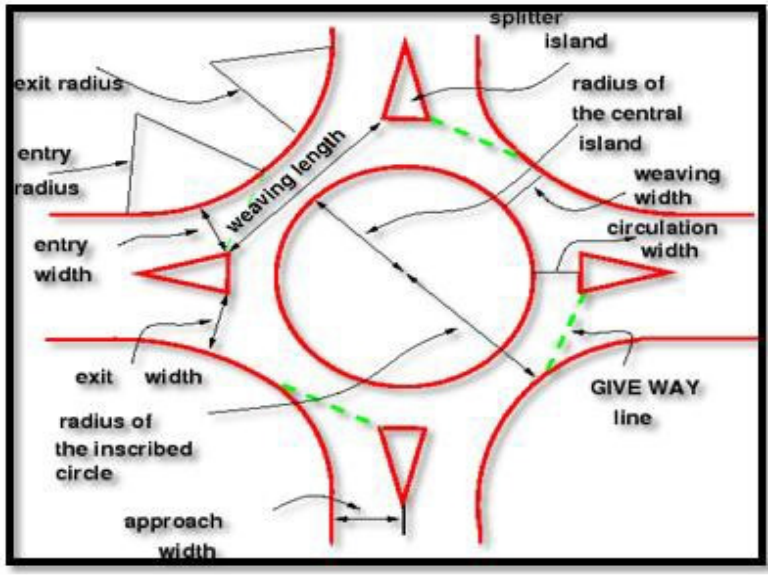

Fig. 2: Components of Rotary Intersection

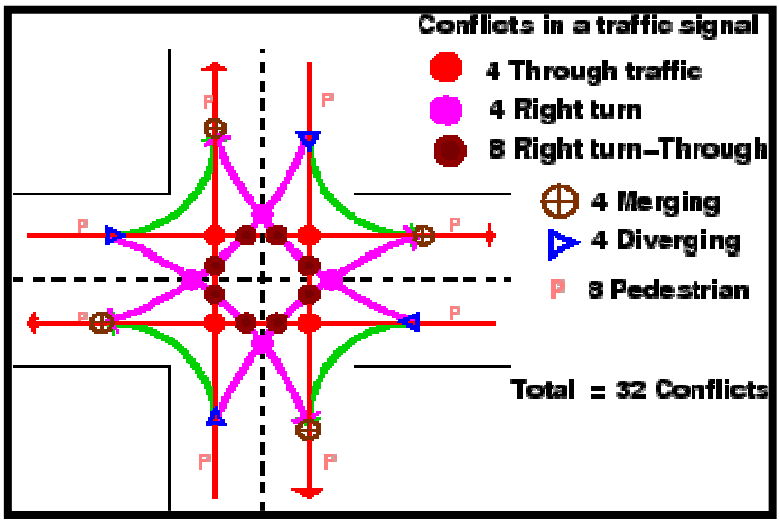

Fig. 3: Conflict Points at 4 Legged Intersection

- Correspond to parameters of spacing (m) and headway (sec)

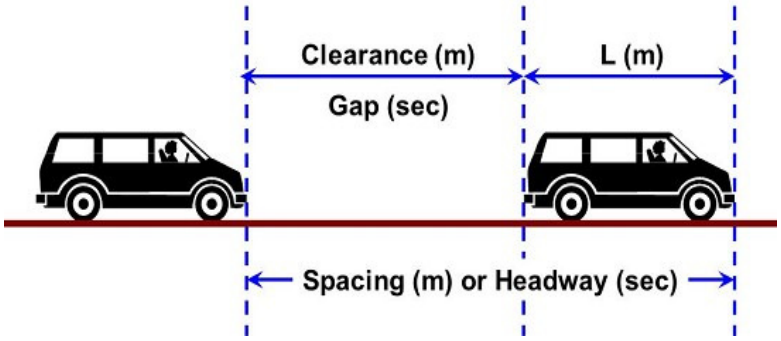

Fig. 4: Headway and Gap Concept

REVIEW OF LITERATURE

This chapter deals with the review of development that has been taken place in the area of the capacity estimation of undisciplined intersections/junctions. This chapter covers the review of research work carried out on the similar type of studies. In the previous year's many researcher have investigated the traffic congestion related problem and their solutions for better performance. Also researches have been carried out for analysis of the unsignalised intersections/junctions.

In the following, a summary of the recent articles and papers found in the literature, about the capacity estimation of undisciplined intersections/junctions. The determination of critical gap is studied and reviewed:

What is traffic?

Traffic can be defined as the movement of pedestrians and goods along a route, and in the 21-century the biggest problem and challenge for the traffic engineer is often imbalance between the amount of traffic and the capacity of the route, leading to congestions. Traffic congestions is not a new phenomenon.

Ashworth R. (1999) define "traffic" as the transportation of goods, coming and going of persons or goods by road, rail, air, etc.

Traffic engineering deals with the traffic planning and designs of roads, of frontage development and of parking facilities and with the concern of traffic to provide safe, convenient and economic movement of vehicle and pedestrians. Traffic engineer is used to either to either improve an existing situation or, in the case of new facility, to insure that the facility is correctly and safely designed and adequate for the demands that will be placed on it [4].

Ashworth, R. (2004) defined a traffic accident as any vehicle accident occurring on a public highway (i.e. originating on, terminating on, or involving a vehicle partially on the highway). These accidents therefore include collisions between vehicles and animals, vehicles and pedestrians, or vehicles and fixed obstacles. Single vehicle accidents, in which one vehicle alone (and no other road user) was involved, are included. All fatality and injury totals include pedestrians, motorcyclists and bicyclists unless otherwise noted [5].

Brilon W. (2005) concluded that the accident databases needed to be investigated further in an effort to choose the most complete database that will provide the crash frequencies. As mentioned earlier, the safety model will utilize accident rates in order to produce the accident risk of a facility based on its free-speed. Therefore, some recent papers on the development of accident rates are presented in this chapter. Some of the accident models developed by various research groups are presented below to demonstrate the fact that most of them refer to a limited amount of variables [7].

Chandra S. et. Al (2012) , collected data for four roundabouts in the suburban area of Chandigarh city and analysed using five different methods of determining the entry capacity and author has observed that the wide variation in the results. The India models give the highest capacity among all methods. However, this method is based on the capacity of weaving section which can accommodate the least traffic [8].

Highway Safety Information System

Ackelik R. (2011) stated that The Highway Safety Information System (HSIS) was developed by the Federal Highway Administration (FHWA). The FHWA proceeded in the development of this database due to the need for a database that would serve as a tool to assist highway engineers and administrators in the decision-making process. The need for an understanding of how safety is affected by the geometric design of the roadway, the use of traffic control measures and the size and performance capabilities of the vehicles led to the development of the HSIS [2].

Akcelik R. et. Al (2005), has taken a single-lane roundabout as a case study from the United States to compare capacity estimates using gap-acceptance based Australian and Highway Capacity Manual method and the linear-regression based UK (empirical) method. Some contradictory results obtained from these models are highlighted and reasons for differences are discussed by the author. Such systematic differences have important design implications [1].

In brief, some of the data files include the following information:

- Crash: contains type of accident, vehicle types, sex and age of occupants, accident severity and weather conditions.
- Roadway Inventory: contains information for types of roadway, number of lanes, lane width, rural urban designation and functional classification.
- Traffic Volume: contains Annual Average Daily Traffic (AADT) data.

Road Safety

There are three factors that result in accident:

1. Road and environment deficiencies
2. Road user errors (human factors)
3. Vehicle defects.

Hwang S. and Park C. (2005) described that Road and environment deficiencies account on their own only for only 2% of all accidents but in combination with road user error account slightly less than 20%. Human factors on their own account for 75 - 80% of accidents [13].

Kusuma A. and Koutsopoulos H. (2011) analyzed that typical road and environment deficiencies are those, which provide misleading visual information or insufficient or unclear information to the road users. Only occasionally accidents are caused solely by bad design. Human factors include excessive speed for the conditions, failing to give way, improperly overtaking or following too close and general misjudgements by both driver and pedestrian [14].

Pollatschek M, Polus A and Livneh M (2001) had analyzed some parameter performances, which included the velocity distribution, the distance distribution of lane changing, the headway distribution of confluence vehicles, and vehicles on circulating lanes, as well as the application of accepted headways [16].

An overview of Transport / Traffic Study Process

Prasetijo J. (2005) presented that at some stages in the planning of a road or road system it will be necessary to carry out the traffic studies to estimate the volume of traffic that will have to be considered in a design year. Traffic data also required for economic and environmental assessment in relation to the justification, scale and location of scheme alternatives. Traffic volume for some future design year is delivered from measurement of current traffic and estimate future traffic. Figures below indicate the basic constituent of design volume for an individual road. By current traffic is meant the number of vehicles that would use the new road if it were open to traffic at the current measurement is taken. Current traffic is composed of reassigned traffic and redistributed traffic. Reassigned traffic is the amount of existing same destination traffic that will immediately transfer from the existing road that the new road is designed to relive [17].

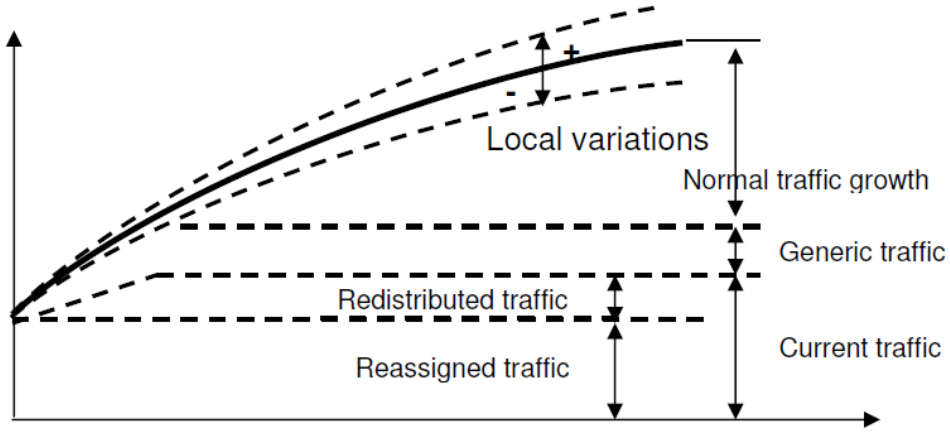

Fig. 5: Constituents of road design traffic volume

Purnima P. and Gangopadhyay.S (2008) concluded that Normal Traffic growth is the increase in traffic volume due to the cumulative annual increase in the number and usage of motor vehicle. Generated traffic is mean the future vehicle

trips that are generated a new as a direct result of the new road. Generated traffic is generally considered to have three constituents' components: induced, converted and development traffic. Induced traffic consist of traffic that did not exist previously in any form and which result from the construction of a new facility, and of traffic composed of extra journey by existing vehicle as a result of increased convenience and reduced travel time via the new road. Converted traffic is that which result from change in mode of travel. Development traffic is the future traffic volume component that is due to developments on land adjacent new road [18].

Automatic Traffic Count

Automatic traffic counts are used to mechanically measure the traffic volume moving past the survey point. The counters normally use a pressure tube or an inductive loop, which is fixed across the road at the census period. The pressure tube is compressed each time a vehicle axle crosses it. This sends a pulse along the tube, which is counted, and hence the vehicular flow can be estimated. More modern system can use piezzo electric tube and the electrical pulses are counted [21].

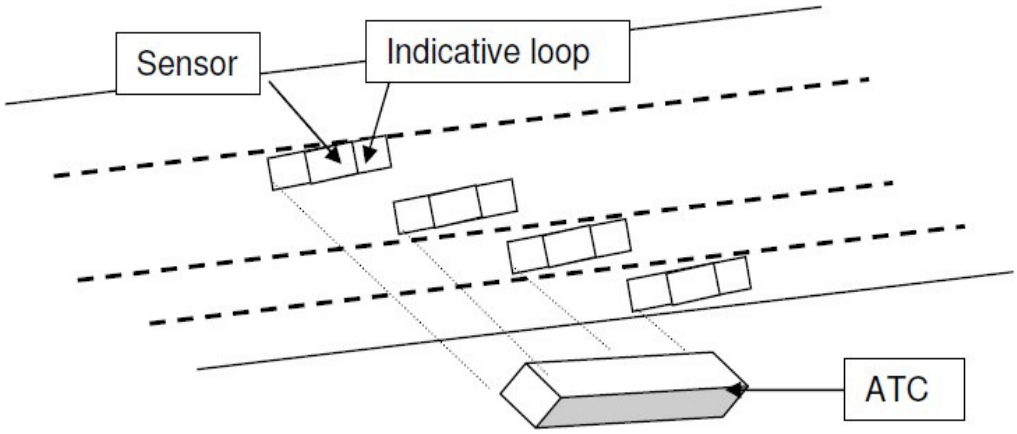

Fig 6: typical automatic traffic counter installation

Manual Counts

Traffic flow can be measured by manual observation, instead of using an automatic counter. Traffic flowing past a survey point is counted by an observer, who would record the flow using either, a tally counter. A Manually Classified Count (MCC) records directional traffic flow past a point survey point. The survey point could mid – link or at a junction [22].

Area – Wide Surveys

The surveys described above are adequate for measuring traffic flow and direction of
movement at a single point, or at a single junction. However, if we wish to understand the movement over a wide area, other methods have to be used [25]. Three techniques are described below:

1. Number Plate Surveys: - to know how the traffic is circulating in a limited area. The technique used is to record the registration mark of each vehicle as it enter and leaves the system being studied and to then match the registration marks, to establish how a vehicle travels through the road system being studied [26].

2. Origin and Destination (O & D) Surveys: - the alternative way to establish where the drivers are travelling is to ask them, using an o & D Survey. The standard techniques are roadside interview and survey and self – completion questionnaires.

3. Roadside interview surveys: - a sample of drivers is stopped at the side of the road and asked their O and D, plus any other data, which could of relevance. Once the driver has been selected for the interview and stopped in the interview bay, he should be asked to provide the necessary answer, not more than 2 minutes, and then released as soon as possible. Although a driver must stop by the police officer, there is no obligation on the driver to participate with the interview

4. Self-completion form: - in some location, it is not possible to safely slow down and stop traffic. In these the circumstance the reply paid questionnaire may offer a suitable alternative methodology, to provide the information required

Speed Survey:

There are two simple techniques to measure the speed of traffic. The first method uses speed-measuring equipment, such as radar gun, to record the speed of the traffic, or a sample of traffic passing a particular point in space based on Doppler Effect of the change in frequency of the microwave beam reflected by the vehicle [27].

The time mean speed, the average speed of a vehicle passing a given point over a specified period is defined as:
V =∑t (V t / n)
Where,

V is the time mean speed
Vt the speed of an individual vehicle
n is the number of vehicle observed

Video Surveys

The use of video as a data collection tool in traffic engineering is the relatively new but potentially very powerful concept. A strategically placed camera can be used to observe traffic and the parking activity in a street and, depending on location and equipment; it is possible to survey up to 400 meters of road from a single vantage point. Cameras are mounted high to minimize the obstruction of the longer view from vehicle near to the camera. One of the key advantages of camera is that it records everything that happens. With the video survey, it is possible to review the video and observe other activities, which were brought to be an important when the survey was planned.

Kusumaa A., et. Al (2011), has assumed that the critical gap has a lognormal distribution among the driver population with a mean value that is a function of a number of explanatory variables. Based on these assumptions the critical gap and its distribution was estimated using maximum likelihood by considering a dual lane roundabout in Stockholm as a case study. Author has concluded that the critical gap depends, among other factors, on the target lane (near or far), the type of the vehicle [13].

Capacity Analysis

Capacity Definition: Capacity of a facility defined as the maximum hourly rate at which a person or vehicle can reasonably be expected to travel a point or uniform section of a lane or roadway during a given time period under prevailing roadway, traffic and control conditions [16].

According to Prasetijo J. (2005), The term capacity when referring to a roadway, link or junction is its ability to carry, accommodate or handle traffic flow. Traditionally capacity has been expressed in number of vehicles or passenger cars units (PCU). (Vehicles vary in their performance and the amount of road space they occupy. The basic unit is the passenger car and other vehicles are counted as their PCU equivalent, e.g. a bus might be 3PCUs and a pedal cycle 0.1PCU.) There is no absolute capacity value that can be applied to a given road way link or junction. Maximum traffic handling capacity of a road depends upon many factors [17].

- Road layout including width, vertical and horizontal alignment, the frontage land use, frequency of junctions and accesses and pedestrian crossings.
- Quality of road surface, clarity of road making, signing and maintenance.
- Proportion of each vehicle type in the traffic flow and their general level of design, performance and maintenance.
- The number and speed of vehicles and the number of other road user, such as cyclist and pedestrian.
- Ambient condition including time of the day, weather and visibility.
- Road user levels of training and competence.

Werner Brilon et. al (1999) gives an overview of some of the important methods for determining critical gaps, been used worldwide. These methods are described by their characteristic properties. For comparison purposes a set of quality criteria has been formulated by which the usefulness of the different methods can be assessed. Among these one aspect

found in study as to be of primary importance is that the results of the estimation process should not depend on the traffic volume on the major street during the time of observation. [6].

Traffic Signs and Markings

An important part of any road is the means by which the traffic engineering conveys information about the road and any regulations that affect the way it is used to users. If this is done successfully it makes to travel both safer and more efficient and it help the road users to insure that they comply with the regulation governing the road that they are using [19].

According to Troutbeck, R. (1992), Traffic signs and markings divide logically in to a number of broad types or categories [24]. These are:

Warning sign: provides advance warning of some feature, in the form of read triangle with the point uppermost and warn of features on the highway. The centre of the triangle is white with graphics in black representing the hazard being warned about.

Regulatory sign: announce and establish traffic regulation. Most of these signs are shown on circular sign with a red border and a white centre showing the regulation or prohibition.

Informatory sign: gives the road user information about features and factor, which may be of assistance to them in making their journey. Rectangular blue signs with a white edge and includes the sign such as the sign showing that the road is a cut – de – sac, etc. advanced warning signs carry the appropriate triangle warning sign.

• **Direction sign:** sign post showing the route to be followed to reach a given destination. Positioning of the signs relative to a junction so that the driver gets suitable sight lines and time to read the sign before having to make navigational decision and maneuvring.

•**Road markings:** cross all groups and can inter alia show the position those vehicles should adopt on the road, hazards

Traffic Management and Control

Traffic management arose from the need to maximize the capacity of existing roadway networks within finite budget and, therefore, with a minimum of new construction. Methods, which may be seen as a quick fix, require innovative solution and new technical developments. Introduction of signal - controlled pedestrian crossing improved the safety of pedestrians but also improved the traffic capacity of road by not allowing pedestrians to demonstrate the crossing point.

CONCLUSIONS

The traffic situation in India has few exclusive features when compared with the traffic in developed countries. Out of various points, one significant basis is the share of categories of vehicles. Indian traffic has almost 60 to 80 percent of vehicles in traffic flow is two-wheeler. From the classified volume count also it can be observed that the proportion of two wheeler in total traffic using the intersection, ranges from 65% to 70%.

Out of various methodologies available for determination of critical gap, the basic 3 methods viz. Harder's method, Raff's Method and Ashworth's Method has been applied to the data collected from the intersection. The critical gap value obtained using the accepted and rejected lag gives the lowest value of critical gap of 1.29 seconds. The Raff's method which uses the statistical distribution function of accepted and rejected gaps and their intercept gives the critical gap value of 1.4 seconds. The Ashworth's method which takes into account the mean and standard deviation of accepted gaps indicates the value of critical gap to be 1.53 seconds.

The percentage reduction in speed for approaching vehicle at every 10 meter interval is found to be more than the increase in speed by leaving vehicle. This average reduction of speed for all the conflict zones, before and after conflict point is observed to be around 17% in both the cases. It is also observed from speed profile that the drivers tend to slow down well in advance before reaching the conflict zone and they increase the speed at high pace as they leaves the conflict zone.

The headway for each leg was determined using one minute volume count data. It indicates that the headway values are dependent on the volume of the traffic and the headway distribution shows that the plot is best fitted as exponential

(negative) with the value ranging from 0.22 to 0.49. The value of lambda for the combined data set of all the legs is found to be 0.35.

REFERENCES

[1]. Kusuma A. and Koutsopoulos H. (2011) "Critical GAP Analysis of Dual Lane Roundabout" 6th International Symposium on Highway Capacity and Quality of Service Stockholm, June28-July 1, 2011. Page 709-717

[2]. Mahmassani H. and Sheffi Y. (1980) "Using Gap Sequence to estimate GAP Acceptance Function" TR[B] Vol 15B. Page 143-148

[3]. Pollatschek M, Polus A and Livneh M (2001) "A decision Model for Gap Acceptance and Capacity at Intersections" Transportation Research Part B 36 (2002). Page no 649-663

[4]. Prasetijo J. (2005) "Development of a new method of capacity analysis at Unsignalized intersections under Mixed Traffic Flow" Proceedings of the eastern Asia Society for Transportation Studies, Vol. 5 Page no 967-983

[5]. Purnima P. and Gangopadhyay.S (2008) Estimation of Fuel loss during idling of vehicles at Signalised Intersections in Delhi, A study report.

[6]. Ruijun G. and Boliang L. "Traffic Operation Performances at Roundabout Weaving Sections" Journal Of Transportation Systems Engineering and Information Technology. Vol. 10, Issue 3, June2010 Page29-34

[7]. Sabanayagam S. (1990) "Capacity Analysis of Unsignalized Traffic Circles" TE Compendium of Technical Papers

[8]. Ackelik R. (2005) "A Review of Gap Acceptance Capacity Models" 29th Conference of Australian Institutes of transportation Research.

[9]. Ackelik R. (2011) "An assessment of the Highway Capacity Manual 2010 roundabout capacity model" Paper presented at the 3rd International Conference on Roundabouts, Carmel, IN.

[10]. Ajaz R. (2013) "Mixed traffic flow behavior analysis and capacity modeling at multi-lane urban roundabout", vol. 3 issue 6, 2013.

[11]. Ashworth R. (1968) "A Note on the Selection of Gap Acceptance Criteria for Traffic Simulation Studies" Transportation Research.Vol.2, Page. 171-175

[12]. Ashworth, R. (1979) "The Analysis and Interpretation of Gap Acceptance Data" Transportation Research, Page 270-280.

[13]. Brilon W, Koeing R. and Troutbeck R (1999) "Useful Estimation Procedures for Critical Gaps" Transportation Research Part A 33 page no 161-185

[14]. Brilon W. (2005) "Roundabouts: A state of the art in Germany" Paper presented at the National Roundabout Conference, Vail, CO.

[15]. Chandra S and Rastogi R. (2012) "Mixed Traffic Flow Analysis on Roundabouts" Paper no: 575, Journal of the Indian Road Congress, Jan-Mar 2012 Page no- 69-77