

 ISSN NO. 2320-5407	Journal Homepage: - www.journalijar.com INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR) Article DOI: 10.21474/IJAR01/8068 DOI URL: http://dx.doi.org/10.21474/IJAR01/8068	
---	--	---

RESEARCH ARTICLE

VEHICLE GAP ACCEPTANCE BEHAVIOUR CONSIDERING CLEARING TIME AT A SELECTED ROUNABOUT INTERSECTION IN DHAKA CITY FOR HETEROGENEOUS TRAFFIC CONDITION IN BANGLADESH.

S Roy, M. A. Uddin and A. C. Dey.

Student, Dept. of Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka-1000,
Bangladesh.

Manuscript Info

Manuscript History

Received: 11 September 2018

Final Accepted: 13 October 2018

Published: November 2018

Keywords:

Clearing time, Critical gap, Gap acceptance, Heterogeneous traffic, Influence area for gap acceptance, Lag acceptance, Roundabout.

Abstract

In this paper vehicle gap acceptance behaviour has been analyzed at a selected roundabout intersection in Dhaka city for the traffic condition in Bangladesh. Traditional gap acceptance measuring methods like Raff method are not effective for the traffic condition of Bangladesh. Consideration of clearing time in gap acceptance study provides a solution to this problem. In this paper gap acceptance behaviour has been study in both traditional Raff method and considering clearing time at particular conflict point in SAARC Fountain intersection. Necessary data for this study was collected from a video recording and the number of accepted gap, accepted lag and clearing of vehicles were counted manually from the video. Critical gap from Raff method was found to be 2.82 sec where considering the clearance time critical gap and critical lag were 3.72 sec and 3.70 respectively showing a significant difference between these two methods.

Copy Right, IJAR, 2018, All rights reserved.

Introduction:-

Gap acceptance is normally considered at intersections where a minor street intersects a major street. But it can also be measured in roundabouts where vehicles of minor streets mainly merge with the vehicle of major street after gap acceptance. Drivers performing simple crossing or merging maneuvers are presented with a series of lags and gaps between vehicles in a conflicting traffic movement. The pattern of arrivals of the major street vehicles result in the creation of time gaps of different durations. A gap between two vehicles is the distance between the rear bumper of the first vehicle and the front bumper of the second vehicle and is usually measured in seconds (FHWA 2009, p 8-1). Lag is the distance in time between the entering vehicle and the successive vehicle in the major stream (Drew 1968, p 177).

When exposed to these lags and gaps, drivers of minor street vehicles would react based on certain behavioral considerations associated with the driver, which is called “critical gap”, an important parameter in gap acceptance behavior. It is the minimum gap that is acceptable to a driver, intending to cross a conflicting stream.

For this study, clearing behavior approach is adopted to determine the critical gap/lag which is defined as the gap/lag corresponding to the intersection point of cumulative curves of gap acceptance and clearing time. The main aim of

Corresponding Author:-S Roy.

Address: - Student, Dept. of Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka-1000, Bangladesh

this paper is to estimate critical gap and critical lag separately by making use of clearing behavior of vehicles in conjunction with gap and lag acceptance data for SAARC Fountain intersection and comparing the result with the critical gap estimated with Raff method.

Background Literature: -

Performance of uncontrolled intersections in a mixed traffic situation has always been a topic of interest among traffic engineers. Even in countries where uniform traffic conditions exist, uncontrolled intersection analysis always presents a rather complex picture. This is mainly due to the unavoidable presence of critical gap in all capacity expressions. Though studies on critical gap are well documented in international literature its vastness indicates the complexities in the estimation of the procedure. It was found that 50% of the gaps of 6.5s duration in the major road traffic stream were accepted by drivers and percentage of acceptance rose to 90 when the gap was 10s (Ashworth and Green, 1966). In one study compared nine different methods of critical gap estimation were compared by generating 100 sets of artificial data through simulation; gaps offered were sampled from a displaced exponential distribution until one of them was accepted (Miller, 1972). It was observed that the flow on main roads substantially influences the gap acceptance characteristics of drivers on the side roads (Adebisi, 1982). From another study it was found that maximum likelihood method is suitable when the minor stream traffic is light and recommended the use of Siegloch's method when there is a continual queuing (Troutbeck, 1992). Troutbeck (1999) reported that the critical gap for a priority movement at un-signalized intersection depends upon the amount of conflicting traffic. Brilon et al. presented a detail description of some of the important methods for the estimation of critical gaps at un-signalized intersection and their characteristics properties (Brilon et. al., 1999). Highway Capacity Manual (2000) provides base critical gap values for various movements of two-lane and four-lane major streets. These values adjusted for heavy vehicles, grade, two stages gap acceptance and for intersection geometry.

R. Ashalatha and Satish Chandra (2007) used the concept of clearing time of a vehicle type under mixed traffic flow and found that critical gap obtained by conventional methods are quite low and there is a lot of variability in the critical gap values given by different methods and concluded that methods developed under homogeneous traffic conditions do not hold good for mixed traffic conditions. They proposed a method to determine critical gap which shows that value of critical gap varies with the type of maneuver and size of vehicle executing the maneuver. They also found that the entry capacity of a vehicle type is a function of conflicting traffic (Ashalatha and Chandra, 2007).

Data Collection and Extraction: -

Data for this study were collected at a five legged roundabout intersection at Dhaka city named SAARC Fountain intersection. A particular conflict area was selected for vehicle gap study which is shown in Fig 1. In this case the minor street was Panthapath Tejgaon Link Road leg which is of two lanes and the major street was Kazi Nazrul Islam Avenue Road which is of four lanes. The gap acceptance behaviour was analyzed only with the vehicles going through Kazi Nazrul Avenue Road or Panthapath Tejgaon Link Road. Vehicle going through Panthapath road were not considered in this study. As those vehicle use left most lanes in the street, different INAFOGA (discussed later) was needed for their gap acceptance behaviour study.

Video recording technique was adopted for data collection. Video filming was done from the roof of TK Bhaban which is near the intersection and the vehicle movement can be observed easily. a vantage point to cover all the three legs of the intersection up to the merge area. Data were collected in the morning at 9:50 AM to 10:50 AM at 30th December, 2017 when it was peak time and the day was a typical weekday. The recorded cassette was replayed on a large screen television monitor to extract the data needed for this study. In this study only four wheelers were taken into consideration as this category covered the maximum vehicles at this conflict point. For gap acceptance data number of gap accepted and rejected was collected, for lag acceptance data number of lags accepted and rejected was collected. And for clearing time study vehicle distribution data for different clearing time were collected.



Figure 1:-SAARC Fountain Intersection

The concept of INAFOGA: -

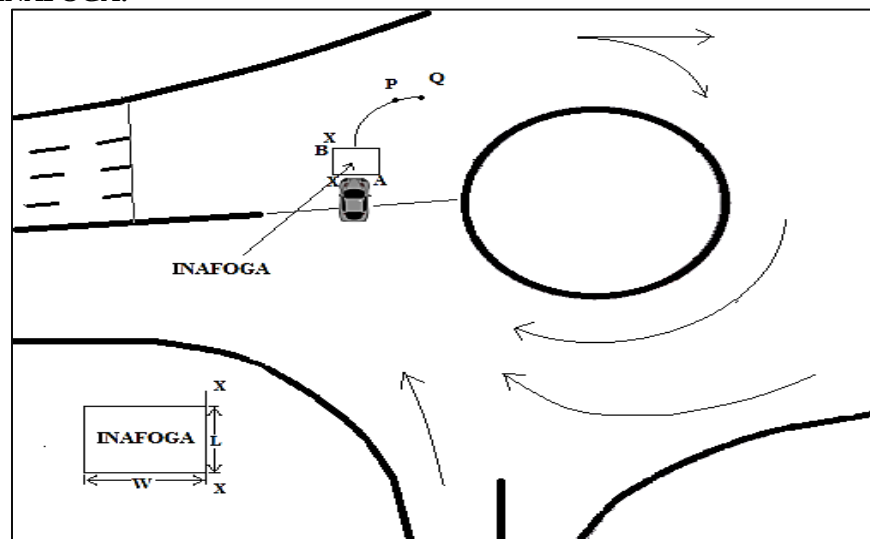


Figure 2:- Schematic representation of influence area for gap acceptance

As described earlier, the traffic of Bangladesh is highly heterogeneous and there is a total lack of lane discipline and respect for traffic signs at majority of unsignalized intersections. Although the stop signs are invariably posted at the minor approaches, the vehicles do not stop before entering the intersection area. They are found rolling some distance into the intersection area before stopping. Therefore, the reference point for a minor street vehicle seeking a gap in the major street traffic needs to be defined here. The minor street vehicles were found to move more than half of lane width into the intersection area from the stop line (position A in Fig. 2) before stopping. Hence the position A which is ahead of the stop line by more than half a lane width was considered as the reference line for recording the arrival of minor street vehicles. The gaps in major street vehicles are generally measured at position B shown in Fig. 2. It gives headway distributions when major street traffic moves unimpeded. In a mixed traffic situation, the rule of priority is often violated and majority of major street vehicles are also required to slow down to provide a gap for minor street vehicle. It is more so in case of a near saturated condition on the major street. These modified gaps offered should be measured just upstream of the conflict area.

Ashalata R. and Satish Chandra introduced the concept of INAFOGA in this case. After careful study of the gap acceptance process at intersections selected for this study, an area as shown in Fig. 2 was considered as the influence area for gap acceptance by a right turning vehicle from minor street. This area has the dimension $L \times W$, where L is equal to 3.2 m (lane width) and W is almost 1.5 times the width of the crossing vehicle. It is a rectangular area having conflict point at its geometric center. The edge XX which is the up-stream boundary of the area so formed

was taken as the reference line for measuring the gaps offered. This area is re-ferred as the Influence Area for Gap Acceptance (Inafoga) in this paper. Lag was measured as the time interval between the arrival of a vehicle on the minor road (lower priority movement) at position A (Fig. 2) and the arrival of the next (first) vehicle on the major street at the upstream end of Inafoga.

In Ashalata R. and Satish Chandra's paper Q was the point of starting of a road after intersection. As SAARC Fountain intersection is a roundabout, Q is assumed as a point where the gap accepted vehicle would be completely aligned with the vehicle in the major street. Clearing time was considered the time interval of 65 to 70% of the time needed to go through AQ. This path is assumed as AP. So the time interval between the time instant when front bumper of a vehicle at point A and back bumper of the vehicle at point P would be considered as clearing time.

The time frames chosen during extraction of data are as follows:

1. T_s = time instant front bumper of the subject vehicle touches the stop line on the minor stream.
2. T_1 = time instant front bumper of the first through traffic vehicle after arrival of the subject vehicle touches the U/S end of 'INAFOGA'.
3. T_n = time instant back bumper of the nth through traffic vehicle after arrival of the subject vehicle touches the U/S end of 'INAFOGA'.
4. T_{n+1} = time instant front bumper of the (n+1) th through traffic vehicle after arrival of the subject vehicle touches the U/S end of 'INAFOGA'.
5. T_c = time instant back bumper of the subject vehicle reaches the point P at Fig. 2

By definition,

a) LAG = time interval b/w arrival of minor street vehicle on stop line and arrival of first through traffic vehicle = $T_1 - T_s$.

b) GAP = difference b/w the time instant back bumper of the nth through traffic vehicle after arrival of the subject vehicle touches the U/S end of 'INAFOGA' and the time instant front bumper of the (n+1) th through traffic vehicle after arrival of the subject vehicle touches the U/S end of 'INAFOGA' = $T_{n+1} - T_n$.

c) CLEARING TIME = difference b/w the time instant front bumper of the subject vehicle touches the stop line on the minor stream and the time instant back bumper of the subject vehicle reaches the point P.

Results: -

Estimation of critical gap by Raff Method: -

Table 1:- Estimation of critical gap by Raff method.

Length of Gap (t sec)	Cumulative Number of Accepted Gap (less than t sec)	Cumulative Number of Rejected Gap (greater than t sec)
0	0	127
1	5	119
2	23	67
3	45	38
4	70	19
5	97	7
6	127	0

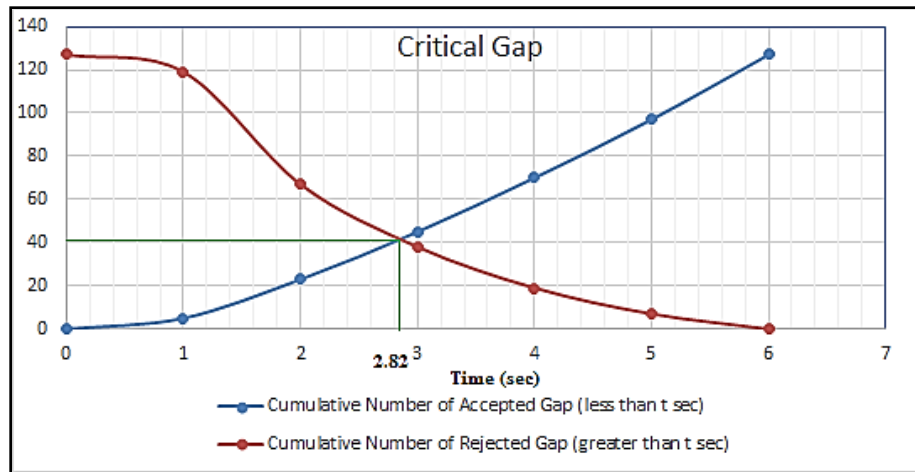


Figure 3:- Critical gap acceptance by Raff method

To measure critical gap in Raff Method Cumulative Number of Accepted Gap (less than t sec) and Cumulative Number of Rejected Gap (greater than t sec) data (See Table 1) for different time length were plotted in a graph paper. The time of intersecting point is the critical gap (See Fig. 3). The critical gap estimated in this method is 2.82 sec.

Critical Lag Considering Clearing Time: -

Table 2:- Critical lag considering clearing time

Length of Gap (t sec)	Cumulative Number of Accepted Lag (less than t sec)	Cumulative Number of Clearance (greater than t sec)
0	0	-
1	7	-
2	22	127
3	45	117
4	71	43
5	99	15
6	127	0

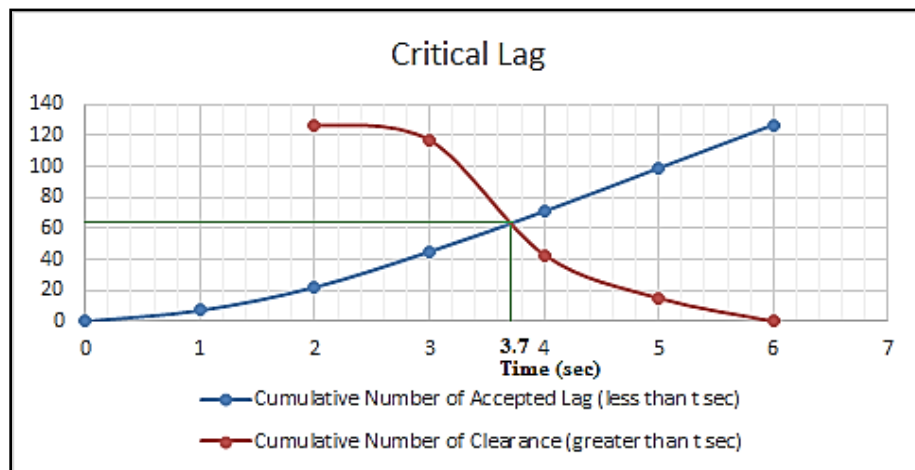


Figure 4:- Critical lag estimation considering clearing time

To measure critical lag by clearance behaviour approach Cumulative Number of Accepted Lag (less than t sec) and Cumulative Number of Clearance (greater than t sec) data (see Table 2) for different time length were plotted in a graph paper. The time of intersecting point is the critical gap (See Fig. 4). The critical lag estimated here is 3.7 sec.

Critical Gap Considering Clearing Time: -

Table 3:- Gap Acceptance by Raff method

Length of Gap (t sec)	Cumulative Number of Accepted Gap (less than t sec)	Cumulative Number of Clearance (greater than t sec)
0	0	-
1	5	-
2	23	127
3	45	117
4	70	43
5	97	15
6	127	0

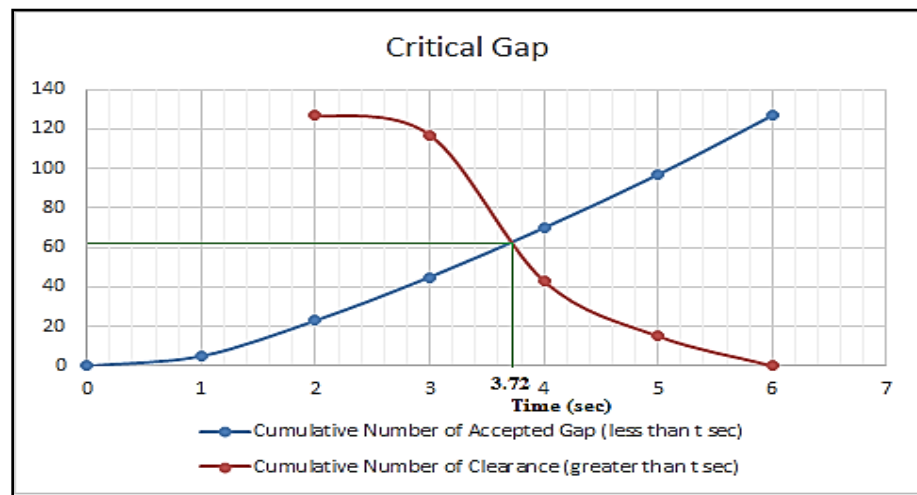


Figure 5:- Critical gap estimation considering clearing time

To measure critical gap by clearance behaviour approach Cumulative Number of Accepted Gap (less than t sec) and Cumulative Number of Clearance (greater than t sec) data (see Table 3) for different time length were plotted in a graph paper. The time of intersecting point is the critical gap (See Fig. 5). The critical lag estimated here is 3.7 sec. Critical Gap estimated here is 3.72 sec.

Discussion: -

The traffic in Bangladesh is highly heterogeneous consisting of a variety of fast moving vehicles such as car, bus, truck, scooter (motorized two-wheeler), auto rickshaw (motorized three-wheeler) and slow moving vehicles (bicycle in this particular intersection). The static and dynamic characteristics of these vehicles vary significantly. In the absence of lane discipline and wide variation in sizes of different types of vehicles, they are found to queue side by side in the minor street approach. Smaller size vehicles often squeeze through any available gap between large size vehicles and move into the intersection area in haphazard manner. A single gap in the major stream can be accepted by more than one vehicle moving parallel to each other and after crossing the conflicting traffic these vehicles move in a single file, after one another. The rule of priority is often violated and the minor stream vehicles enter the intersection area even in smaller gaps forcing the major stream vehicles to slow down and provide sufficient gaps for their movement. It was observed during data extraction that almost 70-75% of major street vehicles are forced to slow down to enable the minor street vehicles to cross the street. This is not necessarily due to high traffic volume on major or minor street but is due to impatient and discourteous behavior of minor vehicles. It changes the behavior

of major street vehicles altogether and the gaps offered to the minor vehicles are not the natural time headway, but the modified ones. This forced gap acceptance which occurs due to non-adherence to priority, significantly affects the entry capacity of the lower priority stream and causes substantial delay to higher priority movements. It makes gap acceptance a very complex process. All these situations require a re-look into the concept of critical gap, conflict area at the intersection and method of data extraction. This study shows that in case of a situation in a heterogeneous traffic condition considering clearing time in gap acceptance study change the result significantly.

Concluding Remarks: -

This study shows that heterogeneous traffic condition in Dhaka city increases the critical gap and critical lag. So considering clearing time in estimating the critical gap or lag will be more effective in case of traffic condition of Bangladesh.

References: -

1. Ashalatha, R. and Chandra, S. (2011). Critical gap through clearing behavior at unsignalized intersection. KSCE Journal of Civil Engineering, 15(8), 1424-1434.
2. Ashworth, R. and Green, B. D. (1966). Gap acceptance at an uncontrolled intersection. Traffic Engineering and Control, Vol. 7, No. 11, pp. 676-678.
3. Adebisi, O. (1982). Driver gap acceptance phenomena. Journal of Transportation Engineering, ASCE, Vol. 108, No. 6, pp. 676-688.
4. Brilon, W., Koenig, R., and Troutbeck, R. J. (1999). Useful estimation procedures for critical gaps. Transportation Research Part A, 33(3-4), 161 – 186.
5. Drew, D. R. (1968). Traffic flow theory and control. McGraw-Hill, New York.
6. FHWA (Federal Highway Administration) (2009). Traffic flow theory. US Dept. of Transport, USA.
7. Highway Capacity Manual (HCM). (2000). Transportation Research Board, National Research Council, Washington, DC.
8. Miller, A. J. (1972). Nine estimators of gap acceptance parameters. Proc., 5th Int. Symp. on the Theory of Traffic Flow and Transp., G. F. Newell, eds., Elsevier, New York, 215 – 235.
9. Troutbeck, R. J. (1992). Estimating the critical acceptance gap from traffic movements. Physical Infrastructure Centre Research Report 92-5, Queensland University of Technology, Brisbane, Australia.