Review on Estimation of Critical Gap at an Unsignalized Intersection

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Abstract: - The efficiency of any road network is basically depending upon the capacity of individual intersections and a measure of overall performance of urban traffic scenario. The capacity of road network majorly depends upon the unsignalized intersections. Various parameters are responsible for performance of unsignalized intersection like geometrical parameters, composition of traffic, traffic movements and volume etc. In India due to heterogeneous traffic lane priorities are not followed and thus it is essential to study the gap acceptance behavior of the drivers. In recent past many researchers have worked on effect of critical gap on performance of such Intersection for heterogenous traffic. The critical gap is the most important parameter to understand the gap acceptance behavior of drivers and to estimate the capacity of an individual movement. Critical gap is a stochastically distributed value and it cannot be measured using field measurements and it varies with drivers, time, movements and traffic conditions. The critical gap had been an interesting topic for researchers and many researchers have proposed different methods to estimate critical gap. In this paper different methods used to estimate critical gap which are used by researchers in the past years has been reviewed.

Keywords: **Critical gap, Gap Acceptance, heterogeneous traffic, Uncontrolled Intersection**

I. INTRODUCTION

To analyse the traffic flow at an uncontrolled intersection has always been an area of interest for traffic engineers due its complex operational behaviour. The driver who is on the minor street has to make an approximate estimation of the gap to cross or merge the intersection conflict area safely. The decision to enter into the conflict area is influenced by driver behaviour, intersection characteristics, vehicular characteristics, opposing flow, type of control, etc. The complexity is further increased in the case of heterogeneous traffic conditions that normally prevail in developing countries, where the rules regarding priority of lanes are very often neglected.

Critical gap is the most significant parameter in the gap acceptance process. A consistent driver will accept all gaps which are more than his critical gap and will reject all other gaps which are less than his critical gap. The determination of capacity at unsignalized intersections is based on critical gap. The Highway Capacity Manual of USA (HCM, 2000) has defined critical gap as the minimum time difference between the arrivals of minor street vehicle during which a minor street vehicle can make its entry into the intersection.HCM (2010) replaced critical gap with critical headway and defined it as the minimum headway in the major traffic stream that will allow the intersection entry of one-minor street vehicle. The term critical headway is basically applicable to conditions of uniform traffic, but when there exists a wide variability in the operating traffic as in the case of heterogeneous conditions, it is meaningful to consider critical gap instead of critical headway.

Critical gap is a parameter which cannot be directly measured from the field, but is estimated on the basis of accepted and rejected gaps. It can be confidently assumed to lie in between the accepted gap and maximum rejected gap. This estimation process become complicated when applied to heterogeneous traffic conditions which are characterised by lack of lane discipline, absence of movement priority, forced entry of lower priority movement, zig-zag crossing of the intersection area etc. The variations in the static and dynamic characteristics of the operating traffic further complicate the estimation process. This paper proposes a new approach for critical gap estimation which can be usedfor bothhomogeneous and heterogeneous traffic conditions.

II.LITERATURE REVIEW

Mithun Mohan et.al.(2016)[6] In this paper auther has reviewed different methods to estimate the critical gap which are developed in the past 60 years and also explained application procedure, advantages and disadvantages of each method. This paper reviews popular techniques which were used in the analysis of TWSC intersections over the past 60 years. Application procedure of each of these methods, along with their advantages and limitations are also included. The accuracy of these methods is checked through simulation. Through movement at a four-legged intersection formed by two single lane one-way streets were simulated in VISSIM software and critical gap values for this movement is compared against estimated critical gap from various methods. The study found that the estimates of many of these methods are dependent on the volume of conflicting traffic. Maximum Likelihood Method, Raff's Method and Probability Equilibrium Method is found to give the closest and consistent estimate for critical gap. Some of these methods are computationally simpler, while other can be solved only by the use of a computer. The conceptual differences among the methods provide different values for estimated critical gaps.

Simulation was used to quantify accuracy of critical gap estimated by various methods. Critical gap was estimated for through movement from minor street at a simulated four-legged TWSC intersection and it was used to determine the accuracy of each method. The study found that MLM, PEM (using only maximum rejected gaps), Raff's and Acceptance Curve Methods gave consistent results while critical gap by Probit, Logit and Ashworth's methods varied with the volume of conflicting traffic. The study also found MLM to give the best estimate followed by PEM and Raff's method. In view of the consistency and accuracy in prediction, this paper suggests MLM, PEM (only considering maximum rejected gaps) and Raff's methods for the estimation of critical gaps at TWSC intersections.

Akhilesh Kumar Maurya et. al. (2016)[1] This paper presents a study of crossing behaviour the drivers on uncontrolled intersections. A four-legged intersection was selected in Ahmedabad for this study. Data collection was done by videography method with the help of five video cameras. The videos were used ro extract data like vehicle arrival rate/time, gap/lag time, speed and approaching vehicle type, waiting time etc. Several existing methods were used to estimate critical gap for three different types of vehicle such as two wheelers, three wheelers and passenger cars. The results were compared.

In this study the parameters that affect the critical gap values are evaluated and the study concludes that driver's age and gender affect significantly the critical gap values. The other factors are waiting time, subject vehicle speed and type and number of rejections on the stop line.

Manish Dutta et. al.(2016)[5] compared The focus of 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 two numbers of three-legged uncontrolled intersections. Critical gap and lag were found to be quite varying depending on the type of intersection. The values of critical lag are found to be less than critical gap in all cases.

A field survey was carried out at two uncontrolled intersections in Silchar, Assam. Using the "INAFOGA' concept for data extraction, estimation of critical gaps for uncontrolled intersections under mixed traffic conditions have been done in this paper. The purpose was to analyze the gap/lag acceptance behavior of drivers and to find the critical gap and critical lag values which are widely used in intersection operational analysis and capacity estimates. The critical gap and lag values obtained were less than those of developed countries which confirms the riskier behavior of drivers in developing countries. Moreover, values of critical lag has been found to be less than critical gap in all cases.

Harsh Jigishbhai Amin et. al. (2015)[4] This paper presents the study of gap acceptance behaviour of drivers on an uncontrolled intersection. In order to examine the gap acceptance behaviour of drivers, 4-legged uncontrolled intersection located in a semi-urban area of Ahmedabad in the state of Gujarat was selected. Video recording technique was adopted for collection and analysis of the data. Different existing methods are used to calculate the critical gap for through and right turning movements from the minor road. Gaps are analysed for three different vehicle types. A comparison between different existing methods of critical gap determination is carried out and their critical analysis is presented. The result shows, except clearing behaviour approach, all other methods are failing to represent the actual scenario of the critical gap under mixed traffic conditions as these all methods had been developed for homogeneous traffic conditions. This estimation procedure is quite simple, and it is applicable for mixed traffic condition as well as homogeneous traffic and similarly it is applicable for both over-saturated as well as undersaturated traffic conditions. The result obtained with this methodology is not highly affected by traffic volume on Major Street as cumulative distribution curve of clearing time and accepted gap act in a contradictory manner. Hence, the overall impact of traffic volume on the result is minimal.

Suprabeet Datta (2014)[9] In this paper, Critical gap has been used as the sole parameter for gap acceptance. Video image processing of 4 U-turn median openings were done to extract the decision variables of the study.Two empirical methods namely Harder's and Satish et al. "INAFOGA" are used for estimating critical gap considering four motorized modes of transport for all the four sections. Bar comparison plots for all four sections are drawn to compare the methods considering the four motorized modes.

A paired sample T-test was done in IBM SPSS 22.0 which revealed that "INAFOGA" method yield critical gap values 28-41% more than those obtained by Harder's method. This explained the effectiveness of "INAFOGA" method in judging mixed traffic conditions for U-turns at median openings. Reason being the abrupt vehicular interactions in mixed traffic conditions. This indicates that the "INAFOGA" concept is successful than Harder's method in gap acceptance analysis under mixed traffic.

Satish Chandra et.al.(2014)[8] has proposed a new method to estimate the critical gap named occupancy time method. Occupancy time may be defined as the time required to cross the conflict area of the unsignalized intersection. To study that the method is feasible for both kind of traffic such as homogeneous and heterogeneous traffic condition they have taken two unsignalized intersections one in USA which represents homogeneous traffic condition and the another one in in India which represents heterogeneous traffic condition. The data collection is done with videography method. They have extracted the data such as occupancy time for minor stream vehicles and the gap in terms of time which is accepted by the subject vehicle. In this paper the authors have estimated critical gap using lag, harder, modified raff, Maximum likelihood method(MLM), Probability equilibrium Method(PEM) and occupancy time method. The results with occupancy time method was slightly higher then the

results from MLM for the heterogeneous traffic conditions and very close for the homogeneous traffic condition which shows that the OT method can be used for both homogeneous and heterogeneous traffic condition.

Ashalatha R.et. al. (2011)[2] Majority of studies on critical gap estimation are reported from homogeneous traffic conditions where lane discipline and the rule of priority are truly respected. Vehicular interactions and drivers' behavior at unsignalized intersections under mixed traffic are very complex. In this study critical gap is estimated by some of the existing methods like lag, Harder, logit, probit, modified Raff and Hewitt methods, at two T- intersections located in the southern part of India. The results show that values of critical gap estimated are as low as 1.60 s and there is a significant variation (12%-38%) among the values estimated by different methods. This highlights the incapability of the existing methods to address the mixed traffic conditions. An alternate procedure of estimation of critical gap making use of clearing behavior of vehicles in conjunction with gap acceptance data is proposed.

The critical gaps are estimated for three types of vehicles and two types of movements at two unsignalized T intersections under mixed traffic conditions, using six different methods available in literature. These values are found to be quite low with wide variation (12%-38%) among the values predicted by the different methods. Results are found to be lower than those given in HCM (2000) but greater than those estimated by existing methods. Entry capacity for a priority movement is calculated using the average critical gap estimated by proposed method and that reported in HCM (2000). Entry capacity in a mixed traffic condition is found to be higher than that in a uniform traffic condition. The method of critical gap estimation proposed in this paper is simple and easy to implement. Knowledge of critical gap is essential in estimating the entry capacity of various movements at unsignalized intersection. Hence this methodology will serve as an easy tool in the hands of the practicing engineers for deciding various strategies under mixed traffic conditions.

Wan Hashim Wan Ibrahim et.al.(2007)[10] In this study, critical gap acceptances under normal saturation flow condition were estimated for unsignalized T-Intersection in Malaysia using the Maximum Likelihood Method. The results indicate that there are significant differences between the critical gap of passenger cars and motorcycles. In this study, the composite critical gap that takes into consideration the differences in traffic compositions were proposed. The composite critical gap enables the use of single representative gap acceptance value for estimating capacity of unsignalized T-intersection based on Malaysian traffic condition.

A composite critical gap formulation is proposed for estimating critical gap of multilane and single lane unsignalised T-Intersection. The adoption of the composite critical gap addressed the issue of mixed traffic where the percentage of motorcycles is higher than the percentage of passenger cars. The use of the composite gap acceptance value enables the usage of single value of critical gaps for the purpose of estimating the capacity of the unsignalized intersection using the critical gap acceptance procedure. The findings of this study are under the normal saturation condition. The application under over-saturated condition requires further research. The proposed findings will be used as an input for Malaysian Highway Capacity Manual for unsignalized T-Intersection condition.

Werner Brilonet. al. (1999)[3] This paper gives an overview of some important methods to estimate critical gap. For comparison purposes a set of quality criteria has been formulated by which the usefulness of the different methods can be assessed. This is the objective that the results of the estimation process should not depend on the traffic volume on the major street during the time of observation. Only if this condition is fulfilled, the estimation can be applied under all undersaturated traffic conditions at unsignalized intersections. To test the qualification of some of the estimation methods under this criterion, a series of comprehensive simulations has been performed. As a result, the maximum likelihood procedure (as it has been described by Troutbeck) and the method developed by Hewitt can be recommended for practical application.

A review of publications about estimation of critical gaps reveals many different proposed solutions. It is difficult to understand which procedure is reliable and which is not. From the sample of methods tested for this paper, the maximum likelihood procedure and Hewitt's method gave the best results. Both were valid for the two cases studied. This explains the selection of the maximum likelihood method for the evaluation of critical gaps for the next edition of the HCM, Chapter 10. The investigation of the different theoretical concepts shows that principles of the various methods could also be combined.

III. CONCLUSION

Capacity analysis of an unsignalized intersection is basically depends upon gap acceptance behaviour. Estimation of critical gap is a first step of this process. In this paper many methods to estimate critical gap is studied which were used by the researchers in their past studies. The conceptual differences among the methods provide different values for estimated critical gaps. In this paper it is also shown that the difficulties and complexities in the estimation of critical gap. It is concluded that the some methods gives the mean value of the critical gap and some methods gives the total distribution of the critical gap. Critical gap estimation methods like raaf's method, harder's method, lag method, acceptance curve method are basically more suitable for homogeneous traffic condition. The occupancy time method and clearing behaviour approach gives satisfactory results in case of the heterogeneous traffic condition.

REFERENCES

[1] Akhilesh kumar maurya, Harsh J. Amin, Arvind Kumar, "Estimation of Critical gap for Through Movement at Four leg Uncontrolled Intersection" 11th transporatation planning and implementation Methodlogies for developing countries, TPMDC 2014

[2] Ashalatha R. and Satish Chandra, "Critical Gap through Clearing Behavior of Drivers at Unsignalised Intersections" KSCE Journal of Civil Engineering (2011) 15(8):1427-1434

[3] Brilon, W., Koenig, R. and Troutbeck, R. J. (1999). Useful Estimation Procedures for Critical Gaps. Transportation Research, Part A, 33 (3), pp. 161-186.

[4] Harsh Jigishbhai Amin; Akhilesh Kumar Maurya, "A review of critical gap estimation approaches at uncontrolled intersection in case of heterogeneous traffic conditions" Journal of Transport Literature, 9(3), 5-9, Jul. 2015.

[5] Manish Dutta, Mokaddes Ali Ahmed, " Critical Gap and Critical Lag Estimation of Uncontrolled T-Intersection Using Clearing Behaviour Approach" Proceedings of National Conference on Recent Advances in Civil Engineering (RACE2016),

[6] Mithun Mohan, Satish Chandra, "Review and Assessment of Techniques for Estimating Critical gap at Two-way Stop-Controlled Intersections" European Transport /Paper no. 8, ISSN 1825-3997

[7] Mithun Mohan & Satish Chandra, "Critical Gap Estimation at Two-Way Stop-Controlled Intersections Based on Occupancy Time Data" ISSN: 2324-9935 (Print) 2324-9943.

[8] Satish Chandra, Mithun Mohan And Timothy J. Gates, "Estimation Of Critical Gap Using Intersection Occupancy Time".

[9] Suprabeet Datta," Critical Gap Comparison between HARDERS and "INAFOGA" Methods for U-Turn Median Openings" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622

[10] Wan Hashim Wan Ibrahim, Mohd Erwan Sanik, "Estimating Critical Gap Acceptance For Unsignalised Tintersection Under Mixed Traffic Flow Condition" Proceedings of the Eastern Asia Society for Transportation Studies, Vol.6, 2007