# Methods of Delay Analysis - A Review Paper

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***Abstract*- Traffic density in Nagpur city is increasing rapidly these days due to industrial, infrastructure growth of the city. Number of vehicles is increased in multiple folds in last decade, resulting in traffic congestion and delays at central business area's intersections. To give suitable solution over delays, a proper method of delay study is need to be studied. This review paper contains study of different methods of delay analysis. Methods used for delay analysis in research papers for delay at signalized intersection, non signalized intersection, at upstream, at downstream and midway between two intersections are investigated. The aim of this review paper is to find out the appropriate, more realistic delay model for delay analysis of heterogeneous traffic as Indian road traffic is having heterogeneous behaviour.**

***Index Terms*- delay analysis, VISSIM simulation, HCM.**

## INTRODUCTION

Delay at signalized intersections is one of the major problems causing personal, social economical and environmental loss as well. Density of vehicles is rapidly increasing urbanization and changing lifestyles of people. Urban crowd is preferring private and own transportation modes rather than using public transportation system due to lack of co ordination, comfort, ease of mode changing in public transportation modes. due to this, urban vehicular density is increasing, at some place, so immensely, that need of restructuring current modes and facilities of transportation occurs. Due to this vehicular flow at some intersections is flowing with beyond capacity limit. Resulting at increased cycle time causing longer queue lengths and overall delay. As Indian road traffic is flowing with heterogeneous characteristics flow parameters used for uniform flow may not describe the actual scenario, more realistic models are need to be studied. Delays are not only a time bound factor but it also affects in many ways and leads to more fuel consumption as most of vehicles remains on at a intersections during red time in the signal cycle. it also increases air pollution as the vehicles are at stable condition and engine is on, when vehicle's engine is off and started at the end of red time, more fuel is consumed for starting the engine, most of the passengers have the tendency to accelerate the engine when starting, many tends to accelerate at initial speeds, all these factors are generally neglected but when they are taken into account, their effect calculated in environmental hazard and in economical equivalences per year are huge. Almost matching the initial cost for taking the right action at the right time. Further, changing the infrastructure, mode of transportation may take more time, planning and economy.

Delays not only deal with economical losses and environmental hazards but it leads to mental and social problems also. Thus, new methods, modes should be adopted to overcome these problems before it reaches total restructuring of existing provisions. For achieving these measures, delay analysis should be done with appropriate models which suit the traffic conditions of the study areas. In India, traffic conditions are of heterogeneous characteristics. Thus, suitable delay models should be used in spite of using traditional delay models.

## PAPERS REVIEWED

1. Arpita Saha et.al. proposed an improved delay model for signalized intersections for heterogeneous traffic conditions. They used Simpson's one third rule in spite of opting traditional delay analysis by Highway Capacity Manual. In their study, they measured the queue lengths directly from the field. In their study, they found that their proposed Model

yielded best results and is more useful for Indian heterogeneous traffic conditions. For calibrating the model, they assumed that not traffic rule was violated in their study which is not possible practically. This may be the major drawback of the study.

Data Collection and Extraction: fifteen isolated signalized intersections were chosen located at five cities by researchers. Two cameras were fixed to record arrival and departure of vehicles at each approach.

Measurement of Saturation Flow and Delay: In the researcher's study, traffic volume, capacity, and saturation flow of an intersection approach were measured in terms of number of vehicles (N). Saturation flow is estimated as the number of vehicles crossed the stop line in that interval. They used the Simpson's one-third rule for estimating the area between queue length and respective time. The area was considered as the total delay of that cycle.

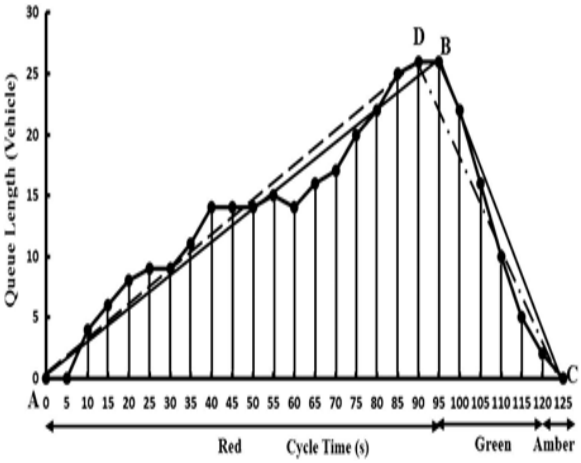


Fig . Delay estimation with triangle method

2. Bruce Hellinga, and Zeeshan Abdy used the collected data as a input to a Monte Carlo simulation to determine associated distribution of intersection delay.

Researchers advised to use empirical data for quantifying the distribution of day to day peak hour traffic volumes and the degree of statistical correlation. They studied the requirement of day's count of turning movement counts in order to estimate intersection performance. They found that degree of day to day variability exists in peak hour traffic volume.

3 S. P. Anusha et.al. opted to use model based approach for determining delay at signalized intersections. They calculated Queue & delay at intersections using advanced detectors in spite of relying on manual surveys, which are generally consisting of manual errors. They choose Input-output method & queue accumulation polygon methods for accumulation. They also Analyze the characteristics of errors occurred in the model during their model calibration/accumulation.

Researchers used statistical parameters of the estimation scheme for a wide range of operating conditions, such as different weather or traffic conditions, for queue and delay estimation at signalized intersection.

4. Ch.Ravi Sekhar et.al. selected study area in Ahmadabad city. Further they collected Traffic data which includes vehicle volume counts, speed and delay data, queue length measurements. They considered idling delay also in their study. Further they estimated idling delays and fuel consumption at signalized intersections and modelled the data and simulated it into VISSIM simulation. They choose Comparative evaluation between base case and proposed scenario. in which mitigation measures were implemented in VISSIM model.

They suggested minor geometric improvements & stabilization of signal timings for corridor in their study. It is observed that the prediction-errors for the simulation model in VISSIM were in the permissible range. To reduce the delay at intersections, researchers suggested the mitigation measures like optimisation of traffic signals based on the traffic on various arms, Geometric improvements at intersections and provision of grade separated facilities along the main direction of traffic flow in their study.

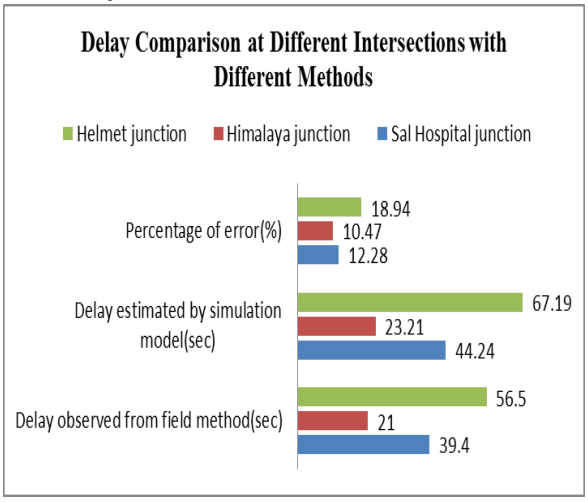


Table: Delay estimation results.

5. Satish Chandra et.al. analyzed different methods of delay measurements worldwide, majority of transportation researchers mostly use highway capacity manual method and Webster's method. They stated that, these models, being based on homogeneous traffic, are not appropriate for highly heterogeneous traffic in India. They also stated that model based delay calculation depending upon actual field data gives results close to actual scenario.

Researcher measured the delay occurred directly from field data to which they compare with results occurred from existing delay models.

They collected data from three cities in India of seven different four legged with left turning channel. Their results indicate that delay at a intersections measured from field data is more accurate.

6. Piotr S. Olszewski said that accurate estimation of vehicle delay is very difficult because of randomness of traffic. Existing delay models simply the real traffic conditions only to provide estimate of average delay.

In this study, a stochastic model was used to study the changing probability of delay .Model is based on any type of arrival process. For this different degree saturation and arrival types was investigated. Variance of delay increases with degree of saturation which is inversely proportional to the approach capacity.

On other hand, other parameters i.e. saturation flow and cycle time do not have a significant effect on delay distribution. Variance of delay are sensitive to arrival process and increase the variance of arrival.

Author concluded that, it gets more dispersed with time in case of fully saturation. The effect of arrival variability (variance to mean ratio) arrivals per cycle on both was found to be strong. Researcher suggests the need for more research on the types of different traffic conditions and their use for delay modeling.

## CONCLUSIONS

After studying various papers on delay analysis methods, widely used method for Delay analysis are:

i) HCM's triangle method: It suggests that the total delay of an under saturated cycle can be measured by plotting a trapezoid or a triangle among queue length of a cycle and cycle time. The area of the triangle or trapezoid represents the total delay associated with that cycle. The primary assumption for constructing a triangle or a trapezoid is the constant arrival and departure rates during the time period.

ii) Webster's Delay model: The delay model developed by Webster is based on the determin - istic queuing theory. Vehicle arrival rate is assumed to be uniform in this method.

iii) The Simpson's one-third rule: The Simpson's one-third rule is used for estimating the area between queue length and respective time. The area is considered as the total delay of that cycle.

iv) Field method of Delay analysis: This method gives delays depending on queue lengths, traffic volume, capacity, and saturation flow of an intersection approach are measured in terms of number of vehicles (N).Saturation flow is estimated as the number of vehicles crossed the stop line in that interval.

v) Software based Delay analysis: micro-simulation in VISSIM software gives detailed analysis of delay at a selected signalized intersection, corridor with nodal analysis which gives personal and overall delay with less erroneous results.

Conventional delay models are not suitable for Indian traffic conditions, as uniform traffic conditions are assumed for the calibration of delay models using HCM or Webster's delay model.

Input-output method & queue accumulation polygon methods for accumulation are more suitable for varying traffic conditions and non uniform flows.

Errors found in the result of delays at selected stretch with the help of VISSIM simulation are in a range of 0.1% to 15% with an average error of 4.95% which is considered good fit.

Simpson's right hand third rule is appropriate for estimating delays in heterogeneous traffic conditions with the help of VISSIM simulation and the comparison of the two gives more accurate results for heterogeneous traffic, which is the state of traffic in India.

Field estimation method of delays at signalized intersections with known queue lengths gives more accurate results and VISSIM micro simulation model method gives results nearly similar to field delay estimation method for traffic having heterogeneous nature.

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