EVALUATION OF DELAY AND LEVEL OF SERVICE FOR SIGNALIZED INTERESECTION OF URBAN AREA

[1]PARTH M. PANDE, [2]SAURABH PATEL, [3]JAIMIN SOLANKI

M.E.- Students, Department Of Civil Engineering,
Hasmukh Goswami College Of Engineering, Vahelal, Ahmedabad

parth93pande@gmail.com

ABSTRACT: *At-grade intersections are one of the most critical elements that influence the performance of urban road network. For safe and efficient movement of large volumes of traffic on city road network, majority of the intersections are usually signalized. Operation and performance of signalized intersections is influenced by the roadway parameters, traffic condition, operating parameters and environmental conditions along with user's behavioural characteristics, which significantly differ among locations. Delay is one of the principal measures of performance used to determine the Level of Service (LOS) at signalized intersections and several methods have been widely used to estimate vehicular delay. Very few studies only have been carried out to estimate delay at signalized intersections under mixed traffic conditions prevailing in developing countries like India. This paper presents the results of the study on analyses of Level of Service and delay conducted at signalized intersections with mixed traffic condition in Ahmedabad, India.*

Keywords*: Delay, Signalized Intersections, Mixed Traffic, PCU, Saturation Flow, LOS.*

1. Introduction

India is a developing country and its cities are undergoing rapid urbanization and modernization as a result there is rapid growth in the road traffic. Traffic movement in India is very complex due to the heterogeneous traffic stream sharing the same carriageway. Also despite having lane markings, most of the times lane discipline is not followed particularly at intersections. Highway Capacity Manual and other works assume homogeneous and lane based traffic for analysis, which exists in developed countries. There is notable lateral movement at intersections and vehicles tend to use lateral gaps to reach the head of the queue and overtake even during saturated part of green phase. Due to these fundamental differences, the standard western relationships for predicting the values of saturation flows and PCU factors are not appropriate for developing countries like India. The ability to accurately quantify vehicle delays at signalized intersections is a critical component for the planning, design and analysis of signal controls. As a result of random fluctuations in traffic flow and interruptions caused by traffic controls, delays that individual vehicles experience at a signalized approach are often subject to highly stochastic and time-dependant variation. Accurate estimation of the delays of individual vehicles at signalized intersections is also essential for road design. Delay estimation at signalized intersections has been extensively studied in the literature and several methods for estimating vehicle delay at signalized intersections have been widely used. However, it seems that the exploration on the method for estimating the delay is still continuously conducted. A detailed description of the characteristics and problems associated with mixed traffic conditions prevailing in India have been presented in the subsequent section following literature review. Hence in the present research work an attempt was made to measure delay at particular identified signalized intersections of urban area in Ahmedabad city.

2. Review of Literature

Ko et al. [1] examined the collection of signalized intersection delay data using vehicles outfitted with global positioning system (GPS) technology. Their technique included algorithms for analyzing speed profiles and acceleration profiles in order to automatically identify critical control delay points, such as deceleration onset points and accelerating ending points. This automated process permits the analysis of large data sets and provides consistent results. However, the approach experienced some difficulty in handling over-capacity conditions and closely spaced intersections. Braun and Ivan [2] studied the methods for determining the average stopped delay at signalized intersection. The average stopped delay encountered by vehicles at eight signalized intersections was measured during afternoon peak hour. The average stopped delay is then determined using the equations described in the 1994 version of the HCM. Average stopped delay was also computed using the 1985 HCM equations to identify improvements realized by applying these new techniques. During the field measurement, peak-hour flow rates are determined as well as intersection geometry and signal phasing. Then the stopped delay was calculated using 1985 HCM and the 1994 HCM equations. Error between field measurement and calculated values was examined and some explanations were given for the major difference. Some recommendations were also given concerning use of delay equations. Arasan and Jagadeesh [3] have studied the effect of heterogeneity of traffic on delay at signalized intersections from the data collected at three intersections of Chennai city. A probabilistic approach based on first-order second-moment method has been adopted to estimate the saturation flow and the delay caused to traffic, at signalized Intersections, under heterogeneous traffic conditions and found that the delay estimated using the probabilistic approach was close to the observed values of delay. Dowling [5] tested the effect on accuracy of replacing most of the required field input data with the default values recommended by HCM. The average stopped delay was calculated for six signalized intersections. The results indicated that users could obtain reliable estimate of intersection LOS and delay using only field-measured turning movements, lane geometry, and signal timing plus the HCM-recommended defaults for rest of the required input data. Lin [4] evaluated the reliability of the HCM 1984 procedure, based on field data, and discussed needed modifications. Stopped delay was measured at seven intersections and compared with the HCM estimates of delay. It was found that the procedure tends to overestimate stopped delay at reasonably well-timed signal operations. The discrepancy between the HCM estimates and the observed delays was very large even when correct cycle length and green durations were used as inputs. William [6] presented a simple and accurate technique for measuring vehicular delay on an approach to a signalized intersection. Precise definitions were established for four measures of performance: stopped delay, time-in-queue delay, approach delay and percentage of vehicles stopping and interrelationships among the four measure of performance were established.

3. Study area

Particular signalized intersection located in fast developing city located in Ahmedabad, India was chosen for the present study. It is four legged isolated type, provided with pre timed signal control operating in four phases with permitted left turns. These study intersection was in such a way that they have fair geometry (level gradient on all the approaches) and there is least interference to traffic by pedestrians, bus stops and parked vehicles etc. Average driving behaviour was assumed and the condition of vehicles was assumed to be moderate. The traffic is highly heterogeneous in nature with poor observance of lane discipline. The composition of traffic consists of a large proportion of motorized two wheelers, a small percentage of auto rickshaws, cars and very smaller proportion of heavy vehicles.

3.1 Site Selection Criteria: Intersection consists major and minor road intersecting on arterial road of Ahmadabad city. At this intersection highly hourly traffic flow causes traffic congestion and traffic congestion causes delay.

Following criteria were applied during site selection:

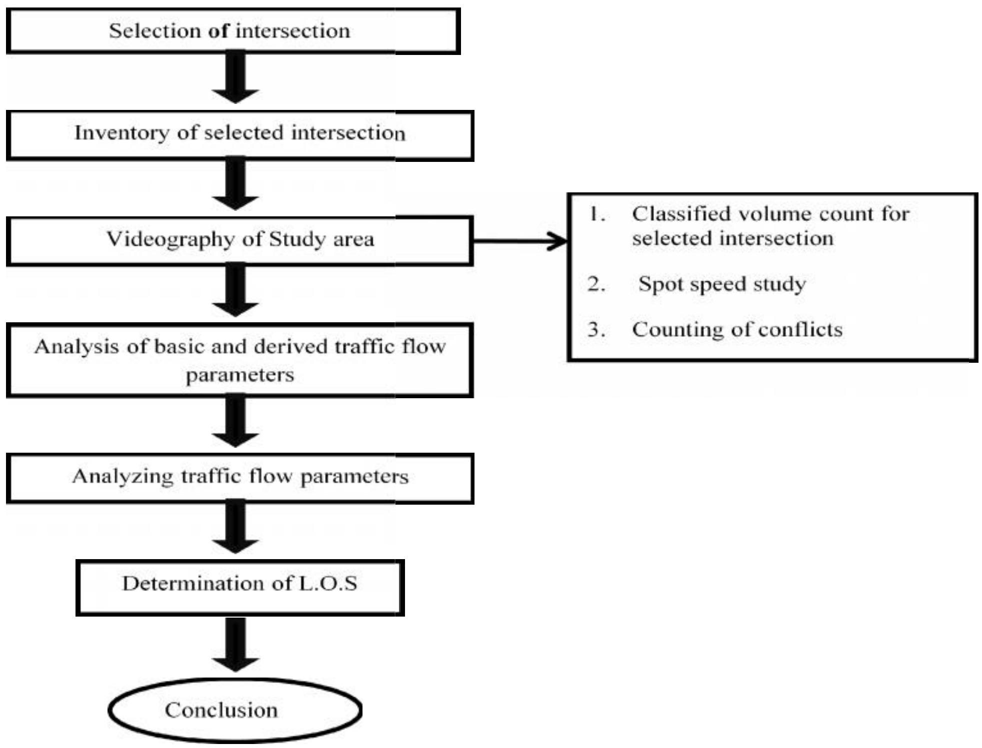
1) The selected approach provides a protected right-turn phase and an exclusive right-turn lane for right turn movement. The impact of right-turn lanes and permitted right-turn phase was not considered in this study.
2) The selected sites have large right-turn traffic demand. The average queue length for right-turning vehicles at selected sites should be greater than five vehicles per cycle.
3) Lane widths are at least 3.5 m.
4) There are few pedestrian or cyclists.
5) There is no roadside parking adjacent to a travel lane within 100 m of the stop bar.
6) The approach grade is level.
7) The intersection is not located in a central business district.

Fig. 1 Arial view of study area

3.2 Data collection and reduction

Traffic survey was carried out at the study intersections. As part of this, turning movement survey was conducted by photographic method on typical week days after posting sufficient number of traffic enumerators to get the classified vehicle count of left turning, straight going and right turning movements and to arrive at the morning and evening peak hours. Later data were collected for the identified peak hours using video recording technique. The video camera was placed at a suitable vantage point near the intersection to record an unobstructed view of all approaches and turning movements. The video tapes were later converted to VCD and played on large screen monitor several times to extract classified volume of traffic, saturation flow, average control delay per vehicle etc.

4. Methodology



5. Data collection & Analysis

5.1 Road inventory data of study area

Table 1: Showing road inventory data of study area

Pakvan Chowkdi				
	Thaltej	Iscon	Ring road	Vastrapur
Carriageway Width (m)	14	14	10	10
Footpath width (m)	1.75	1.75	1.5	1.5
Median Width (m)	2.5	2.5	0.5	0.5
Traffic Signal	Yes	Yes	Yes	Yes
Street Light	Yes	Yes	Yes	Yes
Bus Stand	No	Yes	No	No
Parking	No	No	No	Yes

5.2 Signal Data

Table 2: Four leg signalize intersection data of intersection

Approach from

Pakwan Chowkdi	**Thaltej**	**Ring road**	**Iscon**	**Vastrapur**
Red Time	169 sec	191 sec	169 sec	191 sec
Green Time	68 sec	44 sec	68 sec	44 sec
Amber Time	3 sec	5 sec	3 sec	5 sec
Total Cycle Time	240 sec	240 sec	240 sec	240 sec

5.3 Classified volume count data

Table 3: Classified volumes as per turning movement

Approach	**Left Turning**					**Straight**					**Right Turning**				
	T/W	Auto	Car	B/T	LCV	T/W	Auto	Car	B/T	LCV	T/W	Auto	Car	B/T	LCV
Thaltej	223	36	231	4	9	975	208	975	66	94	148	18	210	9	8
Ringroad	115	25	208	11	10	397	76	365	15	13	190	24	162	7	10
Iscon	123	39	142	6	9	1028	270	1046	53	106	330	53	409	7	16
Vastrapur	131	32	150	6	12	380	59	366	5	16	211	19	164	2	10

Table 4: Total volume on each approach

Approach	**Left Turning**	**Straight**	**Right Turning**
Thaltej	436	2193	372
Ring road	390	793	406
Iscon	299	2341	745
Vastrapur	309	740	356

6. Delay Analysis

- Thaltej Approach

$$d=\frac{240(1-0.28)^2}{2(1-(0.28)(1.47)}+\frac{1.47^2}{2(3052)(1-1.47)}-0.65\left(\frac{240}{3052^2}\right)^{\frac{1}{3}}\left[(1.47)^{2+5(0.28)}\right]$$

= 105 sec

- Ring road Approach

$$d=\frac{240(1-0.18)^2}{2(1-(0.18)(1.62)}+\frac{1.62^2}{2(1561)(1-1.62)}-0.65\left(\frac{240}{1561^2}\right)^{\frac{1}{3}}\left[(1.62)^{2+5(0.18)}\right]$$

= 113 sec

- Iscon Approach

$$d=\frac{240(1-0.28)^2}{2(1-(0.28)(1.67)}+\frac{1.67^2}{2(3473)(1-1.67)}-0.65\left(\frac{240}{3473^2}\right)^{\frac{1}{3}}\left[(1.67)^{2+5(0.28)}\right]$$

= 117 sec

- Vastrapur Approach

$$d=\frac{240(1-0.18)^2}{2(1-(0.18)(1.49)}+\frac{1.49^2}{2(1436)(1-1.49)}-0.65\left(\frac{240}{1436^2}\right)^{\frac{1}{3}}\left[(1.49)^{2+5(0.18)}\right]$$

= 110 sec

7. Analysis of LOS

Table 5: Level of service of four approaches during DRT scenario at intersection

Approach	Carriageway width (m)	Saturation flow (pcu/hour)	Effective green (λ)	Capacity (pcu/hour)	Volume (pcu/hour)	X=v/c	Delay (sec)	LOS
Thaltej	14	7350	0.28	2082	3052	1.47	105	F
Ring road	10	5250	0.18	962	1561	1.62	113	F
Iscon	14	7350	0.28	2082	3473	1.67	117	F
Vastrapur	10	5250	0.18	962	1436	1.49	110	F

8. Conclusion

From data analysis on four approaches of Pakwan intersection, study of Level of Service found that LOS was F at all approaches. This study can be used as a baseline for further research work on analysis of traffic flow at signalized intersection in Ahmedabad as well as in other urban areas of city to further develop and update the level of service, saturation flow and approach width, percentage of different classes of vehicles etc. More intersections located in different parts of the city with different approach widths and varying traffic characteristics be studied for further refinement and updating of present four legged signalized intersection to other improvement in intersection which reduce delay, congestion and increase Level of Service of the intersection.

References

1. Ko J, Hunter M, and Guensler R. “Measuring Control Delay Using second-by-Second GPS Speed Data”, Transportation Research Board 86th Annual meeting compendium of papers TRB 2007.
2. Braun, S. M. and Ivan, J. N. (1996), “Estimating Approach Delay Using 1985 and 1994 Highway Capacity Manual Procedures", Transportation Research Record 1555, TRB, National Research Council, Washington, D.C., pp. 23-32.
3. Arasan, T. V. and Jagadish, K. (1995), “Effect of Heterogeneity of Traffic on Delay at Signalized Intersections”, Journal of Transportation Engineering, ASCE, Volume 121, No.4.pp. 397- 404.
4. Dowling, R. G. (1994), “Use of Default Parameters for Estimating Signalized Intersection Level of Service”, Transportation Research Record 1457, TRB, National Research, Council, Washington, D.C., pp. 82-95.
5. Lin, Feng-Bor (1989), “Application of 1985 Highway Capacity Manual for Estimating Delay at Signalized Intersections”, Transportation Research Record 1225, TRB, National Research Council, Washington, D.C., pp. 18 -23.
6. Reilly, W. R. and Gardner, C. C. (1977), “Technique for Measurement of Delay at Intersections” “, Transportation Research Record 644, TRB, National Research Council, Washington, D.C., pp. 1-7.
7. Al Shu-bo and Y ANG Xiao-kuan (2009), “Capacity of Dual-Right-Turn Lanes at Signalized Intersections under Mixed Traffic Conditions”.
8. Ashworth R. (1976) “A Video — Tape recording system for data collection and analysis”, Traffic Engineering and Control, vol. 17.
9. Australian Road Research Board, (1968), “Australian Road Capacity Guide — Provisional Introduction and Signalized intersection”, ARRB Bulletin No.4.
10. Greenshields, B.D., Shapiro, D., and Ericksen, E.L. (1947). “Traffic Performance at Urban Intersections”, Technical Report No.1. Bureau of Highway Traffic, Yale University.
11. HCM (Highway Capacity Manual) 4th Edition (2000). Transportation Research Board, Washington D.C.
12. Highway Capacity Manual, 2000, “Transportation Research Board, Washington D.C: Chapter 16’’.
13. IRC: 64 (1990), “Guidelines on Capacity of Roads in Rural Area”, (First Revision), Indian Code of Practice, Indian Roads Congress.”
14. IRC-SP: 41 (1994), “Guidelines for Design of At-Grade Intersection in Rural and Urban Areas”, Indian Code of Practice, Indian Roads Congress.