Research Paper Engineering

Capacity Analysis of Signalized Intersections by Use of Saturation Flow Rate under Mixed Traffic Conditions

*Nikunj Patel **Mr. Sanjay G. Patel

*M.E. Student, L.D.College of Engineering, Ahmedabad

**Asst. Engineer, Roads & Buildings Dept., Government of Gujarat.

ABSTRACT

Traffic engineer in many countries have been using saturation flow rate to estimate the capacities of approaches to signalized intersections. The capacities thus estimated are used to evaluate control delays and other performance measures. Errors in capacity estimates are not completely avoidable but can be minimized to reduce the possibility of making the poor planning or operational decision. Hence in present study an attempt was made to verify the applicability of an alternate method of capacity estimation recommended by Feng-Bor Lin and Pin-Yi Tseng for mixed traffic conditions in India.

Saturation Flow (SF) is a key parameter required in capacity analysis of signalized intersections. It is also an important parameter in design of signal timings. Well-established guidelines such as Highway Capacity Manual (HCM) are available for the estimation of SF in developed countries. Traffic characteristics and driver behavior are significantly different in heterogeneous traffic of developing countries. Thus, it is unwise to follow the procedures adopted in developed countries. Another issue in heterogeneous traffic is about unit of expressing flow. In India, flow is expressed in Passenger Car Unit (PCU) in spite of its many limitations. In this study, we develop easy to use an alternate method to the use of saturation flow rate for capacity analysis of signalized intersections having heterogeneous traffic. Traffic data collected at four signalized intersections in Ahmedabad, Gujarat were used for the analysis.

The capacity, therefore, is the maximum hourly flow of vehicles that can be discharged through the intersection from the lane group in matter under the prevailing traffic, roadway, and signalization conditions. The formula for calculating capacity (c) is given below.

$$c = (g/C) \cdot s \quad \text{.....(1)}$$

Where:
c = capacity (pcu/hour)
g = Effective green time for the phase in question (sec)
C = Cycle length (sec)
s = Saturation flow rate (pcu/hour)

2. LITERATURE REVIEW & METHODOLOGY

In the present study, by using an alternate method have developed by Feng-Bor Lin and Pin-Yi Tseng (2003), to estimate capacity from the no. of vehicles that can be discharged from a lane in each signal cycle. According to the method suggested by them equation (1) can be rewritten as

$$c = \frac{sg}{3600} x \frac{3600}{C} \qquad ------(2)$$

Because, sg/3600 is nothing but the no. of vehicles that can be discharged in one cycle, the following equation represents a logical and better way of estimating capacity:

$$c = \frac{3600}{C} \sum_{i=1}^{m} (Ngi = Nyi)F \qquad ------(3)$$

Where,

c= Capacity of lane or lane group (vph or pcu)
C = Cycle length (s)
i = ith phase usable to the vehicles in the lane or lane group being analyzed,
m= number of phases available to the vehicles in the analysis lane or lane group,
Ngi= number of queuing vehicles that can be discharged in the green interval of signal phase i,
Nyi = the number of queuing vehicles that can be discharges in the change interval of signal phase i, and
F= adjustment factor to account for variations not accounted for in estimating Ngi and Nyi.

The use of Equation (3) for capacity estimation eliminates the aforementioned problems associated with the determination of saturation flow and lost time. In addition the modeling of Ngi and Nyi requires the same queue discharge data as those used for determining saturation flow and lost time, the task is greatly simplified and, as a result, the resulting procedure may become more reliable.

3.DATA COLLECTION & ITS APPLICATION

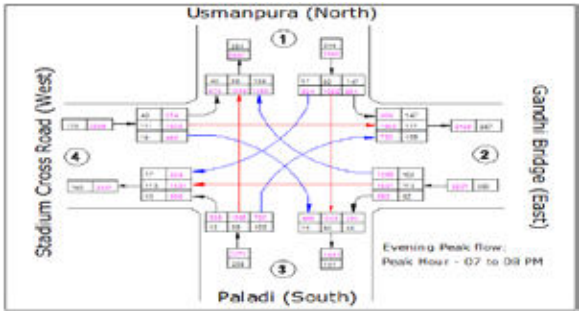
Four signalized intersections located in urban limits of Ahmedabad city, in Gujarat were chosen for the present study. All of them are isolated signals (non coordinated type) provided with pre timed signal control. These study intersections were selected in such a way that they have level gradient on all the approaches and there is least interference to traffic by pedestrians. Average driving behavior was assumed and the condition of vehicles was assumed to be moderate.

Turning movement survey was carried out as per IRC: SP: 41, guidelines to identify the morning and evening peak hour traffic conditions. Later manually data collection was done for all approaches of the study intersections during the identified morning and evening peak hours. Care was taken to cover full queue formed on the study approaches. Simultaneously data on signal timings like cycle length, phase length was collected manually using stop watch. Number of approaches and corresponding widths were also measured.The study intersections are Income Tax Cross Road, Swastik Cross Road, Vijay Cross Road and Delhi Darwaja. The collected data on field meaqsurement of Saturation Flow is given in following Table 1.

Table 1 Field Measured Saturation Flow

Sr No.	Name of Intersection	Approach	Saturation Flow (PCU/H)
1	Incometax Cross Road	N - S	2424
		E - W	3531
		S - N	2379
		W - E	2758
2	Swastik Cross Road	N - S	1340
		E - W	2138
		S - N	1715
		W - E	1154
3	Vijay Cross Road	N - S	1012
		E - W	998
		S - N	1320
		W - E	1110
4	Delhi Darwaja Cross Road	N - S	2232
		E - W	2823
		S - N	2526
		W - E	2018

Figure 1 : Peak Hour Traffic Flow at Income-Tax Intersection



The followings subsequent Tables 2 & 3 are give the estimated capacities from SF by traditional as well as an alternative methods and last table 4 gives the comparision of these two methods of capacity estimation.

Table 2 Estimated Capacities from Saturation Flow (Traditional Method)

Sr No.	Name of Intersection	Approach	Capacity (PCU/H)
1	Incometax Cross Road	N - S	923
		E - W	1345
		S - N	906
		W - E	1051
2	Swastik Cross Road	N - S	469
		E - W	748
		S - N	600
		W - E	404
3	Vijay Cross Road	N - S	337
		E - W	333
		S - N	440
		W - E	370
4	Delhi Darwaja Cross Road	N - S	893
		E - W	1129
		S - N	1010
		W - E	807

Table 3 Estimated Capacities from Alternate Method

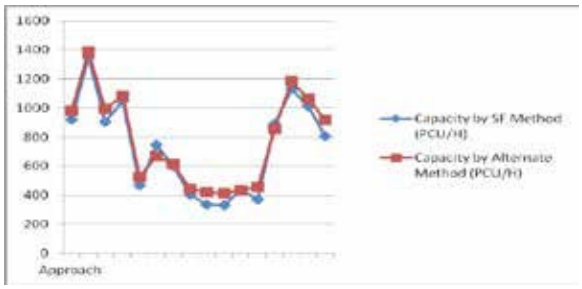
Sr No.	Name of Intersection	Approach	Capacity (PCU/H)
1	Incometax Cross Road	N - S	981
		E - W	1387
		S - N	996
		W - E	1084
2	Swastik Cross Road	N - S	525
		E - W	670
		S - N	613
		W - E	445
3	Vijay Cross Road	N - S	420
		E - W	415
		S - N	435
		W - E	458
4	Delhi Darwaja Cross Road	N - S	859
		E - W	1184
		S - N	1063
		W - E	917

The results obtained from the alternate method were compared to that of the traditional mthod and presented in Table 4 along with their percentage differences. The fig 2 showing the comparative estimates of capacity.

Table 4 Comparision of Traditional and Alternate Methods of Capacity Estimation

Sr No.	Name of Intersection	Approach	Capacity by SF Method (PCU/H)	Capacity by Alternate Method (PCU/H)	Percent Diff.(%)
1	Incometax Cross Road	N - S	923	981	6.26
		E - W	1345	1387	3.08
		S - N	906	996	9.86
		W - E	1051	1084	3.18
2	Swastik Cross Road	N - S	469	525	12.02
		E - W	748	670	-10.52
		S - N	600	613	2.20
		W - E	404	445	10.17
3	Vijay Cross Road	N - S	337	420	24.51
		E - W	333	415	24.75
		S - N	440	435	-1.14
		W - E	370	458	23.65
4	Delhi Darwaja Cross Road	N - S	893	859	-3.75
		E - W	1129	1184	4.89
		S - N	1010	1063	5.25
		W - E	807	917	13.64

Fig. 2 Traditional Vs Alternate Method



4.DISCUSSION

It has been found from the analysis and comparison of results that the capacity of approaches estimated from the alternate method was in close agreement with that from the traditional

method at about nine out of twelve approaches of the study intersections. It can be observed that the percentage variation of the results at these approaches was ranging between plus or minus twelve percent only, including applicability of the alternate method. A large variation in the results of the order of more than 15 % was notices at other three approaches. From a closer look it was found that this large variation was due to not so fair geometry, on street parking and more heterogeneity in the traafic composition. Hence in the opinion of the authors this alternative method of capacity estimation can be tested at the approaches of four legged intersections having level garde with no impedence to traffic due to on street parking, bus stop etc.

5.CONCLUSION

Some of the major conclusions are an alternative method of capacity estimation suggested by Feng-Bor Lin and Pin-Yi Tseng (2005) which assess capacity from number of vehicles that can be discharged from a lane in each signal cycle was tried for the mixed traffic conditions prevailing in india. This method was tested at sixteen approaches of four signalised intersections by taking direct field measurements. It was working well for four legged intersection approaches having level grade. However, it was found to be not suitable for intersection having unfair geometry. It was found that this method can be successfully employed in the capacity analysis of four legged signalised intersections having a level grade and no traffic impediments due to bus stops, parkings, etc. This will not only reduce the problems in saturation flow measurements but also go a long way in improving the reliability of capacity estimation and for appropriate planning level discussions.

REFERENCES

1. Transportation Research Board (2000) Highway Capacity Manual, Washington, D.C. | 2. Tseng, P.Y. and Lin, F.B. (2003), " Alternatives to the use of Saturation Flow for Analysis of Signalised Intersections". Journal of the Eastern Asia Society for Transportaion studies, Vol. 5, October. | 3. Tseng, P.Y. and Lin, F.B. (2005), " Fallacies and Implicatons of Convetioal Saturation Flow Mol of Queue Discharge Behaviour at Signalised Intersections". | 4. Satish Chandra (2008), Passanger Car Units for Indian Roads" IRC Journal, New Delhi. Volume 69-2, July 2008. | 5. Gopal R. Patil, Krishna Rao K. V. (2007) "Saturation Flow Estimation at Signalised Intersections in Developing Countries". TRB 86th Annual Meeting. | 6. Mr. Patel S. G., Dr. Varia H. R., Dissertation work on "Estimation of Level of Service through Congestion on Urban Road Links-Case study of Ahmedabad City."