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Analysis of Traffic Flow Characteristics and Estimation of Level of Service at Narsapur, Telangana

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***Abstract*— 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. In the present study various problems associated with delay estimation under mixed traffic conditions in a developing country (India) and the methods to overcome them were discussed and an attempt was made to improve the accuracy estimating the same.**

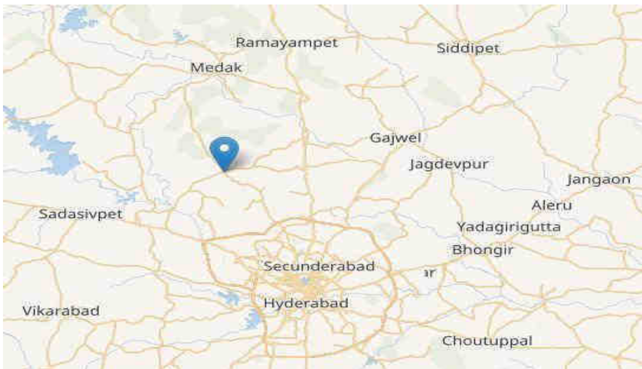
Uncontrolled intersections are vital points on urban roads, the performance of which will influence the traffic flow on entire network. Delays to vehicles at urban uncontrolled intersections depend upon the several factors, the most important among these being major road approach volume, type of turning movement, and vehicular composition. The average delay caused to vehicles is an important measure to evaluate the performance of uncontrolled intersections. The performance of an uncontrolled intersection is described by the service delay experienced by low priority movements. Under mixed traffic conditions, the traffic compositions, apart from the conflicting traffic volume and proportion of turning traffic are vital factors influencing the service delay. Most of the earlier studies conducted on this subject, pertain to homogeneous traffic environment, and only a few studies with limited scope have been conducted under mixed traffic conditions. In this study, the service delay has been analyzed for the intersection located in Narsapur, Telangana. The level of service for the uncontrolled intersections taken under the study has been evaluated using the estimated average service delays.

***Index Terms*— Intersection, Delays,Traffic**

I. INTRODUCTION

Uncontrolled intersections are the intersections which function without any priority assigned to the traffic on any of the intersecting roads, no control (neither STOP signs nor Police- controlled) and the traffic is of heterogeneous nature. These intersections are vital nodal points on urban roads, the performance of which will influence the traffic flow on entire network. Delays to vehicles at urban uncontrolled intersections depend on several factors. The most important among these being the major road approach volume, type of turning movement, and vehicular composition. The extent of intersection of these factors and their collective effect on delay caused to vehicles need to be studied in detailed for better traffic management at these intersections. Field studies due to resources constraint may not include all these, the limited samples that might be obtained will be sufficient to evaluate the effect of various parameters. At uncontrolled intersections in the absence of indication of specific time intervals to each of the streams of traffic to cross the intersection, the drivers look for gaps and cross the intersections. In developing countries like India, in the absence of the concept of major and minor roads in traffic regulation schemes, vehicles approaching the intersections through all roads, on arrival; assume that equal right to enter the intersection. This has made the traffic situation at the uncontrolled intersection highly complex causing considerable delay to traffic. The delay experienced by vehicles is probably most desirable criteria based on which the performance of the uncontrolled intersection can be evaluated.

STUDY AREA



Map showing the Narsapur study area

Narsapur is a Town in Narsapur Mandal in Medak District of Telangana State, India with an area of 7.2 km2 and a population of 18,339 as per 2011 census.

It is situated at a distance of 28km from Sangareddy, 28km from Thoopran, 28 km from Medak, 60km from Hyderabad.

Objectives

1. To develop the readily usable mathematical model to estimate the service delay caused to the subject vehicles at urban uncontrolled intersections, considering interactions of various categories of vehicles under heterogeneous traffic environment.

2. To evaluate the performance of uncontrolled intersections based on the average service delay.
3. To conduct the traffic and delay studies at signalized intersections to evaluate the performance of the signalized intersection
4. To determine the aggregate delay of the intersection.
5. To establish the level of service (LOS) of Narsapur intersection.
6. To analyze the delays and draw meaningful inferences.

II. LITERATURE REVIEW

Unsignalized intersections make up a great majority of at-grade junctions in any street system. Stop and yield signs are used to assign the right-of-way, but drivers have to use their judgment to select gaps in the major street flow to execute crossings and turn movements at two-way and yield controlled intersections. Two methods are discussed in this section: HCM (2000) Delay method and Blunden's (1961) method.

William (1977) 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.

Ternus et al. (1977) developed a procedure for measuring load factor and to determine relationship between load factor, peak hour factor and delay. In this study three locations are considered, volume counts are measured by two methods, one is manual and another is by traffic flow analyzer. A manual counter was used for comparison with the manual volume counts and also to compute peak hour factors. The traffic flow analyzer is used to measure the delay more accurately than with traditional methods with less difficulty and expense. The relation among load factor, constant split ratio and constant flow was calculated from the graph drawn between constant split ratio, constant flow and load factor.

Sosin (1980) has done empirical investigations of delays at some chosen intersections in Poland using time lapse photography technique. The effect of composition of traffic upon delays was also studied and passenger car units estimated using simulation along with the delay observations. The results of the study were compared with the delay models such as Webster and Miller's approach.

Hurdle (1984) presented a paper to serve as a primer for traffic engineers who are familiar with capacity estimation techniques but have not made much use of delay equations. It was noted that the methods available at that time either ignore the way in which the delay vary with the time or try to cope with the variation in ways that are more mathematical application of common sense than mathematical models of traffic signal system. He found that none of the models examined can be expected to give really consistent and accurate results. To obtain such results, one would not need just better models but better information about traffic patterns.

Kadiyali said that a number of definitions and notations need to be understood in signal design. They are discussed below:

TRAFFIC DATA COLLECTION

While taking cognizance of the above, traffic flow data is needed for different purposes by different Ministries and/or Organizations in Narsapur.

Some of the key areas in which traffic flow data is needed for development and management of the road network include:

a) Determination of a programme of road widening needs and general improvement or strengthening of existing road through a programme of reconstruction and construction of a new roads;
b) To check the efficiency of the road network by comparing current traffic volume with the level of service or the calculated capacity;
c) To establish the relationship between traffic volume, number of accidents and causes thereof, as well as determination of the probable occurrences
d) To plan prioritization of roads improvement schemes;
e) To assess economic benefits arising from roads improvements;

TYPES OF TRAFFIC COUNTS

It is essential to know the magnitude of traffic data required or to be collected, which will then determine its quality and type of vehicle classification to be adopted. Traffic counting falls in two main categories, namely; manual counts and automatic counts. There is no distinct difference between the two methods.

MANUAL COUNTS

The most common method of collecting traffic flow data is the manual method, which consist of assigning a person to record traffic as it passes.

AUTOMATIC COUNTS

The detection of vehicular presence and road occupancies has historically been performed primarily on or near the surface of the road. The exploitation of new electromagnetic spectra and wireless communication media in recent year, has allowed traffic detection to occur in a non-intrusive fashion, at locations above or to the side of the roadway.

The most commonly used detector types are:

a) Pneumatic tubes.
b) Inductive loops.

III. INTERSECTION VOLUME DATA ANALYSIS

Measurement of Saturation Flow:

$$\text{Saturation Headway} = \frac{\text{Total saturation green time}}{\text{No.of vehicles}}$$

$$\text{Saturation flow} = \frac{3600}{\text{Saturation Headway}}$$

East Bound:

Total saturation green time = 270 sec
No. of vehicles = 333
Saturation headway = (270/333) = 0.81

Saturation flow = (3600/0.81) = 4444 veh/hr.

West Bound:
Total saturation green time = 270 sec
No. of vehicles = 407
Saturation headway = (270/407) = 0.66 sec/veh
Saturation flow = (3600/0.66) = 5421 veh/hr.

North Bound:
Total saturation green time = 270 sec
No. of vehicles = 362
Saturation headway = (270/362) = 0.75 sec/veh
Saturation flow = (3600/0.75) = 4832 veh/hr.

South Bound:
Total saturation green time = 270 sec
No. of vehicles = 476
Saturation headway = (270/476) = 0.57 sec/veh
Saturation flow = (3600/0.57) = 6340 veh/hr.

Time-in-Queue Calculation
South Bound (Hyderabad Approach):

Vehicles in Queue for South Bound

No. of Cycles	Time Interval	No. of vehicles in queue
1	20	94
2	20	96
3	20	98
4	20	112
5	20	108
6	20	98
7	20	105

Total no. of vehicles in queue

= $\sum V_{iq}$ = 94+96+98+112+108+98+105 = 711

Total vehicles passing through the approach (V_{tot}) = 615

$$\textbf{Time-in-queue per vehicle} = t_i * \frac{Viq}{Vtot} * 0.9$$

Therefore Time-in-queue tiq= 0.9 x [20 x (711/615)] =20.8 sec.
No. of vehicles stopped (Vstop) = 346

Fraction of vehicles stopped (FVS) = (346/615) = 0.562

No. of vehicles stopping per lane each cycle $= \frac{Vstop}{Nc*N}$

= 346/ (7*2)

= 346/14

= 24.71

From HCM 2000, correction factor (CF) = +2

Acceleration-deceleration delay = 0.562 * 2 = 1.12 sec Therefore

Control delay = Time-in-queue + acceleration-deceleration delay

= 20.8 + 1.12

= 22 sec/veh

West Bound (Sangareddy Approach):

Vehicles in Queue for West Bound

No. of Cycles	Time Interval	No. of vehicles in queue
1	20	75
2	20	76
3	20	78
4	20	77
5	20	69
6	20	83
7	20	74

Total no. of vehicles in queue
= $\sum V_{iq}$ = 75+76+78+77+69+83+74 = 532
Total vehicles passing through the approach (V_{tot}) = 506

$$\textbf{Time-in-queue per vehicle} = t_i * \frac{Viq}{Vtot} * 0.9$$

Therefore Time-in-queue t_{iq}= 0.9 x [20 x (532/506)] =18.91 sec.
No. of vehicles stopped (V_{stop}) = 296
Fraction of vehicles stopped (FVS) = (296/506) = 0.585

No. of vehicles stopping per lane each cycle $= \frac{Vstop}{Nc*N}$

= 296/ (7*2)

= 296/14

= 21.14

From HCM 2000, correction factor (CF) = +2

Acceleration-deceleration delay = 0.585 * 2 = 1.17 sec

Therefore
Control delay = Time-in-queue + acceleration-deceleration delay
= 18.91 + 1.17
= 20.08 sec/veh

East Bound (Thoopran Approach):

Vehicles in Queue for East Bound

No. of Cycles	Time Interval	No. of vehicles in queue
1	20	57
2	20	54

3	20	58
4	20	49
5	20	42
6	20	57
7	20	53

Total no. of vehicles in queue

$= \sum V_{iq}$ = 57+54+58+49+42+57+53 = 370

Total vehicles passing through the approach (V_{tot}) = 297

$$\textbf{Time-in-queue per vehicle} = t_i * \frac{Viq}{Vtot} * 0.9$$

Therefore Time-in-queue t_{iq}= 0.9 x [20 x (297/370)] =14.45 sec.

No. of vehicles stopped (V_{stop}) = 154

Fraction of vehicles stopped (FVS) = (154/297) = 0.519

No. of vehicles stopping per lane each cycle $= \frac{Vstop}{Nc*N}$

= 154/ (7*2)

= 154/14

= 11

From HCM 2000, correction factor (CF) = +2

Acceleration-deceleration delay = 0.519 * 2 = 1.04 sec
Therefore

Control delay = Time-in-queue + acceleration-deceleration delay

= 11 + 1.04
= 12.04 sec/veh

North Bound (Medak Approach):

Vehicles in Queue for North Bound

No. of Cycles	Time Interval	No. of vehicles in queue
1	20	61
2	20	67
3	20	63
4	20	60
5	20	55
6	20	64
7	20	59

Total no. of vehicles in queue
$= \sum V_{iq}$ = 61+67+63+60+55+64+59 = 429

Total vehicles passing through the approach (V_{tot}) = 364

$$\textbf{Time-in-queue per vehicle} = t_i * \frac{Viq}{Vtot} * 0.9$$

Therefore Time-in-queue t_{iq}= 0.9 x [20 x (429/364)] =21.21 sec

No. of vehicles stopped (V_{stop}) = 203

Fraction of vehicles stopped (FVS) = (203/364) = 0.558

No. of vehicles stopping per lane each cycle $= \frac{Vstop}{Nc*N}$

= 203/ (7*2)

= 203/14

= 14.50

From HCM 2000, correction factor (CF) = +2

Acceleration-deceleration delay = 0.558 * 2 = 1.12 sec

Therefore
Control delay = Time-in-queue + acceleration-deceleration delay
= 14.50 + 1.12
= 15.62 sec/veh

IV. RESULTS AND DISCUSSIONS

From analysis of results and observation of traffic characteristics the following conclusions are drawn.

1. The above mentioned criteria study area Narsapur Intersection has an aggregate delay of 17.435 sec/veh.
2. Based on the aggregate delay the Level of Service at Narsapur Intersection is LOS "B".
3. The highest saturation flow of 6340 vehicles/hour is observed in South Bound (Hyderabad Approach Road).
4. The least saturation flow of 4444 vehicles/hour is observed in East Bound (Thoopran Approach Road).

SCOPE FOR FURTHER WORK

For better understanding of the methodology, the data should be considered from morning to evening. The acceleration and deceleration delay can be measured directly from the field. By using HCM methodology in this present study reliable results are obtained. Besides HCM methodology, other delay models should also be modified under the heterogeneous road traffic condition to estimate delays for oversaturated conditions. Moreover by considering the variability of delay, more reliable signal control strategies may be generated resulting in improved level of service.

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