PERFORMANCE EVALUATION OF EXISTING TRAFFIC SIGNAL AT BACHUPALLY INTERSECTION

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Abstract — Traffic signals are used to promote the orderly movement of vehicular and pedestrian traffic and prevent excessive traffic delays. Traffic controllers use the concept of phases, which are directions of movement grouped together. An intersection is a shared space that is used by more than one approach at a time. A signalized intersection is one where the shared space is used alternatively by a fixed number of approaches for a pre defined time interval as per the phasing scheme used for the intersection. Delay and queuing process are the main characteristics of such an intersection which help in analysing and designing the intersection.

In this paper, we first present the delays causing due to the existing traffic volume and signals at Bachupally intersection and we designed new signal cycle time by using HIGHWAY CAPACITY MANUAL(HCM), WEBSTERS METHOD and therefore resultant delays are calculated.

We observed there was a huge decrease in the delays for Major Street of the intersection.

Keyword: - Hcm, Websters Method, Signalized Intersection

I. INTRODUCTION

An intersection is the region shared by the joining or crossing of two or more streets. Since the fundamental work of a crossing point is to empower the street client to make a course choice, it is a point of choice. Thus the issues that are experienced by the driver while passing through a crossing point must be recognized and the plan ought to be in such a way that the driving task is as basic as possible.

Intersection is moreover a point of large number of major conflicts, other than a point of choice. These conflicts may be due to the crossing maneuvers of vehicles moving in distinctive bearings. Good intersection plan comes about from a minimization of the magnitude and characteristics of the conflicts and a simplification of driver course choice process.

2.LITERATURE REVIEW

Ming Chen, Master of Science, 2005

Significant effort has been expended to reduce the evacuation time in a geographic evacuation. The majority of these efforts have focused on freeways and it appears that there has been no systematic consideration of signal timing in evacuation planning for urban areas. However, signal control can greatly impact traffic flow in an evacuation. This thesis studies approaches for signal timing to facilitate evacuation and response in the event of a no-notice urban evacuation. A simulation model was constructed with data from Washington, D.C. Experimental results indicate that significant trade-offs exist in setting timing plans as long cycle lengths can lead to reduced evacuation times, but at the expense of delay on minor roadways. Best compromise plans employ cycle lengths greater in length than used in ordinary peak hour plans, giving significantly more green time to the main evacuation routes than to minor roadways as used in peak hour plans.

Objectives

- Analyse the present traffic volume at the intersection.
- Calculate the delays due to the present signal timing.
- Design effective signal timing using manual calculations to reduce the delays.

3. METHODOLOGY

We have adopted the indirect method of manual counting for the study of traffic volume and stopwatch is used for recording signal timings data. One of the fundamental measures of traffic on a road system is the volume of traffic using the road in a given interval of time. It is also termed as flow and is expressed in vehicles per hour.

When the traffic is composed of number of types of vehicles, it is the normal practice to convert the flow into equivalent passenger car units (PCU), by using certain equivalence factors. The flow is then expressed as PCU per hour. We had used HCM and Webster's formula for the design of signal timings.

Steps Involved

- Selection of site
- Identification of the problems at that site

- Scope of study and review of existing aspects
- Finding out objectives
- Study of literature surveys
- Collecting the data of road geometry, traffic volume and signal timings
- Analysis of the data obtained
- Comparison of the data
- Results and conclusion
- Recommendations

Study Area

We opted Bachupally cross roads as our study area. It is one of the Intersection that we come across while travelling to our college and most of the times we face delays due to traffic congestion. As we were practically experiencing this problem, we are interested to find out a proper solution. It is a four legged Intersection, joining the major points like Nizampet and Miyapur.

- North side of the junction connects to Mallampet Village.
- South side of the junction connects to Nizampet village.
- East side of the junction connects to Gandimaisamma.
- West side of the junction connects to Miyapur.

Bachupally Intersection is a controlled at grade intersection. Some Images of Bachupally intersection are shown below

Fig 3.1 Satellite image of intersection taken from google earth pro

Two wheelers	Autorickshaw (3w)	7 seater (3w) / Maxi Cabs	Taxi	Car/Jeep /Van (Other than Taxi)	Mini Bus	APSRTC Bus	Other Bus	LCV	2-Axle Truck	3-Axle Truck	MAV (Truck Trolly)	Tractor-Trolly	Tractor	Cycle	Cycle Rickshaw	Animal Drawn	Others
0.50	0.8	1.0	1.0	1.0	2.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	2.0	0.20	0.8	6.0	4.5

Fig 3.2 showing PCU values of different class of vehicles

Signal phase timings

3.1 Nizampet to Bachupally Intersection

Table.3.1.Showing the signal phase timings from Nizampet to intersection

Green	Amber	Red
72 sec	3 sec	196 sec

Miyapur to Bachupally Intersection

Table.3.2.Showing the signal phase timings from Miyapur to intersection

Green	Amber	Red
81 sec	3 sec	187 sec

Mallampet to Bachupally Intersection

Table.3.3.Showing the signal phase timings from Mallampet to intersection

Green	Amber	Red
40 sec	3 sec	228 sec

Gandimaisamma to Bachupally Intersection

Table.3.4.Showing the signal phase timings from Miyapur to intersection

Green	Amber	Red
66 sec	3 sec	202 sec

Cycle time = 72 + 3 + 196 = 271 sec.

4.ANALYSIS

Head way

It is defined as time taken by a vehicle to cross the stop line once after the green signal is turned on.

The saturation head way is defined as the head way time from which all the vehicles uses same time to cross the stop line.

4.1 Observed headway times

Table.4.1.Observed time headways

VEHICLE	TIME TAKEN(IN SEC)
1	2.8
2	2.7
3	2.5
4	2.3
5	2.1
6	2
7	2

- Therefore Saturation head way (**h**) is 2 sec.

Saturation flow rate

It is defined as the number of vehicles passing per hour of green time per lane. It is denoted by Si.

Si = 3600/h= 3600/2=1800 vph.

4.2 Start-up lost time

It is defined as the sum of differences of individual head ways and saturation head way

L1 = (2.8-2) + (2.7-2) + (2.5-2) + (2.3-2) + (2.1-2) = **2.4 sec.**

Lane capacity

The ratio of effective green time to the cycle length (gi/C) is defined as green ratio. We

664 know that saturation flow rate is the number of vehicles that can be moved in one lane in one hour assuming the signal to be green always Then the capacity of a lane can be computed as,

ci = si*gi /C

Where ci is the capacity of lane in vehicle per hour, si is the saturation flow rate in vehicle per hour per lane, C is the cycle time in seconds

4.3 Determination of cycle length

The cycle length or cycle time is the time taken for complete indication of signals in a cycle. Fixing the cycle length is one of the crucial steps involved in signal design.

Highway capacity manual (HCM) has given an equation for determining the cycle length. It is given by

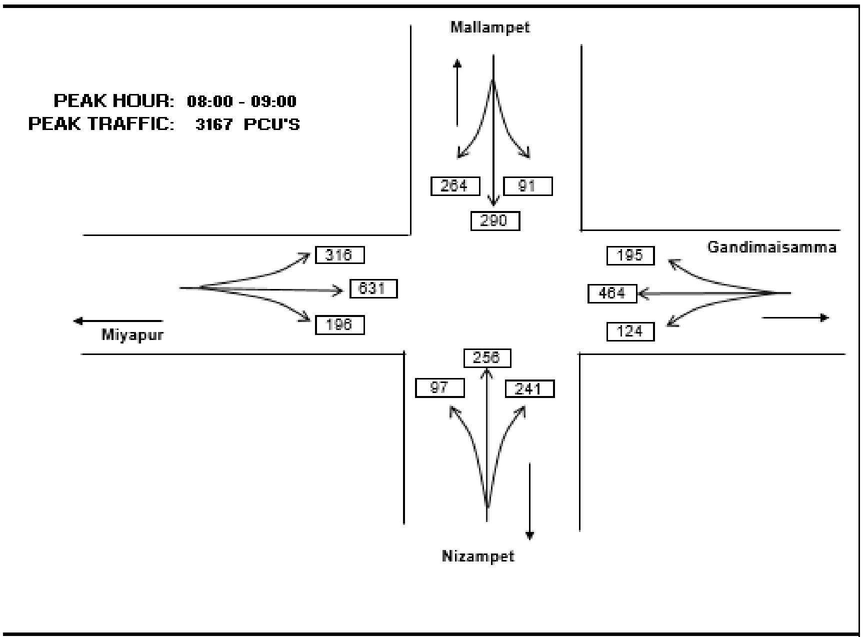
- **C = N.L.XC/XC −Σ(V/s)i**

Where N is the number of phases, L is the lost time per phase, (V/s)i is the ratio of volume to saturation flow for phase i, XC is the quality factor called critical V/C ratio where V is the volume and C is the capacity.

Table.4.2.Showing the green signal and effective green signal timings from all phases

Phase	Green time	Amber time	Effective Green time
1	72	3	72.6
2	81	3	81.6
3	40	3	40.6
4	66	3	66.6

- **Effective green time** = Green time + Amber time – lost time
- Here phase-1 signal is allowing the through and right traffic from Nizampet.
- Here phase-2 signal is allowing the through and right traffic from Miyapur.
- Here phase-3 signal is allowing the through and right traffic from Mallampet.
- Here phase-4 signal is allowing the through and right traffic from Gandimaisamma.



PEAK HOUR FLOW DIAGRAM IN PCU

4.3 Delays

Assume X-Y direction; then delay in X-Y direction is given as,

$$d_{x\text{-}y} = \frac{\frac{\text{Actual cycle time}}{2}\left(1-\frac{\text{(actual green time of that phase)-lost time + amber time}}{\text{actual cycle time}}\right)^{2}}{\left(1-\frac{V_{cx\text{-}y}}{S_i}\right)}$$

$$d_{SN} = \frac{\frac{271}{2}\left(\frac{1-(72)-2.4+3}{271}\right)}{\left(\frac{1-256}{1800}\right)}$$

$= 84.66$ sec/cycle

Similarly Observed remaining values for delays in all directions are

dSE = 83.85 sec/cycle
dWE= 101.91 sec/cycle
dWS =74.27 sec/cycle
dNS =116.75 sec/cycle
dNW = 114.77 sec/cycle
dEW = 103.85 sec/cycle
dEN = 86.44 sec/cycle

4.4 Design and evaluation of signal timings using HCM

Capacity of intersection = si*gi /C
= 1800*261.4/271
= 1736 veh/hr.

- **Cycle length = N.L.XC/XC –Σ (V/s)i**

Xc = volume/capacity
N=no. of phases
L=Lost time per phase

Critical lane volume per hour = 256+631+290+464= 1641 vph
Σ(V/s)i=(256+631+290+464)/1800
=0.911

Xc = v/c =1641/1736

Xc =0.945

- **Cycle length** = 4*2.4*0.945/ (0.945-0.911)
  =266.82
  =267 sec

Effective green time(gi) =cycle length-total lost time
=267 - 4*2.4

gi = 257.4 sec

a) Effective green splitting for phase-1(g1) =257.4*256/1641=40.15 sec
b) Effective green splitting for phase-2(g2) =98.97 sec
c) Effective green splitting for phase-3(g3) =45.48 sec
d) Effective green splitting for phase-4(g4) =72.78 sec

- **Actual green splitting time for**

a) Phase-1(G1)=40.15+2.4-3=39.55=41 sec
b) Phase-2(G2)=98.97+2.4-3=99 sec
c) Phase-3(G3)=45.48+2.4-3=46 sec
d) Phase-4(G4)=72.78+2.4-3=73 sec

- **Actual cycle time** = (41+99+46+73) + 3*4
  =271 sec

4.4.1 Updated Delays:

$$dSN = \frac{\frac{271}{2}\left(1-\frac{(41)-2.4+3}{271}\right)^2}{\left(1-\frac{256}{1800}\right)}$$

= 113.19 sec/cycle

Observed values for delays in all directions are
dSE = 112.10 sec/cycle
dWE= 83.46 sec/cycle
dWS =60.82 sec/cycle
dNS =110.74 sec/cycle
dNW = 108.87 sec/cycle
dEW = 96.86 sec/cycle
dEN = 80.62 sec/cycle

4.5 Design and evaluation of signal timings using Webster's method

- **Start-up lost time (l1t)** = 2.4 sec

Assuming zero all red time. Therefore the lost time per phase = 2.4+0 = 2.4 sec.
Total lost time per cycle length (L) = 4 * 2.4 = 9.6 sec

- We know capacity = 1736 veh/hr/lane

Optimum cycle length (CO) = $\left(\frac{1.5L + 5}{1 - Y}\right)$.

Where Y = sum of ratios of critical lane volume to saturation flow.
Y = (256 + 631 + 290 + 464)/1800 = 0.911667.
Therefore **CO** = (1.5 * 9.6 + 5)/ 1 – 0.911667.
= 220 sec.
Therefore cycle length = 220 sec.
Effective green time = cycle length –total lost time
= 220 – 4*2.4 = 210.4 sec,
Effective green splitting for

- **Phase-1(g1) =** 210.4*256/1641 = 32.82 sec
- **Phase-2(g2) =** 80.90 sec
- **Phase-3(g3) =** 37.18 sec

- **Phase-4(g4)** = 59.49 sec

Actual green splitting time for

- **Phase-1(G1)** = 32.82+2.4-3=39.55=33 sec
- **Phase-2(G2)** = 80.90+2.4-3=81 sec.
- **Phase-3(G3)** = 37.18+2.4-3=38 sec
- **Phase-4(G4)** = 59.49+2.4-3=60 sec
- **Total cycle time** = 33 + 81 + 38 + 60 + 4*3 = 224 sec.

4.5.1 Updated Delays:

$$dSN = \frac{\frac{224}{2}\left(1 - \frac{(33)-2.4+3}{224}\right)^{2}}{\left(1 - \frac{256}{1800}\right)}$$

= 93.33 sec/cycle

Observed values for delays in all directions are
dSE = 93.42 sec/cycle
dWE= 69.69 sec/cycle
dWS =50.79 sec/cycle
dNS =91.46 sec/cycle
dNW =89.91 sec/cycle
dEW =80.29 sec/cycle

5.RESULTS AND OBSERVATIONS

After analysis of collected data we had obtained the 12 hours traffic composition, hourly variation in different class of vehicles, signal delays due existing traffic signals and determined new cycle lengths and their delays.

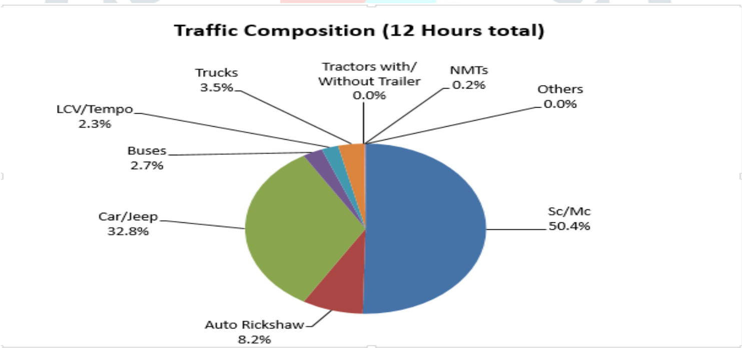
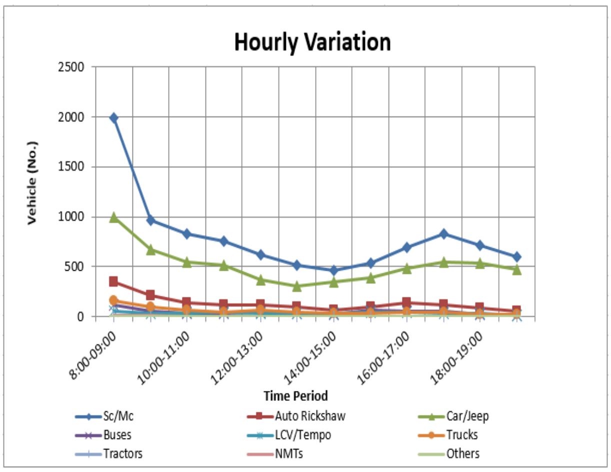


Fig 5.1 Pie chart of 12 hour traffic composition

OBSERVATION

Here we observed that more than 50% of total traffic composition is two wheelers and more than 30% traffic composition are cars



OBSERVATION

From the chart we had observed that the traffic is high during 8:00am – 10:00am and during 4:00pm – 6:00pm.

5.2 Delays for different signal timings

Table.5.1.Delays for existing signal timings

PHASE	GREEN TIME	FLOW DIRECTION	DELAYS(sec/cycle)
1	72	SOUTH-NORTH	84.66
		SOUTH-EAST	83.85
2	81	WEST-EAST	101.91
		WEST-SOUTH	74.27
3	40	NORTH-SOUTH	116.75
		NORTH-WEST	114.77
4	66	EAST-WEST	103.85
		EAST-NORTH	86.44

- Total cycle length = 271 sec
- Amber time in all phases = 3 sec
- Lost time per phase = 2.4 sec

OBSERVATIONS

From the above result it is observed that the delays in the phase-2 and phase-3 are high (i.e. roads connecting Miyapur to Intersection and Mallampet to Intersection).

Table.5.2.Delays for signal timings designed by HCM formula

PHASE	GREEN TIME	FLOW DIRECTION	DELAYS(sec/cycle)
1	41	SOUTH-NORTH	113.19
		SOUTH-EAST	112.10
2	99	WEST-EAST	83.46
		WEST-SOUTH	60.82
3	46	NORTH-SOUTH	110.74
		NORTH-WEST	108.87
4	73	EAST-WEST	96.86
		EAST-NORTH	80.62

- Total cycle length = 271 sec
- Amber time in all phases = 3 sec
- Lost time per phase = 2.4 sec

OBSERVATIONS

From the above result it is observed that the delays in the phase-1 are increased (i.e. road connecting Nizampet to Intersection), as a result of decrease in the delays of rest of the phases.

The cycle length remained same as existing condition.

Table.5.3.Delays for signal timings designed by Webster's formula

PHASE	GREEN TIME	FLOW DIRECTION	DELAYS(sec/cycle)
1	33	SOUTH-NORTH	93.33
		SOUTH-EAST	93.42
2	81	WEST-EAST	69.79
		WEST-SOUTH	50.79
3	38	NORTH-SOUTH	91.46
		NORTH-WEST	89.91
4	60	EAST-WEST	80.29
		EAST-NORTH	66.83

- Total cycle length = 224 sec
- Amber time in all phases = 3 sec
- Lost time per phase = 2.4 sec

OBSERVATIONS

From the above result it is observed that the delays in the phase-1 are slightly increased (i.e. road connecting Nizampet to Intersection) than existing signal time conditions. Delays in all other phases got reduced to an appreciable amount.

The cycle length has reduced than existing length.

CONCLUSIONS

- Total traffic volume for 12hr recorded data is observed as below

Vehicles	PCU
18841	16432

- Observing the hourly variations and PCU values, 8-00am to 10-00am and 4-00pm to 6-00pm can be concluded as peak hours.
- 50% of total traffic composition is occupied by two wheelers.
- Delays in the phase-2 and phase-3 are high for the existing traffic signal conditions.
- Delays got reduced by re-designing the signal timings by using HCM and Webster's formula.
- By comparing the delay results obtained, among both the methods Webster's method yields very least delay values.
-

FLOW DIRECTION	EXISTING DELAYS	DELAYS FOR HCM DESIGN	DELAYS FOR WEBSTERS DESIGN
SOUTH-NORTH	84.66	113.19	93.33
SOUTH-EAST	83.85	112.10	93.42
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EAST-WEST	103.85	96.86	80.29
EAST-NORTH	86.44	80.62	66.83

- During peak hours most of the left turning traffic is blocked by the through and right turning traffic due to insufficient lane width and improper shoulder conditions. Special channelization for left turning traffic is suggestable on Main Street.

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