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SIGNAL DESIGN USING WEBSTER'S METHOD (4 Legged Intersection)

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Abstract- Signal timing is the technique which traffic engineers use to determine who has the right-of-way at an intersection. Signal timing involves deciding how much green time the traffic lights shall provide at an intersection approach. How long the pedestrian walk signal should be, and many numerous other factors. The design of traffic signal nowadays has become an important factor for major intersections of towns and cities. Traffic signal controls the movement of traffic and not only reduces accidents but enables the road safety users to effectively use the area of road at intersection. Traffic volume studies are conducted to determine the number, movements, and classifications of roadway vehicles at a given location. These data can help to identify critical flow time periods, determine the influence of large vehicles or pedestrians on vehicle traffic flow, or document traffic volume trends. The length of the sampling period depends in the type of count being taken and the intended use of the data recorded. Webster method is a rational approach for signal design. The design is simple and is totally based on formulas laid down by Webster, in this method, the total cycle of the signal is determined which forms a total least delay occurring at signal.

Keywords — Signal Design, Webster method, intersections.

I. Introduction

The problems of urban transportation are well known not just for traffic engineers but to people in all walks of life. Overcrowded and congested with vehicles of all type creating lots of traffic problems and pollutions making the cities a veritable jungle. In fact bottlenecks in the urban transportation system have risen because the cities are not planned and built for supporting the volume of population they are given shelter today. Travel has become inherently risky activity in cities.

In spite of very low rate of vehicle registration compared to many developed countries, the accident rates in India are alarmingly very high. This situation is partly explained by heterogeneous mix of vehicles sharing the same right way on our road system with insufficient road width. This creates many problems.

Road signal design is a must requirement for traffic today which enables smooth flow of traffic, prevents accidents and controls traffic movement at an intersection. Due to the growing population in India, there is a rapid growth in employment and therefore transportation, these days have become a very important. In order to get a grip on traffic movement and to eliminate problems, these signals are much more useful.

The Objectives of this research are as follows:

- To develop critical gap and follow up-time for Indian road condition to take into consideration of vehicle composition.
- To develop capacity formulation for unsignalised intersection with respect to Indian road condition.
- To analyse the effect of variation in parameters to the performance of unsignalised intersection calculated using the proposed procedure

II. Review of Literature

A. Phase Design

The signal design procedure involves six major steps. They include the

(1) Phase design

(2) Determination of amber time and clearance time

(3) Determination of cycle length

(4) Apportioning of green time

(5) The performance evaluation of the above design

To illustrate various phase plan options, consider a four-legged intersection with through traffic and right turns. Left turn is ignored. See figure1. The first issue is to decide how many phases are required. It is possible to have two, three, four or even more number of phases.

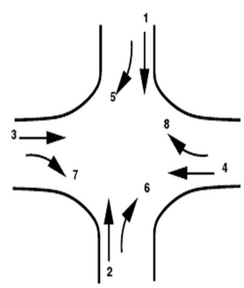

Fig. 1: Four-legged intersection

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B. Two Phase Signals:

Two phase system is usually adopted if through traffic is significant compared to the turning movements. For example, in figure1, non-conflicting through traffic 3 and 4 are grouped in a single phase and non-conflicting through traffic 1 and 2 are grouped in the second phase. However, in the first phase flow 7 and 8 other some conflicts and are called permitted right turns. Needless to say that such phasing is possible only if the turning movements are relatively low. On the other hand, if the turning movements are significant, then a four-phase system is usually adopted.

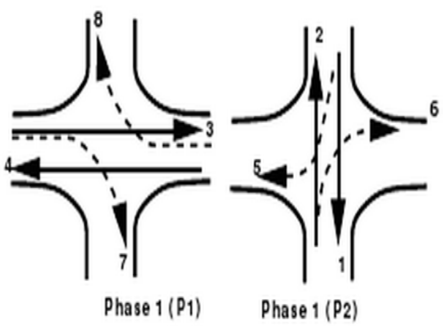

Fig.2. Two phase signal

C. Three Phase Signals:

Three phase signals are adopted for a three-legged intersection, where there are two conflicting movements which are right turns for both the roads and two non conflicting movements which are through movements. The phase plan for this kind of signals is shown in the following figure. From fig. , phase 1 (p1) is provided by only allowing the non conflicting traffic 1, phase 2 (p2) and phase 3 (p3) are provided by allowing the conflicting traffic 3 and 4 respectively.

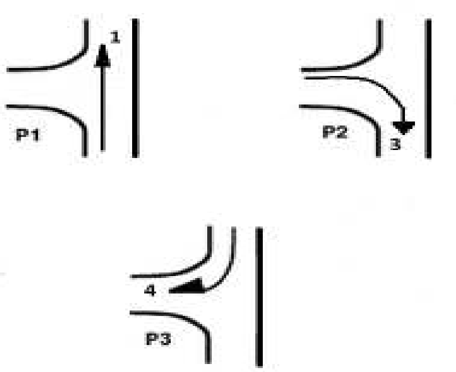

Fig.3 Three phase signals

D. Four phase signals:

There are at least three possible phasing options. For example, figure 2 shows the most simple and trivial phase plan. where, flow from each approach is put into a single phase avoiding all conflicts. This type of phase plan is ideally suited in urban areas where the turning movements are comparable with through movements and when through traffic and turning traffic need to share same lane. This phase plan could be very inefficient when turning movements are relatively low. Figure 3 shows a second possible phase plan option where opposing through trafficc are put into same phase. The non-conflicting right turn flows 7 and 8 are grouped into a third phase. Similarly, flows 5 and 6 are grouped into fourth phase. This type of phasing is very efficient when the intersection geometry permits to have at least one lane for each movement, and the through traffic volume is significantly high. Figure 4 shows yet another phase plan. However, this is rarely used in practice. There are five phase signals, six phase signals etc. They are normally provided if the intersection control is adaptive, that is, the signal phases and timing adapt to the real time traffic conditions.

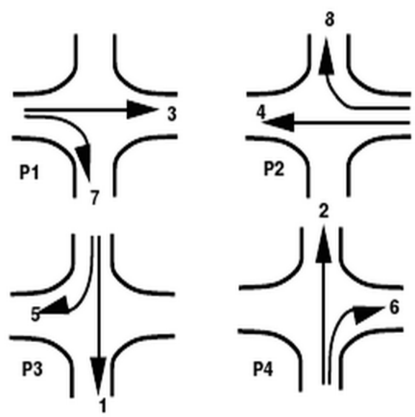

Fig.4. One way of providing four phase signal

III. Methodology

E. Interval Design

The design consideration is that a driver approaching the intersection with design speed should be able to stop at the stop line of the intersection before the start of red time. Institute of transportation engineers **(ITE)** has recommended a methodology for computing the appropriate length of change interval which is as follows:

$$y = t + \frac{v\,85}{2a + 19.6g}$$

Where y = length of yellow interval in seconds, t = reaction time of the driver,

v_{85} = 85th percentile speed of approaching vehicles in m/s,

a = deceleration rate of vehicles in m/s^2,

g = grade of approach expressed as a decimal.

SSD = stopping sight distance and

v = speed of the vehicle

F. Cycle Time

Cycle time is the time taken by a signal to complete one full cycle of iterations. i.e. one complete rotation through all signal indications. It is denoted by C. The way in which the vehicles depart from an intersection when the green signal is initiated will be discussed now.

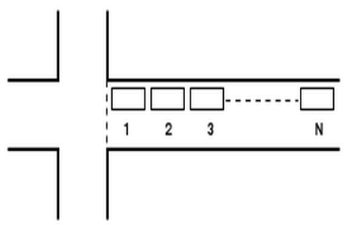

Fig.5. Group of vehicles at a signalized intersection waiting for green signal

Figure 5, illustrates a group of N vehicles at a signalized intersection, waiting for the green signal. As the signal is initiated, the time interval between two vehicles, referred as headway, crossing the curb line is noted as,

$$s = \frac{3600}{h}$$

Where; s = saturation flow rate in vehicles per hour of green time per lane,

h = saturation headway in seconds. vehicles per hour of green time per lane.

As noted earlier, the headway will be more than 'h' particularly for the first few vehicles.

The difference between the actual headway and h for the i th vehicle and is denoted as e_i. These differences for the first few vehicles can be added to get start up lost time, l which is given by,

$$l = \sum_{i=1}^{n} ei$$

The green time required to clear N vehicles can be found out as,

$$T = l + h.N$$

Where; T = time required to clear N vehicles through signal,

l = start-up lost time, and

h = saturation headway in seconds.

G. Design of Isolated Fixed Signal

In the design of a signalized intersection, the objective should be to provide sufficient capacity for the volume of traffic approaching the intersection. The design should aim at minimizing total delay, building short queues, and providing a high probability of passing through the intersection on the first given period for most users. Signal timing should be in accordance with traffic flow on intersection. The cycle lengths are normally 40 to 60 seconds for two phase signal. Longer cycle lengths are in use for complex traffic flow and for more than two phases.

To obtain the above goal, the following methodology should is followed:

- Finding the volume of traffic for different roads and directions.
- Finding the width of the roads.
- From the obtained results of traffic volume, designing signal timing based on guidelines provided by particular method of design.

This project is done using "Webster method of signal timing". This requires computation of traffic volume and also the width of roads after which required results can be obtained using the formulae and also the guidelines given in the method.

H. Analysis of Four-Legged Intersection

Analysis of a Four-legged intersection contains understanding and analyzing the traffic movement occurring at junction. This involves finding conflict points by knowing the directions of traffic. In other way, analysis of an intersection is nothing but finding the conflict points which create traffic problems.

On conducting survey on section at the Un-signalized intersection at Narsingh Junction, we came to know that it is a junction where huge amount of mixed flow of traffic is occurring.

The main problems are-

- conflicting traffic,
- sudden crossing of pedestrians,
- sudden stopping of three wheelers

Here we considered and analyzed this junction into 8 volumes.

- V1 – Mehidipatnam to shankarpally.
- V2 – shankarpally to mehidipatnam.
- V3-manchirevula to manikonda.
- V4-manikonda to manchirevula.
- V5-. shankarpally to manchirevula.
- V6- mehdhipatnam to manikonda.
- V7-manikonda to shankarpally.
- V8-manchirevula to mehidipatnam.

Here v1 to v4 are free lefts hence they are not considered much. The main problem is with conflicting traffic which is from v8 i.e., traffic flow from manchirevula to mehdhipatnam, causing traffic congestion to the primary traffic.Another volume v5 i.e. from shankarpally to manchirevula. And v5 shankarpally to manchirevula. and v6 mehidipatnam to manikonda conflicts with the priority running traffic. Hence a four-phase signal is provided with the following amenities.

- V1 signal to be categorized as 150 secs on red with a 60-sec green release followed.
- V2 signalling to be 145 secs on red with a 50-sec green window.

Similarly,At V3 a 110sec red signal followed by a 60sec green signal.At V4 a 100sec red signal with a 50sec green signal are to be provided

- Hence a signal timer as per the above-mentioned windows and timings is suggested to be installed. And to further decrease disturbances caused by the pedestrians zebra crossings are to be installed at the junctions and the pedestrians are to be guided across on reds.
- And vehicular parking within the prescribed radius of the junctions is to be evoked and prohibited completely.

The following simple figure shows layout of a four-legged intersection.

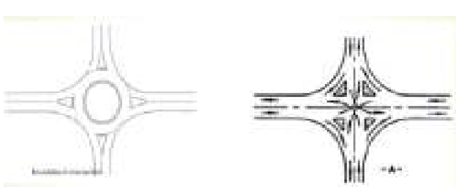

Fig.6 Four-legged intersection

Fig.7. Four-legged intersection

IV. Data Analysis

Webster's method is a rational approach for signal design. The design is simple and is totally based on formulas laid down by Webster. In this method, the total cycle of the signal is determined which forms a total least delay occurring at signal (least delay of road user).

- Because of the mixed traffic flow, the representation of flow in terms of vehicles/hour (or) vehicles/day is not applicable. Therefore such classified volume is brought into a unique volume by considering various factors such as speed, size, disturbance ..etc a new term called Passenger Car Unit (P.C.U) is made. This means that the total volume obtained is represented in terms of P.C.U.
- The values q1, q2, i.e., the normal flow values are measured from the field studies along with the saturation flow values s1, s2, ...etc. If the saturation flow values are not given, then 160 P.C.U per 0.3 metre of road width shall be considered as per I.R.C.

I. Application of Webster's method to Narsingh junction

While doing field studies i.e., finding the traffic volume counts of the roads A & B, the following data was found. This data is shown in the following figures.

Table I. showing the details of the time periods

Road	Green	Amber	Red	Cycle
Road A(G_{A1})	60	10	110	180
Road A(G_{A2})	60	10	110	180
Road B(G_{B1})	35	10	100	145
Road B(G_{B2})	35	10	100	145

B.Traffic Volume studies

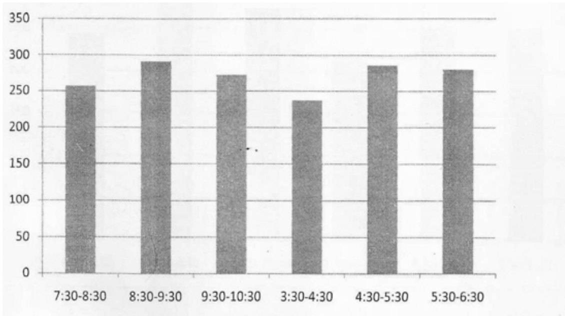

Fig.8. Traffic Volume in No. of Vehicles–From mehidipatnam to shankarpally(09-03-2017)

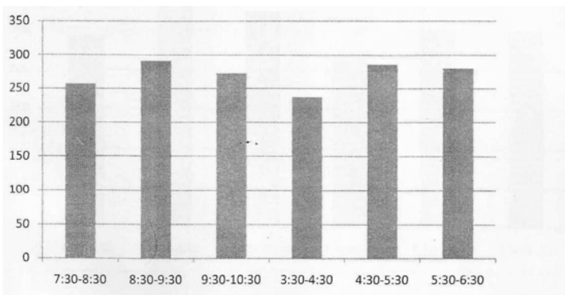

Fig.9.Traffic Volume in PCU – From mehidipatnam to shankarpally (11-03-2017)

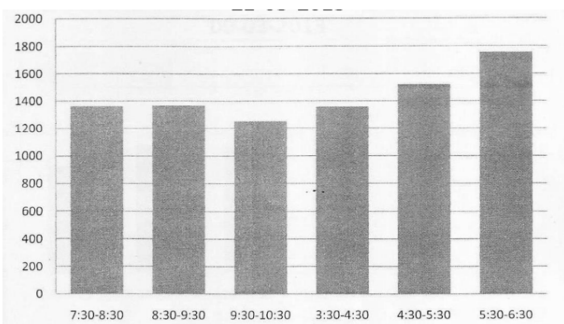

Fig.10. Traffic Volume in No. of Vehicles –From shankarpally to mehidipatnam (09-03-2017)

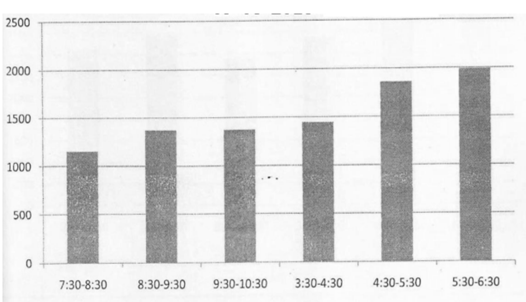

Fig.11.Traffic Volume in PCU – From shankarpally to mehidipatnam (21-03-2017)

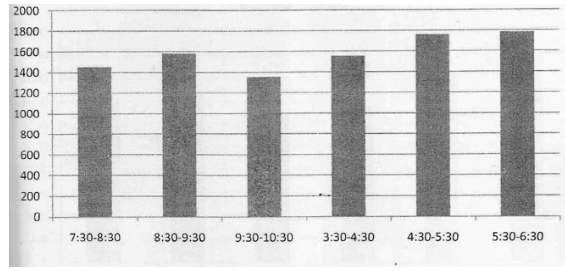

Fig.12. Traffic Volume in No. of Vehicles – From manchirevula to manikonda ring road (11-03-2017)

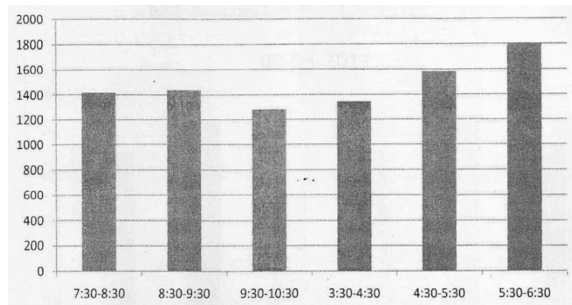

Fig.13. Traffic Volume in PCU – From manchirevula to manikonda ring road(11-03-2017)

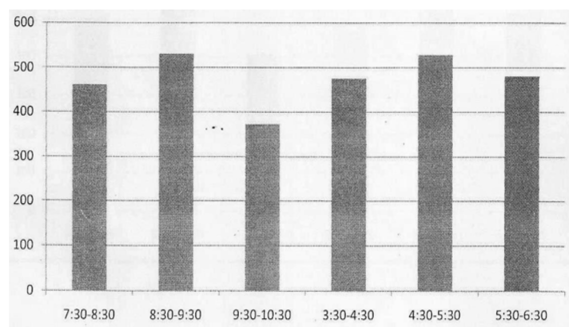

Fig.14. Traffic Volume in No of vehicle – From shenkarpally to manchirevula (11-03-2017)

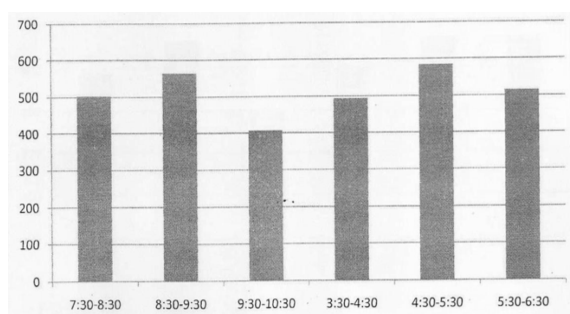

Fig.15.Traffic Volume in no of vehicles – From manikonda to mehidipatnam(21- 03-2017)

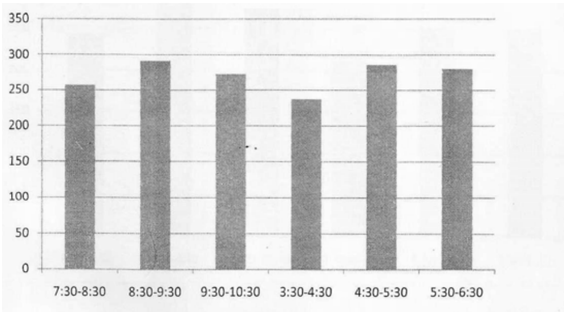

Fig.16.Traffic Volume in PCU– From manikonda to mehidipatnam (11-03-2017)

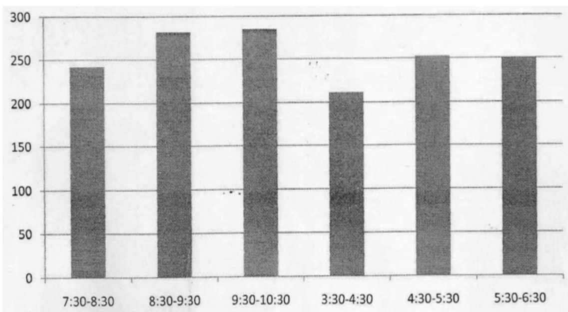

Fig.17. Traffic Volume in no of vehicles – From Manchirevula to manikonda (11-03-2017)

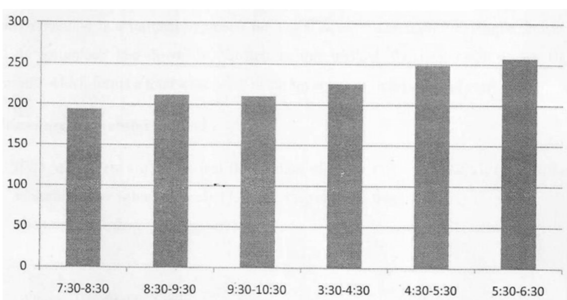

Fig.18. Traffic Volume in PCU – From Manchirevula to manikonda (21-03-2017)

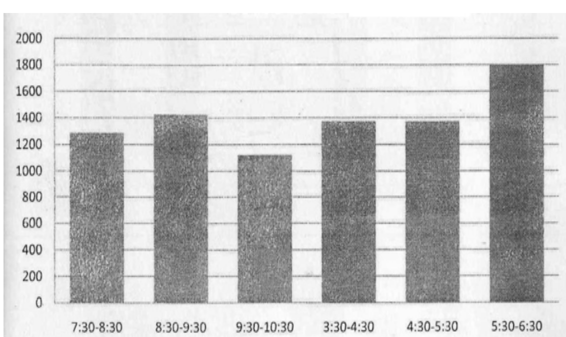

Fig.19.Traffic Volume in No. of Vehicles–From manikonda to mehidipatnam (09-03-17)

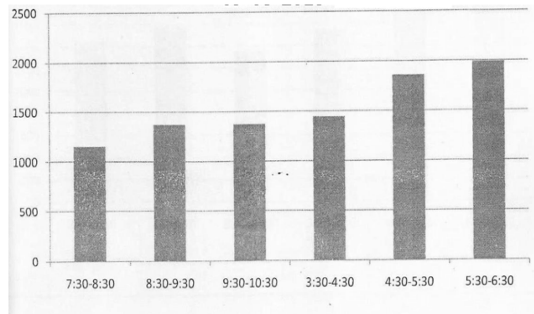

Fig.20. Traffic Volume in PCU – From manikonda to mehidipatnam (09-03-2017)

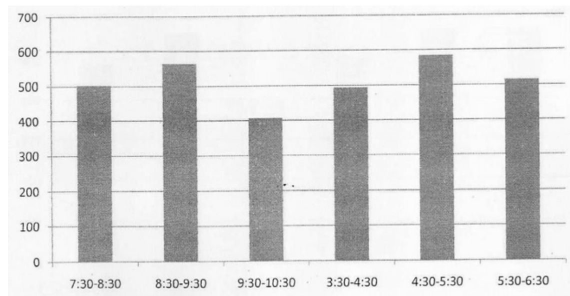

Fig.21. Traffic Volume in vehicle – From mehidipatnam to manchireuvla (11-03-2017)

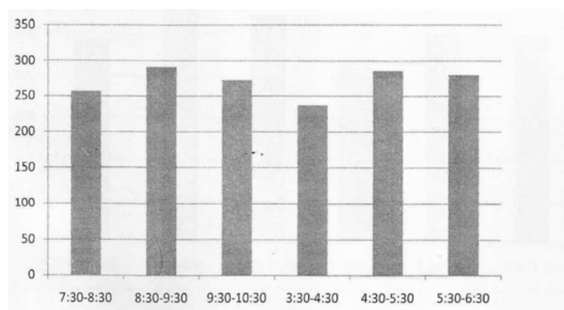

Fig.22. Traffic Volume in PCU – From mehidipatnam to manchireuvla (9-03-2015)

V. Conclusion

It is recommended that, at Narsinghi Junction, the total cycle times for Road A and Road B using Websters method is to be 180 seconds and 145 seconds respectively. The green time that has to be provided for Road A and Road B is 60 seconds and 35 seconds respectively.

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