

## Signal design for T-intersection by using webster's method on NH-18 in Nandyal town, Kurnool District of Andhra Pradesh

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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. Traffic volume studies are conducted to determine the number, movements, and classifications of roadway vehicles at a given location. The collected data is converted into PCU units. These data can help identify critical flow time periods, determine the influence of large vehicles or pedestrians on vehicular traffic flow, or document traffic volume trends. The length of the sampling period depends on the type of count being taken and the intended use of the data recorded. For example, an intersection count may be conducted during the peak flow period. If so, manual count with 15-minute intervals could be used to obtain the traffic volume data. Webster's method is a rational approach for signal design. The design is simple and is totally based on formulae's laid down by Webster. In this method, the total cycle of the signal is determined which forms a total least delay occurring at signal.

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### 1.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. The problem as exist today can hardly be delinked from its problem of town planning and its implementation. 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.

Traffic consists on Indian roads of bi-directional freedom traffic such as two or three wheeled vehicles and uni-directional vehicles such as four wheelers. Or rejected by various modes of traffic. To prevent traffic accidents, conflicting traffic streams are separated either in space or in time.

### 2.Literature Survey

AYYALURU METTA is one of the busiest circles in the town of Nandyal. which is situated at the end of nandyal town on NH-18. Roads from kurnool , kadapa, allagadda, ongole cross the busiest street of Nandyal which is stretched from nunepalli towards ayyaluru and allagadda. The screen shot from Google maps is as sown below. As it has cross section, there are merges and diverges in the crossing of these three roads. And there will be no orderly movement of traffic. In this connection, there is possibility for the traffic jams as well as accidents to occur. So there is a very heavy requirement for regulation of traffic, as well as orderly movement. To achieve this, there is a need of signalized cross-section. As it is a cross-section of three roads, there is a need of a three phase traffic signal.



Fig 2.1. Screen shot of Ayyaluru Metta from google map.



Fig 2.2. Screen Shot of Ayyaluru Metta from Google maps.

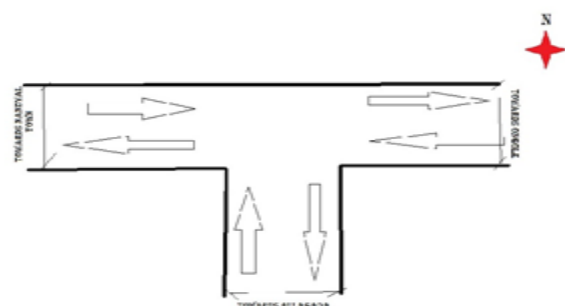


Fig 2.3. Lay out of Ayaluru Metta.

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### 3. TRAFFIC STUDIES

Traffic studies or surveys are carried out to analyze the traffic Characteristics. These studies help in deciding the geometric design features and control for safe and efficient traffic movement. The various traffic studies generally carried out are:

- Traffic study
- Speed studies
- Origin and destination study
- Traffic flow characteristics
- Traffic capacity study
- Parking studies
- Accident studies

### 4. TRAFFIC VOLUME STUDY

One of the fundamental measures of traffic on road system is the volume of traffic using the road in a given interval of time when the traffic is composed of a number of types of vehicles; it is the normal practice to convert the flow into equivalent P.C.U by using certain equivalency factor. The flow is expressed as PCU per hour.

#### METHODS FOR TRAFFIC COUNTS

- Manual methods
- Combination of manual & mechanical method
- Automatic Method
- Moving observer method
- Photographic method

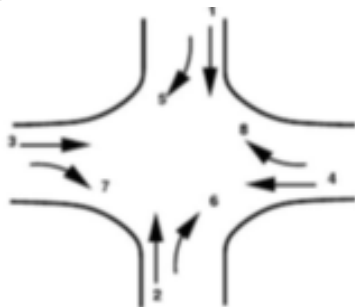
### 5. METHODOLOGY

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.

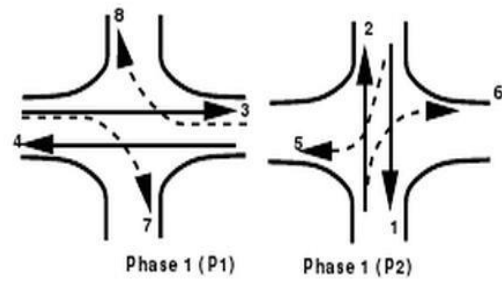
□ The objective of phase design is to separate the conflicting movements in an intersection into various phases, so that movements in a phase should have no conflicts. If all the movements are to be separated with no conflicts, then a large number of phases are required.

□ To illustrate various phase plan options, consider a four legged intersection with through traffic and right turns. Left turn is ignored



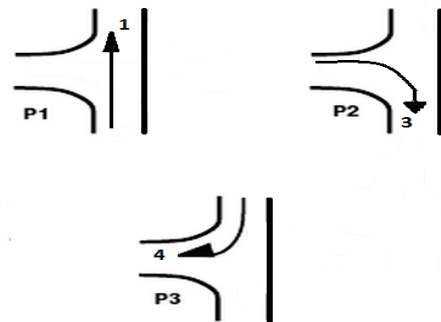
#### 5.1 Two Phase Signals

Two phase system is usually adopted if through traffic is significant compared to the turning movements. 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 over some conflicts and are called permitted right turns.



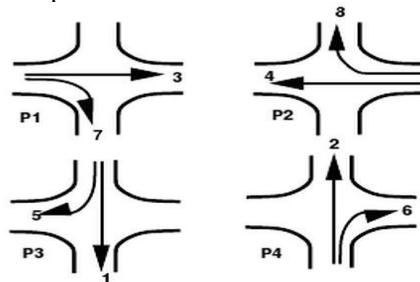
#### 5.2 Three Phase Signals

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.



#### 5.3 Four Phase Signals

There are at least three possible phasing options.. 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.. 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. 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.



#### 5.4 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. In Webster Method corresponding to least total delay to the vehicles at signalized intersection has been worked out.

This is rational approach. The field work consists of finding (i) Saturation flow S per unit time on each approach of the intersection and (ii) the normal flow „q” on each approach during the design approach. The standard values for saturation flow, S according to Webster are given as in the below table.

Width in m	3.0	3.5	4.0	4.5	5.0	5.5
PCU/hr	1850	1890	1950	2250	2250	2900

**Table 5.1** Saturation flow for widths 3 to 5.5 meters Based on the higher value of normal flow, the ratio

$$Y_1 = \frac{q_1}{s_1} \text{ and } Y_2 = \frac{q_2}{s_2} \text{ ----- (I)}$$

are determined on the approach roads 1 and 2. In the case of mixed traffic, it is necessary to convert all the values in terms of PCU values which should be determined separately. The Saturation flow is to be obtained from careful field studies by noting the number of vehicles in the stream of compact flow during the green phases and the corresponding time intervals precisely. In the absence of the data approximately value of saturation flow is estimated assuming 160 PCU per 0.3 meter width of the approach. The normal flow of the traffic is also determined on the approach roads from the field studies from the design period (during the peak or off peak hours, as the case may be.)

The optimum signal cycle is given by

$$C_0 = \frac{(1.5L+5)}{(1-Y)} \text{ ----- (II)}$$

Where L = total lost time per cycle, seconds

$$L = 2n+R \text{ ----- (III)}$$

n = number of phases,  
R = all red time.

$$Y = Y_1 + Y_2 + Y_3 \text{ ----- (IV)}$$

Then  $G_1 = \frac{Y_1}{Y}(C_0 - L)$  and  $G_2 = \frac{Y_2}{Y}(C_0 - L)$  ----- (V)

Similarly the procedure is followed when there are more number of signal phases.

**6. Traffic Counts**

A survey is conducted for six days to obtain traffic hourly counts for all streams. There are 6 streams of flow of traffic at the two road intersection. The streams of the cross-section are as follows

**6.1 Streams**

**Table 6.1.** Streams of traffic flow at the cross section at Ayyaluru Metta.

STAGES	From	Towards
1	GIDDALORE	ALLAGADDA (RT) KADAPA (RT) KURNOOL (UP) NANDYAL (UP)
2	ALLAGADDA	NANDYAL (LT) KURNOOL (LT) GIDDALORE (RT) ONGOLE (RT) MAHANANDI (RT)
3	NANDYAL	ALLAGADDA (RT) KADAPA (RT) GIDDALORE (UP) ONGOLE (UP) MAHANANDI (UP)

where

UP = up ward passing (straight movement)

LT = Left Turn Movement

RT = Right Turn Movement

**Manual Counts**

Very commonly adopted method to get traffic volume like vehicle class wise , turning movements and loading conditions

- Better than mechanical counters.

- Not practicable for all 24hrs field data.
- Done short counts during peak hours.
- Hence need to perform statistical analysis to calculate the ADT and AADT.

**7. Calculation of Cycle Length**

**7.1 Overview**

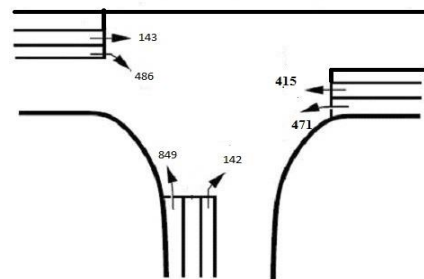
Cycle time is the time taken by a signal to complete one full cycle of iterations. That is one complete rotation through all signal indications. It is denoted by C. In Webster Method, corresponding to least total delay to the vehicles at signalized intersection has been worked out. This is rational approach. The field work consists of finding (i) Saturation flow S per unit time on each approach of the intersection and (ii) the normal flow q on each approach during the design approach. The standard values for saturation flow, S according to Webster are given as in the below table

**Table 7.1. Saturation Flow Values.**

Width in m	3.0	3.5	4.0	4.5	5.0	5.5
PCU/hr	1850	1890	1950	2250	2250	2290

**7.2 Calculation of Cycle length for Morning Session:**

The PCU values for morning session for the corresponding routes are as the below figure.



**Fig 7.2.** PCU value for Morning Session from different streams.

From the above PCU values, the maximum PCU value from each phase is considered for the calculation of cycle length.

For the calculation of cycle length, saturation value, S is required, and it is taken as 1890 as the length of lane is 3.5 meters.

**Normal flows,**

$$q_1 = 387, q_2 = 311, q_3 = 382.$$

$$Y_1 = 387/2900 = 0.133$$

$$Y_2 = 311/2900 = 0.107$$

$$Y_3 = 382/2900 = 0.132$$

$$Y = Y_1 + Y_2 + Y_3 = 0.133 + 0.107 + 0.132 = 0.372$$

Cycle length according to Webster method is calculated using the formula

$$C_0 = \frac{(1.5L+5)}{(1-Y)}$$

where  $L = 2n + R = (2*3) + 9 = 15$  seconds.

$$\text{Therefore, } C_0 = \frac{(1.5*15+5)}{(1-0.372)} = 43.78 = 45 \text{ sec}$$

**Calculation of Green Time:**

**Phase 1**

$$G_1 = \frac{Y_1}{Y}(C_0 - L) = (0.133/0.372)*(45-15) = 11 \text{ Seconds.}$$

**Phase 2**

$$G_2 = \frac{Y_2}{Y}(C_0 - L) = (0.107/0.372)*(45-15) = 9 \text{ Seconds.}$$

**Phase 3**

$$G_3 = \frac{Y_3}{Y}(C_0 - L) = (0.132/0.372)*(45-15) = 10 \text{ Seconds.}$$

Considering all pedestrian time = 9 seconds, Amber time = 2 seconds for each phase = 6 seconds for three phases.

Total Cycle length = 11+9+10+6+9 = 45 seconds.

Total Cycle length = 29+28+33+6+9 = 105 seconds.

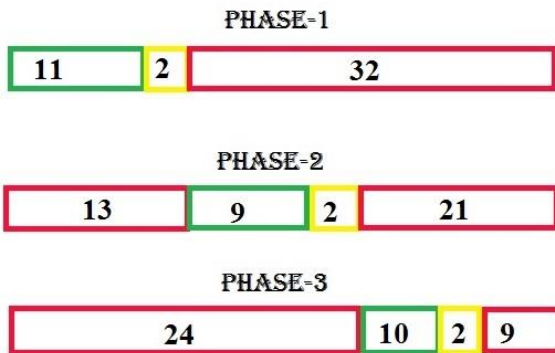


Fig 7.3. Signal Phase Diagram for Morning Session.  
7.3 Calculation of Cycle length for Afternoon Session

Fig 7.5. Signal Phase Diagram for Afternoon Session.  
7.4 Calculation of Cycle length for Evening Session

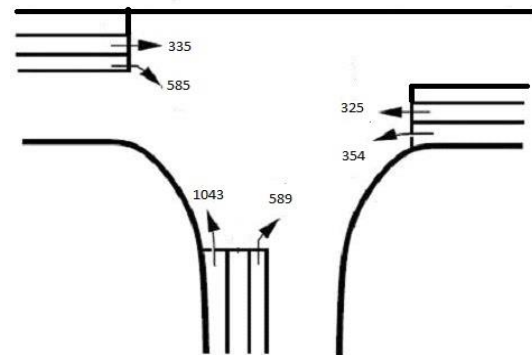
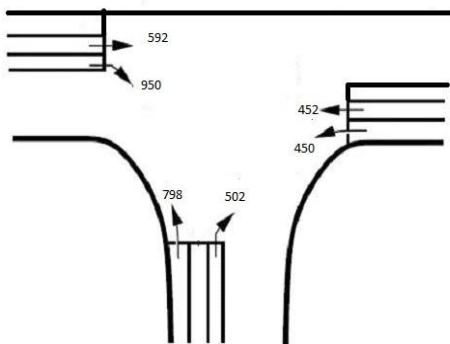


Fig 7.4. PCU Values for Afternoon session from different streams.

Fig 7.6. PCU Values for evening session from different streams

From the above PCU values, the maximum pcu value from each phase is considered for the calculation of cycle length. For the calculation of cycle length, saturation value, S is required, and it is taken as 2900 as the length of lane is 5.5 meters.

**Normal flows,**

$$q_1 = 672, q_2 = 668, q_3 = 783.$$

$$Y_1 = 672/2900 = 0.232$$

$$Y_2 = 668/2900 = 0.230$$

$$Y_3 = 783/2900 = 0.27$$

$$Y = Y_1 + Y_2 + Y_3 = 0.232 + 0.230 + 0.27 = 0.732$$

Cycle length according to Webster method is calculated using the formula

$$C_0 = \frac{(1.5L + 5)}{(1 - Y)}$$

where  $L = 2n + R = (2 \times 3) + 9 = 15$  seconds.

$$\text{Therefore, } C_0 = \frac{(1.5 \times 15) + 5}{(1 - 0.732)} = 102.68 = 105 \text{ sec}$$

**Calculation of Green Time:**

**Phase 1**

$$G_1 = \frac{Y_1}{Y} (C_0 - L) = (0.232/0.732) \times (105 - 15) = 29 \text{ Seconds.}$$

**Phase 2**

$$G_2 = \frac{Y_2}{Y} (C_0 - L) = (0.23/0.732) \times (105 - 15) = 28 \text{ Seconds.}$$

**Phase 3**

$$G_3 = \frac{Y_3}{Y} (C_0 - L) = (0.27/0.732) \times (105 - 15) = 33 \text{ Seconds.}$$

Considering all pedestrian time = 9 seconds, Amber time = 2 seconds for each phase = 6 seconds for three phases.

F For the calculation of cycle length, saturation value, S is required, and it is taken as 1890 as the length of lane is 3.5 meters.

**Normal flows,**

$$q_1 = 494, q_2 = 732, q_3 = 944.$$

$$Y_1 = 494/2900 = 0.17$$

$$Y_2 = 732/2900 = 0.252$$

$$Y_3 = 944/2900 = 0.325$$

$$Y = Y_1 + Y_2 + Y_3 = 0.17 + 0.252 + 0.325 = 0.747$$

Cycle length according to Webster method is calculated using the formula

$$C_0 = \frac{(1.5L + 5)}{(1 - Y)}$$

where  $L = 2n + R = (2 \times 3) + 9 = 15$  seconds.

$$\text{Therefore, } C_0 = \frac{(1.5 \times 15) + 5}{(1 - 0.747)} = 108.69 = 110 \text{ sec}$$

**Calculation of Green Time:**

**Phase 1**

$$G_1 = \frac{Y_1}{Y} (C_0 - L) = (0.17/0.747) \times (110 - 15) = 22 \text{ Seconds.}$$

**Phase 2**

$$G_2 = \frac{Y_2}{Y} (C_0 - L) = (0.252/0.747) \times (110 - 15) = 32 \text{ Seconds.}$$

**Phase 3**

$$G_3 = \frac{Y_3}{Y} (C_0 - L) = (0.325/0.747) \times (110 - 15) = 41 \text{ Seconds.}$$

Considering all pedestrian time = 9 seconds, Amber time = 2 seconds for each phase = 6 seconds for three phases.

Total Cycle length = 41 + 32 + 22 + 6 + 9 = 110 seconds.



**FIG 7.7. Signal Phase Diagram for Evening Session**

#### 8.Specifications for Signal Poles (IRC: 93-1985)

##### 8.1 Specifications for Signal Footing (IRC: 93- 1985):

The poles must be first positioned in pits of 900 mm\* 900 mm\* 1050 mm deep.

The poles shall then embedded in M 20 concrete to a minimum of 300 mm below ground level and 300 mm above the ground level. The circular area of embedded concrete shall have a minimum diameter of 450 mm.

All the cables supplying power to the controller and signal heads shall run through RCC ducts when these are required to cross the carriage way.

The ducts shall be of 450 mm internal diameter and laid at a depth of about 1000 mm from the level of the carriage way. For over head traffic signals, the pit should be 1200 mm \* 1200mm \* 1800 mm deep. The poles are to be embedded in M 20 concrete to a minimum of 500 mm below ground level and 500 mm above ground level. The circular area of embedding concrete shall have a minimum diameter of 500 mm.

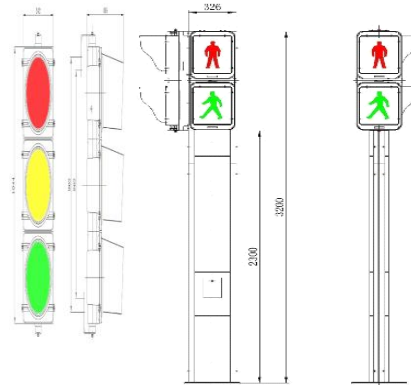
##### 8.2 Specifications for Height of Signal Faces ( IRC : 93-1985):

The bottom of the housing of a signal face, not suspended over a roadway, shall be at a height of 2.5 meter above the footpath or if none above the pavement grade at the centre (crown) of the roadway.

The bottom of the housing of n signal face, suspended over a roadway, shall be at a height of 5.5 meter above the pavement grade at the centre of roadway.

Optimum visibility and adequate clearance should be guiding considerations in deciding signal height. Grades on approaching streets may be important factors, and should be

considered in determining the most appropriate height. However, the maximum heights of bottom of housing of post-mounted signal face should not exceed 4.6 meter and while in the case of overhead signal face, the same should not exceed 5.8 meter



**Fig 8.1. Dimensions of signal post.**

#### 9. Conclusion

Based on the calculations done on the PCU values obtained from the traffic survey, the Signal Cycle Length for Morning session is 45 seconds, for Afternoon session is 105 seconds and for evening session is 110 seconds.

By providing signals, there will be reduction in the conflicts. And also there will be an orderly movement of traffic in the cross- section for the roads from Noonepalli Towards Allagadda, Kadapa, Giddalore, Ongole. And Allagadda Towards Nandyal Kurnool Giddalore, Ongole and Giddalore Towards Allagadda, Kadapa, Nandyal, Kurnool As well, there is no necessary of traffic police to regulate the traffic at ayyalur metta.

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