A STUDY ON ROTARY INTERSECTION AT MANGALURU – A CASE STUDY OF NANTHUR JUNCTION

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Abstract
The traffic congestions are the major problem in any developing city. Mangaluru city being a developing city having traffic problem in several intersections. In the present study an attempt is made to study the behaviour of traffic stream at Nanthur Intersection situated just outskirt of the Mangaluru city. The traffic volume count is done using videography method & the peak traffic flow is determined. For the peak traffic an attempt was made to design traffic signal as per IRC guidelines, which has failed due to high traffic volume. Then a successful attempt was made to re-design the present traffic rotary & a modified roundabout design elements are suggested which can prove economical when compared with other type of grade separated intersection to reduce the delays & congestions.

Keywords:**Traffic,Videography, Intersection, Signal, Roundabout**

I. INTRODUCTION

The rapid development in urban area with economic growth results in huge volume of traffic in most of the cities in India during peak hours. Large volume of traffic is main reason to occur the congestions in urban roads as well as intersections. So the traffic congestion became a serious issue and increasing day by day with the increase of vehicle population. [1] In order to reduce the congestions in urban area and also the city to make living friendly the concept of Smart city was implemented by the Govt. of India in the year 2015.

This problem may raise the vehicle operation cost and make delay in trip, also arises the poor performance of the intersections. The performance of intersections is a vital issue to address the congestion problem. To carry out the study Nanthur Intersection at Mangaluru has been selected as a case study area. Here three national highways coincide in the junction so it is one of the busiest intersections in the city. The main objective of the present study is to present performance of Nanthur rotary intersection is to suggest a modification on the basis of the present classified traffic volume count & to accommodate this traffic safely without much congestion. [2]

Figure 1 - Ariel view of Nanthur Junction

II. EXPERIMENTAL PROGRAM

A. Vehicle Volume Count -

Volume of traffic is a fundamental measure of traffic on a road in a given interval of time. It is expressed as vehicles per hour. When the traffic is composed of a number of types of vehicles, it is normal practise to convert the flow into equivalent passenger car unit (PCU), by using certain equivalency factors. The flow is then expressed as PCUs per hour.

Knowledge of the vehicular volume using a road network is important for understanding the efficiency at which the system works at present and the general quality of service offered to the road users. Knowing the flow characteristics one can easily determine whether a particular section of the road is handling traffic much above or below its capacity. If the traffic is heavy, the road suffers from congestions.

The traffic using a road is composed of a variety of vehicles ranging from the simple two wheelers to the motor cars and heavy commercial vehicles with multi axles. Each type having an influence on the performance of the road in its own way, a simple volume count, without classifying volumes into distinct types, is of limited use. It is therefore, the normal practise is to classify the vehicles into distinct types when doing the volume counting. [3]

Classified volume count - A classified traffic volume count survey was performed at Nanthur Intersection in the peak hours (07:30-10.00AM, 12:30-02:30PM and 04:30-08:00PM). The survey was done by video photography method. It gives a permanent record of volume counts. And analysis can be done conveniently in the office by replaying the video. Sony handy camera was used to shoot the traffic flow. The volume of traffic was classified majorly as two wheelers, three wheelers, Car/Jeep, Mini Truck, Heavy vehicles and Multi axles. The buses and trucks are classified under Heavy vehicles and buses and trucks more than two axles are classified as multi axles. [4]

Junction peak - The junction peak is the volume of traffic that uses the approach or lane group in question during the hour of the day that observes the highest traffic volumes for that intersection.

Typical table of a classified Traffic Volume Count of Mudabidre Road to Mangaluru city road, is shown below

Table 1 - Classified Traffic Volume Count (Mudabidre road to Mangaluru city road)

Types of vehicles	Volume count	PCUs	Equivalent PCUs	Total classified traffic volume
Two wheeler	1685	0.75	1264	2556
Three wheeler	322	2.00	644	
Car/Jeep	482	1.00	482	
Light commercial Vehicle	9	1.40	13	
Bus/Truck	28	2.20	61	
Multi axles (HCV)	23	4.00	92	

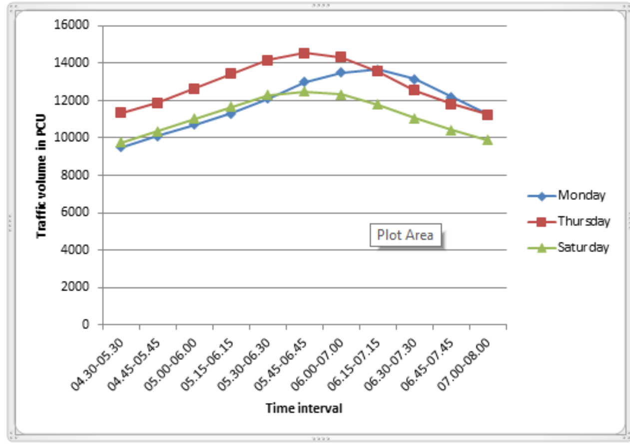

Figure 2 - Peak volume flow at Nanthur Junction

B. Traffic Signal Design -

In India several cities are using flexible and effective traffic signal system to control the traffic flow. The conflicts arising from movements of traffic in different directions are addressed by time sharing principle. The traffic signal has the advantages of orderly movement of traffic, an increased capacity of the intersection and requires only simple geometric design. However, large stopped delays and complexity in the design and implementation are the major disadvantages. Although the overall delay may be lesser than a rotary for a high volume, a user may experience relatively high stopped delay. [5]

Phase design - The signal design procedure involves six major steps. They include: (1) phase design, (2) determination of amber time and clearance time, (3) determination of cycle length, (4) apportioning of green time, (5) pedestrian crossing requirements, and (6) performance evaluation of the design obtained in the previous steps. 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. In such a situation, the objective is to design phases with minimum conflicts or with less severe conflicts. [5]

Four phase signals - Figure 3 shows a second possible phase plan option where opposing through traffic 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.

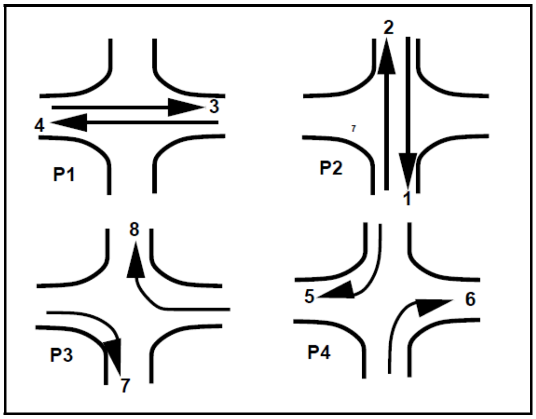

Figure 3 - Movements in four phase signal system

As per IRC recommendation in Indian practise to design the traffic signals for the given traffic volume count is based on Webster’s method.

Webster’s Optimum Cycle Formula [3]

C_0: Optimum Cycle Length, sec

L: Total lost time, sec

$\sum_i^n Y$: Total critical volume/saturation flow

Optimum cycle time: $Co = \frac{1.5L + 5}{1 - Y}$

Minimum inter green period (*I*) = *4 seconds*

Amber period (a) = *2 seconds*

Red/Amber period = *2 seconds*

Time lost due to starting delays

$$L = \sum_{i=1}^{n} I - a + \sum_{i=1}^{n} li$$

$$\frac{q}{s} = \frac{Flow}{saturation\ flow}$$

S= saturation flow = $525\ X\ w\ PCU/hour$

w= Width of approach road I meters measured kerb to inside of pedestrian refuge or centre line, whichever is nearer, or to the inside of central reserve in case of a dual carriage way.

$$\sum_{i}^{n} Y = \frac{qi}{525\ X\ wi}$$

Effective green time per cycle $g_t = C_0 - L$

Effective green time per phases

$$gi = \frac{yi}{\sum_{i=0}^{n} y} gt$$

C. Roundabout or Rotary Intersections -

A rotary intersection is a specialised form of at grade intersection laid out for movement of traffic in one direction round a central island. The vehicles from converging areas are forced to move around the central island in a clockwise direction in an orderly manner and weave out of the rotary movement into their desired movements.

Design elements - This includes [3]

- Design speed
- Radius at entry & exit and Central Island
- Weaving length & width
- Entry and exit widths
- Practical Capacity

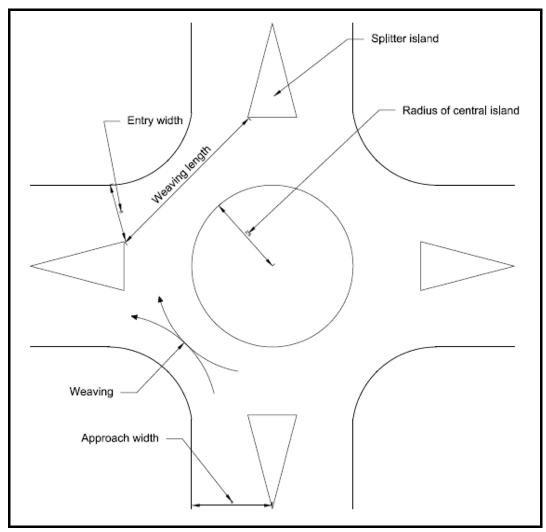

Figure 4 - General diagram of Roundabout

Design Speed - All the vehicles are required to reduce their speed at a rotary. Therefore, the design speed of a rotary will be much lower than the roads leading to it. The normal practice is to keep the design speed as 30 and 40kmph for urban and rural areas respectively.

Entry, exit and island radius -

- The radius at the entry depends on various factors like design speed, super-elevation, and coefficient of friction. The entry to the rotary is not straight, but a small curvature is introduced.

- The exit radius should be higher than the entry radius and the radius of the rotary island so that the vehicles will discharge from the rotary at a higher rate. A general practice is to keep the exit radius as 1.5 to 2 times the entry radius.
- The radius of the central island is governed by the design speed, and the radius of the entry curve, so in practical it is about 1.33 times the radius of entry curve.

Width of the rotary -

- The entry width and exit width of the rotary is governed by
    - The traffic entering and leaving the intersection
    - The width of the approaching road
- The width of the carriageway at entry and exit will be lower than the width of the carriageway at the approaches to enable reduction of speed.
- IRC suggests that a two lane road of 7 m width should be kept as 7 m for urban roads and 6.5 m for rural roads.
- Further, a three lane road of 10.5 m is to be reduced to 7 m and 7.5 m respectively for urban and rural roads.

Practical Capacity – It is directly determined by the capacity of each weaving section, and by the geometrical layout. The Transport and Road Research Laboratory (U.K.) which has pioneered research on this aspect, recommends the formula and that is modification of the well-known Wardrop's formula.

$$Q_p = \frac{280\,w\left(1+\frac{e}{w}\right)\left(1-\frac{p}{3}\right)}{1+\frac{e}{l}}$$

Where, Q_P = Practical capacity

W = Width of weaving section in meters

e = average entry width of the rotary in meters

l = length of weaving section between the ends of the channelizing islands in meters

p = proportion of weaving traffic = $\frac{b+c}{a+b+c+d}$

There is traffic rotary at present in Nanthur Junction with following geometric features

Table 2 - Geometric features of the Junction

Particulars	***Dimensions***
Radius of central island	*28m*
Weaving length	*35m*
Width of weaving section	*24.4m*
Carriage way width	*8.6m*
Width of median	*2m*

III. RESULTS AND DISCUSSIONS

As a first regulatory measure an attempt was made to design a Traffic Signaling as per IRC guidelines for which the design was done for peak values, as given below

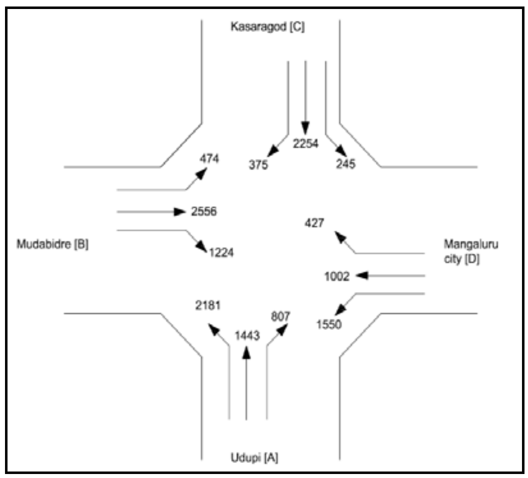

Figure 5 - Traffic volume count – Junction peak at Nanthur Junction

$$\sum_{i}^{n} Y = \frac{qi}{525\ X\ wi}$$

$$y1 = \frac{2001}{525X8.6} = 0.445$$

$$y2 = \frac{1814}{525X10.1} = 0.342$$

$$y3 = \frac{1092}{525X8.6} = 0.242$$

$$y4 = \frac{475}{525X10.1} = 0.09$$

Y = 0.445 + 0.342 + 0.242 + 0.09 = 1.117

The calculated value of Y was greater than 1, means the traffic signal to the intersection cannot be adopted due to heavy traffic flow in peak time as per IRC. Hence we can also conclude that the traffic signalling is not the ultimate solution for the congestion free movement of traffic. So that there is need to be other method of solutions like designing a Roundabouts or grade separator.

Now an attempt has made to re-design the traffic rotary at this site the design is as per IRC-65:1976 guidelines for urban road:

[1] Design speed= 30kmph

[2] Radius at entry $R_1 = \frac{v^2}{127f} = \frac{30^2}{127*0.47}$

R_1= 15.078m

Where f = coefficient of friction = 0.43 to 0.47

As per IRC recommendations for urban roads 15-20m is suggested, therefore adopting 20m.

[3] Radius at exit (R_2)

As per IRC recommendations for urban roads Radius at exit is 1.5 to 2 times Radius at Entry, therefore R_2= 2*20 = 40m

[4] Radius of Central Island (R):

As per IRC recommendations for urban roads, R = 1.33

R_1 = 1.33 * 20 = 26.6m

[5] Weaving Length & Width:

The weaving length is decided on the basis of factors such as the width of the weaving section, the average width of entry, total traffic and the proportion of weaving traffic in it.

Assuming e_1 as 24m, e_2 as 16m.

Therefore width of weaving (w) = $\frac{e1+e2}{2} + 3.5$

W = $\frac{24+16}{2} + 3.5$ = 23.5m

From IRC guidelines, Minimum weaving length is taken as 30m.

As per IRC recommendations for urban roads, the length to width ratio must be equal or greater than 4

Therefore Length of weaving section = 3.5 * w = 3.5 * 23.5 = 82.25m

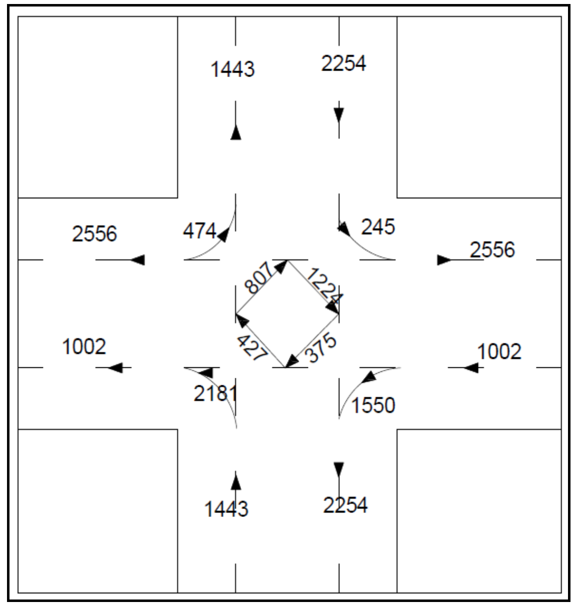

Figure 6 - Assigned traffic network

Proportion of weaving traffic given by, P = $\frac{b+c}{a+b+c+d}$

$$P_{NE} = \frac{2254+375+2556+807}{2254+375+2556+807+245+1224} = 0.803$$

$$P_{NW} = \frac{1443+427+2556+1224}{1443+427+2556+1224+807+474} = 0.815$$

$$P_{SE} = \frac{2254+1224+427+1002}{2254+1224+427+1002+375+1550} = 0.718$$

$$P_{SW} = \frac{1443+807+1002+375}{1443+807+1002+375+2181+427} = 0.582$$

Practical Capacity of Rotary from Wardrop's formula:

$$Qp = \frac{280\,w\left(1+\frac{e}{w}\right)\left(1-\frac{p}{3}\right)}{1+\frac{w}{l}}$$

$$Qp = \frac{280*22*\left(1+\frac{20}{23.5}\right)\left(1-\frac{0.803}{3}\right)}{1+\frac{20}{82.25}} = 6468$$

$$Qp = \frac{280*22*\left(1+\frac{20}{23.5}\right)\left(1-\frac{0.815}{3}\right)}{1+\frac{20}{82.25}} = 6432$$

$$Qp = \frac{280*22*\left(1+\frac{20}{23.5}\right)\left(1-\frac{0.718}{3}\right)}{1+\frac{20}{82.25}} = 6718$$

$$Qp = \frac{280*22*\left(1+\frac{20}{23.5}\right)\left(1-\frac{0.582}{3}\right)}{1+\frac{20}{82.25}} = 7120$$

Now it can be seen that the above results are much greater than the traffic flow at three sides so it is concluded that the design is acceptable for the present traffic data. The sketch for the re-design Rotary Intersection is given in Figure 7.

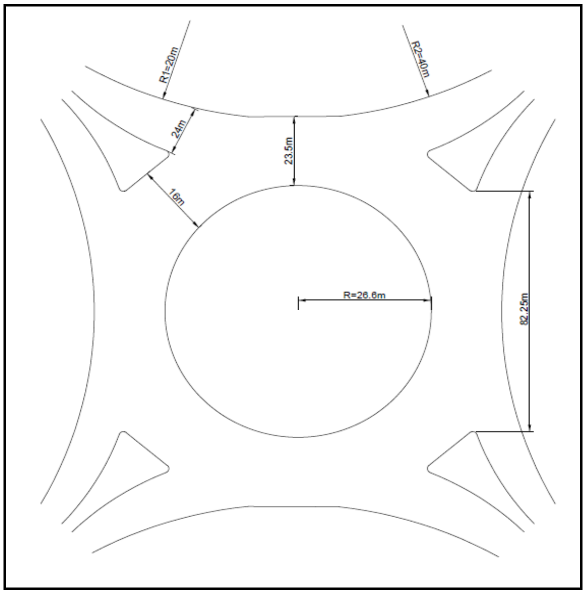

Figure 7 - A sketch of the design elements

IV. CONCLUSIONS

The present rotary Intersection at Nanthur Junction is not functioning adequately due to a reduced capacity and abrupt growth of traffic in present scenario. The attempt made to design a signal was failed and it is essential to modify the rotary intersection by adopting the suggested design in this paper to regulate the traffic effectively in the present scenario, it can be only economical measure to control the congestions and delays are to increase the capacity of the intersection.

V. REFERENCES

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