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Research Article

Design and Analysis of Intersections for Improved Traffic Flow at Bhopal-Case Studies of Jyoti Talkies Square and Vallabh Bhawan Roundabout

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Abstract

Traffic Flow is a major problem in the urban cities. Due to rapid increase in population along with urbanization, industrialization and improving living conditions, the vehicular population is pacing up. A busy road stretch in a city is dotted with traffic signals. These traffic signals regulate the traffic flow at intersections and are also determinant factors for journey and travel time. If coupled with environment, these factors also contribute to vehicular and noise pollution. However, jam conditions can be solved by regulation of signal timing and synchronisation. In this paper, an attempt has been made to suggest measures for improving and easing traffic flow at two of the intersections of Bhopal. The signal timings at "Jyoti talkies square" have been redesigned for afternoon peak flow. Improvement by ***widening of road*** *is recommended. At the other intersection called "Vallabh Bhawan roundabout", capacity of rotary is calculated whether it is within its permissible limits or not. Introduction of* ***Signalized rotary*** *is suggested.*

Keywords: *Cycle time, Webster method, Traffic Volume, PCU, Intersection, Roundabout.*

1. Introduction

Traffic signals are control devices which could alternatively direct the traffic to stop and proceed at intersections using red and green traffic light signals automatically. These operate by providing right of way to a certain set of movements in cyclic order. (Rokade S *et al*, 2014)

The first area analysed is Jyoti talkies Square. It is one of the busiest intersections of Bhopal owning to its location at an important commercial area (MP Nagar). It handles traffic from Board office square, BHEL area, MP Nagar Zone I and Zone II. The intersection has huge traffic flow where mere increasing of total cycle time of the signal is not a solution. Increasing of cycle length leads to increased waiting time. Frequent stopping of vehicles in the 3 continuous intersections (DB City Mall, Board Office, Jyoti talkies) becomes a matter of frustration to the vehicle operators especially during peak flow. There is a need to regularly inspect the requirements of this intersection to handle vehicles well.

Jyoti talkies traffic signal is designed as a 4 Phase flexible progressive system. (Khanna S. K *et al*, 2011)

Figure 1: Map of Jyoti Talkies Square (Source: Google Map)

Vallabh bhawan roundabout is a five legged intersection situated near DB City mall, MP Nagar, Bhopal. It is an important intersection as it directs road to many important offices and institutions as well as commercial areas.

Intersections; where two or more roads cross are potential conflict areas. Especially, the central area bears many conflict points. Hence, islands are constructed at the centre to reduce the conflict points. (IRC 65-1976, 1990)

"A roundabout is a central island at an intersection which gives preference to circulating traffic over

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straight moving traffic. It is generally not supported with a traffic signal else it is called traffic rotary." However, roundabout and rotary are the terms that are used interchangeably.

Traffic rotaries/roundabouts can handle traffic volume up to 3000 PCU/hr. If the capacity is exceeded, the roundabout is not suitable. Then, other measures are to be taken like introduction of traffic signal, flyover, underpass, uplifted roundabout etc. (Patel Mira, 2014; IRC 65-1976, 1990)

Vallabh Bhawan roundabout has huge traffic flow during its peak hours which is difficult to handle. The size of roundabout is large as compared to the size required for it to handle the traffic volume. In the peak hours, frequent stopping of straight moving traffic due to circulating traffic is observed. Hence, its capacity is calculated and checked. Further, introduction of traffic signal is given as a solution. (Ar Jaiswal Anuj *et al* 2012).

Figure 2: Satellite image of Vallabh Bhawan roundabout (Source: Google Map)

2. Methodology

Jyoti talkies square

Generally, the signal time in Bhopal is improved based on trial and error, which involves finding out the approximate time in seconds required for the standing vehicles to cross the intersection.

In our work, we have gathered the data by calculating the traffic volume at all the 4 phases (4 roads) of the intersection. Survey is done throughout the day at 2 hours intervals – 10 am to 12 pm, 1pm - 3pm, 5pm-7pm (weekdays). This **survey work** is carried out on consecutive days in a week for summer months to get the average traffic volume and to know the current trend of traffic volume.

Classified traffic volume data are collected for 12 minute duration. The classified volume (cars, two wheelers, buses, tonga, trucks) are converted to a common unit called **Passenger Car unit**. The 12 minute data is then scaled to 1 hour to find the traffic volume in PCU/hr. (Rokade S *et al*, 2014; Major Project Report, 2015).

In the afternoon peak hours of 1 to 3 pm, by calculation from data collected, the total cycle time (length) comes out to be more than the general timings, when the optimum cycle time of the signal is calculated using the data for traffic volume and saturation volume [Webster method, explained in next section].

Thus, the intersection has been examined in two cases: (for the time 1pm to 3pm) (Major Project Report, 2015)

CASE 1: Increasing the cycle length as calculated using the data collected
CASE 2: Widening of two roads and then calculating the total cycle length.

Vallabh Bhawan roundabout

The roundabout is first analysed whether it is able to handle the current traffic volume by finding its capacity.

For using the formula to find the capacity of a rotary (**given by Transport road research lab-equation 4)**, the design parameters of a rotary should be within its range.

If the capacity exceeds its permissible limit, which happens in this case, other measures are suggested. Since the rotary is incapable to handle peak flow traffic, it is recommended to introduce traffic signal along with the rotary at the Vallabh Bhawan intersection; the signal timings are also designed.

3. Analysis

Traffic analysis is statistical in nature. Traffic volume varies with years, seasons, months, weeks, days and hours. For an intersection design, the modal value of traffic volume statistics is used to regulate the peak hour traffic.

Webster method has been used to design the signal in both the cases. However, at Jyoti talkies intersection, to find out the saturation flow, the formula for Indian scenario has been used. (Patel Mira, 2014).

Webster method adopted to find out the optimum cycle time. Khanna S. K *et al*, 2011; IRC 93-1985).

$$C_0 = [(1.5*L) + 5] / (1 - Y) \quad (1)$$

Where,
C_0 = Optimum Cycle time
L = Total lost time = 2*N + R
N = Number of phase
R = minimum of total red time or 16 seconds
Y= lane capacity of junction = q/s= $y_1 + y_2 + y_3 + y_4$
y_1 , y_2, y_3, y_4 = normal flow in phase (road) 1, 2, 3, 4 respectively.

$$\text{Green time} = G_i = (y_i/Y) * (C_0 - L) \quad (2)$$

For calculating the saturation flow of various roads

Approach widths of the roads of all 4 phases are taken. Approach width is more than the lane width.

Saturation flow is found using the formula for Indian scenario. (Patel Mira, 2014).

$$S = 626*W + 268 \text{ (PCU/hr)} \quad (3)$$

W= Approach Width of the road of each phase.

For the Case 1, the total cycle time using Webster method comes out to be 145 seconds, while in Case 2, after widening of road (PHASE 1 by 3.5 metres and PHASE 2 by 1.75 metres), the total cycle time is reduced to 105 seconds. (Major Project Report, 2015).

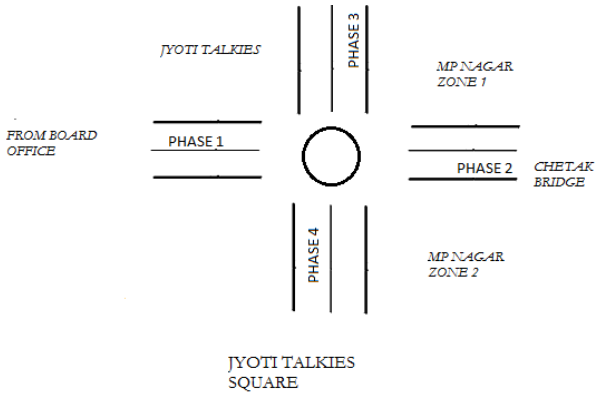

Figure 3: Four Phase System at Jyoti Talkies Square

Graphs showing comparison of case 1 and 2

Case 1: Increasing the cycle length as calculated using the data collected

Case 2: Widening of two roads and then calculating the total cycle length.

1) Change in Saturation Flows

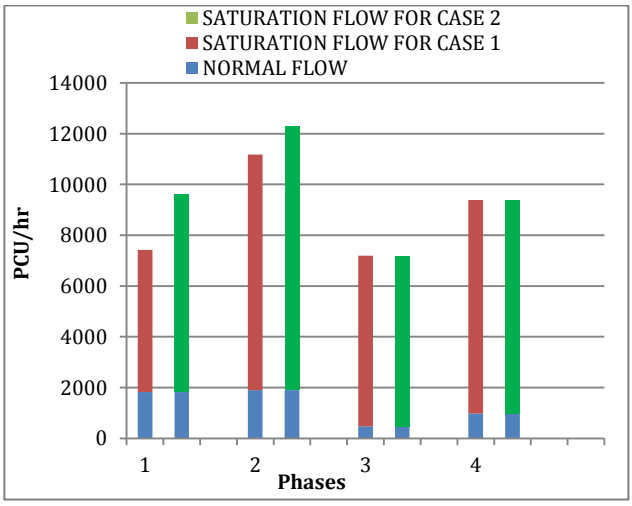

Figure 3: Comparison of saturation flows between Case 1 and Case 2 of Jyoti Talkies Intersection

The above chart shows the comparison of Saturation Flows between the Case 1 and Case 2 at Jyoti talkies Intersection. It can be seen that in Case 2, because of widening of two roads, the maximum traffic holding capacity of roads (saturation flow) is increased. This indicates that more vehicles can be handled by the roads and hence the Optimum Cycle Length will get reduced for Case 2.

2) Signal Timings

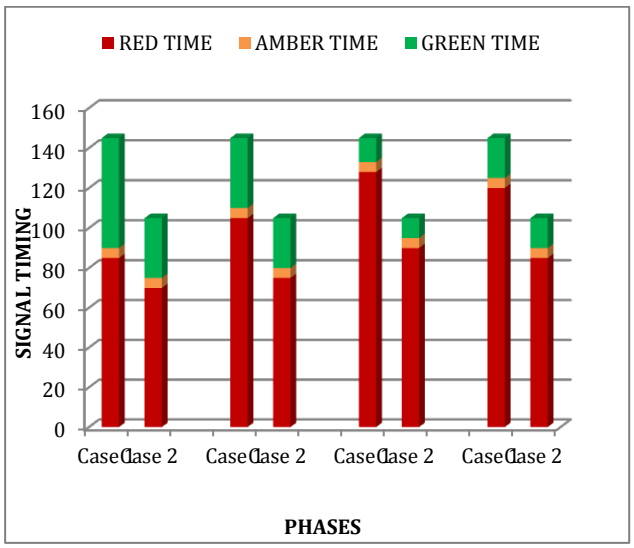

Figure 4: Comparison of signal timing for case 1 and case 2

Above comparison shows the reduction in optimum cycle length for case 2, because of which the red timings of the signal for all phases (roads) are reduced. This reduction in the red timing results in less waiting time and more frequent movement of the vehicles at the intersection. **Hence, case 2 is the recommended case over the case 1.**

Vallabh Bhawan Roundabout

In order to analyse the capacity of a rotary or roundabout, the following parameters of rotary dimensions should be analysed. These should fall within their range.

Dimensions of the roundabout

e= average entry and exit width = $(e_1 + e_2)/2$
W= weaving width
L = length of weaving
P = proportion of weaving traffic to non weaving traffic. (Khanna S.K *et al*, 2011)
$P = [b + c] / [a + b + c + d]$
Here,
a = left turning traffic moving along left extreme lane
b = right turning traffic moving along right extreme lane
c = crossing/weaving traffic turning towards right while entering the rotary
d= crossing/weaving traffic turning towards left while leaving the rotary.

Various dimensions of rotary as measured and calculated are tabulated below: (Major Project Report, 2015)

Table 1: Comparison of rotary parameters

Parameters	Range	Obtained values
Width of weaving section, W	6-18 metres	11 metres
Length of weaving section, L	18-90 metres	23.7 metres
e/W ratio	0.4-1	0.709
W/L ration	0.12-0.4	0.4
Proportioning ratio, p	0.4-0.1	0.4825

Since, the parameters are within their specified range, we can use the formula to find the capacity of rotary.

The classified traffic volume count at Vallabh Bhawan roundabout (to find out **proportioning ratio p**) is taken at 10am to 12 pm duration, which is also the morning peak hour. Data for 15 minutes duration is taken which is then scaled to 1 hour. The traffic volume count is reported in PCU/hr.

Capacity of Rotary (as per Transportation Road Research lab) is calculated as

$$Q_p = \{280W [1+ (e/W)] [1- (p/3)]\} / [1+ W/L] \quad (4)$$

The capacity of traffic rotary/roundabout should not be greater than 3000 PCU/hr.

The traffic capacity of rotary comes out to be 3017 PCU/hr which is greater than 3000 PCU/hr (maximum traffic volume a rotary can handle). When a rotary system fails, then **Signalized Rotary** is provided, which is suggested in this case. (Dr. Mathew Tom V *et al*, NPTEL)

For the introduction of signal, data is collected in the morning peak hours at every phase of the intersection. This intersection is also designed as 4 phase system. Webster method is used.

4. Results and Conclusions

- The current cycle length (traffic signal timings) in the afternoon peak hours at Jyoti talkies square is less than required.

Case 1: The cycle time should be increased to 145 seconds.

Case 2: Widening of road from Board Office to Chetak Bridge by a lane and from Chetak Bridge to Board Office. This will allow more vehicles to pass, reduce jam conditions as well as decrease the overall cycle time (105 seconds in our case), thereby reducing the journey time. (IRC 93-1985)

- An island is required for the traffic coming from Board office and moving to Zone 1, MP Nagar. This island will direct the left turning traffic and the traffic from Milan Restaurant which generally cause troubles to the straight moving and right turning traffic at PHASE 1 (Board Office to Chetak Bridge).
- Road design should be done keeping in view the mentality of road user.
- Capacity of Vallabh Bhawan roundabout comes out to be 3017 PCU/hr which is greater than 3000PCU/hr (maximum permissible). Thus, traffic signal system should be introduced at the intersection with total cycle time of 140 seconds.

Future Work

Latest technology in traffic signal automation aids the traffic signal with GPS, such that the current traffic volume information is provided to the signal system by GPS connected to vehicles coming. GPS techniques can be used at the intersection to know the real time traffic data. Thus this helps in signal synchronisation between two to three consecutive intersections and vastly reduces the waiting time of vehicles.

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