Traffic Signal and Junction Design: A Case Study of Rajkot City

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Abstract—The increase in development and, hence traffic hindering create a critical need to operate our transportation systems with maximum capability. Real time traffic signal control is a main part of new part of the new urban traffic control systems aimed at achieving the best utilization of the road network. The use of traffic signal for control of different streams of vehicular and pedestrian traffic is wide in most of the towns and city. This study focused on the junction of the Rajkot city which is located in the saursashtra region of Gujarat state. A classified volume count survey had been carried out to monitor the traffic and the collected data was utilized for the design of traffic signals using Webster’s formula. Based on the analytical part, author suggested an auxiliary lane design as per IRC 41-1994.

Keywords—Traffic Signal, Auxiliary Lane, Traffic Management, Traffic Volume,

I. INTRODUCTION

Traffic signals are the means of retaining a resolute flow of traffic in an suitable way and to reduce the conflicts at junctions as well as roads. They provide more efficiency if designed properly. The first traffic signal is stated to have been used in London as early as in 1868 and was of the semaphore - arm type with red and green lamps for night use. During the 100 years since then traffic signals have been original to a high grade of difficulty. Providing effective real time traffic signal control for a large hard traffic for a network is a very inspiring circulated control difficult. Signal system process is further more hard by the new advance that views the traffic signal system as a small part of a combined multimodal transportation system.

The urban traffic system is a very difficult system which involves many relationships among them is more complex. The setup the system for an area with the traffic needs to be calculated and before setting it up. This helps in the calculation and the efficiency of the flow through the area and types out the correction that can be applied to growth the traffic flow.

II. AIM AND OBJECTIVES

Aim of this study is to prepare a plan for traffic signal by study of junction design. In particular, in this work we show that i) the geometric and signal setting features of typical traffic signal. ii) Traffic flow pattern through the signal. iii) Estimate the performance of a signal iv) and suggest the remedial measures to improve the performance of the traffic signal.

III. GENERAL BACKGROUND

A. Signals in India

According to Indian Practice, an amber period of 2 seconds as an change intermission between finish of related green drive and display of red signal or between finish of a red signal and origination of related green movement.

B. Pedestrian Signal

According to IRC:093 the Traffic Signals suggests the following symbols for foot-travelers. The red standing man signifies that don’t cross signal and the green walking man represents cross signal. A flashing amber signal is a danger sympathy beacons normally used to warn of blockade and joints to increase regularity signs and to warn of midblock cross - walks

C. Signal Face

- The minimum number of lenses in a signal face is three - red, amber and green. The lenses in a signal face can be prepared in a vertical or horizontal straight line. The relative points are red, amber and green. A simple signal face with three lenses in a vertical line is indicated in the Fig2.

- The lenses are normally of two sizes, viz., 200mm and 300 mm diameter. The larger size is used where the 85th percentile line speeds exceeds 65 K.P.H For problematic area, for all arrow signal, for Caution where signalization may be unforeseen and for conflicts where drivers may view both traffic control and lane directions control signs simultaneously.
Do not mix complete spellings and abbreviations of units: “Wb/m²” or “webers per square meter,” not “webers/m².” Spell units when they appear in text: “...a few henries,” not “…a few H.”

- Use a zero before decimal points: “0.25,” not “.25.”
- Use “cm³,” not “cc.”

D. Traffic Cycle time in Indian practice

In Indian practice, a typical example of signal indications in a three phase signal is red, green and amber. The amber interval is change interval between end of related green movement and starting of a red signal or between finish of a red signal and origination of related green movement. In the first case it is “Permission Amber” and in the second case it is called “Initial Amber”. The amber period is generally 2 seconds.

A. Methodology

To install the traffic signal and for the geometric design of junction we have to conduct out several types of surveys:
1. Classified volume count survey
2. Road side interview survey
3. Public and Para-Transit Transportation survey
4. Origin and Destination survey
5. Home interview survey
6. Registration plate number survey
7. Parking survey
8. Pedestrian survey

- Main purposes of traffic survey:
The main purposes of traffic survey are traffic monitoring, traffic control and management, traffic enforcement, traffic forecasting, model calibration and validating etc.

In this research work, we had perform classified volume count survey there are two major methods of counting vehicle for volume survey

a) Manual Counting Method
b) Automatic counting method.

From the above two methods we had conducted manual volume counting method.

- Importance of Traffic Volume Study:
a) Increase the efficiency and life of roads
b) Reduces traffic volume at a particular section
c) Provide better means for development of infrastructures
d) Provide better means to utilize other roads in case of special events in the city
e) Provide estimate of no vehicles against no of persons

IV. CASE STUDY OF RAJKOT CITY

Rajkot is the fourth-largest city in the state of Gujarat, India, after Ahmedabad, Surat and Vadodara. Rajkot is the centre of the Saurashtra region of Gujarat. Rajkot is having approximately 1.2 millions of population as of 2015 and metropolitan area is 170km²
B. Location of volume count survey

![Location Map](image1)

C. Data Collection and Result Analysis

As we had collected the volume count survey data during morning peak hour and evening peak hour. The data collected during the survey is represented from the following table:

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Time Period</th>
<th>LCV</th>
<th>HCV</th>
<th>NMT</th>
<th>Total</th>
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<tr>
<td></td>
<td>From</td>
<td>To</td>
<td></td>
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</tr>
<tr>
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<tr>
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<td>8:3</td>
<td>0.5</td>
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<td>1.2</td>
</tr>
<tr>
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<td>8:4</td>
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<td>0.5</td>
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</tr>
<tr>
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<td>9:0</td>
<td>0.5</td>
<td>0.5</td>
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<td>10:30</td>
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<tr>
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<td>11</td>
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<td>3.42</td>
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</table>

PCU (Passenger Car Unit)

Morning peak hour data

PCU = Volume/Capacity

PCU = 3531.14/3660

PCU = 0.98087

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<th>HCV</th>
<th>NMT</th>
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<td>10:40</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>3.42</td>
</tr>
</tbody>
</table>

Table 2. Evening peak hour data

Evening peak hour data

PCU = Volume/Capacity

PCU = 3457.90/3660

PCU = 0.960

![Traffic composition during morning peak hour](image2)
Design of signal Timing

1. For Morning Peak data

From equation Webster’s formula we have,

Optimum cycle length in seconds

\[ L = \frac{6 \text{ seconds}}{y} \]

\[ y = \frac{\text{Flow}}{\text{Saturation flow of an approach}} \]

\[ s = \frac{650 \text{ w PCU/ per hour}}{} \]

Therefore,

\[ \text{For phase I} \]

\[ s = 650 \times 6 = 3900 \text{ PCU/ per hour} \]

\[ \text{For Phase II,} \]

The width of the road occupied by the vehicle is considered to be 5 m whose saturation value is provided accordingly to equation and hence the saturation value has to be increased as per observation by 650.

\[ s = \left( \frac{1890 \times 650}{525} \right) = 8190 \text{ PCU/ per hour} \]

\[ \text{For phase III,} \]

\[ s = \left( \frac{1890 \times 650}{525} \right) \times 3 = 8190 \text{ PCU/ per hour} \]

Now,

\[ Y = y_1 + y_2 + y_3 \] (Since it's a three phase signal) where, \( Y \) is the ratio of actual flow to saturation flow.

\[ \text{i.e., } Y = \frac{\text{Volume}}{\text{Saturation flow for critical approach in each phase}} \]

\[ y = \frac{q}{s} \]

\[ \text{For Phase I,} \]

\[ y_1 = \frac{1696}{3900} = 0.43 \]

\[ \text{For Phase II,} \]

\[ y_2 = \frac{1969}{8190} = 0.24 \]

\[ \text{For Phase III,} \]

\[ y_3 = \frac{1927}{8190} = 0.23 \]

Therefore,

\[ Y = 0.43 + 0.24 + 0.23 \]

\[ Y = 0.90 \]

From equation

\[ C_0 = \frac{(1.5 \times s) + 5}{1 - 0.90} \text{ seconds} \]

\[ C_0 = 140 \text{ seconds} \]

Therefore, the total effective green time can be given as

\[ C_0 = (C_0 - L) \text{ seconds} \]

\[ = 140 - 60 \]

\[ = 130 \text{ seconds} \]

Effective green time for each phase,

Where

\[ g = \left( \frac{y_1}{Y} \right) \times \text{total effective green} \]

\[ \text{For Phase I,} \]

\[ g_1 = \left( \frac{0.43}{0.90} \right) \times 134 = 64.02 \text{ seconds} \]

\[ \text{For Phase II,} \]

\[ g_2 = \left( \frac{0.24}{0.90} \right) \times 134 = 42.72 \text{ seconds} \]

\[ \text{For Phase III,} \]

\[ g_3 = \left( \frac{0.23}{0.90} \right) \times 134 = 34.24 \text{ seconds} \]

However, provide a minimum green time of 15 seconds. Therefore, taking \( g_3 \) as 34.24 seconds. The total cycle time by providing 3 seconds for amber is found to be 143 seconds.
2. For Evening Peak data

From equation
\[
C_0 = \frac{1.5 \times L + 5}{1 - \frac{Y}{s}} \text{ seconds}
\]

We have, \(L = 6\) seconds (lost time per cycle)

Considering the saturation to be high, Taking, \(s = 650\) w PCU/ per hour

Therefore,

- For Phase I,
  \(s = 650 \times 6 = 3900\) PCU/per hour

- For Phase II,
  The width of the road occupied by the vehicle is considered to be 5 m whose saturation value is provided accordingly to equation and hence the saturation value has to be increased as per observation by 650.
  \(s= \frac{(1890 \times 650)}{525} \times 3 = 8190\) PCU/per hour

- For phase III,

Therefore,

\(s = \frac{(1890 \times 650)}{525} \times 3 = 8190\) PCU/per hour

Now,

\[Y = y_1 + y_2 + y_3\] .... (Since it's a three phase signal)

where, \(y\) is the ratio of actual flow to saturation flow. i.e

\[y = \frac{q}{s}\]

- For Phase I,
  \(y_1 = \frac{1608}{3900} = 0.41\)

- For Phase II,
  \(y_2 = \frac{2010}{8190} = 0.24\)

- For Phase III,
  \(y_3 = \frac{2238}{8190} = 0.27\)

Therefore,

\[Y = 0.41 + 0.24 + 0.27\]

\[Y = 0.92\]

From equation
\[
C_0 = \frac{(1.5 \times 6 \times L + 5)}{1 - \frac{Y}{s}} \text{ seconds}
\]

\(C_0 = 175\) seconds

Therefore, the total effective green time can be given as
\[
C_G = (C_0 - L) \text{ seconds}
\]

\[C_G = 175 - 6 = 169\] seconds

Effective green time for each phase,

Where

\[g = \left(\frac{y_1}{Y}\right) \times \text{total effective green}\]

- For Phase I,
  \[g_1 = \left(\frac{0.41}{0.92}\right) \times 169 = 75.13\] seconds

- For Phase II,
  \[g_2 = \left(\frac{0.24}{0.92}\right) \times 169 = 44\] seconds

- For Phase III,
  \[g_3 = \left(\frac{0.27}{0.92}\right) \times 169 = 49.59\] seconds

However, provide a minimum green time of 15 seconds. Thus taking \(g_3\) as 49.59 seconds. The total cycle time by providing 3 seconds for amber is found to be 178 seconds.

Fig 10: Timing Diagram (Evening Peak)

V. SOLUTION

1. Provide proper timing cycle to peak hour morning and evening time

2. Provide Auxiliary Lanes at road to reduce traffic congestion
   - As per IRC 41-1994, Intersection operation can be increased by including auxiliary lanes for right turn (fig1), or left turn (fig2) or through lanes.
   - When turning speeds are more than 25 km ph., the lane generally separated by an island, which also serves as pedestrian refugee
   - Right turn lane is provided by recessing the median.
   - The length of the lane usually varies from 30 to 90 m, depending upon flow.
VI. CONCLUSION

On the basis of comparative studies of the traffic signal and junction design, we have concluded that an auxiliary on junction with slope of 10:1 at the intersection of road width two auxiliary lane are provided to reduce traffic congestion problem. A great care should be taken to design junction at intersection for pedestrian and bicycle track. With the study of traffic volume count survey it is given in IRC that if traffic volume less than 5000 so we have to give rotary or round about, but in our study traffic volume count is more than 5000, so we conclude suggest Auxiliary lane on both side of the road.

ACKNOWLEDGMENT

We would like to take this opportunity to express our profound gratitude and deep regard to the final year B.Tech students of RK University, Rajkot for their exemplary work, valuable feedback and constant encouragement throughout the duration of the project.

VII. REFERENCES