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Signal Redesign at Intersection Using Irc and Webster Method: A Case Study of Vadodara

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Abstract:
Traffic congestion is a major issue for all the developing cities. Traffic congestion has emerged as one of the main challenges for engineers, planners in urban areas. Modern, social and economic structure shaped by car ownership and rapid growth in the rate of vehicles is main reason for traffic congestion. The project has been carried out in order to analyze and redesign the traffic signal at a fatehgunj post office circle, Baroda Gujarat in order to solve the problem of traffic congestion. Detailed volume count survey was carried out for the selected intersection by videography. The signal is redesigned by using Webster and IRC method. After redesigning the signal by both the methods highest cycle time amongst both the method will be adopted.

Keywords: Traffic volume count, Traffic Signal, PCU, Webster method, IRC

I. INTRODUCTION

India is a developing country and its cities are undergoing rapid urbanization and modernization as a result there is rapid growth in the road traffic. There are major issues related to traffic movement due to heterogeneous traffic. As vehicular traffic is increasing day by day which is creating congestion on road and hampering safety and efficient movement of traffic. It is therefore necessary to increase the operational characteristics of highways. Therefore provision of traffic signals with proper timing is essential. Traffic signals are control devices that directs the traffic to proceed and stop at the intersections. At intersections where number of crossings and right turning vehicle are more there are chances of accidents. Hence this research study is carried out to re design the signal at one of the busiest intersection in Vadodara city.

II. NEED OF THE STUDY

Intersection plays an important role in the road network, where traffic directions converge. Due to the disturbance of pedestrian, bicycle to vehicles and loss of green time for beginning and clearance and so on reduces the capacity of intersections. Thus, the intersection acts as bottlenecks of the network as it is the prime cause of traffic jams and traffic accidents.

III. AIM OF THE STUDY

To analyze the characteristics of mixed traffic flow at signalized intersection and to redesign the traffic signal at a selected intersection.

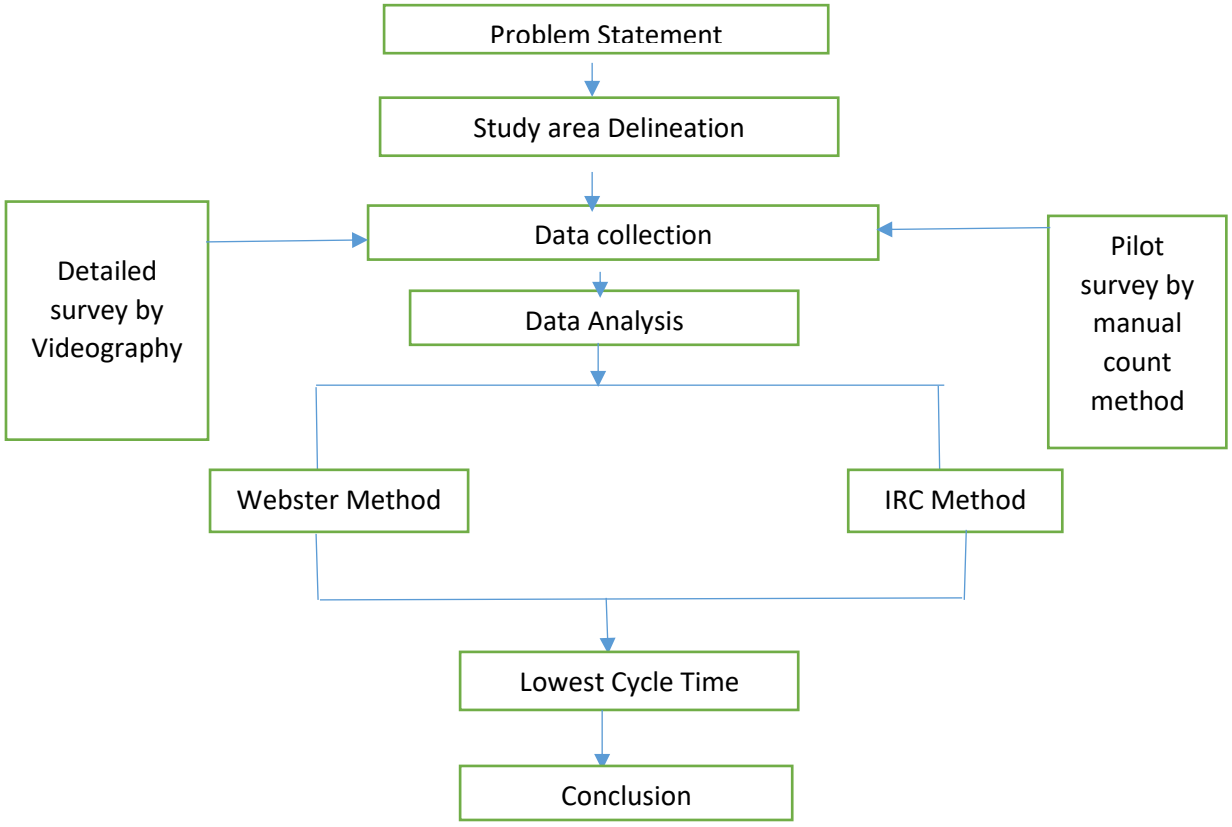
IV. OBJECTIVES

- To estimate the basic parameters for the selected roads.
- To identify the traffic conflicts.
- To evaluate the performance of the signal and redesigning the signal.
- To suggest remedial measure.

V. SCOPE OF THE STUDY

- To collect the information of the study area in detail.
- To collect preliminary data.
- To understand different parameters and variables associated with the study.

VI. METHODOLOGY



VII. STUDY AREA

Vadodara is administered by the Vadodara Mahanagar SevaSadan (VMSS). Some of the regions surrounding the city are administered by the Vadodara Urban Development Authority (VUDA). The details of selected intersection are mentioned in Table-2.

Table -1 Civic Administration Of Vadodara

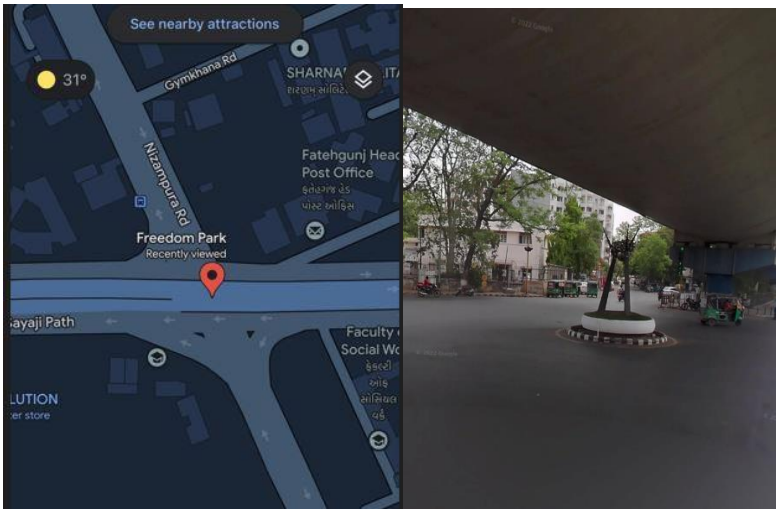
Country	India
State	Gujarat
District	Vadodara
Zone	4
Ward	28
Governing Body	VMSS and VUDA

Legislation type	Municipal Corporation
Area Rank	18

Table-2 Directions and Road Geometrics

Name of the road	Width of carriageway in (meters)	Geometry	District
Polytechnic to Fathehgunj	13	Divided	Vadodara
Fatehgunj to Polytechnic	13	Divided	Vadodara
Saffron tower to Nizzampura	11	Divided	Vadodara
Nizzampura to Saffron tower	11	Divided	Vadodara

VIII. LOCATION OF SITE



IX. PASSENGER CAR UNIT

The passenger car is considered as the standard vehicle unit to convert other vehicle classes and this unit is called Passenger Car Unit. In mixed traffic flow, the traffic volume and capacity are generally expressed as PCU / hour or PCU / lane / hour & traffic density as PCU / km length of lane. Different classes of vehicles as cars, vans, buses, trucks, auto rickshaw, motor cycles, pedal cycles, bullock carts etc. are found to use the common roadway facilities. The flow of such vehicles on roadway forms the heterogeneous or mixed traffic flow. It is difficult to estimate the traffic volume and capacity of roadway facilities under mixed traffic flow. So, the different vehicle classes are converted to one common standard vehicle unit.

Table-3 PCU Equivalents for Traffic Signal Computation

TYPE OF VEHICLES	PCU EQUIVALENT
Heavy or medium goods vehicles	1.75
Light goods vehicles	1.00

Bus	2.25
Motor cycle or scooter	0.33
Pedal cycle	0.20

X. DETAILS OF EXISTING SIGNALS

Table-4 Existing signal timings

Name of the road	Red Time in (Seconds)	Amber Time (Seconds)	Green Time (Seconds)
Polytechnic to Fathehgunj	160	5	45
Fatehgunj to Polytechnic	75	5	45
Saffron tower to Nizzampura	125	5	30
Nizzampura to Saffron tower	50	5	30

XI. DESIGN OF SIGNAL

A. By Webster's Method

Webster's method for traffic signal design is an analytical approach of determining optimum cycle time corresponding to minimum total delay to all the vehicle at the approach road of the intersections. Studies have shown that the average and overall delay at the intersection varies with the signal timings. Delay at the intersection depends upon the cycle time. If cycle time is short the delay caused is considerably large whereas when the cycle time is large the delay at the intersection is less.

The optimum cycle time depends on the geometric details of the intersection and the volume of traffic approaching the intersection from all the approach roads during the design hour. The field work consists of determining the following two sets of values on each approach road near the intersection: The normal flow, q on each approach during the design hour and the saturation flow S per unit time. The normal flow values, q_1, q_2, q_3 and q_4 on roads are determined from field studies conducted.

The saturation flow of vehicles is determined 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.

Terminologies related to Signal Design

Cycle Length: Cycle length is the time in seconds that it takes a signal to complete one full cycle of indications.

Green Interval: Amount of green timing.

Red Interval: Amount of red timing.

Change interval and Clearance interval: Amount of yellow or orange timing.

Phase: Green interval + Change interval and clearance interval.

Lost time: Time lost due to reaction time of first vehicle.

Saturation flow: Maximum amount of flow that road can carry.

Signal Design by Webster's Method

Data for the selected intersection was collected using videography survey and data collected was converted into PCU for designing the signal. Data collected is as mentioned below.

Table-5 Data collected

Approach	Design hour flow (PCU/hr)
Polytechnic to Fathehgunj	1020
Fatehgunj to Polytechnic	1310
Saffron tower to Nizzampura	1328
Nizzampura to Saffron tower	800

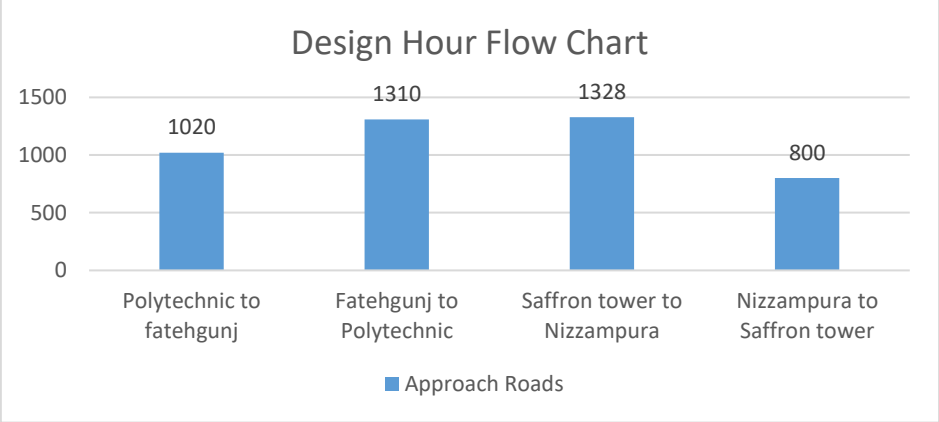


Fig-1 Chart showing Design Hourly Flow

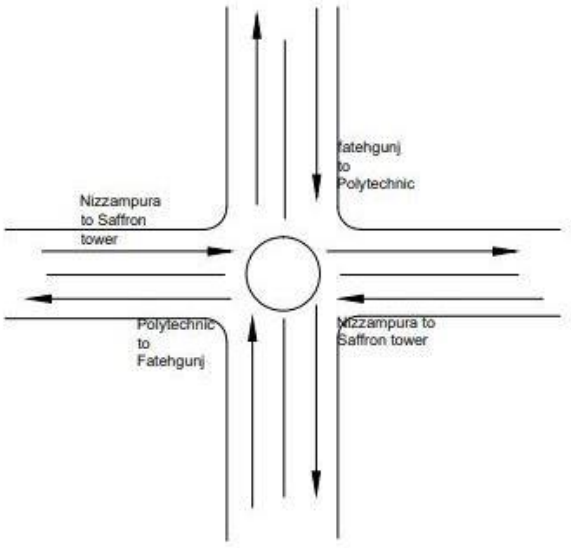


Fig-2 Direction of Traffic at Approach

Calculation of Saturation Flow:

For designing signal timings the following formula is given by Road Research Laboratory, U.K

s = 525 w PCU/hour

Where,

s = Saturation flow

w = width of approach road in meters
The above formula is valid for widths from 5.5 to 18 meters.
Saturation flow for Road 1 and Road 2
Width of Road 1 and Road 2 = 13 meters
Saturation flow = 525 x 13 = 6825 PCU/ hour.
Saturation flow for Road 3 and Road 4
Width of Road 3 and Road 4 = 11 meters
Saturation flow = 525 x 11 = 5775 PCU/hour

Table-6 Saturation Flow

	Polytechnic to Fathehgunj	Fatehgunj to Polytechnic	Saffron tower to Nizzampura	Nizzampura to Saffron tower
Design hour flow (q) in PCUs/Hour	1020	1310	1328	800
Saturation Flow (s) in PCUs/Hour	6825	6825	5775	5775

Calculation of Normal Flows:
$Y_1 = q_1 / s_1 = 1020/6825 = 0.14$
$Y_2 = q_2 / s_2 = 1310/6825 = 0.19$
$Y_3 = q_3 / s_3 = 1328/5775 = 0.22$
$Y_2 = q_2 / s_2 = 800/5775 = 0.13$
$Y = Y_1 + Y_2 + Y_3 + Y_4$
$= 0.14 + 0.19 + 0.22 + 0.13 = 0.68$
Lost Time (L) = 2n + R = 2(4) + 12 = 20 seconds

C_o (optimum cycle length) = 1.5L + 5 / (1-Y)
= (1.5 * 20) + 5 / (1-0.68)
= 110 seconds.

Effective Green time per Cycle = C_o – L =.110 – 20 = 90 seconds
$G = y_1 / Y (Co – L)$
G_1 = 20 seconds
G_2 = 25 seconds
G_3 = 30 seconds
G_4 = 15 seconds

Name of the road	Red Time in (Seconds)	Amber Time (Seconds)	Green Time (Seconds)	All red Timings
Polytechnic to Fathehgunj	73	5	20	12
Fatehgunj to Polytechnic	68	5	25	12

Saffron tower to Nizzampura	63	5	30	12
Nizzampura to Saffron tower	78	5	15	12

By IRC Method

The Indian Road Congress (IRC) is the apex body of highway engineers in the country. The IRC was setup in December 1934 on the recommendation of best known Jayakar Committee for road development in India.

According to IRC vehicle arriving on an approach distribute equally on different lanes meant for a particular direction. Number of vehicle arriving on approach have identical cycle length. The reaction time of first vehicle on the approach is 6 seconds and consecutive vehicles follow uniform headway of 2 seconds. Green time is equal to width of the carriage way in meters divided by assumed walking speed of 1.2 m/s plus reaction time of 7 seconds. Optimum cycle length should be such that the delay at the intersection is minimized. The cycle length should not exceed 120 seconds and it should be taken in multiple of five. Optimum cycle length is calculated using Webster's method.

Step-1

Let the amber time be 2 seconds (medium approach)
Pedestrian green time for Road-1 and Road-2 = (13/1.2) + 7 = 17.8 seconds.
Where pedestrian walking speed = 1.2 m/sec.
Initial walk period = 7 seconds.
Pedestrian green time for Road-3 and Road-4 = (11/1.2) + 7 = 16.16 seconds.

Step – 2

Green time for Road-1 = 17.8 X (1310/1020) = 25.11 seconds.
Green time for Road – 3 = 16.16 X (1328/800) = 26.82 seconds.

Step-3

Adding respective amber time and 2 seconds for inter green period.
Total cycle time required = (2 + 25.11 + 2) + (2 + 17.8 + 2) + (2 + 26.82 + 2) + (2 + 16.16 + 2) = 101.89 seconds.
For convenience set signal timings as 105 seconds.
Thus extra 3.11 is proportioned to green time 1.61 for Road 1 and 4 and 1.5 for Road 2 and 3.
G_1 = 26.72 seconds, G_2 = 19.48 seconds, G_3 = 28.32 seconds, G_4 = 17.77 seconds.

Step – 4

Vehicle arrival per lane for Road – 1 = (1020/105) = 9.71 PCU/Cycle.
Minimum green time for Road – 1 = 6 + (9.71-1) * 2 = 23.42 seconds.
Vehicle arrival per lane for Road – 2 = (1310/105) = 12.47 PCU/Cycle.
Minimum green time for Road – 1 = 6 + (12.47-1) * 2 = 28.94 seconds.
Vehicle arrival per lane for Road – 1 = (1328/105) = 12.64 PCU/Cycle.
Minimum green time for Road – 1 = 6 + (12.64-1) * 2 = 29.29 seconds.

Vehicle arrival per lane for Road – 1 = (800/105) = 7.61 PCU/Cycle.
Minimum green time for Road – 1 = 6 + (7.61-1) * 2 = 19.2 seconds.

Step – 5

Lost time per cycle = (2 + 2+ 2)*4 = 24 seconds
$Y_1 = 0.14$, $Y_2 = 0.19$, $Y_3 = 0.22$, $Y_4 = 0.13$
Y = 0.68

Step – 6

Optimum cycle time by Webster's Method
C_o (optimum cycle length) = 1.5L + 5 / (1-Y)
= (1.5 X 24) + 5 / (1- 0.68)
= 100 seconds < 105 seconds.
Therefore Cycle length of 105 seconds is acceptable.

CONCLUSION

From the data analysis saturation flow as well as normal flow was determined and traffic signal is designed and compared with the existing traffic signal. This study can be used as a baseline for research work for Traffic analysis at signalised intersections at Vadodara or any urban areas. It has been determined from the signal design that the existing signal needs to be modified in order to reduce delay and jams at the intersections. From the data analysis it can be concluded that IRC method is best suitable for re designing the existing signal.

CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest or personal relationships that could have influenced the work reported in this paper.

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