Improvement of Existing Signal Timings & Other Operational Parameter on Selected Signalized Intersection of Rajkot City

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Abstract— As we all know traffic volume is increasing day by day in cities due to growth of industrialization and urbanization of cities. Thus to manage the present traffic volume new methods were adopted to provide better, easy and safe movement of traffic. The traffic conflictions are major on intersections of two roads. Traffic signals is a way to control the traffic at the intersections of the cities and avoid the conflictions of the vehicles at the intersection. Traffic signals also helps the traffic to move with safety and easily, which tends to minimize the collision between the vehicles at the intersection. In this dissertation we surveyed the traffic volume of intersections of the Rajkot city and traffic signals were designed at Nana Mauva intersection. The one part of the thesis is survey of traffic volume, which is done by manual method, wherein the vehicles are counted manually without using any device or sensor with respective vehicle categories like passenger, commercial and agricultural etc. and the other part is design of traffic signals, which is done according to the Webster's method of signal design by adopting maximum PCU on the intersection in each direction. 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. The design of traffic signals at these intersections in Rajkot will help the growing traffic to move with ease and safety and also helps in reducing the accident rate at the intersections due to congestions and confliction between vehicles.

Key words: Signal Design, Demand Flow Rate, Saturation Flow Rate

I. INTRODUCTION

Traffic signals are perhaps the most important traffic control devices for at grade intersection in the urban traffic system. Proper installation of traffic signals can reduce the number of accidents and minimize delays to vehicles at intersections. Road traffic conditions in India get worse day by day. Spending hours in traffic jam have become part and parcel of the metropolitan lifestyle, leading to health and environmental hazards. The rapid increase in vehicle ownership in India in particular has increased the traffic intensity that has created various serious problems such as congestion and formation of long queues ultimately causing heavy delays and increase in the number of accidents at various locations on roadways.

In order to solve this problem, there could be two approaches: The first approaches are to come up with infrastructure involving wider roads, flyovers, bypasses and expressways. But this approaches, solutions area very serious concern about space and money for developing countries like India. The second approach is to manage existing traffic with the same infrastructure, with the use of technology and by involving commuters in the process. Concentrating on the second approach that is an Intelligent Transportation System (ITS) which makes use of communication technology to alleviate road traffic problems. Different ITS techniques aim to provide information like current road congestion level, predicting travel time, predicting traffic congestion. Commuters can make use of this information to plan their travel better- by choosing a less congested road if there is a choice, by adjusting travelling time to avoid peak-traffic hours. It will be necessary to review the traffic signal timing. For a particular intersection, cycle time is an important parameter to minimize delays that ultimately cause formation of long queues and accidents. An important component required for the optimum cycle time is saturation flow.

Established work has been conducted to estimate the saturation flow and lost time in developed countries. The procedure in HCM (Highway Capacity Manual) and other such studies assume that the traffic flow is homogenous and follows lane discipline. Traffic composition in India and other developing countries is mixed in nature with different types of vehicles and the vehicles do not follow lane discipline. Hence, the procedure for assessing the facility in India which has been adopted from developed countries will not be suitable in India.

Accuracy of saturation flow values is of prime importance when determining the capacity of signalized intersections. The objective of the study is to collect a large sample of field data and computation of saturation flow values. The Saturation Flow values can be used as input for determining intersection capacity and optimize signal systems.

II. OBJECTIVES OF STUDY

- To evaluate the Demand Flow rate and Saturation Flow rate at selected intersection.
- To optimize intersection signal timing with considering the operational parameter at selected intersection.

III. LITERATURE REVIEW

1) Sachin Jat Mr. S.S. Goliya Sachin NarayachRohitGurjar (2015)"Controlling Traffic by Designing Signal At Intersection of Vidisha"

Traffic volume is increasing day by day in cities due to growth of industrialization and urbanization of cities. Thus to manage the present traffic volume new methods were adopted to provide better, easy and safe movement of traffic. The traffic conflictions are major on intersections of two roads. Traffic signals is a way to control the traffic at the intersections of the cities and avoid the conflictions of the vehicles at the intersection. Traffic signals also helps the traffic to move with safety and easily, which tends to minimize the collision between the vehicles at the intersection.

In this dissertation the main objective of authors is calculating he knew signal design at Intersection of Vidisha city. Author has used IRC method to used signal design and also used Webster method to define green cycle time for each approaches. By studying the road traffic of the city we analyzed that the major accident cause is collision of vehicles at the intersections. The collision may be rear shunt on approach to junction, right angled collision, principle right turn collisions and pedestrian collision. These collisions can be avoided if proper design of signal is done at the intersection so that the main objective of the dissertation is to provide better and safe movement of traffic through signal design at the intersection of the Vidisha city is satisfied.

The signal is designed as per IRC guidelines so that the signal can justify the proper movement of the traffic. The effect of the signal design can be seen in reduction of accident cause by which the reduction in fatal injuries at the intersection. Thus provide a better and safe movement of the traffic. The signal design can also help the pedestrian to cross the road safely.

2) NomanHyder Md. Ruhul Amin(2013) "Traffic Signal Design of an Isolated Intersection for Dhaka City Condition"

The main objective of author of this study was to investigate the traffic signal performance of some intersection in the metropolitan city of Dhaka. This is also aimed at looking into other features regarding controlling and regulating the traffic and developing a computer program. Accordingly, the study involved the technique of collecting traffic data. Most of the data were collected by field investigation. Traffic in Bangladesh consists of two distinct categories of vehicles i.e. motorized and non-motorized vehicles. The characteristics of these vehicles differ widely even within the same class, though they all use the same right of way. Lack of lane discipline makes the traffic system mixed and heterogeneous in nature. Before developing a systematic design method for the traffic signal a comprehensive literature review was performed. Based on the review signal design parameters and relationships were identified for customizing in local traffic environment. Finally a user friendly computer program was developed using different signal design parameters for the local condition. Data of the surveyed intersections were used as inputs for the computer program and values of cycle time, signal timing and delay were found from the program. The calculated values from the program were less than the values found by field observation.

The study results showed that a scientific and systematic traffic signal system can reduce the delay time and thus can reduce traffic congestion. This kind of programs can also be used for estimating the signal timing in different intersections. The study infers that the traffic control devices should be set on proper traffic engineering ground to achieve an effective traffic control system.

3) K VenkateshRatodVinod Kumar(2014) "Traffic Impact Study and Signal Design at Suchitra Junction, Qutubullapur, Rangareddy, Telangana, India"

Author has discuss about the traffic signal is an aid to control traffic at intersection. Where other control measures fail, the signals operate by providing night of way to certain set of movement in a cycle order. Interruption of continuous traffic flow on the major street exceeding 1000 vehicles per hour at selected study area.

Author described the various traffic studies for the gap of communities to like. Additional traffic associated with new development based on particles. Briefly discuss about 1) clearance green alone 2) yellow 3) red alone 4) green yellow etc. The author have used Webster method for signal designing. cvc survey are carried out at selected study area. Various figurative data gives and particular no. of vehicle crossing a major street in selected study area.

IV. DATA COLLECTION

For the data collection to design signal timing there are different methods for traffic survey, ranging from manual to complex automatic techniques. All these methods have some own goodness. Any method, which should be selected for any study depends on many factors like the type of study, availability of manpower, ease of analysis, cost and should provide a permanent record of data for further analysis at any time. Methodology for study is mostly depends on many Parameter like vehicle speed, Saturation flow, Width of Road, Gradient, Traffic Composition etc. this all data collected by considering three of survey include, Classified Volume Count, Demand Flow Rate and Saturation Flow Rate at Intersection.

V. DATA ANALYSIS

A. Road Inventory Survey

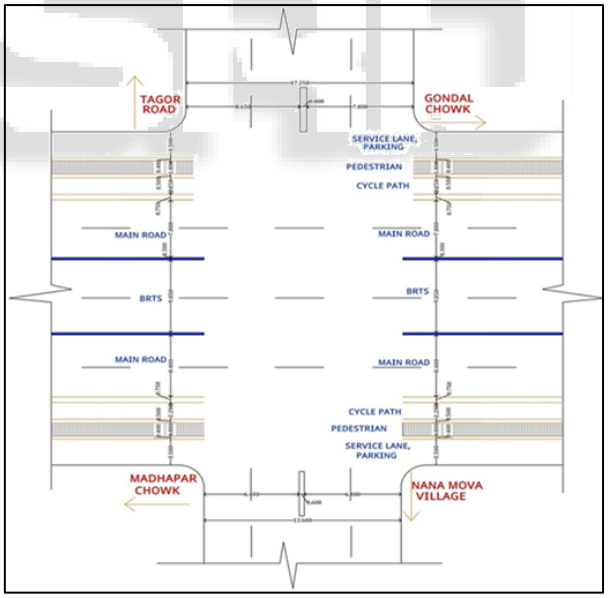

Fig. 1: Road Inventory Features of Nana Mauva Intersection

Demand Flow Rate at Intersection

Demand Flow Rate survey is carried out manually at intersection at morning peak hour (9:00am to 1:00pm) and evening peak hour (5:00pm to 9:00pm) based on it the Average PCU/Hr defined.

Approach	left turning	Straight turning	Right turning	Total
From kkv circle	549	1121	213	1883
From raj nagar	678	277	508	1463

From Mavdi Circle	253	982	497	1732
From Nana Mauva	594	314	662	1570

Table: 1 Avg. PCU/Hr of Demand Flow at Morning Time

Approach	left turning	Straight turning	Right turning	Total
From KKV Circle	670	1291	241	2201
From Raj Nagar	736	335	544	1615
From Mavdi Circle	328	1294	612	2234
From Nana Mauva	712	333	527	1572

Table: 2 Avg. PCU/Hr of demand flow at evening time

B. Saturation Flow Rate at Intersection

Saturation flow rate is the equivalent hourly flow rate at which previously queued vehicles can traverse an intersection approach under prevailing conditions, assuming that the green signal is available at all times and no lost times are experienced, in vehicles per hour of green or vehicles per hour of green per lane.

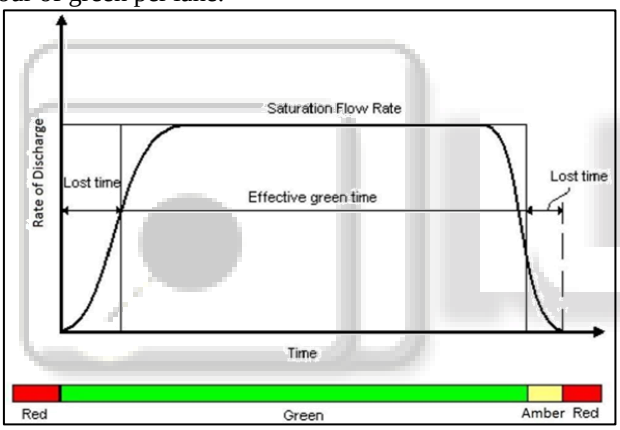

Fig. 3: The Flow of Traffic during the Green Period from a Saturated Approach

C. Saturation Flow Rate at Intersection

Saturation Flow Rate survey is carried out manually at intersection at morning peak hour (9:00am to 1:00pm) and evening peak hour (5:00pm to 9:00pm) on 3 second green time interval, based on it the Average PCU/Hr defined.

Saturation Flow Rate at 3 sec Time Interval				
	Morning Peak hour		Evening Peak Hour	
Approach	Total PCU/cycl	Total PCU/Hr	Total PCU/cycl	Total PCU/Hr
From KKV Circle	102.9	6735	132.6	8680
From Raj Nagar Chowk	85.6	6848	104.6	8368
From Mavdi Chowk	103	6742	129.8	8496
From Nana Mauva Village	82.90	6632	96.54	7723

Table 3: Maximum Saturation Flow Rate at 3 Sec Time Interval

From the survey of 3 sec time interval of green time for all four phase of intersection the maximum saturated cycle of green period is shown in graph.

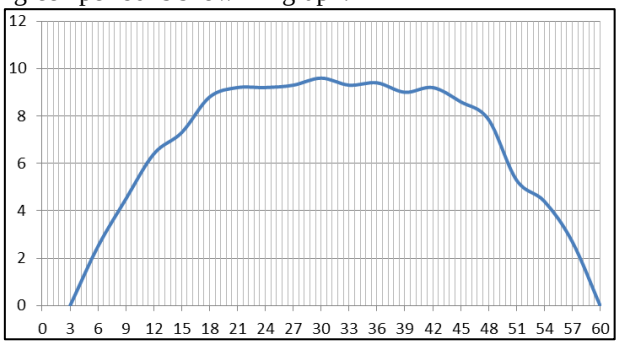

Fig. 4: Highly Saturated Cycle of Phase 1 of Intersection at Evening Peak Hour

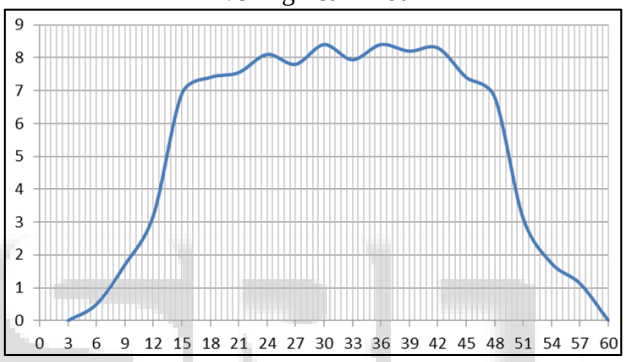

Fig. 5: Highly Saturated Cycle of Phase 2 of Intersection at Evening Peak Hour

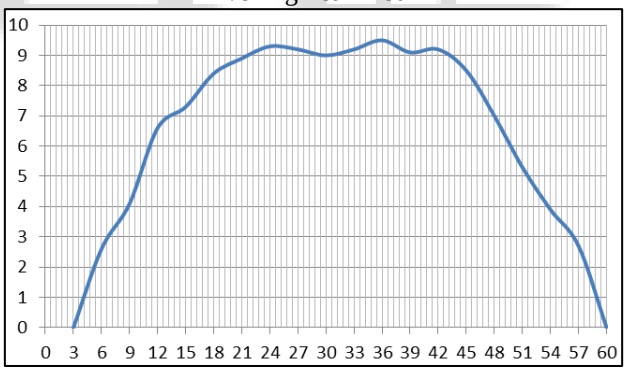

Fig. 6: Highly Saturated Cycle of Phase 3 of Intersection at Evening Peak Hour

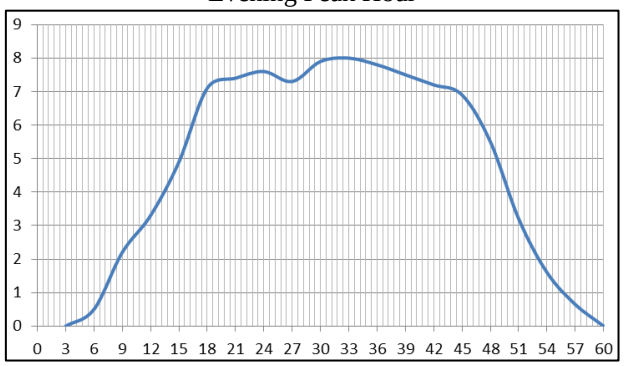

Fig. 7: Highly Saturated Cycle of Phase 4 of Intersection at Evening Peak Hour

VI. SIGNAL DESIGN

A. Phase 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. In such a situation, the objective is to design phases with minimum conflicts or with less severe conflicts. There is no precise methodology for the design of phases. This is often guided by the geometry of the intersection, flow pattern especially the turning movements, the relative magnitudes of flow. Therefore, a trial and error procedure is often adopted.

B. Optimum Cycle Time

One of the important steps in designing a fixed time signal system is to determine the cycle time. Main consideration in selecting the cycle time should be that the least delay is caused to the traffic passing through the intersection. For each traffic flow volume there is an optimum cycle time which results in the minimum delay to the vehicles. It is obvious that these maximum departure flow rates are higher than the saturated flow rates obtained on fully utilized green cycle.

In the calculation of signal cycle time, generally saturation flow rate of fully utilized green time is considered, which may under estimate the actual maximum departure capacity of approach particularly in mixed traffic condition having no lane discipline like in India. Here, the Webster's method formula is used for the Two phase Signal Design.

$$Co = \frac{1.5L+5}{1-Y}$$

Where,
Co = optimum cycle time, sec
L = total lost time per cycle, sec
Y= y1 + y2 + y3 + ……+ yn And y1, y2, y3 …yn are the maximum ratios of flow to saturation flow for phases 1, 2…n. (i.e. q / s where q is the flow and s is the saturation flow).
L=Total lost time per cycle =2n + R (n is the number of phase and R is all red- time)
Green time for Phase 1,

$$G1 = \frac{Y1}{Y}(C_0 - L)$$

And ,Green time for Phase 2,

$$G2 = \frac{Y2}{Y}(C_0 - L)$$

Max. Demand flow rate for Phase1 (q_1)
(q_1) = 2201 PCU/Hr
Max. Demand flow rate for Phase2 (q_2)
(q_2) = 1615 PCU/Hr
Max. Demand flow rate for Phase3 (q_3)
(q_3) = 2234 PCU/Hr
Max. Demand flow rate for Phase4 (q_4)
(q_4) = 1572 PCU/Hr
And, Max. Saturation flow rate for Phase1 (S_1)
(S_1) = 8680 PCU/Hr
Max Saturation flow rate for Phase2 (S_2)
(S_2) = 8361 PCU/Hr
Max Saturation flow rate for Phase3 (S_3)
(S_3) = 8496 PCU/Hr
Max Saturation flow rate for Phase4 (S_4)
(S_4) = 7723 PCU/Hr

From this,

$$Y_1 = \frac{q1}{S1} = \frac{2201}{8680} = 0.25$$

$$Y_2 = \frac{q2}{S2} = \frac{1615}{8368} = 0.19$$

$$Y_3 = \frac{q3}{S3} = \frac{2234}{8496} = 0.26$$

$$Y_4 = \frac{q4}{S4} = \frac{1572}{7723} = 0.20$$

Then, $Y = y_1+y_2+y_3+y_4$
$= 0.25 + 0.19 + 0.26 + 0.20$
$= 0.90$
Total Cycle Time(C_0) :

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

$$C_0 = \frac{1.5(2+2+2+2)+5}{1-0.90}$$

C_0 = 170 sec.
Now, Green Time for phase 1 (G_1)

$$G_i = \frac{yi}{Y}(C_0 - L)$$

$$G_1 = \frac{0.25}{0.90}(170 - 8)$$

G_1 = 45 sec.
Green Time for phase 2 (G_2)

$$G_j = \frac{yj}{Y}(C_0 - L)$$

$$G_2 = \frac{0.19}{0.90}(170 - 8)$$

G_2= 34 sec.
Green Time for phase 3 (G_3)

$$G_j = \frac{yj}{Y}(C_0 - L)$$

$$G_3 = \frac{0.26}{0.90}(170 - 8)$$

G_3= 47 sec.
Green Time for phase 4 (G_4)

$$G_j = \frac{yj}{Y}(C_0 - L)$$

$$G_4 = \frac{0.20}{0.90}(170 - 8)$$

G_4= 36 sec.
Signal Timing for Phase 1,

Signal Timing for Phase 2,

Signal Timing for Phase 3,

Signal Timing for Phase 4,

VII. CONCLUSION

The study presented in the paper has been conducted to formulate the delay mode of the selected stretch.

– After computing the cycle time, modified time for phase 1 green time is 45 second and red time is 123 sec. and for phase 2 the green time is 34 sec. and red time is 134 sec. phase 3 green time is 47 second and red time is 121 sec. and for phase 4 the green time is 36 sec. and red time is 132 sec. As compare with the old cycle time for phase1 green time 55 sec and red time154 sec and for phase 2, green time 45 sec, and red time 155 sec. phase3 green time 55 sec and red time 154 sec and for phase 4, green

time 45 sec, and red time 155 sec. Modified signal running in four phase, each based on the demand flow rate, because there are minimum variation in demand flow rate of each approach. From this signal number of cycle increase and stop delay will decrease. As per the data collection of turning movement, right turning movement is less compare with the other turning movement so it will not create much problem in four phase design. By reducing the red time queue length also decrease in particular peak hour.

