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RESEARCH ARTICLE

Checking the Adequacy of Signal Timings at an Isolated Signalized Intersection under Mixed Traffic Conditions: A Case study of ECIL Cross Roads Signalized Intersection in Hyderabad City, India

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ABSTRACT

Many signalized intersections functioning in India are fixed time signals and most of the times the signal timings are decided based on the prevailing traffic volume conditions using some approximations. The signalized intersection located at ECIL cross roads attracts huge traffic from all the legs. In the present study traffic volume data was extracted from the video footage obtained from the city traffic wing. One of the unique feature of the present study was that, while extracting data from the video footage python programming code was used and hence the data was retrieved very quickly from the video footage. The other special features of the study include determination of saturation flow from the actual data collected using the saturation headway and PCU values recommended by Indo HCM 2017 for signalized intersections were used to convert the different vehicles of mixed traffic into equivalent PCU s. Using these inputs of traffic volume, saturation flow determined relatively more accurately, the optimum cycle time and signal timings were designed by Webster method. For Computing the signal timings, a C program was written and executed successfully. It was found from the analysis of results that at two approaches the existing green timings were not adequate and at the third approach, it was over estimated.

Keywords: HCM, PCU, Isolated, ECIL

INTRODUCTION

Road traffic signals are the major bottlenecks in the smooth flow of traffic in general and more so in case of mixed traffic conditions, where in all the different types of vehicles with varying static and dynamic characteristics share the common space. Due to this reason the traffic flow at these locations is affected and results in increased delay to the vehicles. In order to reduce the delay and smoothen the flow of traffic, it is always desirable to check the adequacy of signal timings periodically at these locations. Periodicity may depend on several factors, but one of the major factor is increase in traffic volume and the resulting delay to the vehicles. In view of the above, in the present study, it is proposed to check the adequacy of signal timings at the ECIL signal, located in Hyderabad, India. Many times the road users expressed their dissatisfaction regarding the delay caused to the vehicles. As part of the study, it is proposed to collect the classified traffic volume data entering into the intersection from various approaches, and also to study the existing geometric condition of the intersection. It was observed from the geometry of the intersection that, there was a small rotary existing at the intersection, in addition to the traffic light signals. It is also proposed to use open CV software for retrieving the video recorded traffic data. Indo HCM 2017 proposed PCU values for signalized intersections were used to convert the different vehicle groups into PCUs. It is planned to determine the saturation flow, an important input parameter for signal timings from the average of several saturation headways and finally design the cycle length and signal timings, following Webster method and using a C program.

REVIEW OF LITERATURE

Pranav Kumar Pal and Kamal Nabh Tripathi (2022) carried out research on signal timing design for a in Luck now city and used Webster method and IRC methods for design. Hima Bindu Maripini *et al* (2022) presented an optimal signal design using sample travel time information collected from mobile data and found that the proposed design is capable of handling traffic flow fluctuations without requiring the entire traffic stream data. They also demonstrated that sample data from four probe vehicles per phase is adequate for real-time optimal signal design. Jiangfan Yang *et al*(2021), optimized the signal timings using Webster method and from their results found that the average delay at the intersection is reduced by nearly 7 seconds, and the optimization effect is significant. Madhav Kumar *et al* (2020) redesigned the signal timings according to the present scenario of traffic. The design was according to the IRC and Webster method of signal design. The field traffic flow data was taken for an hour using a digital video camera. The study concluded that the IRC method is more suitable than Webster for the existing traffic conditions. To ensure the free flow of traffic and reduction in conflicts redesigning was done. Prasanna Kumar *et al* (2018) carried out a study for improving the safety of an uncontrolled road traffic junction at Maisammaguda, in Hyderabad and it is a T-junction and designed the traffic signals based on the Webster method.

Objectives of the Present Study

In the present study the following objectives are defined.

- To collect the geometric details of the study intersection
- To collect the classified traffic volume data of the study intersection from the video footage using Open CV software
- To determine the saturation flow rate
- To design signal timings using Webster method with the help of C program

Methodology and Data Collection

The methodology followed in the present study is given in the following steps.

1. Identification and description of study location
2. Geometric details of the intersection
3. Collecting the Video footage of traffic data pertaining to the location from traffic police wing and
4. Retrieval of the data from the Video footage using open CV software

5. Conversion of traffic volume into PCUs and determination of design hourly volume
6. Determination of saturation flow rate
7. Computation of optimum cycle time and signal timings using Webster's method
8. Presenting the signal timings in signal timing diagram
9. Comparison with existing timings

Identification and Description of Study Location

The study location is the signalized intersection located near ECIL cross roads, in Hyderabad, Telangana state of India and is locate at Latitude: 17.451749 and Longitude: 78.567116. It is an important intersection catering to the diverse categories of residential, commercial and school and college users. It also connects several important areas surrounding the location that include Moula Ali. AS Rao Nagar, Tarnaka, and Kushaiguda.

Geometric Details of the Intersection

Geometric details of the intersection such as number of lanes, width of lanes etc. was collected by taking physical measurements at the location and the diagram showing all the geometric details is given in **Figure -2**. Classified traffic volume data was collected for the identified peak hour by extracting the video footage data obtained from the traffic wing of Hyderabad police.

Collecting the Video footage of traffic data pertaining to the location from traffic police wing and Retrieval of the data from the Video footage using open CV software

For retrieving the video graphic data, an advanced vehicle detection and classification system with the aid of Open CV was used. YOLOv3 algorithm in conjunction with Open CV was used to detect and classify objects. YOLOv3 is trained on the COCO dataset, to read the files containing different categories of vehicles and store them in a list. The COCO dataset includes 80 distinct classes. In the present study it is only needed to detect cars, motorcycles, buses, and trucks, and hence the required class index contains the index of those classes from the coco dataset. A random colour is generated for each class of vehicle in the dataset using the np.random. randint() function. These colours were used to draw the rectangles around the objects. The random. seed() function saves the state of a random function so that it can generate some random number on each execution. Frames from a video file were retrieved and then Cap.read() reads each frame from the capture object after reading the video file through the video capture object. The frame was cut in half by using cv2.reshape (). The crossing lines were then drawn in the frame using the cv2.line() function. Finally, the output image was displayed using the cv2.im show() function. Snap shots of retrieval of video data is shown in Figure -3. Summary of traffic volume data obtained from the four legs of the study intersection is furnished in Table -1 below.

Conversion of traffic volume into PCUs and determination of design hourly volume

In the present study, the PCU values developed for signalized intersections and given in Indo HCM 2017 were used to convert the vehicles of different types and arrive at the design hourly volume. The PCU values used I the study are presented in Table 2.

Determination of saturation flow rate

Saturation flow was computed from the average saturation headway of 25 cycles from each of the approaches for the straight going and right turning vehicles and then determined the number of vehicles going in the determined hourly saturation flow rate by dividing number of seconds in an hour (3600) with the average saturation headway. The obtained Saturation flow values are presented in Table: 4 below.

Computation of optimum cycle time and signal timings using Webster's method

Optimum Cycle Time by Webster's Method

Cycle length is the total period during which one complete sequence of signalization takes place around an intersection. A complete cycle comprises all the phases with their respective signal indications. The cycle length with minimum delay is often termed optimum cycle length, and it can be determined by Webster's equation:

C_0=1.5L +5 /1-Y_i
where C_0 = optimum cycle length in seconds
and L= sum of the lost time (seconds) for all phases=l_1+l_2+l_3...+l_i up to i number of phases.
Lost time per phase= Start up time (usually 1-2 sec) + Clearance lost time
Clearance lost time=A portion of the Amber interval (usually 1-2 sec) + All-Red interval Yi = Y_i = summation (y_1 + y_2 + y_3 + y_4 +y_i)
Y_i= Flow ratio
Calculation of Green Time
Effective Green time (g_i) for the respective i^{th} phase can be calculated from the following expression g_i=y_i/Y_i (C_0-L_i)
where g, - effective green period of phase i y = flow factor of phase i;
C = cycle length;
L = total lost time
Y = sum of y factors and
C_0-L_i= total effective green time
The C program written for signal timing design is presented as Annexure -1
The signal timings obtained are given in Table:5 below and the timing diagram is shown in figure 5 below.

SUMMARY, CONCLUSION AND RECOMMENDATION

Signal timing design was carried out from the real time data collected from traffic police wing and extracted using open CV software and a C program was executed to compute the signal timings in Webster method. It was found that at North bound approach and west bound approaches the existing green timings were not adequate and at south bound approach the existing green time was over estimated. It is believed that these signal timings estimated in the present study based on actual traffic conditions, if implemented will reduce the delay to vehicles. It is also recommended that the rotary present inside the intersection area be removed so that the traffic flow can be improved and delay to vehicles also can be significantly reduced.

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Annexure -1
'C' Program for Signal timing design

```
#include <stdio.h>
 #include <math.h> int main()
{
int n, r, l;
float qa, qb, sa, sb,sc,qc;
float ya, yb,yc, y, co, b, a, ga, gb,gc;
printf ("Enter the number of phases - n = ");
scanf ("%d", &n);
printf ("Enter the value of all red time - r = ");
scanf ("%d", &r);
l = 2 * n;
 l = l + r;
printf ("\n The value of lost time is %d sec ", l);
printf ("\n Calculate the optimum cycle length ");
printf ("\n Enter the value of normal and saturation flow ");
scanf ("%f%f%f%f%f%f", &qa, &qb,&qc,&sa,&sb,&sc);
ya = floorf((qa / sa)*10)/10;
yb = floorf((qb / sb)*10)/10;
yc = floorf((qc / sc)*10)/10;
y = ya + yb+yc;
printf ("\n The value of ya is %.1f", ya);
printf ("\n The value of yb is %.1f", yb);
printf ("\n The value of yc is %.1f", yc);
printf ("\n the value of y is %.1f", y);
co=((1.5*l)+r)/(1-y);
printf ("\n The value of co is %.1f ", co);
 a = co - l;
ga = (ya*a)/y;
printf ("\n The value of green time at phase A is %.1f ", ga);
gb = (yb*a)/y;
printf ("\n The value of green time at phase B is %.1f ", gb);
gc = (yc*a)/y;
printf("\n The value of green time at phase c is %.1f ",gc);
return 0;
}
```

Table: 1 Traffic Volume Data at the Intersection

Name of the approach	No of Autos	No. of two Wheelers	No of Buses	No.of Cars	No.of LCVs	No. of HCV
North Bound (Straight and Right)	257	1738	37	207	88	28
South (Straight and Right)	162	854	36	270	21	04
West (Straight and Right)	311	1465	68	713	82	11

Table: 2 PCU Values Used

SNo	Vehicle Type	PCU
1.	Two Wheelers	0.4
2.	Autos	0.5
3.	Passenger Cars	1.0
4.	LCVS	1.1
5.	HCVS	1.6*
6.	Bus	1.6*

Source: Indo HCM 2017

Table: 3 Design hourly Volume in PCU/h

SNo	Name of the approach	Design hourly volume (PCU/h)
1.	North Bound	1232
2.	South Bound	780
3.	West Bound	1672

Table: 4 Saturation Flow in PCU/h

SNo	Name of the approach	Saturation Flow (PCU/h)
1.	North Bound	2073
2.	South Bound	3346
3.	West Bound	10004

Table: 5 Comparison of Signal Timings

SNo	Name of the approach	Green Time (Seconds)	
		Existing	Proposed
1.	North Bound	90	110
2.	South Bound	55	45
3.	West Bound	20	25

Figure 1:Ariel View of the Study Intersection

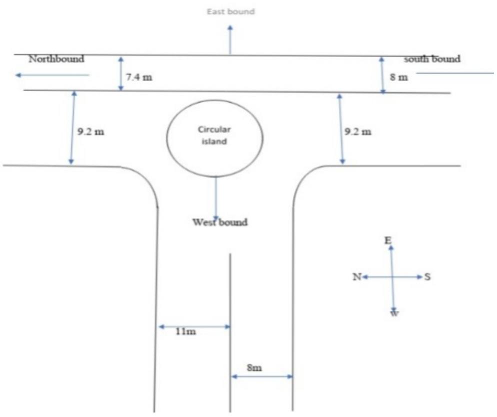

Figure 2: Geometric Details of Study Intersection

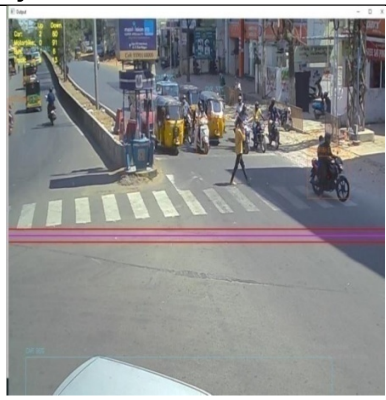

Figure 3: Snapshots of retrieval of video data

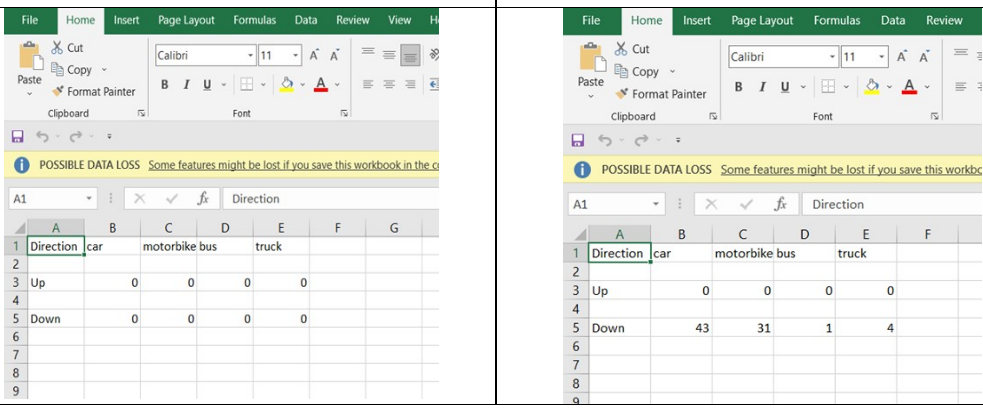

Figure 4: Excel Sheet before and after Execution

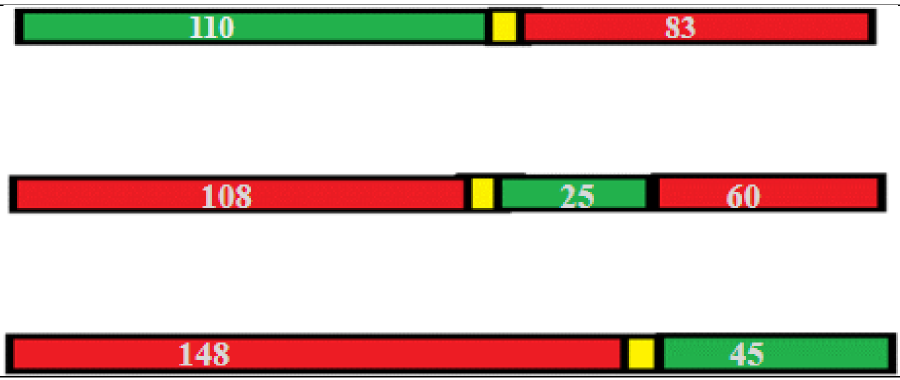

Figure 5: Timing Diagram