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The Design of Traffic Signals at Intersection

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ABSTRACT- The traffic volume at intersections has been arising a problem which leads to accidents, conflicts and congestions. An efficient traffic control at intersections helps in reduction of delays of all vehicles and the probability of crashes. The movement of vehicles efficiency is increased by providing traffic signals, roundabouts, channelized islands at an intersection. Signal timing is most important if we use traffic signals in which green time decides the efficiency of movement of vehicles along with pedestrian walk timing. At an intersection, traffic volume studies are done with the movement and classification of vehicles along with the geometric elements of the road. The video graphic method is used to collect the volume of vehicles for every 15-minutes interval and converted into PCU units. Webster's and IRC code method are used for signal design. Saturation flow, lost times and passenger car units, width of the road are the significant parameters used to optimize the signal timing in planning, design and control of signalized intersection.

KEYWORDS- PCU, roundabouts, channelized islands, optimization, saturation flow

I. INTRODUCTION

A traffic light, traffic signal, or stop light is a signalling device positioned at a road intersection, pedestrian crossing, or other location in order to indicate when it is safe to drive, ride, or walk using a universal color code. In Malaysia, the traffic lights for vehicles commonly have three main lights, a red light that means stop, a green light that mean go and yellow that means ready to stop. However, for the pedestrians, there have only two lights, a red light and a green light that mean go and stop respectively. The traffic lights have given many benefits to all road users. Besides reducing the number of accidents, it made the traffic flow smoothly and possibly could save people time [1].

The world's first traffic light came into being before the automobile was in use, and traffic consisted only of pedestrians, buggies, and wagons. Installed at an intersection in London in 1868, it was a revolving lantern with red and green signals. Red meant "stop" and green meant "caution." The lantern, illuminated by gas, was turned by means of a lever at its base so that the appropriate light faced traffic. On January 2, 1869, this crude traffic light exploded, injuring the policeman who was operating it.

The traffic jams are the common problem in most of the city in the world. The one of the main cause of this problem is accident. To find the way to maximize the traffic flow smoothly can reduce the numbers of the accident and can reduce the people time in road. The government has carried out a few rules to overcome this problem. Beside take the punishment to all the traffic offenders, the traffic lights have been made at the location that high risk in accident. However, increasing the numbers traffic lights have contributed some contra issues/problems

Increasing the number of vehicle in road, have cause the heavy traffic jams. This happened usually at the main junctions commonly at the morning, before office hour and at the evening, after the office hour. The main effect of this matter is increasing time wasting of the people at the road [2].

The traffic light has contributed more wasting time people at road. At the certain junction, sometime there have no traffic. But because the traffic light still red, the road users should wait until the light turn to green. If they run the red light, unfortunately they maybe should pay the fine about RM 300.

II. TRAFFIC VOLUME COUNT

The result of traffic counting is subject to sampling error and observational uncertainty. Sampling error in traffic counting is error emanating from collected traffic data while observational error relates to vehicle classification by vehicle types resulting in some vehicles being wrongly classified. In this context, vehicle classification cannot be defined without ambiguity and therefore is a subject of enumerators' interpretation of the passing traffic stream. To minimize the error, statistical methods are more preferable to use for analysis to smooth out sampling and observational errors [3-5].

Automatic counters mainly use the distance between axles to classify vehicles. In situations where vehicles of different make have similar axle spacing, the automatic counter cannot ascertain that these are two different vehicles. The resulting scenario is that either the system rejects all vehicles it cannot classify or misclassifies them, thus resulting in classification error. Where there is a significant proportion of unclassified vehicles the level of error is deemed to be very high and the results should not be used for any economic decision making purpose.[6-7]

A. Cordon Count

These are made at the perimeter of an enclosed area. Vehicles or persons entering and leaving the area during a specified time period are counted

B. Screen Line Count

These are classified counts taken at all streets intersecting an imaginary line bisecting the area. These counts are used to determine trends, expend urban travel data traffic assignment etc.

C. Pedestrain Count

These are used in evaluating sidewalk and crosswalk needs justifying pedestrian signals, traffic signals timings etc.

D. Intersection Count

These are measured at the intersections and are used in planning turn prohibitions, designing channelization, computing capacity analyzing high accidents intersections etc.

E. Methods Of Traffic Volume Count

There are different types of methods in traffic volume counts[8]. They are

- Manual Method
- Automatic Method
- Moving Observer Method
- Photographic Method

III. PASSENGER CAR UNIT

Different vehicle types occupy different spaces on the road, move at different speeds, and start at different accelerations. Furthermore, the behavior of drivers of the different types of vehicles may also vary considerably. This poses a problem for designing roads, intersections, and traffic signals. A uniform measure of vehicles is thus necessary to estimate traffic volume and capacity of roads under mixed traffic flow. This is rather difficult to achieve unless the different vehicle types are stated in terms of a common standard vehicle unit. For this reasons, the concept of Passenger Car Unit (PCU) or Passenger Car Equivalent (PCE) was developed to become as a common practice to convert the other vehicle types into PCUs[9]. It is generally expressed as PCU per hour, PCU per lane per hour, or PCU per kilometre length of lane. Transportation engineers and professionals in Palestine and more specifically in Gaza Strip do not have local standards to use for PCU values. International standards provided by the Highway Capacity Manual adopted in the USA and standards provided by the Department of Transport in the UK are usually used[10-11]. These values are being used without local validation. In this work the authors are trying to provide local validation for some PCU values. The main objective of this paper is to determine the value of passenger car units for animal-driven carts and buses at signalized intersections in Gaza City. Like many other cities in developing countries, Gaza City traffic includes animal-driven carts in addition to other motorized vehicles. The paper will also compare the estimated Gaza PCU values to those from United Kingdom and India.

Table 1: PCU values

Vechilecategory	Pcu
Bike	0.5
Car	1
Auto	0.8
Bus	3.5
Truck	3.5
Tractor	3.5
Rickshaw	0.3
Bicycle	0.2

IV. METHODOLOGY

The signal design procedure involves six major steps:

- Phase design
- Determination of amber time and clearance time
- Determination of cycle length
- Apportioning of green time
- The performance evaluation of the above design.
  Methods Used
- Webster method

V. RESULT AND DISCUSSION

The findings of this study on traffic signal design at intersections demonstrate the critical role that proper signal configuration plays in optimizing traffic flow and enhancing safety. Through careful analysis of traffic patterns, signal timing, and pedestrian considerations, the proposed designs showcase notable improvements in congestion reduction and smoother vehicular movement.

Cycle length for morning hours using Webster method.

phase: 1 G=33.75s A=2s R=84.85s

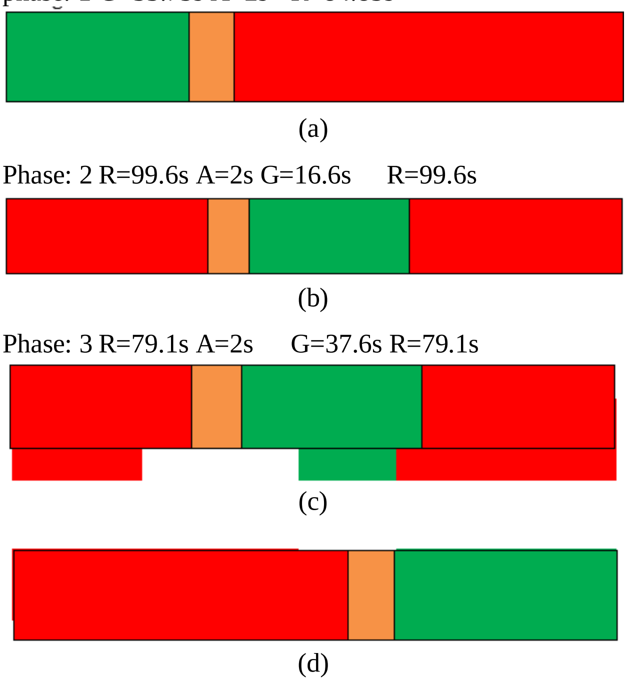

Figure 2: Cycle length

Additionally, the integration of advanced technologies like adaptive signal control systems exhibits potential for real-time adjustments to traffic conditions. These results underscore the significance of precise signal planning in mitigating traffic congestion and ensuring efficient intersection operations, thus contributing to overall urban mobility and safety.

A. Webster Method

The optimum signal cycle is given by:
C0=1.5L+5/1-Y
Where L = total lost time per cycle, seconds = 2n + R
Phase: 4 R= 82.57s A=2s G=34.13s
(n is the number of phase and R is all red-time)
Y=y1+y2
Then, G1=y1/Y (C0-L) and G2=y2/Y (C0-L)
Similar procedure is followed when there is more number of signal phases.

B. Irc Method

The pedestrian green time required for the major and minor roads are calculated based on walking speed of 1.2m/s. And initial walking time of 7.0 secs These are the minimum green time required for the vehicular traffic on the major and minor roads respectively. The green time required for the vehicular traffic on the major road is increased in proportion to the traffic on the two approach roads. The cycle time is calculated after allowing amber time of 2.0 secs each. The minimum green time required for clearing vehicles arriving during a cycle is determined for each lane of the approach assuming that the first vehicle will take 6. 0secs.And the subsequent vehicles (PCU) of the queue will be cleared at a rate of 2.0 secs. The minimum green time required for the vehicular traffic on any of the approaches is limited to 16 secs.
The optimum signal cycle time is calculated using Webster's formula. The saturation flow values may be assumed as 1850, 1890, 1950, 2250, 2250 and 2990 PCU per hour for the approach roadway widths of 3.0, 3.5, 4.0, 4.5, 5.0 and 5.5meter; for widths above 5.5m, the saturation flow may be assumed as 525 PCU for hour per meter width. The lost time is calculated from the amber time, inter- green time and the initial delay of 4.0secs. For the first vehicle, on each leg. The signal cycle time and the phases may be revised keeping in view the green time required for clearing the vehicle and the optimum cycle length determined.
Total cycle length = 116.6s
Cycle length for morning hours using IRC method.

Phase: 1 G=14.37s A=2s R=102.33s

(a)

Phase: 2 R=99.6s A=2s G=16.6s R=99.6s

(b)

Phase: 3 R=79.1 A=2s G=37.6s R=79.1s

(c)

Phase: 4 R= 82.57s A=2s G=34.13s

(d)

Figure 2: Cycle length

VI. CONCLUSION

Traffic control signal shall be installed at Bahadurpally junction for the following signal warrants meeting

- As the average traffic flow for 8 hours on approaches exceeding 800 vehicles.
- Interruption of continuous traffic flow on the major street exceeding 1000 vehicles per hour.
- As 150 or more pedestrians per hour crossing a major street with over 600 vehicles per hour on both approaches.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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