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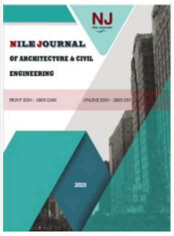

Effects of Traffic Control Lights on the Flow in Urban Areas

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Abstract

Traffic signals are considered to be the best solution for traffic control at large intersections and crossings right-turning of which a large amount of traffic has to come across several conflict points and hence there is a possibility of accidents.
In the development of urbanization, a traffic motorization and traffic controlling by signal lights must not be dispensed with. This paper describes the effect of traffic control lights on the traffic flow such as active, passive, cost, and environmental effects. It is an important requirement to adopt such a traffic control requiring the least of sacrifices both from the part of traffic and persons partaking in urban traffic.
In general, several constant time programs can be practically applied. However, traffic light can only be operated with one or two programs.

Key Words: traffic control, signal lights, urban areas

1. Introduction

Urban control strategies often seek to minimize delay over a network in contrast to the linking of signals along specified traffic routes which minimizes delay to major rout traffic at the expense of vehicles on the reminder of network. The actual Co-ordination of signals will depend upon the traffic and road pattern and the objective which is to be attained.

The advantages of traffic control lights are:
i. They reduce the frequency of certain types of accidents.
ii. Controlling the order of waiting of vehicles on roads and squares.
iii. They can be used to permit other traffic, pedestrian or vehicular, to cross.
iv. They represent a considerable economy, as compared with manual control, at intersections where the need for some definite means of assigning right-of-way first to one movement and then to another is indicated by the volumes of vehicular and pedestrian traffic, or by the occurrence of accident [Manual on Uniform Traffic Control Devices for Streets and Highways, 1971].

A Decision to use traffic control lights in preference to roundabout control or as a means on increasing traffic capacity at priority intersections may be made from the overall view-points of traffic management.

A more detailed decision on the installation of traffic signals may also be made on the basis of traffic flow, pedestrian safety, accident experience and the elimination of traffic conflicts.

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2. Time Losses in Urban Areas

The delay caused in urban areas may be investigated according to phases and so may be the whole loss of time in urban areas. When signal control is employed in preference to priority or roundabout control, then major road vehicles which previously passed unimpeded through the junction are on occasions required to stop and wait. On the other hand, minor road vehicles suffer reduced delay.

The total delay in urban areas should be taken. That arrangement, of systems, is the optimum where the sum of delays is a minimum. By minimizing the delays also the operating expenses will decrease and also the nerve strain on the drivers lessens and so does the harmful ecological effect of the transportation.

Numerous relationships exist for determining the traffic delay. All of them try to find interdependence between the characteristics of traffic control lights, the intensity of the traffic flow and the anticipated delay. Webster's theoretical model has been produced on a digital computer by a simulation, with the assumption that in the effective green phase a saturated flow of traffic look place. Webster's delay formula is as follows [Salter, R.J., 1989]:

$$d = \underbrace{\frac{c(1-\lambda)^2}{2(1-\lambda x)}}_{\text{I.}} + \underbrace{\frac{x^2}{2q(1-x)}}_{\text{II.}} \underbrace{- 0.65\left(\frac{c}{q^2}\right)^{1/3} x^{(2+5\lambda)}}_{\text{III.}} \qquad (1)$$

Where:

$d =$ Average loss of time per vehicles,
$c =$ Cycle time,
$\lambda =$ Proportion of the cycle that is effectively green for the phase under consideration (That is, effective green time, cycle time),
$q =$ Flow intensity in each direction,
$x =$ Degree of saturation, which is the ratio of actual flow to the maximum flow that can be passed through the approach (That is q/λs).
$s =$ Saturation flow,

The first term in this expression is the delay due to a uniform rate of vehicle arrival, the second term is the delay due to the random nature of the vehicle arrivals. The third term was empirically derived from the simulation of traffic flow.

For practical use, the formula may be given in a better ordered from (the involved constants being tabulated) [kÖves-Gilicze, Ē.-Pălmai, G., 1976].

$$d = (CA + \frac{B}{q})(\frac{100-\rho}{100}) \quad (2)$$

Where:

A, B and C	=	Constants,
ρ	=	% of reduction value for the lost time.

3. Time Consideration Related to Analysis Effects

The basic principle of the economical investigation method is to compare the active and passive effects.

3.1. Optimum Criteria Considerations

In economically analyzing a particular centre with more than four branches, the consideration of the following four optimum criteria is advisable:

a) Cycle time (period),
b) Number of phases,
c) Phase sequence,
d) Green time distribution.

By differentiating the equation of the overall delay at an intersection with respect to the cycle time it was found that the cycle time with the minimum delay could be represented by:

$$c = \frac{1.5L+5}{1-y_1-y_2-......y_n} = \frac{1.5L+5}{1-Y}(\text{sec.}) \quad (3)$$

where:

y_1, y2 …….y_n are the maximum ratios of flow to saturation flow for phases 1, 2 . n,

Y = Σ y,

L = is the total lost time per cycle.

This cycle time will be referred to as the "optimum cycle time". The length of the period effects the length of the waiting time and degree of saturation. In case of short cycle, but a few vehicles can pass through the centre in each direction, a long queue of vehicles remain waiting, in turn in case of a long cycle, direction will seldom change this is why the waiting time will be lengthened.

Although increase in phase number contributes to realizing an undisturbed flow of traffic and improves safety of phasing through the centre-augmentation of the number of phases lengthens, the waiting time, and reduces the capacity of the centre. The phase sequence is important in case of more than two phases.

The sequence must be such that every stream has right of way sometime in the cycle. Many junctions are simple enough for there to be only one or a very few sequences, and for these to be obvious. In more complicated cases, however, it may not always be clear what the possibilities are?. Tully, I.M.Z., 1976 following Stoffers K.E., 1968 has developed a computer program for identifying all those sequences in which the signal controlling each stream changes from green to red and back again just once per cycle. It would probably be useful if this program could be extended to generate also sequences in which the signals controlling certain streams changed four times per cycle, thus allowing those streams to have two separate green periods in the cycle, because this arrangement is sometimes useful in practice [Richard E. Allsop., 1979].

Distribution of the green time is instrumental in realizing economy. A little careful establishment of green time increases the loss of time.

3.2. Active Effects:

The strength of the active effects and their calculation method is influenced by numerous local conditions and parameters, for example:

- The ratio of the mass to private transportation passing through the centre;
- Number of routes joining the centre;
- Ratio of utilization of the capacity of centre;
- The cycle and time schedule of the control light system.

3.2.1. Expressible Active Effects

a) The vehicles of mass transportation (Bus, tram) cross the centre without stop, detention, hence at a minimum delay.

Accordingly:

- Turn-over time of the vehicles will be shorter, the same passenger transportation is performed by less vehicles, thus equipment expenses may be reduced;
- Work time of drivers will be shortened, use of fewer vehicles means a saving in labors and wages;
- Passenger's travel time will be reduced.

b) In the private motor-car traffic, traveling time and expenses may be saved and the public passenger vehicles may rise the passenger transportation performances.
c) Considering the total number of vehicles, the number of decelerations, accelerations, and stops will be reduced and so will be the fuel consumption, brake and tire wear.
d) Time schedule of the optimum program may be better adjusted to traffic requirements; therefore, the transmittance of the centre is better utilized than in case of a non-optimized program.

3.2.2. Non-Expressible Active Effects

a) The optimum control light program more suitable to the requirements of the traffic technique better satisfies the safety requirements in centre and reduces the risk of accidents.
b) A uniform, rhythmical movement of vehicles comes about within the centre.
c) Noise level will be reduced.
d) Air pollution will be diminished.
e) Never strain of the persons partaking in traffic decreases.
f) Maintenance costs of road surfaces will be reduced.

3.3. Passive Effects

Optimization may be realized only in constant knowledge of the traffic characteristics. Therefore, in each centre, systematical traffic survey should be carried out. For this purpose, extra wages or traffic recording equipment are needed.

3.4. Cost Effects

In analyzing the costs, the differences in vehicle-operating costs, time cost of passengers and freight might be calculated in case of traffic control light system differing in any of the optimization factors from that of optimum cycle, green light phase distribution, phase number, and sequence.

An optimum traffic control light program decreases the continuous costs of vehicles crossing the centre. The change in optimum costs is highly influenced by the composition of the traffic which, besides, also effects the establishment of the traffic control light program; therefore, it is advisable to calculate the savings according to types of vehicles.

3.5. Effect of Traffic Control on Pedestrians

In the United Kingdom the Department of Transport [Advice Note TA 15, 1981] advises that a separate pedestrian stage or one combined with a traffic stage may be required when the flow of pedestrians across any one arm of the junction is of the order of 300/hr or more or when the turning traffic flowing into any arm has an average headway of less than 5 seconds during the time that such traffic can flow and is conflicting with a pedestrian flow of at least 50 pedestrians/hr.

If a pedestrian facility is to be provided it may take the form of a full pedestrian stage where all traffic is stopped when pedestrians are allowed to cross all the arms of the junction. The pedestrian stage is demanded by push button but has the disadvantage of imposing additional delay on vehicular traffic. A more efficient form of control form the viewpoint of vehicular movement is the use of a parallel pedestrian facility. As the provision of any pedestrian facility will normally reduce the proportion of green time available for vehicle movements, it may be necessary when a junction is close to capacity to install a pedestrian facility away from the junction.

3.6. Environmental Effects

The environmental effects are hardly expressible in numbers. Townsmen are heavily paying for the comfort of urban life in terms of rapidly worsening, harmful environmental effects. The conditions are growing unfavorable with the increase of the number of vehicles. Therefore, one should use every means to try to decrease the effects of the two environmental damages "air and noise" pollutions.

From environmental aspects, also the increase of noise is harmful. Damaging physiological and psychological effects are caused mainly by the intensity of noise; however, neither the duration of the noise effect is indifferent. Intensity of the noise increases at the starting of vehicles, and the duration of the noise making is proportionate to the average speed of the vehicles.

4. Egyptian Aspects

In Egypt, with the rapid development of motor transportation, the level of air pollution increases not only linearly with the number of motor vehicles but exponentially, due to the saturation of the roads and the inadequate control system, the ever increasing number of stops in front of the traffic control light and the idling of motors. These operating conditions are worse than continuous running with respect to the increased amount and harmful composition of the exhaust gases. Evidently, the stopping vehicles caused a higher level of air pollution.

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Nervous overstrain of persons partaking in road traffic is a harmful phenomenon of our age. Increasing of travel time and congestions of vehicles, slow progression, etc., cause unnecessary strain on nerves. Experienced drivers are known to become impatient in such situations and often infringe the regulations. A similar phenomenon occurs with pedestrians and individuals in mass transportation.

5. Conclusion and Recommendations

From the capacity and utilization of urban areas, the control and time schedule of traffic and in determining the periods and phase times, one should endeavor to arrange the traffic flows according to their nature, quantities and qualities with a minimum of constraint, restriction and disturbance, and one should take for starting principle the optimum use of the capacity of the centre, the continuous flow, as high travel speed (i.e., the shortest, still tolerable detention) as possible.

Accordingly, the most important partial tasks of the traffic control are as follows:

i. Increase of safety in road traffic, particularly as concern the pedestrian traffic.
ii. Control of the flow conditions in centre in such a way as to minimize the delay and to increase economy in traffic flow as much as possible.
iii. It provide for orderly movement of traffic. It can increase the traffic-handling capacity of the intersection.
iv. Under conditions of favorable spacing, they can be coordinated to provide for continuous or nearly continuous movement of traffic at a definite speed along a given route.

Intersections that carry large vehicular volumes cannot be safety and satisfactorily controlled without traffic signals. It is recommended that the crossing not to be more than 50m from the mouth of the junction, the pedestrian stage is incorporated within the junction signal cycle and the position of the stage is chosen to minimize delay to traffic flow.

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