DESIGN OF TRAFFIC SIGNALS AND SIGNAL CO ORDINATION IN URBAN AREAS

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ABSTRACT

Coordinated traffic lights that implement green waves along major arterial roads are an increasingly used traffic management strategy for reducing travel times in urban context. The potential positive effect of this measure on emissions is often called upon as an additional support for its introduction. Although a smoother traffic flow will generally lead to lower air pollutant emissions, it will not necessarily lead to lower noise missions. Because of the challenges associated with measuring the emissions caused by a stream of vehicles, up to now , little scientific research has been spent on the effects of synchronized traffic lights on emissions. This paper presents the results computations of study and the effect of traffic signal coordination on vehicle emissions along arterial road. The methodology consists coupling microscopic traffic simulation model with state –of-the-art models for instantaneous emission of Noise , CO2, NO2 and particulate matter. The influence of traffic intensity, signal timing and signal coordination parameters is investigated through the simulation of a wide range of scenarios. The introduction of a green wave was found to reduce air pollutant emissions by up to 40% in the most favorable conditions, depending on traffic flow and signal timing setting. Sound pressure levels were generally found to decrease near the traffic signals, but to increase in between intersections.

INTRODUCTION:-

Design principles of traffic signal:- Traffic signals are one of the most effective and flexible active control of traffic and is widely used in several cities worldwide. The conflicts arising from movements of traffic in different directions are addressed by time sharing principle. The advantages of traffic signal include an orderly movement of traffic, an increased capacity of the intersection and require only simple geometric design. However, the disadvantages of the signalized intersection are large stopped delays, and complexity in the design and implementation. Although the overall delay may be lesser than a rotary for a high volume, a user may experience relatively high stopped delay. This chapter discuss various design principles of traffic signal such as phase design, cycle length design, and green splitting. The concept of saturation flow, capacity, and lost times are also presented. First, some definitions and notations are given followed by various steps in design starting from phase design.

A signal cycle is one complete rotation through all of the indications provided.

Cycle length:
Cycle length is the time in seconds that it takes a signal to complete on full cycle indications. It indicates the time interval between the starting of green for one approach till the next time the green starts. It is denoting by C.

Interval:
Thus it indicates the change from one stage to another. There are two types of intervals change interval and clearance interval. Change interval is also called the Yellow time indicates the interval between the green and red signal indications for an approach.

Green interval:
It is the green indication for a particular movement or set of movements and is denoted by G. This is the actual duration the green light of a traffic signal is turned on.

Red interval:
It is the red indication for a particular movement or set of movements and is denoted by R. This is the actual duration the red light of a traffic signal is turned on.

Amber interval:
It is the red indication for a particular movement or set of movements and is denoted by A. This is the actual duration the amber

light of a traffic signal is getting ready to move.

Phase:

A phase is the green interval plus the change and clearance intervals that follow it. Thus, during green interval, non conflicting movements to flow and safely halt the flow before the phase of another set of movements start.

Lost time:

It indicates the time during which the intersection is not efficiently utilized for any movement. For example, when the signal for an approach turns from red to green, the driver of the vehicle which is in the front of the queue, will take some time to perceive the signal (usually called as reaction time) and some time will be lost before vehicle actually moves and gains speed.

PHASE DESIGN:

- Determination of amber time and clearance time.
- Determination of cycle length. Apportioning of green time.
- Pedestrian crossing requirements, and
- Performance evaluation of the design obtained in the previous steps.

LITERATURE REVIEW:-

Webster's Analysis :-

The pioneering study regarding the signalized intersections is reported by Webster (1958). The basic concepts proposed by Webster are still being followed and the signal design based on his theory is considered as a standard procedure in many countries. Webster has treated the saturation flow rate as an indicator of the capacity of the approach to a signalized intersection and based on extensive research, he has proposed an equation for the estimation of saturation flow rate. According to Webster, saturation flow rate in PCU/hour, S is given by S=525w.

Where;

w = approach width available for the movement in m.

In order to take into consideration the different types of vehicles Webster has also suggested a set of PCU factors to be adopted at a signalized intersection. His work deals extensively with the corrections and modifications to saturation flow rate under different phase patterns.

Saturation Flow Studies under Mixed Traffic Situation:-

Sarna and Malhotra (1967) have developed an equation for the saturation flow rate under mixed traffic conditions. The basic concept of the positive linear relationship between the saturation flow rate and the approach width is reflected in their model also, but the coefficients and the constant changed. The equation proposed by them is

$$\boxed{S = 431.7W + 103.5}$$

, where

S = Saturation flow rate, PCU/hr; and

W = Approach width available for the movement under consideration, m

The estimated saturation flows in this case are far lower than those proposed by the equation of Webster.

Bhattacharya and Mandall (1980) have proposed an equation for the estimation of saturation flow rate as a function of approach width. According to them the Saturation flow rate is given by the formula

$$\boxed{S = 490\ W\ 360}$$

Where S = Saturation flow rate, PCU/hr, and W= Approach width available for the movements under consideration, m. It is quite clear from the equation that the estimated saturation flow values by Bhattacharya's equation are also very much less than those proposed by Webster.

Bikram Das (1984) proposed an approach for the determination of the saturation flow rates under mixed traffic conditions. He has developed saturation flow rate curves based on the composition of traffic. Satish Chandra and Sikdar (1993) have studied the capacity of a signalized intersection under mixed traffic conditions and according to their observations the saturation flow rate estimation for the

Indian urban conditions needs a different approach that gives due emphasis for the dominating presence of smaller vehicles such as two wheelers. One of the significant observations from their study is that the increased approach width results in lesser discharge because of the increased freedom to maneuver enjoyed by the smaller vehicular modes. The dynamic PCU factors are proposed based on the saturation flow rate and the approach width. According to their work, the saturation flow rates for straight and right directional movements at a signalized intersection can be estimated as:

$$\mathbf{S = 1241+293\ W} \text{ and } \mathbf{1895 + 250\ W - 31735.7/R}$$

Where S = Saturation flow rate for through movement, PCU/hr;
= Saturation flow rate for the right turning movement, PCU/hr;
W = Approach width available for the movement under consideration, m; and
R = Radius of right turn, m

Ravinder (1997) has reported in his study that the direct application of Webster's equation gives lower saturation flow rates than what are actually observed. He has also reported that the 2/3 wheeler composition in urban traffic is very high ranging from 60 to 90 percent. He has proposed different saturation flow rate equations for straight and right directions at a signalized intersection.

According to the observation, the saturation flow rates can be estimated as
= -185.527 + 4989.18 W - 13202.8 and
= -586.79 72.88 W – 11382.4
Where S = Saturation flow rate for straight, vph;= Saturation flow rate for right, vph
W = Width available for the movement under consideration, m; The applicability of HCM

$$\mathbf{S= 5554 + 12001PHMV + 557\ W}$$

Where S = Saturation flow rate, vph;
PHMV = Proportion of highly maneuverable vehicles; and

procedure to the Indian urban traffic conditions is studied by Madhusudhana Rao (1997). He observed that the HCM procedure can be adopted for the mixed traffic dominated by the 2/3 wheelers, if the saturation flow rate can be computed with a modified equation. **Sreenivasa Reddy (1998)** has conducted studies on the saturated green times and he observed that the Hyderabad urban traffic is dominated by 2/3 wheeler group with an average proportion of 0.70.17

Sankara Rao (1999) made a study on saturation flow rates at urban intersection making use of overall headway. He has suggested that the estimation of saturation flow rate under mixed traffic conditions has to consider the composition of traffic.

Capacity and Level of service of signalized urban intersections is studied by

Sunil Anand (1999) and he has suggested that saturation flow rate in vph can be estimated using an equation S=2000W, where S is the saturation flow rate in vph and W is the width available for the movement in m.

Hari Narayana Murthy (1999) has proposed an equation for the estimation of the saturation flow rate at signalized intersections where the slow moving vehicles composition is high. He has proposed that the Equivalent Passenger Car Units (EPCU) are dynamic in nature and the saturation flow rate can be computed as

$$\mathbf{S = 1619 + 463\ W}$$

Bhanu Murthy (2000) has proposed an equation for saturation flow rate at signalized intersections. He has suggested that the estimation of saturation flow rate under mixed traffic conditions has to consider the proportion of highly maneuverable vehicle group. According to the observations the saturation flow rate can be computed as

W = Width available for the combined straight and right movement from an approach,

M. Yanming et al (2012) studied the effect of different states of bicycles crossing a signalized intersection. The saturation flow rates of right turn and left turn vehicles under the influence of bicycles are modeled considering different stages of bicycles and results could supplement the HCM method of intersection capacity analysis and design of intersection signal timing design.

CONSOLIDATED DATA

S. No	NAME OF JUNCTION	PHASE	NORMAL FLOW PCU/HR	SATURATED FLOW PCU/HR
1	LB NAGAR	PHASE 1 : HAYATHNAGAR TO DILSHUKNAGAR	5593	26411
		PHASE 2: UPPAL TO LBNAGAR	5593	26411
		PHASE 3 : DSNGR TO HAYATHNAGAR	5593	26411
		PHASE4 : LBNAGAR TO UPPAL	5593	26411
2	KAMINENI	PHASE 1: LB NAGAR TO UPPAL	5593	26411
		PHASE 2: UPPAL TO LB NAGAR	5593	26411
		PHASE 3 : SAHARA TO KOTHAPET	5593	26411
		PHASE 4 : KOTHAPET TO SAHARA	5593	26411
3	ALKAPURI	PHASE 1: UPPAL TO LB NAGAR	5593	26411
		PHASE 2: LB NAGAR TO UPPAL	5593	26411
		PHASE 3: BABA TEMPLE TO SAI NAGAR	5593	26411
		PHASE 4: SAI NAGAR TO BABA TEMPLE	5593	26411
4	NAGOLE	PHASE1 :UPPAL TO LB NAGAR	5593	26411
		PHASE 2: BANDLAGUDA TO KOTHAPET	5593	26411
		PHASE 3: LBNAGAR TO UPPAL	5593	26411
		PHASE 4: KOTHAPET TO BANDLAGUDA	5593	26411

DESCRIPTION OF CORRIDORS:-

For the present study, we have selected the corridors from L.B NAGAR to NAGOLE JUNCTION. The corridor is having with four intersections as L.B NAGAR, KAMINENI, and ALKAPURI & NAGOLE. It is observed that all intersection mentioned above are overloaded with heavy traffic along the corridor. Each intersection having there phases except L.B NAGAR which has four phases. All intersections are provided with traffic signals. The corridor is one of the main junction in the Hyderabad city working the traffic coming from L.B NAGAR cross roads and travel towards UPPAL cross roads. The traffic at intersection is saturated phases the condition of the roads is foundation to be good along the corridor, having the divider at the centre.

DESIGN

LB NAGAR JUNCTION:

CYCLE TIME (Co)

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

L=I-a+i

= 4(8-5)+4(2)

=4(3)+8 = 12+8

=20sec.

$Y_1 = \frac{5593}{26411} = 0.2110$

$Y_2 = \frac{6239}{32053} = 0.1946$

$Y_3 = \frac{5997}{33486} = 0.1790$

$Y = \frac{6465}{22588} = 0.2860$

$Y = Y_1+Y2+Y3+Y4$

= 0.87

$$C_O = \frac{1.5L+5}{1-0.9277}$$

$$= \frac{1.5*20+5}{0.0723}$$

= 269 SEC.

GREEN TIME:

$G_1 = \frac{Y1}{Y}(C_0\text{-}L)$

$$= \frac{0.2110(268-20)}{0.87}$$

=0.24(248)

= 59sec

$G_2 = \frac{Y2(C0-L)}{Y}$

$$= \frac{0.1946(248)}{0.87}$$

= 0.223(248)

= 55sec

$$G_3 = \frac{Y3(C0-L)}{Y}$$

$$= \frac{0.1793(248)}{0.87}$$

=51sec

$$G_4 = \frac{Y4(C0-L)}{Y}$$

$$= \frac{0.2860(248)}{0.87}$$

=81sec

RED TIME:

R1 = Co-(G_1+A)

= 269-(59+5)

= 205sec

R2 = Co-(G_2+A)

= 269-(55+5)

= 209sec.

R3 = C_O-(G_3+A)

= 269-(51+5)

=213sec.

R4 = C_o-(G4+A)

=269-(81+5)

= 183SEC.

KAMINENI JUNCTION:

CYCLE TIME (Co) $= \frac{1.5L+5}{1-Y}$

L=I-a+i

= 4(6-3)+4(2)

=4(3)+8 = 12+8

=20sec.

$Y_1 = \frac{2241}{15600}$ = 0.1430

$Y_2 = \frac{2550}{8708}$ = 0.2928

$Y_3 = \frac{1401}{10337}$ = 0.1355

$Y = \frac{1554}{8100}$ = 0.1906

Y = Y_1+Y2+Y3+Y4

= 0.7624

$C_O = \frac{1.5L+5}{1-0.7624}$

$= \frac{1.5*20+3}{0.2376}$

= 139 SEC.

GREEN TIME:

$G_1 = \frac{Y1}{Y}(C_0\text{-}L)$

$= \frac{0.1430(119)}{0.7624}$

=0.1875(119)

= 22sec

$G_2 = \frac{Y2(C0-L)}{Y}$

$= \frac{0.2928(119)}{0.7624}$

= 0.3840(119)

= 45sec

$G_3 = \frac{Y3(C0-L)}{Y}$

$= \frac{0.1355(119)}{0.7624}$

=21sec

$G_4 = \frac{Y4(C0-L)}{Y}$

$= \frac{0.1906(119)}{0.7624}$

= 29sec

RED TIME:

R1 = Co-(G_1+A)

= 139-(23+3)

= 114sec

R2 = Co-(G_2+A)

= 139-(45+3)

= 91sec.

$R3 = C_O-(G_3+A)$

$= 139-(51+3)$

$=115$sec.

$R4 = C_o-(G4+A)$

$=139-(81+3)$

$= 107$sec.

ALKAPURI JUNCTION:

CYCLE TIME (Co) $= \frac{1.5L+5}{1-Y}$

$L=I-a+i$

$= 4(6-3)+4(2)$

$=4(3)+8 \quad = 12+8$

$=20$sec.

$Y_1 = \frac{2263}{9883} = 0.2289$

$Y_2 = \frac{2094}{14433} = 0.1450$

$Y_3 = \frac{904}{10400} = 0.0869$

$Y4 = \frac{851}{9900} = 0.0859$

$Y = Y_1+Y2+Y3+Y4$

$= 0.5467$

$C_O = \frac{1.5L+5}{1-0.5467}$

$= \frac{1.5*20+5}{0.4533}$

$= 72$ SEC.

GREEN TIME:

$G_1 = \frac{Y1}{Y}(C_0-L)$

$= \frac{0.2289(52)}{0.5467}$

$=0.4186(52)$

$= 21$sec

$G_2 = \frac{Y2(C0-L)}{Y}$

$= \frac{0.1450(52)}{0.5467}$

$= 0.2652(52)$

$= 13$sec

$G_3 = \frac{Y3(C0-L)}{Y}$

$= \frac{0.0869(52)}{0.5467}$

$=8$sec

$G_4 = \frac{Y4(C0-L)}{Y}$

$= \frac{0.0859(52)}{0.5467} = 8$sec

RED TIME:

$R1 = Co-(G_1+A)$

$= 72-(21+3)$

$= 48$sec

$R2 = Co-(G_2+A)$

$= 72-(13+3)$

= 56sec.

R3 = C_O-(G_3+A)

= 72-(8+3)

=61sec.

R4 = C_o-(G4+A)

=72-(8+3)

= 61sec.

NAGOLE JUNCTION :

CYCLE TIME (Co) $= \frac{1.5L+5}{1-Y}$

L=I-a+i

= 4(6-3)+4(2)

=4(3)+8 = 12+8

=20sec.

$Y_1 = \frac{2935}{24345} = 0.1200$

$Y_2 = \frac{855}{15730} = 0.0543$

$Y_3 = \frac{2583}{23068} = 0.1119$

$Y = \frac{813}{15192} = 0.0535$

Y = Y_1+Y2+Y3+Y4

= 0.34

$C_O = \frac{1.5L+5}{1-0.34}$

$= \frac{1.5*20+5}{0.66} =$ 50SEC.

GREEN TIME:

$G_1 = \frac{Y1}{Y}(C_0\text{-}L)$

$= \frac{0.1200(30)}{0.34}$

=0.352(30)

= 11sec

$G_2 = \frac{Y2(C0-L)}{Y}$

$= \frac{0.0543(30)}{0.34}$

= 0.159(30)

= 5sec

$G_3 = \frac{Y3(C0-L)}{Y}$

$= \frac{0.1119(30)}{0.34}$ = 10sec

$G_4 = \frac{Y4(C0-L)}{Y}$

$= \frac{0.0535(30)}{0.34}$

= 5sec

RED TIME:

R1 = Co-(G_1+A)

= 50-(11+3)

= 36sec

R2 = Co-(G_2+A)

= 50-(5+3)

= 42sec.

$R3 = C_O-(G_3+A)$

= 50-(10+3)

=37sec.

$R4 = C_o-(G4+A)$

=50-(5+3)

= 42sec.

PRINCIPLESOF COORDINATED OPERATION:

The decision to use coordination can be considered in a myriad of ways. There are numerous factors used to determine whether coordination would be beneficial establishing coordination is the easiest to justify when the inter sections are in close proximity and there is a large amount of traffic on the coordinated street. The MUTCD provides the guidance that the traffic signals with in 800 meters (0.5miles) of each other along a corridor should be coordinated unless operating on different cycle lengths.

COORDINATION OBJECTIVES:

Coordination large strategic approach to synchronize signals together to meet specific objectives . while there are numerous objectives for the coordination of traffic signals, a common objective is stated succinctly in the national report card. The intent of coordinating traffic signals to provide smooth flow of traffic along streets and highways in order to reduce travel times. Stops and delay(1). A well-timed coordinated system permits continuous movement along an arterial or thorough a network of major streets with minimum stops and delays .which, reduces fuel consumptions and improve air quality(2). Figure6-1 illustrates the concept of moving vehicles thorough a system of traffic signals using a graphical representation known as a time space diagram. The time space diagram will be described to additional detail in later sections of chapter.

TIME DISTANCE METHOD

Band width=the distance b/w two parallel lines obtained from –graph
Saturation flow= no of PCU s passing per hour in a obtained green time.
Speed=distance/time

Caluculations:

Band width : 3.5 cm
Saturation flow: 10377 pcu's /hour
=10377/3600*62
=465.5 pcu's
Speed= distance/time
=400/22
=57.5 KMPH

CONCLUSION

BASED ON OUR STUDY we came to conclusion that the vehicles maintaining the speed of about 57.5Kmph will travel without delay from LB NAGAR to UPPAL as per the received signals timing obtained from Time-distance Graph..

From graph we conclude that the maximum amount of the traffic volumes that passes through these intersection is 465.6 pcu per hour.

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