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Design of Traffic Signal and Pedestrian Signal at Gandimaisamma Intersection, Hyderabad a case study

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ABSTRACT

Traffic management is a major problem at all busy junctions or intersections. The rapid growth of traffic at an intersection might cause problems like road accidents, traffic congestion, conflicts and bottleneck situations. Traffic signals are the most suitable method to monitor and control road traffic at an intersection. It can be achieved by providing automated volume based traffic signal system. Improvement of traffic performance in terms of safe and efficient movement of traffic at road networks and terminals it is done by systematic traffic studies with engineering applications. This includes planning and geometric design on one side and regulating and traffic control on the other. An intersection is a crucial point of conflict and congestion in road networks the capacity of urban road network depends upon traffic signals. The major problems like accidents and hazards can be minimized using proper traffic survey and analysis of geometric studies. A signalized intersection capacity mainly depends up on the following physical factors like roadway width, number of lanes, geometric design, intersection and phases of traffic signal. This research mainly focuses on design of traffic signal, placement of signals, and Pedestrian signal by using approximate design procedures like trial cycle method, approximate method, Webster method and IRC method.

Keywords: Intersection, traffic congestion, traffic signal, Pedestrian signal and geometric design.

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I. INTRODUCTION

Traffic Engineering is a branch of Transportation Engineering which deals with the improvement of traffic performance at broad networks and terminals it can be achieved by the application of scientific principles, tools and techniques for safe and convenient movement of goods and people. Road traffic consists of various categories of vehicular and pedestrian traffic. The vehicular traffic has again has two components first is human as element and his machine as vehicle. The study of traffic engineering is broadly divided into six categories as

Traffic characteristics: Human element is involved in all actions of road users like pedestrian, cyclist or motorist. In this four characteristics like physical, mental, Psychological and Environmental affect the ability of human being to operate motor vehicle safely or to serve as pedestrian.

Traffic studies and analysis: Traffic characteristics are analyzed by traffic surveys or studies. There are various traffic studies like traffic volume study, spot speed study, speed and delay study, origin and destination study, traffic flow characteristic, traffic capacity study, parking study and accident study. This report helps us in geometric design for safe and efficient movement of traffic flow.

Traffic operation control and regulation: To have safe traffic operation traffic control devices, like traffic signals and signs, pavement markings, are used to regulate, warn and guide traffic flow. Traffic regulation and law implemented by legislature is obligatory on all road users which gain control on driver, vehicle, flow regulation and general regulations

Planning and analysis: It mainly consists of design of intersections and parking facility. Traffic efficiency, speed, safety, cost of operation and capacities of road system are influenced by intersection design. These intersections are further classified as unchannelized, channelized and rotary intersection. The pedestrian movement at intersection causes hazards and delay for traffic slow. Vehicle parking deign consists of on street parking (kerb parking) where the vehicles are parked on the kerb which is designed of parking and off street parking here the parking facility is designed and provided at a separate place away from the kerb.

Geometric design: Highway geometric design mainly consists of the following elements like cross sections, sight distances, horizontal and vertical alignments and intersections.

Administration and management: Transport administration and traffic management is to develop various efficient opportunities for transport and travel of business committees by improving safety standards, reducing environmental impact by collecting the information of traffic situation from traffic management centres and also providing guidelinesin particular direction.

II. METHODOLOGY

It mainly consists of two stages

Data collection: It consists of traffic volume survey on daily basis for3 days at peak hours.

Design of traffic signal: It consist of four methods trial cycle method, approximate method Webster's method and IRC method.

Table 1: Traffic data for one day on hourly basis at peak hours

Time	Motor Cycles	Autos	Cars	Buses	Heavy vehicles
7 to 8AM	715	59	450	83	330
8 to 9AM	1527	170	710	221	245
9 to 10AM	1754	243	860	157	386
4 to 5PM	1211	190	690	162	295
5 to 6PM	1081	136	690	128	268
6 to 7PM	892	98	616	101	220

Design of traffic signals by various methods

Trial cycle method: In this method 15 minute-traffic counts n_1 and $n_2$on road 1 and 2 are noted during the design peak hour flow. Some suitable trial cycle C_1 seconds is assumed and the number of the assumed cycles in the 15 minutes or 15 x 60 seconds period is found to be (15 x 60)/C_1 i.e.(900/C_1). Assuming average time headway 2.5 seconds, the green periods G_1 andG_2 of roads 1 and 2 are calculated to clear the traffic during the trial cycle.$G_1= 2.5n_1C_1/900$ and $G_2=2.5n_2C_2/900$.The amber periods A_1 and A_2 are either calculated or assumed suitably (3 to 4 seconds) and the length C_1'is calculated, equal to (G_1 + G_2 + A_1+ A_2) seconds. If the calculated cycle length C_1'works out to be approximately equal to the assumed cycle length C_1, the cycle length is accepted as the design cycle. Otherwise the trials are repeated till the trial cycle length works out approximately equal to the calculated value.

Simple design of pedestrian and traffic signals by approximate method: Based on approach speeds of the vehicles, the suitable, clearance interval between green and red period i.e., clearance amber periods are selected. The amber periods may be taken as 2, 3 and 4 seconds for low, medium and fast approach speeds. Based on pedestrian walking speed of 1.2 m per second, the clearance for pedestrian time is also calculated. Minimum red time of traffic signal is taken as pedestrian clearance time for crossing plus initial interval for pedestrians to start crossing. This red time is equal to the minimum green time plus amber time for the cross road. The minimum green time is calculated based on pedestrian criterion, equal topedestrian clearance time for cross road plus an initial interval when pedestriansmay start to cross minus amber period. This is equal to red time for cross road minus amber period for the cross road.With pedestrian signal the initial interval is the walk period; this should not be less than seven seconds.Where no pedestrian signal is used, a minimum period of five seconds is used as initial interval.The actual green time needed is then increased based on the ratio of approachvolume for the heaviest traffic volume per hour per lane. The cycle length so obtained is adjusted for the next higher 5-second interval. The extra time is thendistributed to green timings in proportion to the approaching volumes of traffic. The values so obtained are calculated on percentage basis if the controller settings are in percent of cycle. The timings so obtained are installed in the controller and the operations are then observed at the site during peak traffic hours. Corrections or modifications are carried out if needed.

Webster's method: In this method, the optimum signal cycle C_0corresponding to least total delay to the vehicles at the signalized intersection has been worked out. This is based on rational approachThe field work consists of finding The saturation flow S per unit time on each approach of the water section and The normal flow q on each approach during the design hour.Based on the higher value of normal flow, the ratio $y_1= q_1/ s_1$ and $y_2= q_2/ s_2$ aredetermined on the approach roads 1 and 2. In the case of mixed traffic, it is necessary to convert all the normal flow and saturation flow values in terms of suitable PCU values which should be determined separately.The saturation flow is to be obtained from careful field studies by noting the number of vehicles in the stream of compact flow during the green phases and the corresponding time intervals precisely. In the absence of data, the approximate value of saturation flow is estimated assuming 160pcu per 0.3metre width of the approach. The normal flow of the traffic is also determined on the approach roads from the field studies for the design period (during the peak or off-peak hours as the case may be).The optimum signal cycle is given by C_0=1.5L+5/1-Y, where L = total lost time per cycle, seconds. =2n+R (n is the number of phase and R is all red-time). Y = y_1+ y_2Then,G_1 = y_1 (C_0-L)/Y andG_2= y_2 (Co-L)/Y.

Design Method as per IRC Guideline The pedestrian green time required for the major and minor roads are calculated based on walking speed of 1.2 m/secondand initial walking time of 7.0 seconds. These are the minimum green time required for the vehicular traffic on the minor and major 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 seconds each.The minimum green time

Required for clearing vehicles arriving during a cycle is determined for each lane of the approach road assuming that the first vehicle will take 6.0seconds. And the subsequent vehicles (PCU) of the queue will be cleared at a rate of 2.0 seconds. The minimum green time required for the vehicular traffic on any of the approaches is limited to 16 seconds.

Webster's formula is used to calculate optimum signal time. The saturation flow values may be assumed as 1850, 1890,1950,2250,2550 and 2990 PCU per hour for the approach roadway widths (kerb to median or Centre line) of 3.0, 3.5, 4.0, 4.5, and 5.0 and 5.5m;for widths above 5.5 m,thesaturation flow may be assumed as 525 PCU per hour per metrewidth. The losttime is calculated from the amber time, inter-green time and the initial delay of 4.0 secs for the first vehicle on each leg.The signal cycle time and the phases are revised to determine optimum cycle length by view the green time required for clearing the vehicles.

III. ANALYSIS

Trial cycle method In this method 15 minute-traffic counts on cross roads l and road 2 during peak hour are observed as144 and 126 vehicles per lane respectively approaching the intersection in the direction of heavier traffic flow. If the amber times required are 3 and 2 seconds respectively for two loads based on approach speeds, design the signal timings by trial cycle method during green phase assume average time headway as 2.5seconds.

Table 2: Calculation for trail cycle length

Trial	Assumed trial cycle length (L) in seconds	Number of cycles in 15 minutes (x=15*60/L)	Number of vehicles on road1(n_1)	Number of vehicles on road2 (n_2)	Green time for road 1 in seconds $G_1=n_1*2.5/x$	Green time for road 2 in seconds $G_2=n_2*2.5/x$	Total cycle length in seconds $T=G_1+G_2+A_1+A_2$
1	60	900/60=15	144	126	144x2.5/15=24.0	126x2.5/15=21.0	24.0+21.0+3.0+2.0 =50.0
2	55	900/55=16.3	144	126	144x2.5/16.3=22.0	126x2.5/16.3=19.3	22.0+19.3+3.0+2.0 =46.3
3	50	900/50=18	144	126	144x2.5/18=20.0	126x2.5/ 18=15.7	20.0 +15.7 +3.0+2.0 =40.7
4	45	900/45=20	144	126	144x2.5/20=18.0	126x2.5/ 20=15.7	18.0 +15.7 +3.0 +2.0 =38.7
5	40	900/40=22.5	144	126	144x2.5/22.5=16.0	126x2.5/ 22.5=14	16.0 +14.0 +3.0 +2.0 =35.0
6	35	900/35=25.7	144	126	144x2.5/25.7=14.0	126x2.5/25.7=12.2	14.0 +12.2 +3.0 +2.0 =31.2
7	30	900/30=30	144	126	144x2.5/30=12.0	126x2.5/ 30=10.5	12.0 +10.5 +3.0 +2.0 =27.5
8	25	900/25=36	144	126	144x2.5/36=10.0	126x2.5/ 36=8.7	10.0 +8.7 +3.0 +2.0 =23.7
9	20	900/20=45	144	126	144x2.5/45=8.0	126x2.5/ 45=7.0	8.0+7.0+3.0+2.0 = 20.0

The trial cycle of 20 secondsis adopted with the following signal phases

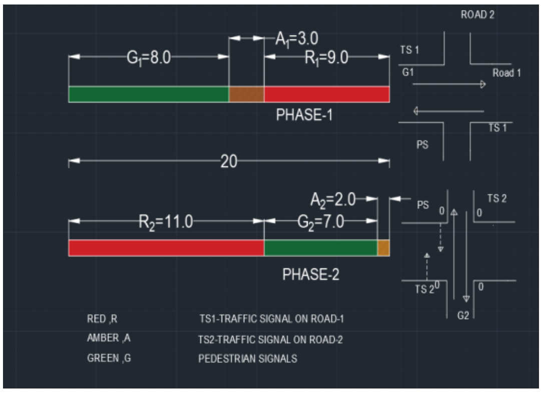

Fig1.Designed traffic signal cycle length for 20 seconds by trail cycle method

Simple design of pedestrian and traffic signals by approximate method

An isolated signal with pedestrian's indication is to be installed on a right angled intersection with road A 14.4 m wide and. road B,7 m wide. The heaviest volume per hour for each lane of road A and road B are 1240 and 1080, respectively. The approach speeds are 50 and 40 kmph, for A and road B respectively. Design the timings of traffic and pedestrian signals.

Design of traffic signals

It is mainly based on the approach speed and amber periods:

Table 3: Calculation for minimum green time

Design of traffic signals	Road A	Road B
Approach speed in Kmph	55.0	40.0
Amber period in seconds	4.0	3.0
Pedestrian clearance time in seconds=(Road width/pedestrian walking speed)	14.4/1.2=12.0	7/1.2 =5.83
Adding 7 secs for initial walk-period	12+7.0=19.0	5.83+7.0 =12.83
Minimum green times based on pedestrian criterion in seconds	12.8-4= 8.8	19-3 = 16.0

Based on approach volume, the green time calculated is increased for Road A with higher traffic volume.Using relationG_A/ G_B = n_A/n_B. G_A and G_B are green timesfor road A and road Bsimilarlyn_A and n_B are approach volume per lane for road A and road B.

Calculation of Green time for Road A (G_A)

G_B is taken as 16 seconds.

$G_A = (n_A / n_B)* G_B$

G_A= (1240/1080)*16=18.37sec

Total cycle length=$G_A+A_A+G_B+A_B$= 18.37+4.0+16.0+3.0=41.37secs.

Hence adopt cycle length of 42secs.

The additional period of 42-41.37=0.63 secs is distributed to green timings in proportion to approach traffic volume.

G_A = (GA + additional time) ×nA/(nA + nB)

G_A = (18.37+0.63) ×1240/ (1240+1080) =18.57secsand G_B = (16+0.63)*1080/ (1240+1080) =16.29secs.

$R_A = G_B + A_B$=16.29+3.0=19.29secs and

$R_B = G_A + A_A$=18.57+4.0=22.57secs.

Design of pedestrian signal

Do not Walk (DW) period of pedestrian signal at road A (PS_A) is red period of traffic signal at B.

Pedestrian signal at road A (PS_A): DWA = R_B=22.57secs.

Pedestrian signal at road B (PS_B): DW_B= R_A=19.20secs.

Pedestrian clearance intervals (CI) are of 12 and 5.83 secs.Respectively, for roads A and B

The walk time (W) is calculated from total cycle length.

For PS_A: W_A =42-(22.57+12) =7.43secs.

For PS_B: W_B= 42-(19.29+5.83)=16.80secs.

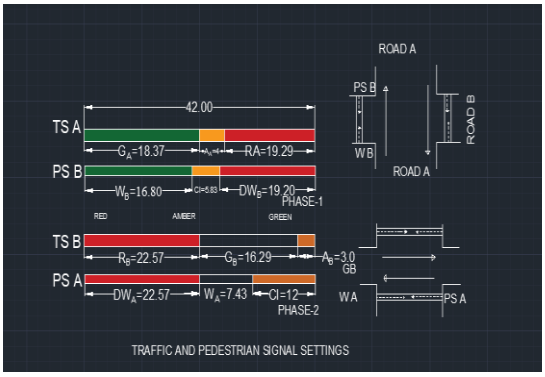

Fig2. Traffic and pedestrian signal by approximate method

Webster's method

The average normal flow of traffic on cross roads A and B during design period are 1756 and 1216 PCU per hour the saturations flow values on these roads are estimated as 7680 and 3730 PCU. Per hour respectively the all-red time required for pedestrian crossing is 12 secs. Design two phase traffic signal by Webster's method.

Calculation of traffic flow ratio along road A,

$Y_a = q_a/ s_a$ =1756/7680 =0.22

Normal flow for road A= q_a

Saturation flow for road A= s_a

Calculation of traffic flow ratio along road B,

$Y_b = q_b/ s_b$=1216/3730=0.32

Normal flow for road B= q_b
Saturation flow for road B= s_b
Total traffic flow ratio along road A and road B,
$Y = Y_a + Y_b = 0.22+0.32 = 0.54$
Calculation for total lost time per cycle (L)= 2n+R=2(2)+12 =16 secs.
Where n=number of phases
R= R is all red-time
The optimum signal cycle (C_0) =1.5L+5 /1-Y =1.5(16)+5/1-0.54 =63 secs.
Green time for road A (G_a) = y_a (C_0-L)/Y =0.22(63-16)/0.54=19.14 secs.
Green time for road B (G_b)=y_b(Co-L)/Y=0.32(63-16)/0.54=26.85secs.
Consider red time for pedestrian as crossing 12 secs Providing Amber times of 2.0 secs each for clearance, total cycle time=19.14+26.85+12+4= 62 secs.

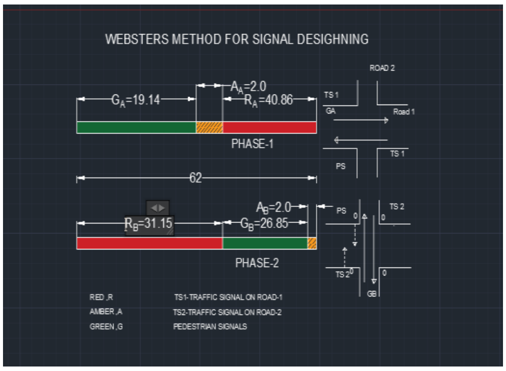

Fig 3.Traffic signal by Webster method

Design Method as per IRC Guideline

At a right angled intersection of two roads, Road A has four lanes with a total width of14.40 m and Road B has two lanes with a total width of 7.0 m. The volume of traffic approaching the intersection during design hour are 1080 and 677 PCU/hour on the two approaches of Road A and 620 and 597 PCU/hour on the two approaches of Road B.Design the signal timings as per IRC guidelines.
Design traffic on road A = higher of the two approach volume per lane = 1080/2=540 PCU/hr.
Design traffic on road B=620 PCU/hr
Pedestrian green time for Road A=14.4/1.2+7 =19.0sec
Pedestrian green time for Road B= 7/1.2+7 =12.8secs.
Green time for vehicles on Road B, G_B= 19secs.
Green time for Road A, G_A= 19*540/620=16.5secs. adding 2.0 secs. each towards clearance amber and 2.0 secs.inter-green period for each phase, total cycle time required =(2+19+2)+(2+16.5+2) =43.5secs.

Signal cycle time may be conveniently set in multiples of five seconds and so the cycle time =55secs.
The extra 2.5 secs per cycle may be apportioned to the green times of Roads A and B,as 1.5 and 1.0 secsand so G_A=16.5+1.5 =18secs.G_B=19+1.0 =20secs.
Vehicle arrivals per lane cycle on Road A=540/55 =9.8PCU
Minimum green time for clearing vehicles on Road A= 6+(9.8-1.0)2=23.6secs.
Vehicle arrivals per cycle on Road B = 620/55 =11.3PCU
Minimum green time for clearing vehicles on Road B=6+(11.3-1.0)2=26.6secs.
As the green time provided for the two roads by pedestrian crossing criteria in(ii)above are higher than these values, the above design values are alright.
Lost time per cycle= (amber time+ Inter-green time +time lost for initial delay of first vehicle) for two phases=(2+2+4) ×2=16 sec.
Saturation flow for Road A =525*7.2=3780 PCU/hr
Saturation flow for Road B = 1890PCU/hr
Y_A=1080/3780 =0.28and y_B=620/1890 =0.32
Y = y_A+ y_B=0.28+0.32 =0.60sec
Optimum cycle time (C_0) =1.5L+5 /1-Y =1.5*16+5/1-0.60=56.25

Table 4. Total cycle length for road A and road B by IRC method

Road	Green	Amber	Red	Cycle
A	18	2	33+2	55
B	20	2	31+2	55

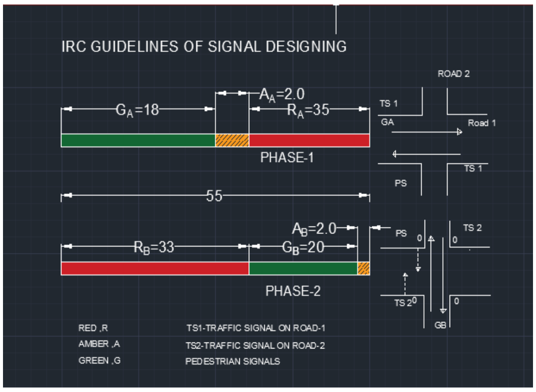

Fig 4. Traffic signal design using irc guidelines.

IV. CONCLUSIONS

Based upon 15 minutes traffic count on cross roads 1 and 2 during peak hours. The designed signal timings by the trail cycle method are 20 seconds. Green time for road 1 and road 2 are 8.0seconds and 7.0 seconds with amber time for road 1 and road 2 as 3.0 seconds and 2.0 seconds respectively.

The design timings of traffic signal by the approximate method for one-hour traffic count on road A and road B during peak hours are 42seconds and the designed pedestrian signal on road A for Do-not walk and walk periods are 22.57 seconds and 7.43 seconds similarly for road B Do-not walk and walk periods are 19.20 seconds and 16.80 seconds.

From Webster's the total cycle time is 62 seconds with green time along road A and road B are 19.14 seconds and 26.85 seconds with pedestrian crossing and amber time as 12 seconds and 4 seconds respectively.

According to IRC method the designed cycle time for road A and road B is 55 seconds.

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