Orchestration of Traffic Lights in the Planned Cities

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Abstract: Traffic Problem is continuously increasing around the world, especially in the planned cities. The growth of road traffic in India is at a very rapid pace due to industrial growth and socio-economic changes in the society. In this paper study has been carried out in a planned city like Chandigarh(India) in order to regularise the flow of traffic and to reduce the accidents, and minimize cumulative traffic delay period. For study purpose one of the critical intersection(PU-PGI) has been selected in the city .The main aim of this study is to critically examine this intersection and suggest improvement in their management.

Key words- Traffic, intersection, pavement.

I. INTRODUCTION:

Traffic studies or surveys are carried out to analyse the traffic characteristics at a specific problem location or as basic planning data for an urban area as a whole. These studies help in deciding the geometric features and traffic controls for safe and efficient traffic movements. In addition they help in deciding the measures to be adopted for the improvement of an inefficient or faulty traffic facility.
Field traffic studies which have been carried out for the purpose of the present study are:

i) Traffic volume studies
ii) Traffic speed studies.

1.1 Traffic volume studies

Traffic volume or traffic flow is the number of vehicles crossing a section of road during certain period of time (hour, day, month, year). Acknowledge of the vehicular volume using a road network is important for understanding the efficiency at which the system works at present and the general quality of service offered to the users Knowing the flow characteristics, one can easily determine whether a particular section of the road is handling traffic much above or below its capacity

1.2 Purpose of the study

The objects and uses of traffic volume study are :

1) Traffic volume study is used in planning traffic operation and control of existing facilities and also for planning and designing the new facilities.
2) To determine the composition and amount of traffic on a system of roads that is accepted as a true measure of the relative importance of roads and in deciding the priorities for improvement and expansion.
3) Turning movement study is used in the design of intersection, in planning signal timings, channelization and other control devices.
4) Classified volume study is useful in structural design of pavement, in geometric design and in computing roadway capacity.
5) This study is used in the analysis of accident data, traffic pattern and trends.

II. ANALYSIS OF TRAFFIC VOLUME STUDY OF PU-PGI STAGGERED INTERSECTION

Volume study is helpful in understanding the traffic characteristics. The volume study has been carried out by manual method for the period of 7:30 AM to 7:30 PM on different working days. Data is collected for the total traffic entering from the different legs of intersection. By collecting the data a comparative study of traffic behaviour at all the legs of intersection was done. The graph presented gives the detailed description about the variation of traffic flow. A bar chart presented gives the contribution of traffic volume flow of four legs of intersection. From the collected Data and plotted graphs following information may be derived.

1. There are three distinct peak hours i.e. morning, noon and evening peak hours (8:30 AM to 9:30 AM, 12:30 PM to 1:30 PM and 4:30 PM to 5:30 PM). The morning peak hour may because of college, school and office timing. The noon peak hour may be due to lunch time or finishing of school and college. The evening peak hour may be due to off time college, PU, PGI and office.
2. The traffic was found to be maximum i.e. 3605 PCU/hr between 8:30 AM to 9:30 AM and then decreases to 2694 PCU/hr. It again increases to 3142 PCU/hr. between 12:30 PM to 1:30 PM and again decreases to 2615 PCU/hr between 2:30 PM to 3:30 PM. It is again increase to 3079 PCU/hr during evening peak hour and after that it continuously decreases.
3. The maximum traffic coming from roundabout (sector 11, 12, 14, and 15) is 1410 PCU/hr during morning peak hours and then it is almost constant ranging between 1157 PCU/hr to 1054 PCU/hr throughout the day.
4. The maximum traffic coming from Mullapur side is 1097 PCU/hr for the period of 8:30 AM to 9:30 AM and then continuously decreases to 541 PCU/hr till 4:30 AM and then slightly increases to 589 PCU/hr.

5. The traffic coming from PGI increases from 451 PCU/hr (7:30 AM to 8:30 AM) to 798 PCU/hr (12:30 PM to 1:30 PM).. The maximum traffic is 927 PCU/hr during evening peak hours (4:30 PM to 5:30 PM).
6. The flow of traffic coming from PU remains almost constant and gets to maximum value of 588 PCU/hr during noon peak hour (12:30 PM to 1:30 PM).

The traffic is found out to 3605 PCU/hr for the period of 8:30 AM to 9:30 AM from the collected data. So, for analysis and discussion, this period have been considered. The detail description for the period of 8:30 AM to 9:30 AM . Traffic flow diagram is also shown which gives the various details of traffic movement at the given intersection.

The percentage of traffic entering form different legs to different direction is shown in table .

Table 1.1 Traffic movement in different direction

Approach	Left turning	Straight	Right
Roundabout	25.11	40.35	34.5
Mullapur	10.75	76.2	13
PGI	77.05	17.7	5.25
PU	5.4	47.10	47.4

The percentage of left turning from PGI side is maximum i.e. 77.05%. This is due to high traffic of patients with their kiths & kins going to Chandigarh side. Therefore, a slip road near PGI gate may be provided to take care of high volume of left turning traffic which will helpful to lesson the burden on intersection. The percentage of right turning traffic from roundabout side is maximum i.e. 34.5% due to location of PGI. 77.05% of the traffic coming from Mullanpur side is straight moving, as Mullanpur side being on outskirts of the city, therefore most of the traffic entering to Chandigarh comes from this route. The traffic entering from PU is 5.4% left turning, and 47.4% right turning, goes to Chandigarh side. Remaining 50% traffic goes to PGI. This may be due to students follow the inner road of PGI to go towards geri route.

Table 1.2 Traffic entering in different direction from different approach

Approach	Left	Straight	Right	Total traffic
Roundabout	9.9	14.9	13.9	38.7
Mullapur	3.1	23.9	3.6	30.6
PGI	12.5	2.8	8	14.1
PU	0.4	7.2	7	14.6
Total Traffic	25.9	14.8	25.3	100

Note: The straight traffic coming from PGI & PU left turning for intersection 1&2 respectively, thereafter left Turing traffic is (25.9+10.0)36.9% and right turner for intersection 2&1 respectively,, therefore right turning traffic is(25.3+10.0) 35.3%.

The table 1.2 shows that maximum traffic on roundabout Mullapur road which is 69.3% (1410+1097). 38.8% of total traffic is straight traffic on the roundabout Mullapur road. This shows that there is to & fro movement of vehicles. This is due to the working people, students, employees etc. go to their destination point during morning hours. The other reason may be the contribution of CTU buses runs to & fro at this intersection.

A careful analysis shows that there is large contribution of slow moving vehicles. The percentage of slow moving vehicle on all the legs of intersection has been present in table 5c.

Table 1.3 Slow moving vehicle (%)

Approach	Percentage of slow moving vehicles
Roundabout	11
Mullapur	28
PGI	24
PU	22

The maximum slow moving traffic is entering from Mullapur side i.e. 28%. This large number of slow moving vehicles may be because of lower class people or labour comes to Chandigarh for their work.

2.1 Predicted traffic volume

The volume has been predicted assuming 10% growth in traffic using the relation.

A = $P(1+r)^{n+Y}$
A = Predicted traffic volume
P = Present traffic volume (3605 PCU/hr)
R = Growth rate of traffic (10%)
Y = No. of years from the percent year to the predicted year

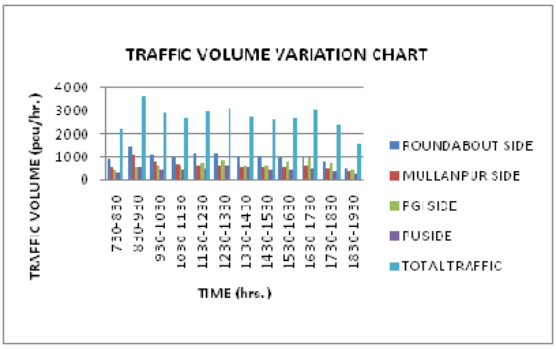
For Year 2016

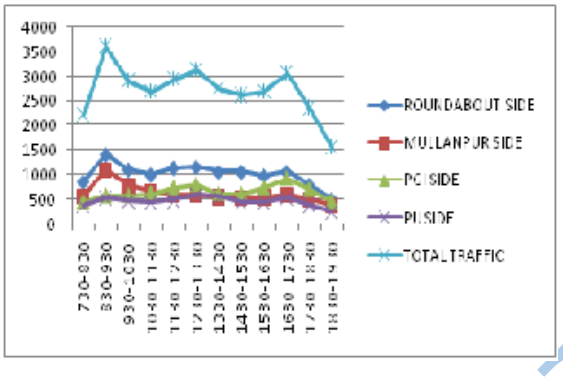
A = $P(1+r)^{n+5}$
= $3605\ (1+.1)^5$
= 5805 PCU/hr

For Year 2021

A = $P(1+r)^{n+10}$
= $3605(1+1)^{10}$
= 9350 PCU/hr

From the field studies, the traffic volume was found to be 3605 PCU/hr for the period of 8:30 AM to 9:30 AM. The right turning traffic is 36%, which is more than that of maximum limit prescribed by IRC i.e. 15% for unsignalised intersection. This much of traffic and right turning traffic is one of important reasons of getting the intersection congested, conflicted and unsafe. The traffic cannot be handled smoothly and safely by any other devices such as road sign, road marking, manually operated device (police control) etc. In coming years, the traffic is bound to increase exponentially. The predicted traffic volume for the year 2006 and year 2011 assuming 1 0% growth in traffic may be found out as 5805 PCU/hr and 9350 PCU/hr respectively. Thus, in order to take care of present and future traffic, signals are considered to be the best alternative.





III. Design of Signal Timings at Unsignalised PU-PGI Staggered Intersection

3.1 Design of Signal timings

PGI-PU staggered intersection consists of two T-intersections. For design purposes these to T-intersections have to be designed separately PGI leg to the intersection is taken as intersection I and PU leg of the intersection as intersection 2. The three phrases that exists at intersection I are:

Phase I : Mullapur Road Side

Straight towards Roundabout, Left towards PGI & Straight towards Mullapur road side from Roundabout.

Phase II : PGI Side

Left towards Roundabout, Right towards Mullapur road side & Left from Mullapur road side.

Phase III: 11, 12, 14 & 15 Roundabout Side

Straight towards Mullapur road side, Right towards PGI & Left from PGI. Similarly phasing existed at interaction 2 are.

Phase I: Roundabout Side

Straight towards Mullapur road side, Left towards PU & Straight towards Roundabout from Mullapur road side.

Phase II: PU Side

Left towards Mullapur road side, Right towards Roundabout & Left from Roundabout.

Phase III: Mullapur Road Side

Straight towards Roundabout, Right toward PU & left from PU.

6.2.1 Calculation of Saturation flow

Saturation flow for traffic from different roads in PCUs/Hour has been worked out taking into account the good side characteristics and as such saturation flow values has been taken as 120% of the standard value.

Intersection – 1 (PGI Side)

1. Lane A_1 from Mullapur road side
   Average width = 10m
   Saturation Flow S_1 = 1.2 x 525 x w
   = 1.2 x 525 x 10
   = 6300 PCUs/Hour
2. Lane B_1 from PGI side
   a) Right turning traffic

$$S_2 = \frac{1800}{1+1.52/r} \times 1.2 \text{ (Single File Stream)}$$

As per IRC recommendations and site conditions turning
radius (r) = 15m

$$S_2 = \frac{1800}{1+1.52/15} \times 1.2$$

S_2 = 1961 PCUs/Hour

   b) Straight and Left turning traffic
   Average width = 7.5m
   S_2 = 1.2 x 525 x w
   S_2 = 1.2 x 525 x 7.4
   = 4725 PCUs/Hour

3. Lane C1 from Roundabout side
   a) Right Turning Traffic

$$S_3 = \frac{3000}{1+1.52/r} \times 1.2 \text{ (Double File Stream)}$$

As per IRC recommendations and site conditions turning
radius (r) = 15m

$$S_3 = \frac{3000}{1+1.52/15} \times 1.2$$

S_3 = 3269 PCUs/Hour

   b) Straight traffic towards Mullapur road side
   Average Width = 10.0m
   S_3 = 1.2 x 525 x w
   S_3 = 1.2 x 525 x 10.0
   = 6300 PCUs/Hour

Intersection – 2 (PU Side)

1. Lane A_2 from Roundabout side
   Average width = 10m
   S_1 = 1.2 x 525 x w
   S_1 = 1.2 x 525 x 10.0
   = 6300 PCUs/Hour
2. Lane B_2 from PU side

a) Right turning traffic

$$S_2 = \frac{1800}{1+1.52/r} \times 1.2 \text{ (Single File Stream)}$$

As per IRC recommendations and site conditions turning
radius (r) = 15m

$$S_2 = \frac{1800}{1+1.52/15} \times 1.2$$

S_2 = 1961 PCUs/Hour

b) Straight and Left turning traffic

Average width = 7.5m

S_2 = 1.2 x 525 x w

S_2 = 1.2 x 525 x 7.4

=4725 PCUs/Hour

3. Lane C3 from Mullapur road side

a) Right turning traffic

$$S_3 = \frac{1800}{1+1.52/r} \times 1.2 \text{ (Double File Stream)}$$

As per IRC recommendations and site conditions turning radius (r) = 15m

$$S_3 = \frac{1800}{1+1.52/15} \times 1.2$$

S_3 = 1961 PCUs/Hour

c) Straight and Left turning traffic

Average width = 7.5m

S_3 = 1.2 x 525 x w

S_3 = 1.2 x 525 x 7.4

= 6300 PCUs/Hour

Calculation of y value

Table1.4 Intersection – 1 (PGI SIDE)

From	**Mullapur Road Side**			**PGI Side**			**Roundabout Side**		
To	L	S	R	L	S	R	L	S	R
Present traffic flow pcu/hr	118	836 1443	-	1014 40	-	30	-	569 29	472 248
Correction for left turner (+25%)	30			136					
Phase I Total flow (q_1)	1127						598		
Saturation flow (s_1)	6300						6300		
Y value $Y_1 = q_1/s_1$	0.18						0.094		
Phase II Total flow (q_2)	148			677 30					
Saturation flow (s_2)	6300			4725 1961					
Y value $Y_2 = q_2/s_2$	0.02			0.14 0.015					
Phase III Total flow (q_3)				677			598 739		
Saturation flow (s_3)				4725			6300 3269		
Y value $Y_3 = q_3/s_3$				0.14			0.0894 0.22		

Table 1.5 Intersection – 2 (PU SIDE)

From	**Roundabout**			**PU Side**			**Mullapur Road**		
To	L	S	R	L	S	R	L	S	R
Present traffic flow pcu/hr	354	569 487	-	2925 2	-	246	-	836 440	143 101
Correction for left turner (+25%)	89			71					
Phase I Total flow (q_1)	1499						1276		
Saturation flow (s_1)	6300						6300		
Y value $Y_1 = q_1/s_1$	0.23						0.20		
Phase II Total flow (q_2)	443			352 246					
Saturation flow (s_2)	6300			4725 1961					
Y value $Y_2 = q_2/s_2$	0.066			0.074 0.13					
Phase III Total flow (q_3)				352			1276 244		
Saturation flow (s_3)				4725			6300 1961		
Y value $Y_3 = q_3/s_3$				0.074			0.20 0.124		

3.2.1 Calculation of Optimum Cycle Length

INTERSECTION – 1 (PGI SIDE)

Based on the approach speed at the Intersection and as per British Practice, the following assumptions can be made:

Inter Green Period 1 = 4 seconds

Amber Period a = 3 seconds

Time Lost due to starting delays 1 = 2 seconds per phase

Total lost time per cycle L is calculated below:

$L = \sum (I-a) + \sum 1$

L = 3 (4-3) + 3x2 (Number of phases = 3)

L= 9 seconds

Optimum cycle length Co is calculated below:

$$Co = \frac{1.5\,L + 5}{1 - Y_1 - Y_2 - Y_3}$$

$$Co = \frac{1.5 \times 9 + 5}{1 - 0.17 - 0.14 - 0.22}$$

Co= 40.21 seconds
Co = 40 seconds

IV. INTERSECTION – 2 (PU SIDE)

Based on the approach speed at the Intersection and as per British Practice, the following assumptions can be made:
Inter Green Period 1 = 4 seconds
Amber Period a = 3 seconds
Time Lost due to starting delays 1 = 2 seconds per phase
Total lost time per cycle L is calculated below:
L = ∑ (I-a) + ∑1
L = 3 (4-3) + 3x2 (Number of phases = 3)
L= 9 seconds
Optimum cycle length Co is calculated below:

$$Co = \frac{1.5\,L + 5}{1 - Y_1 - Y_2 - Y_3}$$

$$Co = \frac{1.5 \times 9 + 5}{1 - 0.22 - 0.12 - 0.197}$$

Co= 42.04 seconds ~ 42 seconds

3.2.1 Green time apportionment

Now appropriate green time for each phase shall be computed. It has been found that least delay occurs when the effective green time for each phase is proportional to its Y Value. The above rule gives:

$$g = \frac{Yn}{Y_1 + Y_2 + \ldots\ldots + Yn} \times (Co - L)$$

Co = Optimum Cycle Length
L = Total Lost Time per Cycle
Co-L = Effective Green Time

INTERSECTION – 1 (PGI SIDE)

Phase 1

$$g_1 = \frac{Y_1}{Y_1 + Y_2 + Y_3} \times (Co - L)$$

$$g_1 = \frac{0.17}{0.53} \times (39 - 9)$$

g_1 = 9.6 sec ~ 10 sec

Phase II

$$g_2 = \frac{Y_1}{Y_1 + Y_2 + Y_3} \times (Co - L)$$

$$g_2 = \frac{0.14}{0.53} \times (39 - 9)$$

g_1 = 7.9 sec ~ 8 sec

Phase III

$$g_3 = \frac{Y_1}{Y_1 + Y_2 + Y_3} \times (Co - L)$$

$$g_3 = \frac{0.22}{0.53} \times (39 - 9)$$

g_3 = 12 sec

Minimum Green Time governed by the need the pedestrians at this intersection taking the widest approach of the intersection to reach the refuge is calculated as follows.
Pedestrian Speed = 1.2m/sec
Time to cross 10.0m wide approach = 10.0/1.2 = 8.4 sec
Additional initial starting interval of 7 seconds as per IRC recommendations is given.
Therefore, Maximum Time required by pedestrians to cross the widest road
= 8.4 + 7 = 15.4 sec
Total time = 15 sec
Here Green Time required by pedestrians is less than the time available based on the traffic criterion, so there is no need to give more time to pedestrians.
As per IRC guidelines, the minimum green time required for the vehicular traffic on any of the approached is limited to 16 sec. Therefore, increase green time to 16 sec. Hence,
g_1 = 16 Sec
g_2 = 16 Sec
g_3 = 16 Sec
Taking Amber period as 3 seconds after each green time.
New cycle length = 16 + 3 + 16 + 3 + 16 + 3
= 57 sec
As per H.M.S.O "Technical paper Number 56" the cycle length is in between 0.75 Co to 1.5 Co. Hence, the delay will not more 10 to 20% above that given by optimum cycle. Total green time including Amber Time are:
Gn = gn + 2
G1 = 16 + 2 = 18 sec
G2 = 16 + 2 = 18 sec
G3 = 16 + 2 = 18 sec
Controller setting for various phases: Gn – a

Phase I : **18 – 3 = 15 sec**

Phase II : **18 – 3 = 15 sec**

Phase III : **18 – 3 = 15 sec**

The timing and phasing diagrams are given in figure 6.1

INTERSECTION – 2 (PU SIDE)

Phase 1

$$g_1 = \frac{Y_1}{Y_1 + Y_2 + Y_3} \times (Co - L)$$

$$g_1 = \frac{0.22}{0.537} \times (40-9)$$

g_1 = 12.7 sec ~ 13 sec

Phase II

$$g_2 = \frac{Y_1}{Y_1+Y_2+Y_3} \times (Co-L)$$

$$g_2 = \frac{0.12}{0.537} \times (40-9)$$

g_1 = 6.9 sec ~ 7 sec

Phase III

$$g_3 = \frac{Y_1}{Y_1+Y_2+Y_3} \times (Co-L)$$

$$g_3 = \frac{0.197}{0.537} \times (40-9)$$

g_3 = 11.3 sec ~ 11 sec

Minimum Green Time governed by the need of the pedestrians at this intersection taking the widest approach of the intersection to reach the refuge is calculated as follows.

Pedestrian Speed = 1.2m/sec

Time to cross 10.0m wide approach = 10.0/1.2 = 8.4 sec

Additional initial starting interval of 7 seconds as per IRC recommendations is given.

Therefore, Maximum Time required by pedestrians to cross the widest road

= 8.4 + 7 = 15.4 sec

Total time = 15 sec

Here Green Time required by pedestrians is less than the time available based on the traffic criterion, so there is no need to give more time to pedestrians.

As per IRC guidelines, the minimum green time required for the vehicular traffic on any of the approached is limited to 16 sec. Therefore, increase green time to 16 sec. Hence,

g_1 = 16 Sec

g_2 = 16 Sec

g_3 = 16 Sec

Taking Amber period as 3 seconds after each green time.

New cycle length = 16 + 3 + 16 + 3 + 16 + 3

= 57 sec

As per H.M.S.O "Technical paper Number 56" the cycle length is in between 0.75 Co to 1.5 Co. Hence, the delay will not more 10 to 20% above that given by optimum cycle. Total green time including Amber Time are:

Gn = gn + 2

G1 = 16 + 2 = 18 sec

G2 = 16 + 2 = 18 sec

G3 = 16 + 2 = 18 sec

Controller setting for various phases: Gn – a

Phase I : 18 – 3 = 15 sec

Phase II : 18 – 3 = 15 sec

Phase III : 18 – 3 = 15 sec

The timing and phasing diagrams are given in figure 6.2.

3.2.3 Interlinking in design of signal

This staggered intersection is divided into two-T-intersection intersection 1 (PGI side) and Intersection 2 (PU side). The phase signal timing has been designed separately. If these T-intersection are not co-ordinated, there would be queuing of vehicles, congestion and delay. In order to avoid queuing of vehicles, reduce delay to traffic and smooth flow of traffic, these T-intersections should be interlinked. The green time for each of the phase was found out to be same i.e. 16 sec. The inner to inner distance between the intersection is 23m and centre to centre distance is 44 m. If a vehicle move at a speed at 45 kmph, there is only 3.5 sec required to cross this intersection. Since green time is same for each of the phase and distance is very less, the simultaneous system signal for interlinking is suitable and used. In this system, signal along controlled section display the same aspect to the same stream at the same time. Thus, phase I, II, and III of Intersection 1 interlinked with phase I, II and III of Intersection 2 respectively.

3.3 Geometric Design of the Intersection

3.3.1 Approach width

In order to pass the required flow smoothly it is necessary for the intersection approaches where queuing taken place to be order than the road which feed these approaches.

For a T-function with two phase control, the extra width required for both minor & major approaches are proportioned to the flows as under:

$$\frac{w_1}{w_2} = \sqrt{\frac{q_1}{2q_2}}$$

Where W_1 & W_2 are the major road width & minor road width respectively and q_1 & q_2 are the traffic on major road & minor road respectively.

INTERSECTION – 1

$$\frac{w_1}{w_2} = \sqrt{\frac{q_1}{2q_2}}$$

W_1 = width of major road coming from Mullapur side

W_2 = width of minor road coming from PGI

q_1 = maximum traffic flow on W_1 (1097)

q_2 = maximum traffic flow on W_2 (927)

Therefore,

$$\frac{W_1}{W_2} = \sqrt{\frac{1097}{2 \times 927}} = .77$$

INTERSECTION – 2

$$\frac{w_1}{w_2} = \sqrt{\frac{q_1}{2q_2}}$$

W_1 = width of major road coming from Roundabout side
W_2 = width of minor road coming from PU
q_1 = maximum traffic flow on W_1 (1410)
q_2 = maximum traffic flow on W_2 (588)

Therefore,

$$\frac{W_1}{W_2} = \sqrt{\frac{1410}{2 \times 588}} = 1.09$$

From above it can be seen that staggered roads should be as wide as roundabout – Mullapur road.

3.3.2 Entry, Exit and Right Turning radii

Refering to IRC specification it is proposed to provide

Entry radius	=	25m
Exit radius	=	50m
Right turning radius	=	15m

These radii will help drivers to clear the intersection safely and rapidly.

V. CONCLUSION

After studying the traffic behaviour of the chosen location, following conclusions and recommendations have drawn:

1. Due to heavy traffic during peak hours and higher percentage of right turning, lock up occurs at the intersection. The present maximum traffic volume at the intersection is found out to be 3405 pcu/hr with 36% right turning traffic for the morning peak hours between 8:30 AM to 9:30 AM.

So, in order to avoid locking up of the intersection, traffic signals have been recommended. The signal timing is provided with amber time of 3 sec & red/amber time of 2 sec. The details of signal timings are given in table.

Table 1.6

Intersection	Side	Phase	Signal	Time (Sec)
1.(PGI side)	Mullapur	I	Green Red	15 37
	PGI	II	Green Red	15 37
	Roundabout	III	Green Red	15 37
2.PU (Side)	Roundabout	I	Green Red	15 37
	PU	II	Green Red	15 37
	Mullapur	III	Green Red	15 37

2. It has been observed from the studies that about 3% of the traffic coming from PU is left turning, goes to Mullapur side and 47% traffic is right turning, goes to roundabout. The remaining 50% traffic goes to PGI, which is right turning traffic for intersection 1 (PGI side).

It is thus, recommended that closing the gate No. 2 of PU at least during peak hours i.e. 8:30 AM to 10:30 AM, 12:00 Noon to 2:00 PM & 4:30 PM to 5:30 PM and diverting the entire traffic to the other gate (No. 1 & No. 3) will result in large scale reduction in traffic and hence reduction of accidents. With closing the gate, no signal will be required to be installed for the present traffic. This is due to consideration of PGI Emergency block located near the intersection. Serious patients rushing to PGI in the need of immediate medical help may have to be stopped at the signalized intersection waiting for green phase. As such, closing the gate No. 2 of PU during peak hours may be proved as an alternative solution to proposed signalized intersection.

3. It was observed that the percentage of left turning traffic coming out form PGI is 78% which is very high

Slip roads are recommended to be provided along the exit of PGI. This will help in reducing the congestion caused by vehicles coming from PGI.

4. It was observed during the survey that the bus terminal on the left of PGI is 66m away from the intersection 1 (PGI side) and only about 22m away from intersection 2 (PU side), whereas the minimum distance recommended by IRC is 75m from the intersection. Also it has been observed from the studies carried out that the number of buses moving to & fro from bus terminal are about 420 in 12 hours. Thus the frequency of buses moving is about 35 buses in one hour, which is quite high.

Since the presence of bus terminal is a constant source of congestion and frequency of buses is also quite high, it is thus recommended to move the bus terminal to right of PGI a least 75m away from intersection 1 (PGI side).

5. Out of the total traffic coming from Mullapur side, 28% of the vehicle contribute to cyclists. Since there is a provision of providing to separate lane for such vehicle coming from Mullapur side, this will ensure the safety and reduce the chances of accidents to a large extent.
6. The intersection is divided into two T-intersections each having 3 phases. The signal timing is same for all the phases and distance is also very less (44m). So, interlinking of these two T-intersections is recommended by simultaneous system i.e. phase I, II, III of intersection 1 is provided with phase, I, II, III of intersection 2 respectively.
7. The congestion on the roads is because of increased traffic volume. It has been seen that maximum traffic is in between 8:30 AM to 9:30 AM. One of the reason is because the people go to offices, institutes at that time. So, the various alternatives like car pooling & changing of office hours should be adopted.
8. The prevalent road user's behaviour and field studies calls for immediate improvement of the intersection by providing zebra crossings, traffic markings, railing, junction lighting to provide a smooth traffic flow with safety.
9. The future traffic for the year 2001 has been found out to be 8832pcu/hr, which is more than double the present traffic.

10. The safe speed has been found to be 50kmph for major road & 44 kmph for staggered roads i.e. PGI & PU.
11. The minimum speed to avoid hindrance to traffic has been found out to 30 kmph for all the approaches.

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