STUDYING OF TRAFFIC SIGNAL DESIGN AND CALCULATION OF CYCLE INTERVAL AFTER TRAFFIC SURVEYING OF A ROTARY

PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT
OF THE DEGREE OF
BACHELOR OF TECHNOLOGY
IN
CIVIL ENGINEERING

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CERTIFICATE

This is to certify that project report entitled “Studying of Traffic signal design and Calculation of cycle interval after Traffic surveying of a Rotary”, submitted by Shahbaaz Singh Mann (101647) in partial fulfillment for the award of degree of Bachelor of Technology in Civil Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

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Date: 15/05/2014

Shahbaaz Singh Mann(101647)

(Signature)

ABSTRACT

Highways and the roads are like the veins of nation connecting all the parts of the country efficiently to each other for transportation and forming a well connected network. Designing of the highways and other related parts of the system plays a very pivotal role for swift movement of traffic. Proper traffic surveys are to be conducted before designing any part of the highway or traffic signals for swift movement of traffic on that route.

In this project I perform traffic surveys at a rotary measuring different parameters determining the peak hour of traffic of the rotary and other traffic volume surveys determining the traffic flow at the rotary. The data is then further used in designing of a traffic signal design on the rotary considering different phases at a time and for efficient movement of traffic at that rotary. The project encompasses the different parameters significant to be studied before designing a traffic signal. In this project I also cover the different steps that might be taken for efficient movement of traffic across that rotary.

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INTRODUCTION

The conflicts arising from movements of traffic in different directions is solved by time sharing of the principle. The advantage of traffic signal includes an orderly movement of traffic, an increased capacity of the intersection and requires only simple geometric design. However the disadvantages of the signalized intersection are it affects larger stopped delays and the design requires complex considerations. Although the overall delay may be lesser than a rotary for a high volume, a user is more concerned about the stopped delay.

TRAFFIC SIGNALS

An intersection where there is a large number of crossing and right turn traffic, there is possibility of several accidents as there cannot be orderly movements. The earlier practice has been to control the traffic by means of traffic police by showing stop signs alternately at the cross roads so that one of the traffic streams may be allowed to move while the cross traffic is stopped. Thus, the crossing streams of the traffic flow by time, segregation. Traffic signals are control devices which alternately direct the traffic to stop and proceed at intersections using red and green light signals automatically. The main requirements of a traffic signal are to draw attention, provide meaning and time to respond and to have minimum waste of time.

ADVANTAGES OF TRAFFFIC SIGNALS

Properly designed signals have the following advantages:

- They provide orderly movement of traffic and increase the traffic handling capacity of most of the intersections at grade.
- They reduce certain types of accidents, notably the right angled collisions.
- Pedestrians can cross the roads safely at the signalized intersection.
- The signals allow crossing of heavy traffic flow with safety.
- When the signal system is properly co-ordinated, there is a reasonable speed on the major road traffic.

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- Signals provide a chance of crossing traffic of minor roads to cross the path of the continuous flow of traffic streams at reasonable interval of time.
- Automatic traffic signals may work out to be economical when compared to manual control.
- The quality of traffic flow is improved by forming compact platoons of vehicles, provided all the vehicles move at approximately the same speed.

DISADVANTAGES OF TRAFFIC SIGNALS

- The rear end collisions may increase.
- Improper design and location of signals may lead to violations of the control system.
- Failure of the system due to electric power failure or any other defect may cause confusion to the road users.

TYPE OF TRAFFIC SIGNALS

The signals are classified into following type

I. Traffic control signals
II. Pedestrian signals
III. Special traffic signals

The traffic control signals have three colored lights facing each direction of traffic flow. The red light is meant for stop , the green light indicates go and amber or yellow light allows the clearance time for the vehicles which enters intersection area by the end of green time , to clear off.

Fixed time signal or pre-timed signals are set to repeat regularly , a cycle of red , amber and green lights. The timing of each phase of the cycle is pre-determined based on the traffic studies and they are the simplest type of automatic traffic signals which are electrically operated. The main drawback of the signal is that sometimes the traffic flow on one road may be almost nil and the traffic on the cross road may be quite heavy.yet as the signal operates with fixed timings, the traffic in the heavy stream will have to stop at red phase.

Traffic actuated signals are those in which timings of the phase and cycle are changed according to traffic demand. In semi actuated traffic signals the normal clean phase of an approach

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may be extended up to a certain period of time for allowing a few more vehicles approaching closely, to clear off the intersection with the help of detectors installed at the approaches.

In some cities in India the traffic police are assigned the duty to watch the traffic demand from suitable observations point during the peak hours on various approaches and to vary the timings of the phases and cycle according to the actual traffic demand.

When there are series of signals on the city road at each intersection with the cross road, the signal system may be operated with only one controller. But it is desirable thet a vehicle moving along a main road at normal speed should not have to stop at every signalised intersection till getting the “go” signal. Hence there should be proper co-ordination of the signal system to provide a through band.

TYPE OF TRAFFIC SIGNAL SYSTEM

There are 4 general types of co-ordination of signals for road networks, as listed below:

- Simultaneous system
- Alternate system
- Simple progressive system
- Flexible progressive system

SIMULTANEOUS SYSTEM

In this system all signals along a road always show the same indications (red, green and yellow) at same time. As the division of cycle is also same at all intersections, this system does not work satisfactorily.

ALTERNATE SYSTEMS

In this system, alternate signals or groups of signals show opposite indications in a route at same time. The system is also operated by a single controller, but by reversing the red green indicator connections at successive signal systems. This system generally is considered more satisfactory than simultaneous system.

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SIMPLE PROGRESSIVE SYSTEM

A time schedule is made to permit, as nearly as possible, a continuous operation of groups of vehicle along the main road at reasonable speed. The signal phases controlling “Go” indications along this road is scheduled to work at the predetermined time schedule. The phases and intervals at each signal installation may be different; but signal unit works as fixed time signal, with equal signal cycle length.

FLEXIBLE PROGRESSIVE SYSTEM

In this system it is possible to automatically vary the cycle length, cycle division and the same time schedule at each signalized intersection with help of computer. This is most efficient system of all four types described above.

Pedestrian Signal are meant to give right way to pedestrians to cross a road during the ‘walk period’ when the vehicular traffic shall be stopped by red or stop signal on the traffic siganls of the road.

Flashing Beacons are meant to warn the traffic. At flashing red signals, the drivers of vehicles shall stop before entering the nearest cross walk at an intersection or at a stop line, when marked. Flashing yellow signals are caution signals meant to signify that drivers may proceed with caution.

DEFINITIONS AND NOTATIONS

A number of definitions and notations need to be understood in signal design.They are discussed below:

Cycle: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 one full cycle of indications.It indicates the time interval between the starting of green for one approach till the next time the green starts.It is denoted by C.

Interval: 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 and it indicates the

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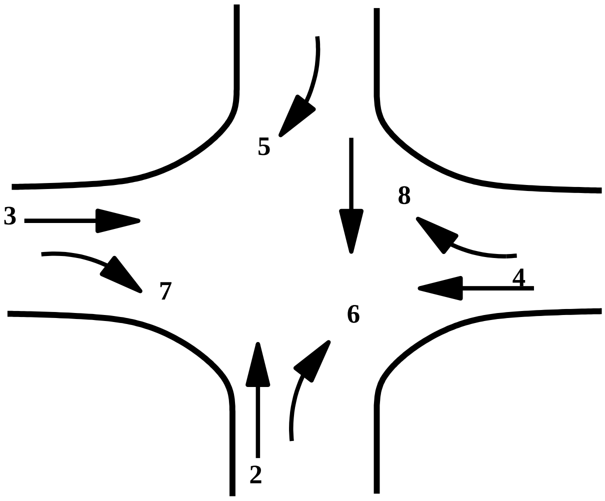
interval between the green and red signal indications for an approach.Clearance interval indicates a period during which all signal faces show red and is used for clearing off the vehicles in the intersection.

Green Interval: It is the green indication for a particular movement or set of movements and is denoted by G_i.This is the actual duration during which 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_i.This is the actual duration during which the red light of a traffic signal is turned on.

Phase:A phase is the green interval plus the change and clearance intervals that follow it.Thus during green interval,non conflicting movements are assigned into each phase.It allows a set of 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 effectively utilized from 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 here before he moves.



1. Four legged intersection

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PHASE DESIGN

The signal design procedure involves six major steps.This includes the(i)phase design,(ii)determination of amber time and clearance time,(iii)determination of cycle length,(iv)apportioning of green time,(v)pedestrian crossing requirements and (vi)the performance evaluation of the above design.The objective of phase design is to separate the conflicting movements in an intersection into various phases,so that movements in a phase should have no conflicts.If all the movements are to be separated with no conflicts,then a large number of phases are required.In such a situation,the objective is to design phases with minimum conflicts or with less severe conflicts.

There is no precise methodology for the design of phases.This is often guided by the geometry of the intersection,flow pattern especially the tuning movements,the real magnitudes of flow.Therefore,a trial and error procedure is adopted.However,phase design is very important because it affects the further design steps.Further,it is easier to change the cycle time and green time when flow pattern changes,where as a drastic change in the flow pattern may cause considerable confusion to the drivers.To illustrate various phase plan options,consider a four legged intersection with through traffic and right turns.Left turn is ignored.See figure 1.The first issue is to decide how many phases are required.It is possible to have two,three,four or even more number of phases.

TWO PHASE SIGNALS

Two phase system is usually adopted if through traffic is significant compared to the turning movements.For example in above figure non-conflicting through traffic 3 and 4 are grouped in a single phase and non-conflicting through traffic 1 and 2 are grouped in the second phase.However,in the first phase flow7 and 8 offer some conflicts and are called permitted right turns.Needless to say that such phasing is possible only if the turning movements are relatively low.On the other hand,if the turning movements are significant,then a four phase system is usually adopted.

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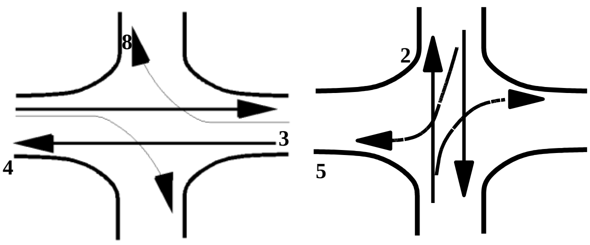

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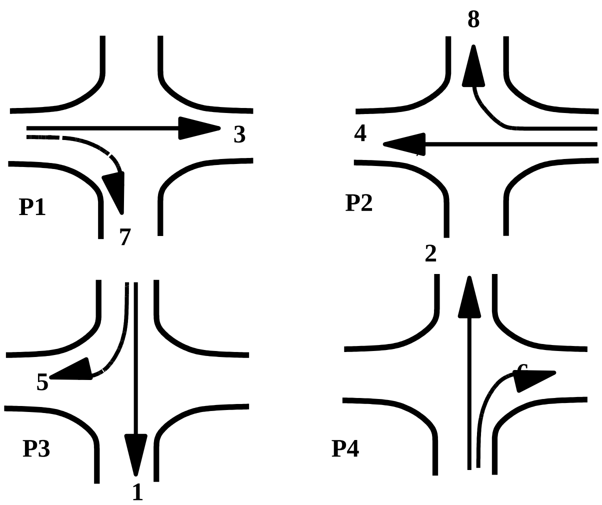
FOUR PHASE SIGNALS

There are atleast three possible phasing options.For example,figure above shows the most simple and trivial phase plan where flow from each approach is put into a single phase avoiding all conflicts.This type of phase plan is ideally suited in urban areas where the turning movements are comparable with through movements and when through traffic and turning traffic need to share the same lane.

Figure below shows a second possible phase plan option where opposing through traffic are put into same phase.The non-conflicting right turn flows 7 and 8 are grouped into a third phase.Similarly,flows 5 and 6 are grouped intofourth phase.This type of phasing is very efficient when the intersection geometry permits to have atleast one lane for each movement,and the through traffic volume is significantly high.

There are five phase signals,six phase signals,etc.They are normally provided if the intersection control is adaptive,that is,the signal phase and timing adapt to the real time traffic conditions.



One way of providing four phase signals

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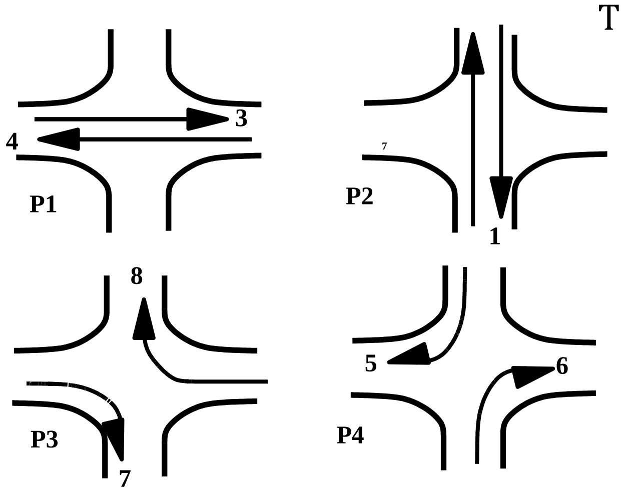
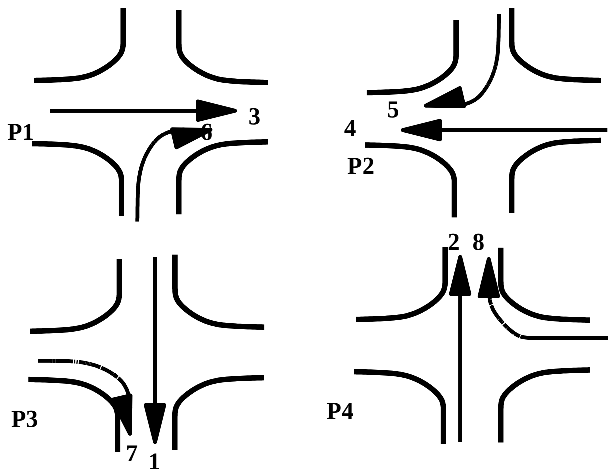


Second possible way of providing a four phase signal



Third possible way of providing a four-phase signal

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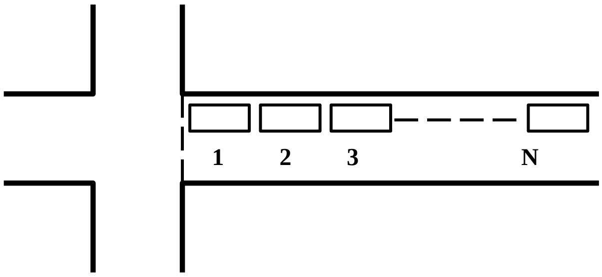

Group of vehicles at a signalized intersection waiting for green signal

INTERVAL DESIGN

There are two intervals,namely the change interval and clearance interval,normally provided in a traffic signal.The change interval or yellow time is provided after green time for movement.The purpose is to warn a driver approaching the intersection during the end of a green time about the coming of a red signal.They normally have a value of 3 to 6 seconds.

The design consideration is that a driver approaching the intersection with design speed should be able to stop at the stop line of the intersection before the start of red time.Institute of Transportation Engineers(ITE)has recommended a methodology for computing the appropriate length of change interval which is as follows:

$$Y = t + (V_{85} / 2a + 19.6g),$$

where y is the length of yellow interval in seconds,t is the reaction time of the driver,V_{85} is the 85^{th} percentile speed of approaching vehicles in m/s,a is the deceleration rate of vehicles in m/s^2,g is the grade of approach expressed as a decimal.Change interval can also be approximately computed as y=(SSD/v),where SSD is the stopping sight distance and v is the speed of the vehicle.The clearance interval is provided after yellow interval and as mentioned earlier,it is used to clear off the vehicles in the intersection.Clearance interval is optional in a signal design.It depends on the geometry of the intersection.If the intersection is clear,there is no need of clearance intervalwhereas for very large intersections,it may be provided.

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CYCLE TIME

Cycle time is the time taken by a signal to complete one fully cycle of iterations i.e. one complete rotation through all signal indications.It is denoted by C.The way in which the vehicles depart from an intersection when the green signal is initiated will be discussed now.Figure below illustrates a group of N vehicles at a signalized intersection,waiting for the green signal.As the signal is initiated,the time interval between two vehicles,referred as headway,crossing the curb line is noted.The first headway is the time interval between the initiation of the green signal and the instant vehicle crossing the curb line.The second headway is the time interval between the first and the second vehicle crossing the curb line.Successive headways are then plotted as in figure.The first headway will be relatively longer since it includes the reaction time of the driver and the time necessary to accelerate.The second headway will be comparatively lower because the second driver can overlap his/her reaction time with that of the first driver's.After few vehicles,the headway will become instant.This constant headway which characterizes all headways beginning with the fourth or fifth vehicle,is defined as the saturation headway,and is denoted as h.This is the headway that can be achieved by a stable moving platoon of vehicles passing through a green indication.If every vehicle require h seconds of green time,and if the signal were always green time,then s vehicles per hour would pass the intersection.Therefore,

$$S=(3600/h)$$

where s is the saturation flow rate in vehicles per hour of green time per lane,h is the saturation headway in seconds vehicles per hour of green time per lane.As noted earlier,the headway will be more than h particularly for the first few vehicles.The difference between the actual headway and h for the i^{th} vehicle and is denoted as shown in figure.These differences for the first few vehicles can be added to get start up lost time.

The green time required can be found out as,

$$T=l_1+hN,$$

where T is the time required to clear N vehicles through signal.It is the start-up lost time required to clear N vehicles through signal,l_1 is the start-up lost time,and h is the saturation headway in seconds.

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EFFECTIVE GREEN TIME

Effective green time is the actual time available for the vehicles to cross the intersection.It is the sum of actual green time(G_i)plus the yellow minus the applicable lost times.This lost time is the sum of start-up lost time(l_1)and clearance lost time(l_2)denoted as t_1.Thus effective green time can be written as,

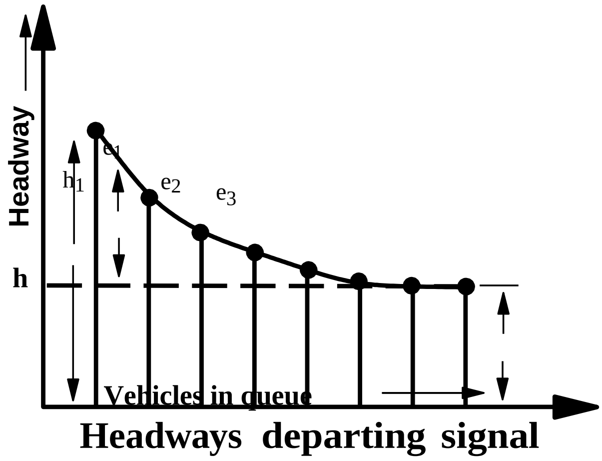
$$G_g=G_i+Y_i-t_i$$

LANE CAPACITY

The ratio of green time to the cycle length(g/c)is defined as green ratio.We know that saturation flow rate is the number of vehicles that can be moved in one lane in one hour assuming the signal to be green always.

CRITICAL LANE

During any green signal phase,several lanes on one or more approaches are permitted to move.Thus it requires more time than any other lane moving at the same time.If sufficient time is allocated for this lane,then all other lanes will also be well accommodated.There will be one and only one critical lane in each signal phase.The volume of this critical lane is called critical lane volume.



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DESIGN METHODS

1.TRIAL CYCLE METHOD

The 15 minute-traffic counts n1 and n2 on road 1 and 2 are noted during the design peak hour flow. Some suitable trial cycle C_1 second is assumed and the number of assumed cycle in 15 minutes or 15*60 seconds period is found to be (15*60) / C_1 , i.e. 900/C_1. Assuming an average time headway 2.5 seconds, the green periods G_1 and G_2 of roads 1 and 2 are calculated to clear the traffic during the trial cycle.

$G_1 = 2.5\ n_1 C_1 / 900$ and $G_2 = 2.5\ n_2 C_2 / 900$

The amber periods A_1 and A_2 are either calculated or assumed suitably (3-4 seconds) and 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 assumed cycle length C_1 , the cycle length is accepted as design cycle. otherwise the trials are repeated till trial cycle length works out approximately equal to calculated value.

2.APPROXIMATE METHOD

The following design procedure is suggested for the simple design of the two phase signal unit at cross roads , along with pedestrian signals :

- Based on approach speed of the vehicles , the suitable , clearance interval between green and red period i.e. clearance amber period are selected . The amber period 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 sec. , 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 pedestrian to start crossing. This red time is equal to the the minimum green time plus amber time for the cross road.

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- The minimum green time is calculated based on pedestrian criterion , equal to pedestrian clearance time for cross road plus an initial interval when pedestrian may start to cross minus amber period. This is equal to the red time for the 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 increased based on the ratio of approach volume for the heaviest traffic volume per hour per lane. The cycle length so obtained is adjusted for the next higher 5-seconds interval. The extra time is then distributed to green timings in proportion to the approaching volumes of the traffic.
- The values so obtained are calculated in percentage basis is the controller settings are in per cent of cycle.
- The timings so obtained are installed in the controller and the operations are then observed at the site during the traffic peak hours. Corrections or modifications are carried out if needed.

1. WEBSTER’s METHOD

In this method, the optimum signal cycle C_0 corresponding to least total delay to the vehicles at the signalised intersection has been worked out. This is a rational approach. The field work consist of (i) The saturation flow S per unit time on each approach of the water section and (ii) 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 $y_2 = q_2/S_2$ are determined on the approach road 1 and 2. In 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 interval precisely. In the absence of data the approximate value of saturation flow is estimated assuming 160pcu per 0.3 m

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width of the approach. The normal flow of the traffic is also determined on the approach road 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:

$$C_O=(1.5L+5)/(1-Y)$$

where L = total lost time per cycle, seconds = 2n+R (n is the no. of phase and R is all red-time)

$$Y=y_1+y_2$$

Then $G_1=y_1(C_o–L)/Y$ and

$G_2=y_2(C_o–L)/Y$

Similar procedure is followed when there are more no. of signal phases.

SPECIAL DESIGN CONSIDERATIONS

1. CONTROL OF ACCESS

To ensure safe and efficient circulation of traffic, which serves the various land uses adequately and ensures logical community development, the network of roads in an urban area has to be divided into different subsystems each serving a particular function or a purpose,. The principal factor to be considered in designation of roads into different categories are the travel desire lines, access needs of adjacent properties, network pattern and land use. For the purpose of these guidelines, urban highways/ streets are considered to be divide into following types :

- Arterial highways/ streets
- Sub-arterial streets
- Collector streets
- Local street

2. SPACING OF INTERSECTIONS

Although the standards for the locations of access points depend largely on the need of an area, the following guidelines which are indicative of good practice, may be followed as far as possible.

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- Spacing between intersections should have regard to the relevant geometric design and traffic requirements, such as type of traffic, length of right turn or speed change lanes etc.

As a rough guide, the suggested minimum spacing along various types of roads is given below :

a.	Arterial highways / streets	500 metres
b.	Sub-arterial	300 metres
c.	Collector streets	150 metres
d.	Local streets	Free access

Where necessary, a greater distance than given above should be adopted, as for example between junctions with linked traffic signals.

- Arterial streets should preferably be linked to have a progressive system, permitting continuous movement of vehicles at a planned speed of travel. As far as possible, all such intersections should approximately the same spacing.
- Apart from regular intersections, limited number of access points with intervening streets may be permitted at a spacing closer than mentioned above provided only left turns and from the main streets are permitted.
- The location and spacing of all major points of access including accesses to bus terminals, railways station, parking areas etc. should be carefully planned so as to ensure safety and freedom from congestion, bus bays should not be located too close to intersection. It is desirable that they are located 75m from either side, preferable on farther on farther side of intersection.
- On arterials, direct access to residential plots is not permitted. Driveways may, however, be permitted on a restricted basis for commercial and industrials complexes and other public locations when these are major generators of traffic. Right turn from these driveways should not be permitted unless the crossing fulfils the spacing criteria given above. Moreover, adequate road geometries should be provided to enable safe operations of vehicles.
- On sub arterials, direct access to residential property should be granted only where alternative cannot be provided at reasonable cost.

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- On collector streets, access to abutting propertis may be allowed to a limit extent keeping in view the safety of traffic.
- On local streets, which will have no through traffic, access to abutting properties can be freely given.

1. PEDESTRIANS AT JUNCTION

Pedestrian crossings may be designed in accordance with the ‘Guidelines on pedestrians’ facilities’ by IRC.

2.CYCLE TRACKS

- it is desirable to segregate cycle traffic at intersections also since intersections also since intersections are dangerous, accident-prone locations. This could be achieved by a suitable system of multi-phase signalisations.
- Where cycle tracks are not segregated, suitable safety measures at intersections should be adopted, such as provision of separate lanes for cycle traffic, provision of cycle boxes ahead of stop lines, and provision of turning cycle paths in conjunction with signalisation. Cyclist crossings must always be marked in accordance with IRC guidelines.

At signalised intersections, a separate lane for cycle traffic along with a reservoir space between pedestrians’ crossings zone and stop line for motorised vehicle provides an efficient regulation. A separate cycle track of minimum 1.2m width should be provided in the approaches of intersection. There would be two stop lines, one for motor vehicle and other for cyclists such that the cyclists can wait in the reservoir space, for signal to turn green.

CONTROL MEASURES

CHANNELISATION

Channelisation involves the use of islands a intersections to guide and protect the traffic it provides reference points within the intersection which enable drivers to better predict the path and speed of

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other drivers. They increase the driver’s ability to avoid accidents and congestions. Channelised islands should be at least 4.7m^3 and preferably 7.1m^3 in area , not less than 2.4m and preferably 3.6m on any side rounding of corners if triangular and at least 1.2m and preferably 3.6m if elongated.

CARRIAGEWAY MARKINGS

Carriageway markings and direction signs should be located sufficiently in advance of the intersection to enable drivers to select and follow the lane and path they should take through the intersection , Markings at intersections can be a combination of centre lines , turn markings , stop lines , route direction arrows , pedestrian crossings etc.

OTHER ASPECTS

VISIBILITY

The safety of traffic can be ensured only if the visibility is full and unimpeded along both roads . Any obstruction should be clear of the minimum visibility triangle for a height of 1.2m above the roadway.

The intersection should be planned and located to provide as much sight distance as possible. In achieving a safe highway design , there should be sufficient sight distance for the driver on the minor highway to cross the major highway without requiring the approaching traffic to reduce speed.

LIGHTING

From the operation point of view , road illumination should provide pleasant and accurate night seeing conditions so that traffic movements may be made easily and safely. More light is required if the pedestrian crossing the intersections are larger in number. With light to medium pedestrian traffic and vehicular traffic upto 500 veh / hour.., 120 mtrs , staggered lamp posts with lamps of 10000 lumens will be sufficient.

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DESIGN AS PER I.R.C METHOD

The design of a signal scheme includes the selection of the type of signal, number of phases, amber period, cycle time and time allotted to each phase as also other specific features such as exclusive turning phase or pedestrian phase. Based on the field data, volume and speeds. The signal timings are calculated by IRC method.

DESIGN METHOD AS PER IRC GUIDELINES

- 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 seconds. These are the minimum green time required for vehicular traffic on major and minor roads respectively.
- The green time required for 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 if 2 sec each.
- The minimum green time required for clearing vehicles arriving during the cyclist determined for each lane of approach road assuming that first vehicle will take 6.0 sec. and the subsequent vehicles (**PCU**) of the queue will be cleared at the rate of 2.0 sec. The minimum green time required for the vehicular traffic on any of the approaches is limited 16 sec.
- The optimum signal cycle time is calculated using Webster formula. The saturation flow values may be assumed as 1850,1890,1950,2250,2550 and 2990 PCU per hour for the approach roadway width (kerb to median or centre line) of 3.0,3.5,4.0,4.5,5.0 and 5.5 metre, for width above 5.5 metre, the saturation flow may be assumed as 525 PCU per hour per metre width. The loss time is calculated from amber time, inter-green time and initial delay of 4 seconds for first vehicle, on each leg.
- The signal time and the phases may be revised keeping in view the green time required for clearing the vehicles and the optimum cycle length determined in steps 4 and 5 above.

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FIELD STUDIES AND GENERAL REVIEW

Traffic studies are conducted with the aim of analyzing the existing traffic characteristics and to provide a national basis for the evolution of a geometrically safe and efficient traffic control facility. These studies also help in deciding upon measures to be adopted for the improvement of any inefficient or faulty exiting traffic facility.
The following field studies have been conducted for the purpose of this study:-

1. Traffic Volume Studies
2. Traffic Speed Studies

PERIOD OF STUDY

Peak flow timings are of necessity to form the basis for conducting traffic studies. By observation it was found that peak flow conditions exist between 9:30 A.M. to 10:30 A.M. and again between 5:00 P.M. to 6:00 P.M at the sector 17 approaching road and between 9:00 A.M. to 10:00 A.M. and again between 4:30 P.M. to 5:30 P.M on the industrial area approaching road, between 9:00 A.M. to 10:00 A.M. and again between 5:30 P.M. to 6:30 P.M on the sector 26 approaching road, between 8:30 A.M. to 9:30 A.M. and again between 6:00 P.M. to 7:00 P.M on the sector 32 approaching road at the selected intersection of Sectors 27-28-29 & 30 and covered a heterogeneous mix of traffic which included commercial , office-going, school/college going and city (CTU) buses. Studies were conducted on Tuesdays ,Wednesdays ,Thursdays while Saturdays , Sundays and Holidays were excluded. There were no maintenance or repair works being carried out any of the four legs of the intersection during the period of study. Field studies were conducted during Feb / March. 2014.

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TRAFFIC VOLUME STUDIES

Traffic volume is the number of vehicles crossing a section of road during a selected period. A knowledge of the flow characteristics helps us determine whether a particular section of the road is efficiently capable of handling the volume of traffic for which it has been designed. The volume is recorded in vehicles / day or PCU / hour. A comprehensive volume study must record the volume of various types of traffic and the distribution by direction and turning movements per unit time.

PURPOSE OF TRAFFIC VOLUME STUDY

The objectives of a traffic volume study are as follows :-

- To analyse traffic patterns and trends.
- For planning traffic operations and controls of existing facilities , and for designing new facilities.
- Classified volume study is useful in structural design of pavements , in geometric design and in computing road capacity , and thereby deciding on priorities for improvement and expansion.
- Volume distribution study is used in planning one-way streets and other regulatory measures.
- Pedestrian volume study is used for planning side walks , cros walks , subways and pedestrian signals.
- Turning movements study is used in design of intersection , in deciding on signal timings , channelization and other control devices.
- Traffic volume study is used in deciding on the relative importance of roads and in allocating priorities for the improvement of existing facilities.

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METHOD OF TRAFFIC COUNT

The various methods available for traffic counts are listed below, and the method which has been used in the present study is explained thereafter.

a) Manual Method
b) Combination of manual and mechanical method
c) Automatic devices
d) Moving observer Method

(a)MANUAL METHOD

While each of the methods have their own advantages , the manual method is the most convenint wherein field personnel are used to count and classify traffic flowing part a fixed point. This method is also advantageous when counts are for fairly short durations , and when severe weather conditions could interfere with the use of mechanical or other equipment is available. The number of observers needed to count the traffic depends on the number of lanes or rounds converging at the intersection under study. As there are four approaches to the roundabout , a team of 5 observers was required on each approach to record the traffic volume and Scooters / Mopeds / 3-Wheelers / motorcycles and Cycles / Cycle i.e. straight , left turning and right turning. The volume count was conducted with the help of four observers , over a number of days and the results are summed up and tabulated.

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CONCEPT OF PASSENGER CAR UNITS

Vehicles of different types require different amounts of road space. As each type of vehicle has an influence on the performance of a traffic facility in its own different way , it is the normal practice to convert the flow into equivalent passenger car units (PCUs) by using certain equivalence factors. The basic unit is the car (taxis , light vans and three wheelers all count as one unit). Buses and trucks which cover more road space impose a greater traffic load on the roads than cars do and thus the

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overall effect of a truck or bus is equivalent to several passenger car units. Hence for design purposes , we convert all the vehicles into passenger car units (PCUs) with the car taken as basic unit.

The appropriate PCU values for different types of vehicles under varying conditions are given in table 1 in annexure

TABULATION AND PRESENTATION OF TRAFFIC VOLUME DATA

For the purpose of collection of traffic volume data at the intersection vehicles have been classified into five broad categories as follows :

a) Heavy vehicles comprising buses and trucks

b) Medium vehicles comprising cars / jeeps / vans and light vehicles.

c) Scooters , mopeds , motor cycles.

d) Cycles and cycle rickshaws

e) Animal driven carts

The traffic counts were made for the above classes of vehicles respect to their respective directional movements i.e. for straight moving , left turning and right turning by the manual method. The traffic volume data was collected with the help of colleagues engaged in similar research studies , posted on each approach during the peak hour flow specified earlier.

The peak traffic volumes have been calculated after converting the various traffic classifications mentioned above into Passenger Car units. Traffic volumes for signal design and rotary design were calculated separately for their respective PCU values as given in table above. These are given in Tables appended in the next section for signal and rotary design respectively.

The Traffic flow diagrams for both signal design and rotary design have been shown in fig. for peak hour volume for signal design and for peak hour volume for rotary design.

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RESULTS

DESIGN OF SIGNAL

STEP1

ROAD 1 (R1) –Sector 17- INDUSTRIAL AREA
ROAD 2 (R2) – Sector 26- Sector 32

ROADS	MORNING PCU	EVENING PCU
From Sec 17 (R1)	1040	1321
From Ind. Area (R1)	750	340
From Sec 26 (R2)	376	728
From Sec 32 (R2) (GMCH)	564	210

Max. PCU for R1 = 1321
Max. PCU for R2 = 728
Width of roads R1 and R2 = 19.5m (4 lanes)
Design traffic for R1 = 1321/2 = 660.5 PCU/hr
Design traffic for R2 = 728/2 = 364 PCU/hr

Pedestrian green time for R1 = (19.5/1.2) + 7 = 23.25
Pedestrian green time for R2 = (19.5/2) +7 = 23.25

Green time for vehicles on R2= 23.25
Green time for vehicles on R1 = 23.254 * (660.5/364) = 42.18

Now, adding 2 seconds each towards clearance amber and 2 seconds inter-green period for each phase

Therefore, total cycle = (2+42.18+2) + (2+23.5+2)
= 73.44 seconds = 75 seconds

Therefore,
Green for R2 , G1 = 24 seconds
Green for R1, G2 = 43 seconds

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STEP 2

Vehicle arrival per lane on R2 = 364/75 = 4.85 PCU
Minimum green time for clearing vehicles on Road 2 = 6 + (4.85 - 1)*2
= 13.7 seconds < 24 seconds

On Road 1,
Vehicle arrival per lane on R1 = 660.5/75 = 8.8 PCU
Minimum green time for clearing vehicles on Road 1 = 6 + (8.8 – 1)*2
= 21.6 seconds < 43 seconds

As green time provide for two roads by pedestrian crossing criteria are higher than these values, the above design is alright.

STEP 3

Lost time per cycle = (amber time +inter-green time+ time lost in initial delay of first vehicle) for two phases
= (2+2+4) * 2
= 16 seconds

Saturation flow for Road 1 = 525 * 9.75 = 5118.75 PCU/hr
Saturation flow for Road 2 = 525 * 9.75 = 5118.75 PCU/hr

Y_1 = 1321/5118.75 = 0.258
Y_2 = 728/5118.75 = 0.142
$Y = Y_1 + Y_2 = 0.4$

Now, OPTIMUM CYCLE TIME C_o = (1.5 L + 5) / (1 – Y)
= ((1.5*16)+5) / (1-0.4)
= 48.3 seconds

Therefore the cycle time of 75 seconds designed earlier is acceptable.

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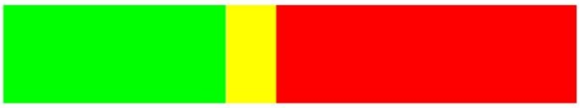
Details of signal timings is given below :-

ROAD	DIRECTION	GREEN	AMBER	RED	CYCLE
R1	STRAIGHT	27	2	46	75
R1	RIGHT	14	2	59	75
R2	STRAIGHT	14	2	59	75
R2	RIGHT	8	2	65	75

*Time is in seconds



PHASE-1

PHASE-2

PHASE-3

PHASE-4

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CONCLUSIONS AND RECOMMENDATIONS

ALTERNATE PROPOSALS IN GENERAL

The collected traffic data in tables and survey plan of the intersections gives a complete idea of the problem. The first traffic control measure is the control with the use of signs, but such a large traffic volume which occurs at peak hours negates its utility; for effective traffic control by police constables is not satisfactory.

The present traffic volume also does not justify a grade-separated interchange, although such a measure may be required at a future in time. The other options available are either redesign of roundabout or the installation of traffic signals.

TRAFFIC VOLUME

The existing and predicted traffic volumes should be one of the most important criteria in evolving the type of intersection required and traffic control measure best suited for it. If the predicted traffic volume (at least 10 years hence) is not taken into account it may result in an avoidable situation of an intersection design providing inadequate, and requiring a redesign every now and then.

The most ideal design of an intersection should be as such as would cater for future traffic conditions with minimum alterations in the control system. At the rotary under study, the present peak traffic volume is more than what a rotary intersection can handle effectively. Therefore excessive delays and frequent stoppage of traffic is caused due to high traffic volume and it can be concluded that the main purpose of rotary is defeated.

GEOMETRIC LAYOUT

In build up areas the geometrical layout of intersection is normally the controlling factor. Very often the adjacent building lines do not permit the construction of roundabout of large dimensions. The layout of existing intersection proves that a roundabout requires more land/area than a signalised intersections. Keeping in view the master plan of chandigarh, the only type of control feasible at this intersections is traffic signals.

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ALTERNATIVE – 1 : IMPROVEMENT OF ROUNDABOUT

Keeping in view a 10 year projection of traffic volume based on the existing data for 1999, the following would have to be considered to improve the roundabouts.

1. Enlarging the central island.
2. Providing channelizing islands.
3. Introducing separate left turning roads (slip roads).
4. Incorporation of adequate rotary design elements as per IRC specifications.

The improvement of the roundabout can be achieved mainly by providing separate traffic lanes for left turning traffic, and by increasing carriageway widths.

The redesign roundabout has to handle a peak traffic volume of more than 2.0 times the present one in coming years. This is obviously impracticable if not possible as it will require to keep changing the geometric elements of the rotary to cater for the increase in the traffic volume which will ultimately be a very expensive option.

ALTERNATE 2 – TRAFFIC SIGNAL INSTALLATION

The present traffic volume warrants the installation of a traffic signal which can easily handle the present traffic with major alterations in the signal layout.

If the traffic volume during the middle of the day, or for a considerable period between the peak hours is much lower than the peak hour volume (design volume), the signal controller can be adjusted to give two cycle length, one for peak hour volume and other for normal volume at other than peak hour timings.

A future increase in the traffic volumes can easily be catered for by adjusting the signal controller to give a suitable cycle length, which would obviously be quiet economical to implement. The proposed traffic signal has a reserve capacity of 21%. This indicates that the signal can handle a future traffic volume 21% more than present volume.

From the work done in this study, it is justified that the roundabout may be converted into a signal controlled intersection. In the following section a typical signal with minimum delay and maximum safety and convenience to traffic is given.

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Conclusion:

In conclusion, it needs to be emphasized that “efficient intersection means efficient city and efficient city means efficient economy”. It should be appreciated that only by regulating, managing and developing efficient intersections can we ensure that urban mobility of “today” does not have to be rationed “tomorrow” and that it does not turn into immobility “day-after-tomorrow”.

- Under mixed traffic conditions, such as the one in Chandigarh, there is no queue or lane discipline followed by traffic; and the vehicles occupy the available road space on approaches as densely as possible in a haphazard manner. This condition chokes the roundabout completely during peak hours. The roundabouts constructed some 20years ago to cater for the then prevailing traffic volume are now totally inadequate to handle the present day volume.
- The unrestricted mixing of various vehicles at the intersections without their physical segregation creates various complex problems such as, speed reduction and difficult turning manoeuvres. Hence, a significant amount of vehicular interaction exists at intersections which results in traffic scrambles and utter chaos.

The speed reduction and manoeuvring, which is a part of an intersection flow, become manifold due to different vehicle operating conditions. Within a turning manoeure, the problems get multiplied due to speed differential and different vehicular operational characteristics.

- The geometric elements of the existing roundabout do not strictly conform to the I.R.C standards especially the entry and exit radii, weaving length etc.
- ‘Before and After’ studies should be undertaken to evaluate the impact of each improvement in terms of traffic operations.
- “Enforcement and Education” as restrictive measures can play their roles effectively only when Engineering has been exploited to its fullest potentialities for intersection control.

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RECOMMENDATIONS

- The results of this study reveal that provision of slip roads at existing roundabouts is not going to increase the capacity of the intersection as the left turning traffic is not high. The main reason of the lock-up is the right turning and straight going traffic which weaves and crosses through the intersectional area. The increase in the capacity of the roundabout by increasing its radius will not serve any useful purpose as the delay factor will not be removed due to more time taken by traffic to go around the rotary than crossing the signalized intersection; especially the right turning traffic.

To provide highest level of service to the traffic, as it was experiencing on straight road, the intersection must be designed for the increased traffic. It is therefore, recommended that the present existing roundabout selected for investigation be replaced by a signal controlled intersection.

- The performance of signalized intersections greatly influences the level of urban road network, hence traffic control devices and markings should also be installed as per I.R.C guidelines.
- Facilities should be provided for pedestrian crossing. Provision shall also be available for flashing of the red pedestrian crossing signal for a period of six seconds during the clearance interval.
- Facilities shall be provided for flickering of left turn arrows.
- The standard controller shall have provision for 3 cycles with different intervals in each cycle patters to cater to morning, evening and off-peak traffic flow conditions during the day. A circuit shall also be incorporated which enables different phasing sequence in each cycle if so required. In addition, one cycle of amber flashing on main roads and red flashing on minor roads shall also be provided to cater to night traffic conditions. The controller shall be capable of changing over automatically from one pattern to the next one at present times of the day.
- There shall be facility for manual control of the signal indication as optional.
- Although the four phases of the selected intersection have been suggested at present to eliminate certain conflicts, yet “no intersection design can be considered as final because of the evergrowing but varying traffic requirements”. Also the traffic road network and traffic control measures on the adjoining roads of the intersection have to be checked and observed,

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since the installation of the signal may affect the traffic patterns and volumes which have not been accounted for in the design. Therefore, it is recommended that the traffic data be updated and re-evaluated regularly and the number and timing of phases may be adjusted accordingly.

- The responsibility for its maintenance should be clearly established. The responsible agency should provide for the maintenance of the signal and all of its appurtenances in a responsible manner.

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APPENDIX

TABLE-1

Sr No.	Class of vehicles	Urban area	Rural area	Round about design	Traffic Signal Design	Level Terrain	Rolling Terrain	Mountainous Terrain
1	Cars/ Jeeps/ Van	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	Motor Cycle / Scooters. Mopeds / 3 Wheelers	0.75	1.00	0.75	0.33	1.00	1.25	
3	Medium to heavy goods vehicle / horse drawn vehicles	2.00	3.00	2.80	1.75	2.00	4.00	6.00
4	Buses / Coaches / Trams / Heavy Trucks	3.00	3.00	2.80	2.25	3.00	6.00	8.00
5	Pedal cycles / Cycle Rickshaws	0.33	0.50	0.50	0.20	0.50	0.60	

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TABLE-2

Traffic Volume Study at Roundabout between Sectors 27-28-29-30 for Signal Design

Weather: Good Date: 17-02-14 & 18-02-14

Road Surface: Good Time: 9:30 am to 10:30am &9:00am to 10:00am

Vehicle Class	PCU		Traffic Entering the Intersection					
			Sector-17 End[9:30AM to 10:30AM]			Industrial Area End[9:00AM to 10:00AM]		
			Left No. PCU	Straight No. PCU	Right No. PCU	Left No. PCU	Straight No. PCU	Right No. PCU
Car/Jeep	1		135 135	423 423	214 214	89 89	244 244	227 227
Motor scooter	0.4		82 33	194 78	161 65	63 26	149 60	154 62
Bus/Truck	2.2		1 3	19 42	3 7	0 0	14 31	1 3
3wheeler	0.5		4 2	52 26	23 12	4 2	5 3	6 3
PCU/Hour 295				173	569	298	117	338
G.Total PCU/Hour					1040			750
% Turning Left					16.63%			15.6%
% Turning Right					28.65%			39.33%

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Figure 1: approaching road from sector 17 direction

Figure 2: approaching road from industrial end direction

TABLE-3

Traffic Volume Study at Roundabout between Sectors 27-28-29-30 for Signal Design

Weather: Good Date: 19-02-14 & 20-02-14
Road Surface: Good Time: 5:00pm to 6:00pm&4:30pm to 5:30pm

Vehicle Class	PCU		Traffic Entering the Intersection					
			Sector-17 End[5:00PM to 6:00PM]			Industrial Area End[4:30PM to 5:30PM]		
			Left No. PCU	Straight No. PCU	Right No. PCU	Left No. PCU	Straight No. PCU	Right No. PCU
Car/Jeep	1		89 89	520 520	379 379	64 64	92 92	89 89
Motor scooter	0.4		49 20	199 80	334 134	47 19	63 26	61 25
Bus/Truck	2.2		2 5	19 42	2 5	1 3	1 3	2 4
3wheeler	0.5		13 7	30 16	48 24	12 6	9 5	7 4
PCU/Hour 122				121	658	542	92	126
G.Total PCU/Hour					1321			340
% Turning Left					9.1%			27.05%
% Turning Right					41.02%			35.88%

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Figure 3: approaching road from sector 17 direction

Figure 4: approaching road from industrial end direction

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TABLE-4

Traffic Volume Study at Roundabout Between Sectors 27-28-29-30
For
Signal Design

Weather: Good Date: 24-02-14 & 25-02-14
Road Surface: Good Time: 9:00am to 10:00am&8:30am to 9:30am

Vehicle Class	PCU		Traffic Entering the Intersection					[9:00AM to 10:00AM]
			Sector-26 End[9:00AM to 10:00AM]			GMCH End[8:30AM to 9:30AM]		
			Left No. PCU	Straight No. PCU	Right No. PCU	Left No. PCU	Straight No. PCU	Right No. PCU
Car/Jeep	1		97 97	38 38	137 137	69 69	257 257	100 100
Motor scooter	0.4		96 39	59 24	84 34	61 25	193 78	66 27
Bus/Truc k	2.2		0 0	0 0	0 0	2 5	1 3	0 0
3wheeler	0.5		5 3	3 2	4 2	2 1	3 2	1 1
PCU/Hour 128				139	64	173	100	340
G.Total PCU/Hour					376			568
% Turning Left					36.96%			37.31%
% Turning Right					46.01%			22.53%

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Figure 5: approaching road from sector 32 direction

Figure 6: approaching road from sector 26 direction

TABLE-5

Traffic Volume Study at Roundabout Between Sectors 27-28-29-30 For Signal Design

Weather: Good   Date: 26-02-14 & 27-02-14
Road Surface: Good   Time: 5:30pm to 6:30pm&6:00pm to 7:00pm

Vehicle Class	PCU		Traffic Entering the Intersection					
			Sector-26 End[5:30PM to 6:30PM]			GMCH End[6:00PM to 7:00PM]		
			Left No. PCU	Straight No. PCU	Right No. PCU	Left No. PCU	Straight No. PCU	Right No. PCU
Car/Jeep	1		190 190	306 306	63 63	20 20	48 48	51 51
Motor scooter	0.4		122 49	217 87	42 17	55 22	40 16	50 20
Bus/Truck	2.2		0 0	1 3	2 5	1 3	2 3	2 4
3wheeler	0.5		6 3	6 3	4 2	14 7	24 12	7 4
PCU/Hour 79				242	399	87	52	79
G.Total PCU/Hour					728			210
% Turning Left					33.24%			24.76%
% Turning Right					11.95%			37.61%

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Figure 7: approaching road from sector 32 direction

Figure 8: approaching road from sector 26 direction

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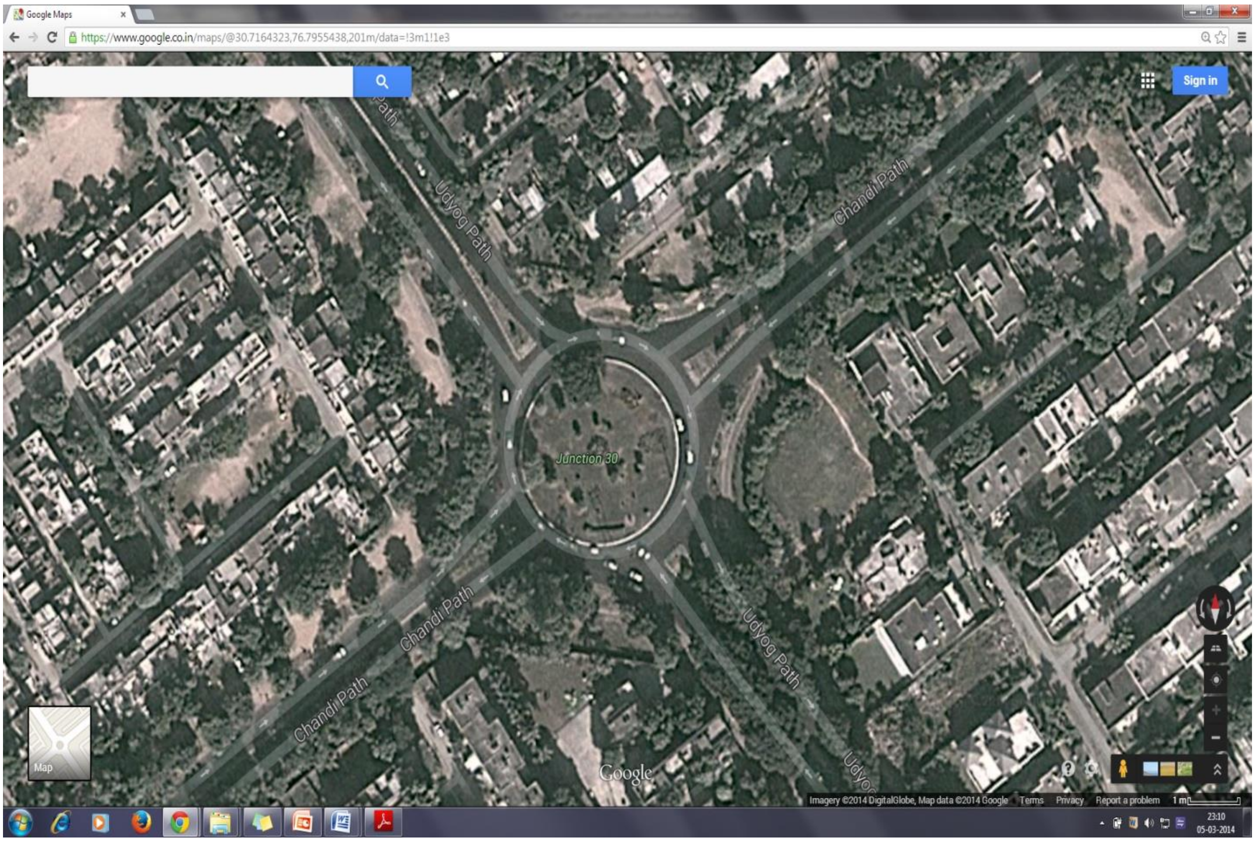

Figure 9: Google earth view of the rotary

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