

QUESTION BANK**CE 6006 TRAFFIC ENGINEERING AND MANAGEMENT****UNIT III TRAFFIC DESIGN AND VISUAL AIDS****2 MARKS****1. What are the various types of traffic signs?**

Traffic signs give timely warning of hazardous situations when they are not self - evident.

The various types of traffic signs are:

- a) Prohibitory signs
- b) Mandatory signs
- c) Information signs, further sub-divided into:
 - i) Indication signs
 - ii) Advanced direction signs and direction signs
 - iii) Place and route identification signs

2. What are mandatory signs?

Mandatory signs are part of regulatory signs and are intended to convey definite positive instructions when it is desired that motorists take some positive action.

3. What are warning signs?

Warning signs are used when it is deemed necessary to warn traffic of existing or potentially hazardous conditions on or adjacent to a highway or street. Warning signs are of great help in ensuring safety of traffic.

4. What are informatory signs?

Informatory signs are intended to guide the motorist along streets and highways, to inform him of interesting routes, to direct him to cities, villages or other important destinations, to identify rivers and streams, parks, forests and historical sites, and generally give him information as well as help him along his way in the most simple, direct manner possible.

5. List out any four regulatory signs.





			
HORN PROHIBITED	NO PARKING	NO STOPPING	STRAIGHT PROHIBITED NO ENTRY

6. Draw the GIVE WAY sign as per Indian Road Congress (IRC) with its relevance.



GIVE WAY is a mandatory sign. The GIVE WAY sign as per IRC is a downward pointing equilateral triangle having a red border and a white background. The side of equilateral triangle is 900 mm long in the standard sized sign and 600 mm long in the smaller sized sign. It shall be used in combination with a definition plate carrying the message GIVE WAY.

7. Draw any four sketches of warning signs.

			
INTERSECTION	INTERSECTION	CROSS ROAD	IRREGULAR INTERSECTION

8. What are the different types of road markings available?

The two types of road markings are:

a) Carriage markings

b) Object markings

9. Write the formula to calculate optimum cycle time.

$$C_0 = (1.5 L + 5) / (1 - Y)$$

where, C_0 = Optimum cycle time (s)

L = Total lost time per cycle (s)

$Y = y_1 + y_2 + \dots + y_n$ { $y_1 + y_2 + \dots + y_n$ are the maximum ratios of flow to saturation flow for phases 1, 2, ... n (i.e. q/s , where q is the flow and s is the saturation flow) }.

10. Write any two advantages of vehicle actuated signals.

The advantages of vehicle actuated signals are:

- a) They are flexible and are able to adjust to changing traffic conditions automatically
- b) Delay is held to a minimum and maximum capacity is achieved

11. What are the main traffic control aids?

The various traffic control aids are:

- a) Roadway delineators
- b) Safety barriers
- c) Speed breakers
- d) Barricades
- e) Railings
- f) Traffic signs

12. What are the different methods by which street light arrangement can be done?

The different methods by which street lighting arrangements can be done are:

- a) Single - sided
- b) Staggered
- c) Central
- d) Opposite
- e) Combination of (c) and (b) or (c) and (d)

13. State the factors governing the spacing of lanterns in street lighting.

The factors governing the spacing of lanterns are:

- a) The spacing of lanterns is determined by the shape, and in particular the length, of the bright patch and the extent to which it is desired that individual patches should overlap
- b) The spacing has to be satisfactory from the point of view of pedestrian requirements
- c) In general, the spacing should not exceed 55 m, and should preferably be 35-45 m on important routes

14. Differentiate silhouette from reverse silhouette in street lighting.

Silhouette	Reverse silhouette
In artificial lighting, if the conditions are such that the brightness of the objects is less than that of the background (i.e. pavement) discernment of the objects is said to be by silhouette.	In artificial lighting, if the brightness of the objects is more than that of the background, discernment is by reverse silhouette.

15. What are the types of traffic signals?

The various types of signals are:

- a) Fixed time signals
- b) Vehicle - actuated signals
- c) Semi - vehicle - actuated signals

16. Define – Intersection

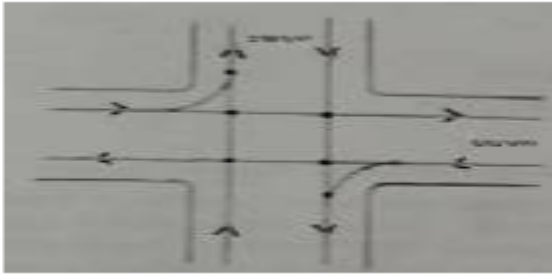
An intersection is defined as the general area where two or more highways join or cross, within which are included the roadway and roadside facilities for traffic movements in that area.

17. What are the various types of conflicts at intersections?

The various types of conflicts at an intersection are:

- a) Crossing conflicts
- b) Merging conflicts
- c) Diverging conflicts

18. Give the conflict point sketch of one-way regulation on both roads.

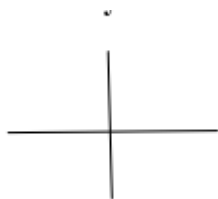


Total numbers of potential conflict points are 6 nos.

19. What is an at-grade intersection?

An intersection where all roadways join or cross at the same level is known as an at-grade intersection.

20. Draw any four basic forms of at-grade intersections.



Cross Roads



T-Junction



Y-Junction



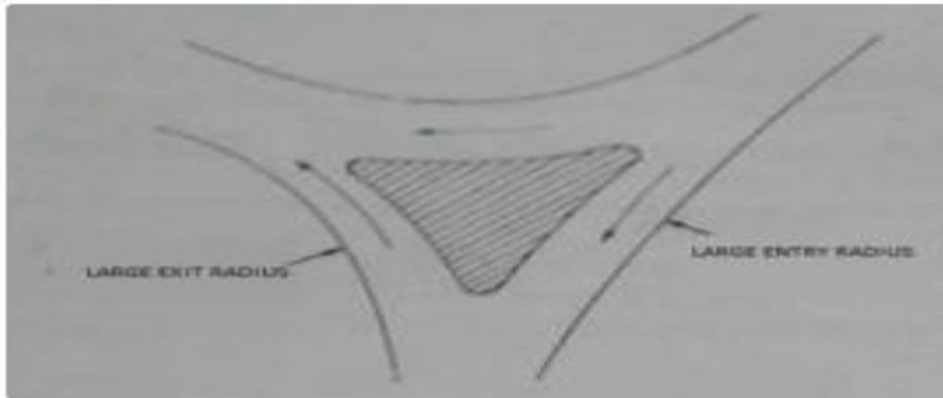
Staggered Junction

21. What are channelized and unchannelized intersections?

A channelized intersection is one in which traffic is directed into definite paths by islands and markings. An unchannelized intersection is the one without islands for directing traffic into definite paths.

22. With a neat sketch, write any one Channelizing island as per IRC standard with its function.

One of the important functions of channelized island is the control of speed. To reduce the speed of traffic entering the intersection and increase the speed of traffic leaving the intersection, bending or funnelling by suitable channelization techniques is resorted to.



The above figure shows the control of radius of entry and exit for control of speed.

23. What are the advantages of channelized intersections?

The following are the advantages of channelized intersections:

- a) Separation of conflicts
- b) Control of angle of conflict
- c) Control of speed
- d) Protection of traffic for vehicles leaving or crossing the main traffic stream
- e) Protection of pedestrians
- f) Elimination of excessive intersectional areas
- g) Blockage of prohibited areas
- h) Location of traffic control devices

24. What are the advantages of rotary intersections?

The advantages of rotary intersections are:

- a) An orderly and regimented traffic flow is provided by rotary one - way movement
- b) All traffic proceeds simultaneously and continuously at fairly uniform, low speed
- c) All turns can be made with ease, although little extra travel distance is required for all movements except left turns
- d) For moderate traffic, rotaries are self governing and need no control by police or traffic signals

25. What are the drawbacks of a conventional round about?

The drawbacks of a conventional round about are:

- a) A rotary requires more land and may not be feasible in many built-up locations
- b) Where pedestrian traffic is large, a rotary by itself is not sufficient to control traffic and has to be supplemented by traffic police
- c) When used on high speed roads, rotaries require extremely large size
- d) Where the angle of intersection between two roads is too acute, it becomes difficult to provide adequate weaving length

26. What is a grade separated intersection?

An intersection layout which permits crossing manoeuvres at different levels is known as grade - separated intersections.

27. What are the types of grade - separated intersections?

The two types of grade - separated intersections are:

- a) Grade - separated intersections without interchange
- b) Grade - separated intersections with interchange

28. What are the factors on which the choice between an At Grade Intersection and a Grade Separated Intersection depend upon?

The factors on which the choice between an At Grade Intersection and a Grade Separated Intersection depend upon are traffic, economy, safety, aesthetics, delay, etc.

29. What is an interchange?

An interchange is a system whereby facility is provided for movement of traffic between two or more roadways at different levels in the grade separated junction.

30. How are interchanges classified?

The interchanges are classified as:

- a) Three leg interchange
 - i) T interchange
 - ii) Y interchange

- iii) A partial rotary interchange
- b) Four leg interchange
- i) Diamond interchange
- ii) Half clover leaf interchange
- iii) Clover leaf interchange
- iv) Rotary interchange
- v) Directional interchange
- c) Multi-leg interchange
- i) Rotary interchange

16 MARKS

1.Explain In Detail About Traffic Control Devices

Traffic control device is the medium used for communicating between traffic engineer and road users. Unlike other modes of transportation, there is no control on the drivers using the road. Here traffic control devices comes to the help of the traffic engineer. The major types of traffic control devices used are-traffic signs, road markings , traffic signals and parking control. This chapter discusses traffic control signs. Different types of traffic signs are regulatory signs, warning signs and informatory signs.

Requirements

The requirements of traffic control devices are listed below:

- 1.The control device should fulfill a need : Each device must have a specific purpose for the safe and efficient operation of traffic flow. The superfluous devices should not be used.
- 2.It should command attention from the road users: This affects the design of signs. For commanding attention, proper visibility should be there. Also the sign should be distinctive and clear. The sign should be placed in such a way that the driver requires no extra effort to see the sign.
- 3.It should convey a clear, simple meaning: Clarity and simplicity of message is essential for the driver to properly understand the meaning in short time. The use of color, shape and legend as codes becomes important in this regard. The legend should be kept short and simple so that even a less educated driver could understand the message in less time.
- 4.Road users must respect the signs: Respect is commanded only when the drivers are conditioned to expect that all devices carry meaningful and important messages. Overuse, misuse and confusing messages of devices tends the drivers to ignore them.
- 5.The control device should provide adequate time for proper response from the road users: This is again related to the design aspect of traffic control devices. The sign boards should be placed at a distance such

that the driver could see it and gets sufficient time to respond to the situation. For example, the STOP sign which is always placed at the stop line of the intersection should be visible for at least one safe stopping sight distance away from the stop line.

Communication tools

A number of mechanisms are used by the traffic engineer to communicate with the road user. These mechanisms recognize certain human limitations, particularly eyesight. Messages are conveyed through the following elements.

1.Color: It is the first and most easily noticed characteristics of a device. Usage of different colors for different signs are important. The most commonly used colors are red, green, yellow, black, blue, and brown . These are used to code certain devices and to reinforce specific messages. Consistent use of colors helps the drivers to identify the presence of sign board ahead.

2.Shape : It is the second element discerned by the driver next to the color of the device. The categories of shapes normally used are circular, triangular, rectangular, and diamond shape. Two exceptional shapes used in traffic signs are octagonal shape for STOP sign and use of inverted triangle for GIVE WAY (YIELD) sign. Diamond shape signs are not generally used in India.

3.Legend : This is the last element of a device that the drive comprehends. This is an important aspect in the case of traffic signs. For the easy understanding by the driver, the legend should be short, simple and specific so that it does not divert the attention of the driver. Symbols are normally used as legends so that even a person unable to read the language will be able to understand that. There is no need of it in the case of traffic signals and road markings.

4.Pattern: It is normally used in the application of road markings, complementing traffic signs. Generally solid, double solid and dotted lines are used. Each pattern conveys different type of meaning. The frequent and consistent use of pattern to convey information is recommended so that the drivers get accustomed to the different types of markings and can instantly recognize them.

Types of traffic signs

There are several hundreds of traffic signs available covering wide variety of traffic situations. They can be classified into three main categories.

1.Regulatory signs: These signs require the driver to obey the signs for the safety of other road users.

2.Warning signs:These signs are for the safety of oneself who is driving and advice the drivers to obey these signs.

3.Informative signs: These signs provide information to the driver about the facilities available ahead, and the route and distance to reach the specific destinations

In addition special type of traffic sign namely work zone signs are also available. These type of signs are used to give warning to the road users when some construction work is going on the road. They are placed

only for short duration and will be removed soon after the work is over and when the road is brought back to its normal condition. The first three signs will be discussed in detail below.

Regulatory signs

These signs are also called mandatory signs because it is mandatory that the drivers must obey these signs. If the driver fails to obey them, the control agency has the right to take legal action against the driver. These signs are primarily meant for the safety of other road users. These signs have generally black legend on a white background. They are circular in shape with red borders. The regulatory signs can be further classified into :

1.Right of way series:

These include two unique signs that assign the right of way to the selected approaches of an intersection. They are the STOP sign and GIVE WAY sign. For example, when one minor road and major road meets at an intersection, preference should be given to the vehicles passing through the major road. Hence the give way sign board will be placed on the minor road to inform the driver on the minor road that he should give way for the vehicles on the major road. In case two major roads are meeting, then the traffic engineer decides based on the traffic on which approach the sign board has to be placed. Stop sign is another example of regulatory signs that comes in right of way series which requires the driver to stop the vehicle at the stop line.

2.Speed series:

Number of speed signs may be used to limit the speed of the vehicle on the road. They include typical speed limit signs, truck speed, minimum speed signs etc. Speed limit signs are placed to limit the speed of the vehicle to a particular speed for many reasons. Separate truck speed limits are applied on high speed roadways where heavy commercial vehicles must be limited to slower speeds than passenger cars for safety reasons. Minimum speed limits are applied on high speed roads like expressways, freeways etc. where safety is again a predominant reason. Very slow vehicles may present hazard to themselves and other vehicles also.

3.Movement series:

They contain a number of signs that affect specific vehicle maneuvers. These include turn signs, alignment signs, exclusion signs, one way signs etc. Turn signs include turn prohibitions and lane use control signs. Lane use signs make use of arrows to specify the movements which all vehicles in the lane must take. Turn signs are used to safely accommodate turns in unsignalized intersections.

4.Parking series:

They include parking signs which indicate not only parking prohibitions or restrictions, but also indicate places where parking is permitted, the type of vehicle to be parked, duration for parking etc.

5.Pedestrian series:

They include both legend and symbol signs. These signs are meant for the safety of pedestrians and include signs indicating pedestrian only roads, pedestrian crossing sites etc.

6.Miscellaneous:

Wide variety of signs that are included in this category are: a "KEEP OF MEDIAN" sign, signs indicating road closures, signs restricting vehicles carrying hazardous cargo or substances, signs indicating vehicle weight limitations etc.

Some examples of the regulatory signs are shown in figure 1. They include a stop sign, give way sign, signs for no entry, sign indicating prohibition for right turn, vehicle width limit sign, speed limit sign etc.

Warning signs

Warning signs or cautionary signs give information to the driver about the impending road condition. They advice the driver to obey the rules. These signs are meant for the own safety of drivers. They call for extra vigilance from the part of drivers. The color convention used for this type of signs is that the legend will be black in color with a white background. The shape used is upward triangular or diamond shape with red borders. Some of the examples for this type of signs are given in fig 2 and includes right hand curve sign board, signs for narrow road, sign indicating railway track ahead etc.

Informative signs

Informative signs also called guide signs, are provided to assist the drivers to reach their desired destinations. These are predominantly meant for the drivers who are unfamiliar to the place. The guide signs are redundant for the users who are accustomed to the location.

Some of the examples for these type of signs are route markers, destination signs, mile posts, service information, recreational and cultural interest area signing etc. Route markers are used to identify numbered highways. They have designs that are distinctive and unique. They are written black letters on yellow background. Destination signs are used to indicate the direction to the critical destination points, and to mark important intersections. Distance in kilometers are sometimes marked to the right side of the destination. They are, in general, rectangular with the long dimension in the horizontal direction. They are color coded as white letters with green background.

Mile posts are provided to inform the driver about the progress along a route to reach his destination. Service guide signs give information to the driver regarding various services such as food, fuel, medical assistance etc. They are written with white letters on blue background. Information on historic, recreational and other cultural area is given on white letters with brown background. In the figure 3 we can see some examples for informative signs which include route markers, destination signs, mile posts, service center information etc..

2.Write Short Notes On Roadway Markings

The essential purpose of road markings is to guide and control traffic on a highway. They supplement the function of traffic signs. The markings serve as a psychological barrier and signify the delineation of traffic path and its lateral clearance from traffic hazards for the safe movement of traffic. Hence they are very important to ensure the safe, smooth and harmonious flow of traffic. Various types of road markings like longitudinal markings, transverse markings, object markings and special markings to warn the driver about the hazardous locations in the road etc. will be discussed in detail in this chapter.

Classification

The road markings are defined as lines, patterns, words or other devices, except signs, set into applied or attached to the carriageway or kerbs or to objects within or adjacent to the carriageway, for controlling, warning, guiding and informing the users. The road markings are classified as longitudinal markings, transverse markings, object markings, word messages, marking for parking, marking at hazardous locations etc.

Longitudinal markings

Longitudinal markings are placed along the direction of traffic on the roadway surface, for the purpose of indicating to the driver, his proper position on the roadway. Some of the guiding principles in longitudinal markings are also discussed below.

Longitudinal markings are provided for separating traffic flow in the same direction and the predominant color used is white. Yellow color is used to separate the traffic flow in opposite direction and also to separate the pavement edges. The lines can be either broken, solid or double solid. Broken lines are permissive in character and allows crossing with discretion, if traffic situation permits. Solid lines are restrictive in character and does not allow crossing except for entry or exit from a side road or premises or to avoid a stationary obstruction. Double solid lines indicate severity in restrictions and should not be crossed except in case of emergency. There can also be a combination of solid and broken lines. In such a case, a solid line may be crossed with discretion, if the broken line of the combination is nearer to the direction of travel. Vehicles from the opposite directions are not permitted to cross the line. Different types of longitudinal markings are center line, traffic lanes, no passing zone, warning lines, border or edge lines, bus lane markings, cycle lane markings.

Center line

Center line separates the opposing streams of traffic and facilitates their movements. Usually no center line is provided for roads having width less than 5 m and for roads having more than four lanes. The center line may be marked with either single broken line, single solid line, double broken line, or double solid line depending upon the road and traffic requirements. On urban roads with less than four lanes, the center line may be single broken line segments of 3 m long and 150 mm wide. The broken lines are placed with 4.5 m gaps. On curves and near intersections, gap shall be reduced to 3 meters. On undivided urban roads with at least two traffic lanes in each direction, the center line marking may be a single solid line of 150 mm wide as in figure 2, or double solid line of 100 mm wide separated by a space of 100 mm as shown in figure 3.

Traffic lane lines

The subdivision of wide carriageway into separate lanes on either side of the carriage way helps the driver to go straight and also curbs the meandering tendency of the driver. At intersections, these traffic lane lines will eliminate confusion and facilitates turning movements. Thus traffic lane markings help in increasing the capacity of the road in addition ensuring more safety. The traffic lane lines are normally single broken lines of 100 mm width.

No passing zones

No passing zones are established on summit curves, horizontal curves, and on two lane and three lane highways where overtaking maneuvers are prohibited because of low sight distance. It may be marked by a solid yellow line along the center or a double yellow line. In the case of a double yellow line, the left hand element may be a solid barrier line, the right hand may be a either a broken line or a solid line . These solid lines are also called barrier lines. When a solid line is to the right of the broken line, the passing restriction shall apply only to the opposing traffic.

Warning lines

Warning lines warn the drivers about the obstruction approaches. They are marked on horizontal and vertical curves where the visibility is greater than prohibitory criteria specified for no overtaking zones. They are broken lines with 6 m length and 3 m gap. A minimum of seven line segments should be provided.

Edge lines

Edge lines indicate edges of rural roads which have no kerbs to delineate the limits up to which the driver can safely venture. They should be at least 150 mm from the actual edge of the pavement. They are painted in yellow or white.

All the lines should be preferably light reflective, so that they will be visible during night also. Improved night visibility may also be obtained by the use of minute glass beads embedded in the pavement marking materials to produce a retroreflective surface.

Transverse markings

Transverse markings are marked across the direction of traffic. They are marked at intersections etc. The site conditions play a very important role. The type of road marking for a particular intersection depends on several variables such as speed characteristics of traffic, availability of space etc. Stop line markings, markings for pedestrian crossing, direction arrows, etc. are some of the markings on approaches to intersections.

Stop line

Stop line indicates the position beyond which the vehicles should not proceed when required to stop by control devices like signals or by traffic police. They should be placed either parallel to the intersecting roadway or at right angles to the direction of approaching vehicles.

Pedestrian crossings

Pedestrian crossings are provided at places where the conflict between vehicular and pedestrian traffic is severe. The site should be selected that there is less inconvenience to the pedestrians and also the vehicles are not interrupted too much. At intersections, the pedestrian crossings should be preceded by a stop line at a distance of 2 to 3m for unsignalized intersections and at a distance of one meter for signalized intersections. Most commonly used pattern for pedestrian crossing is Zebra crossing consisting of equally spaced white strips of 500 mm wide.

Directional arrows

In addition to the warning lines on approaching lanes, directional arrows should be used to guide the drivers in advance over the correct lane to be taken while approaching busy intersections. Because of the low angle at which the markings are viewed by the drivers, the arrows should be elongated in the direction of traffic for adequate visibility. The dimensions of these arrows are also very important.

Object marking

Physical obstructions in a carriageway like traffic island or obstructions near carriageway like signal posts, pier etc. cause serious hazard to the flow of traffic and should be adequately marked. They may be marked on the objects adjacent to the carriageway.

Objects within the carriageway

The obstructions within the carriageway such as traffic islands, raised medians, etc. may be marked by not less than five alternate black and yellow stripes. The stripes should slope forward at an angle of 45° with respect to the direction of traffic. These stripes shall be uniform and should not be less than 100 mm wide so as to provide sufficient visibility.

Objects adjacent to carriageway

Sometimes objects adjacent to the carriageway may pose some obstructions to the flow of traffic. Objects such as subway piers and abutments, culvert head walls etc. are some examples for such obstructions. They should be marked with alternate black and white stripes at a forward angle of 45° with respect to the direction of traffic. Poles close to the carriageway should be painted in alternate black and white up to a height of 1.25 m above the road level. Other objects such as guard stones, drums, guard rails etc. where chances of vehicles hitting them are only when vehicle runs off the carriageway should be painted in solid white. Kerbs of all islands located in the line of traffic flow shall be painted with either alternating black and white stripes of 500 mm wide or chequered black and white stripes of same width.

Word messages

Information to guide, regulate, or warn the road user may also be conveyed by inscription of word message on road surface. Characters for word messages are usually capital letters. The legends should be as brief as possible and shall not consist of more than three words for any message. Word messages require more and important time to read and comprehend than other road markings. Therefore, only few and important ones are usually adopted. Some of the examples of word messages are STOP, SLOW, SCHOOL, RIGHT TURN ONLY etc. The character of a road message is also elongated so that driver looking at the road surface at a low angle can also read them easily.

Parking

The marking of the parking space limits on urban roads promotes more efficient use of the parking spaces and tends to prevent encroachment on places like bus stops, fire hydrant zones etc. where parking is undesirable. Such parking space limitations should be indicated with markings that are solid white lines

100 mm wide. Words TAXI, CARS, SCOOTERS etc. may also be written if the parking area is specific for any particular type of vehicle. To indicate parking restriction, kerb or carriage way marking of continuous yellow line 100 mm wide covering the top of kerb or carriageway close to it may be used.

Hazardous location

Wherever there is a change in the width of the road, or any hazardous location in the road, the driver should be warned about this situation with the help of suitable road markings. Road markings showing the width transition in the carriageway should be of 100 mm width. Converging lines shall be 150 mm wide and shall have a taper length of not less than twenty times the off-set distance.

3. Write In Detail About Ypes Of Intersection

Intersections may be classified into two broad groups:

Intersection at grade: An intersection where all roadways join or cross at the same level

Grade separated intersection: An intersection layout which permits crossing maneuvers at different levels

Types of At Grade Intersections

At grade Intersections may be classified into two broad groups:

Un channelized intersections

Channelized intersections

Special type - Rotary Intersection

Un channelized intersection:

Intersection area is paved and there is absolutely no restriction to vehicles to use any part of intersection area. Hence the un channelized (all-paved) intersections are the lowest class of intersection, easiest in the design but most complex in traffic operations resulting in maximum conflict area and more number of accidents, unless controlled by traffic signals or police.

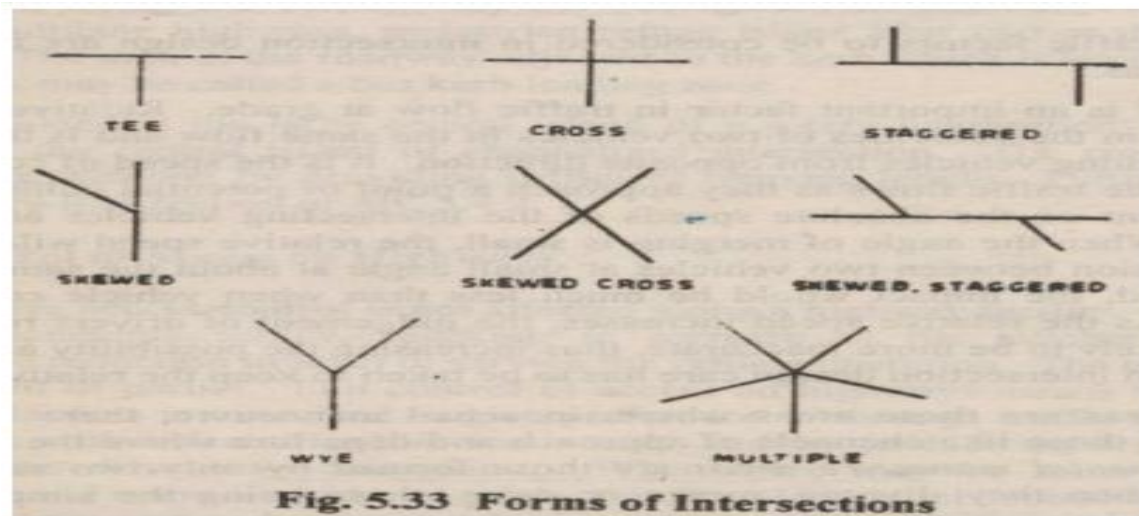
Un channelized intersection:

Plain intersection: No provision for additional pavement width for turning movements

Flared intersection: Provision for additional pavement width for turning movements

Intersection at grade- Forms of Intersection

Tee, Cross, Staggered, Skewed, Skewed cross, Skewed staggered, Wye, Multiple



Traffic Islands

Traffic islands are raised areas constructed within the roadway to establish physical channels through which the vehicular traffic may be guided

Classification – based on the function:

Divisional islands

Channelizing islands

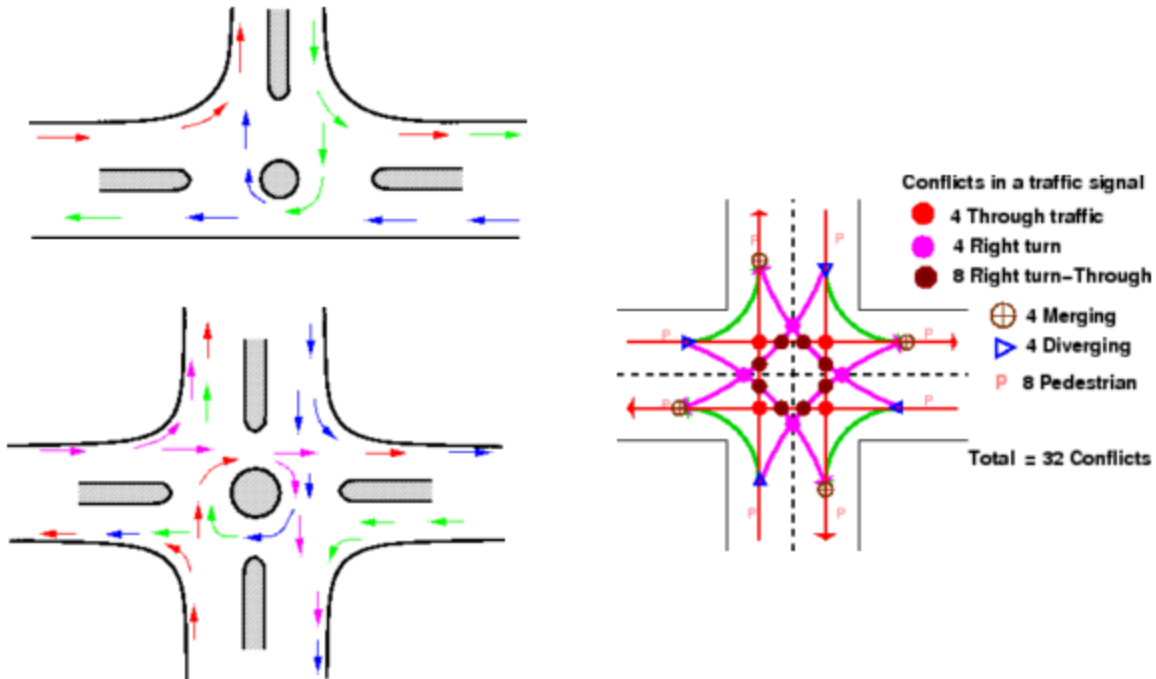
Pedestrian loading islands

Rotary

Channelized intersection:

Channelized intersection is achieved by introduction of islands into the intersectional area, thus reducing the total conflict area available in the un channelized intersection. These islands help to channelized turning traffic, to control their speed and angle of approach and to decrease the conflict area at the intersection

Channelized intersections



Advantages:

Vehicles can be confined to definite paths

The channelizing islands provide proper place for installation of signs and other traffic control devices

Refuse islands can be provided for pedestrians within the intersection area

Types

Grade separated Intersections may be classified into following broad groups:

Overpass

Underpass

Interchanges

This design is the highest form of intersection treatment. Causes least delay and hazard to the crossing traffic and in general is much superior to intersection at grade from the traffic safety and efficient operation.

4.Expalin In Detail About Design Of Rotary Intersections

Rotary intersections or roundabouts are special form of at-grade intersections laid out for the movement of traffic in one direction around a central traffic island. Essentially all the major conflicts at an intersection namely the collision between through and right-turn movements are converted into milder conflicts namely merging and diverging. The vehicles entering the rotary are gently forced to move in a clockwise direction in orderly fashion. They then weave out of the rotary to the desired direction.

Advantages

1. Traffic flow is regulated to only one direction of movement, thus eliminating severe conflicts between crossing movements.
2. All the vehicles entering the rotary are gently forced to reduce the speed and continue to move at slower speed. Thus, more of the vehicles need not to be stopped.
3. Because of lower speed of negotiation and elimination of severe conflicts, accidents and their severity are much less in rotaries.
4. Rotaries are self governing and do not need practically any control by police or traffic signals.
5. They are ideally suited for moderate traffic, especially with irregular geometry, or intersections with more than three or four approaches.

Disadvantages

1. Even when there is relatively low traffic, the vehicles are forced to reduce their speed.
2. All the vehicles are forced to slow down and negotiate the intersection. Therefore the cumulative delay will be much higher than channelized intersection.
3. Rotaries require large area of relatively at land making them costly at urban areas.
4. The vehicles do not usually stop at a rotary. They accelerate and exit the rotary at relatively high speed. Therefore, they are not suitable when there is high pedestrian movements

Traffic operations in a rotary

As noted earlier, the traffic operations at a rotary are three; diverging, merging and weaving. All the other conflicts are converted into these three less severe conflicts.

Diverging: It is a traffic operation when the vehicles moving in one direction is separated into different streams according to their destinations.

Merging: Merging is the opposite of diverging. Merging is referred to as the process of joining the traffic coming from different approaches and going to a common destination into a single stream.

Weaving: Weaving is the combined movement of both merging and diverging movements in the same direction.

Design elements

The design elements include

Design speed

Radius at entry & exit

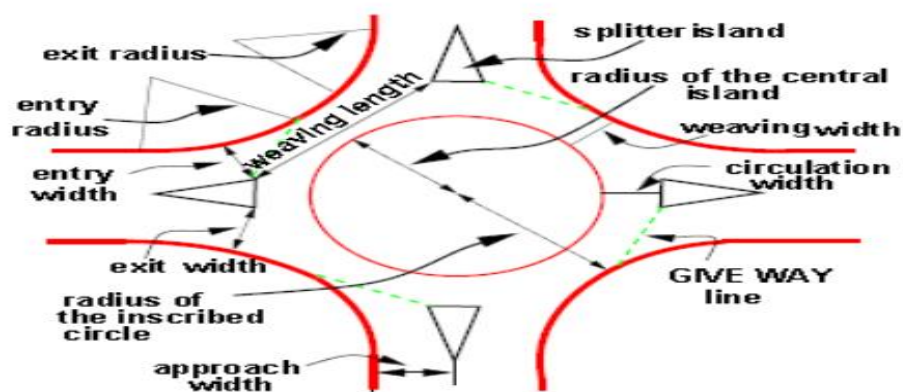
The central island,

Weaving length & width,

Entry and exit widths.

In addition the capacity of the rotary can also be determined by using some empirical formula.

Design of a rotary



Design Speed

All the vehicles are required to reduce their speed at a rotary. Therefore, the design speed of a rotary will be much lower than the roads leading to it. Although it is possible to design roundabout without much speed reduction, the geometry may lead to very large size incurring huge cost of construction. The normal practice is to keep the design speed as 30 and 40 kmph for urban and rural areas respectively.

Entry, exit and island radius

The radius at the entry depends on various factors like design speed, super-elevation, and coefficient of friction. The entry to the rotary is not straight, but a small curvature is introduced. This will force the driver to reduce the speed. The speed range of about 20 kmph and 25 kmph is ideal for an urban and rural design respectively.

The exit radius should be higher than the entry radius and the radius of the rotary island so that the vehicles will discharge from the rotary at a higher rate. A general practice is to keep the exit radius as 1.5 to 2 times the entry radius. However, if pedestrian movement is higher at the exit approach, then the exit radius could be set as same as that of the entry radius.

The radius of the central island is governed by the design speed, and the radius of the entry curve. The radius of the central island, in practice, is given a slightly higher reading so that the movement of the

traffic already in the rotary will have priority of movement. The radius of the central island which is about 1.3 times that of the entry curve is adequate for all practical purposes.

Width of the rotary

The entry width and exit width of the rotary is governed by The traffic entering and leaving the intersection and The width of the approaching road The width of the carriageway at entry and exit will be lower than the width of the carriageway at the approaches to enable reduction of speed. IRC suggests that a two lane road of 7 m width should be kept as 7 m for urban roads and 6.5 m for rural roads. Further, a three lane road of 10.5 m is to be reduced to 7 m and 7.5 m respectively for urban and rural roads.

Width of the rotary

The width of the weaving section should be higher than the width at entry and exit. Normally this will be one lane more than the average entry and exit width.

$$W_{\text{weaving}} = \left(\frac{e_1 + e_2}{2} \right) + 3.5\text{m}$$

Thus weaving width is given as Where, e_1 - width of the carriageway at the entry and e_2 - carriageway width at exit .

Capacity

The capacity of rotary is determined by the capacity of each weaving section. Transportation road research lab (TRL) proposed the following empirical formula to find the capacity of the weaving section.

$$Q_w = \frac{280w[1 + \frac{e}{w}][1 - \frac{p}{3}]}{1 + \frac{w}{l}}$$

Where,

e - average entry and exit width, i.e, $(e_1 + e_2)/2$,

w - weaving width, l - length of weaving, and

p - proportion of weaving traffic to the non-weaving traffic.

Weaving width at the rotary is in between 6 and 18 metres. The ratio of average width of the carriage way at entry and exit to the weaving width is in the range of 0.4 to 1. The ratio of weaving width to weaving

length of the roundabout is in between 0.12 and 0.4. The proportion of weaving traffic to non-weaving traffic in the rotary is in the range of 0.4 and 1. The weaving length available at the intersection is in between 18 and 90 m.

5. Write short notes on Traffic signals

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

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: Thus it indicates the change from one stage to another. There are two types of intervals - change interval and clearance interval. Change interval is also called the yellow time indicates the interval between the green and red signal indications for an approach. Clearance interval is also called all red and is provided after each yellow interval indicating 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 . This is the actual duration the green light of a traffic signal is turned on.
- Red interval: It is the red indication for a particular movement or set of movements and is denoted by R . This is the actual duration the red light of a traffic signal is turned on.
- 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 for any movement. For example, when the signal for an approach turns from red to green, the driver of the vehicle which is in the front of the queue, will take some time to perceive the signal (usually called as reaction time) and some time will be lost before vehicle actually moves and gains speed.

Phase design

The signal design procedure involves six major steps. They include:

- (1) phase design,
- (2) determination of amber time and clearance time,
- (3) determination of cycle length,
- (4) apportioning of green time,
- (5) pedestrian crossing requirements, and
- (6) performance evaluation of the design obtained in the previous steps.

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, the flow pattern especially the turning movements, and the relative magnitudes of flow. Therefore, a trial and error procedure is often 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, whereas 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. 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 Figure 2, 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 flow 7 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.

Four phase signals

There are at least three possible phasing options. For example, figure 3 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 same lane. This phase plan could be very inefficient when turning movements are relatively low.

The non-conflicting right turn flows 7 and 8 are grouped into a third phase. Similarly flows 5 and 6 are grouped into fourth phase. This type of phasing is very efficient when the intersection geometry permits to have at least one lane for each movement, and the through traffic volume is significantly high. Figure 5 shows yet another phase plan. However, this is rarely used in practice.

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

Cycle time

Cycle time is the time taken by a signal to complete one full 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.

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.

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 constant. 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 vehicles require t_g seconds of green time, and if the signal were always green, then S vehicles per hour would pass the intersection. Therefore, where S is the saturation flow rate in vehicles per hour of green time per lane, h is the saturation headway in seconds. 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 vehicle and is denoted as Δt_i shown in figure 7. These differences for the first few vehicles can be added to get start up lost time, which is given by, The green time required to clear N vehicles can be found out as, where t_g is the time required to clear N vehicles through signal, L is the start-up lost time, and h is the saturation headway in seconds.