

Unit – III

INTERSECTION DESIGN

Topics:

- Conflicts at Intersections
- Channelization: Objectives
- Traffic Islands and Design criteria
- Types of Intersections
 - At-Grade Intersections
 - Grade Separated Intersections
- Rotary Intersection
 - Concept of Rotary and Design Criteria-
 - Advantages and Disadvantages of Rotary Intersection.

Introduction:

- Intersection is the area where two or more roads join or cross each other.
- This area is designated for the vehicles to turn to different directions to reach their desired destinations.
- This is because vehicles moving in different direction want to occupy same space at the same time.

The objective of intersection design:

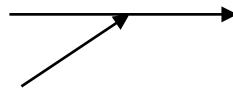
- To regulate traffic operation and ensure safety of road users.
- To maintain design speed and maximize the capacity of intersection.

Conflicts at Intersections:

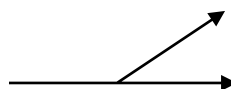
Conflict points are the **points** where two vehicles can potentially clash with each other. We can determine the number of **conflict points** based upon the type of intersection.

Traffic conflicts could be classified into :

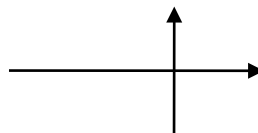
- **Merging Conflicts:** merging conflicts occur when vehicles enter a traffic stream. It is a traffic operation when the vehicles moving in one direction is separated into different streams according to their destinations.



- **Diverging Conflicts:** diverging conflicts occur when vehicles leave the traffic stream. 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.

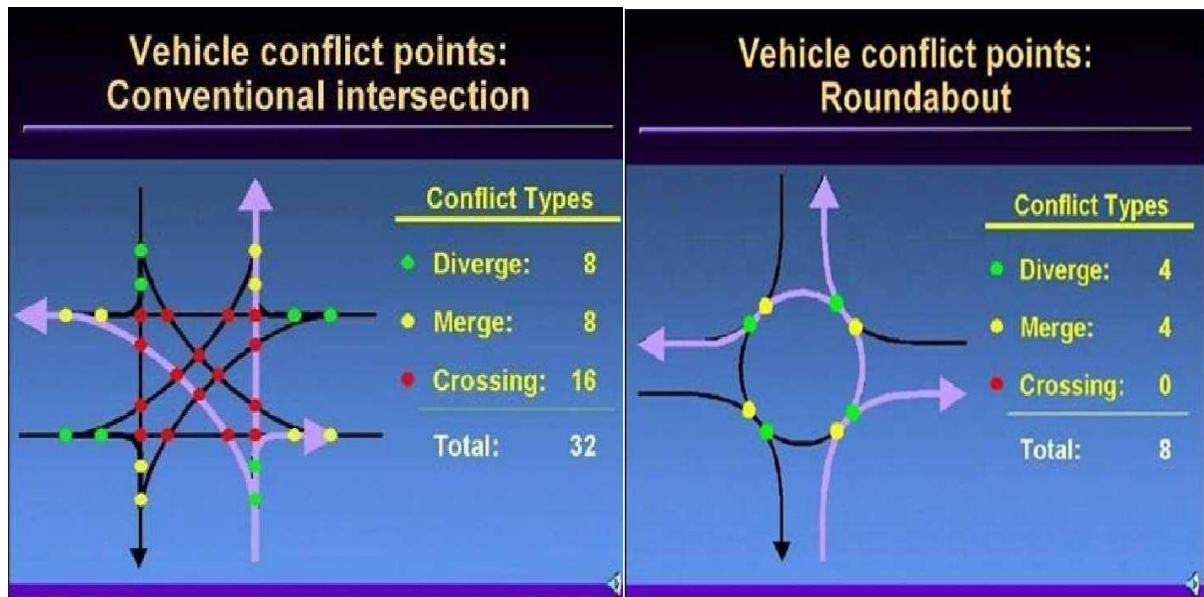


- **Crossing:** Crossing conflicts occur when they cross paths directly.



- **Weaving Conflicts:** weaving conflicts occur when vehicles cross paths by first merging and then diverging. Weaving is the combined movement of both merging and diverging movements in the same direction.





Traffic Islands:

A small raised area in the middle of a road, which provides a safe place for pedestrians to stand and marks a division between two opposing streams of traffic.

(Or)

A traffic island is a solid or painted object in a road that channelizes traffic. It can also be a narrow strip of island between roads that intersect at an acute angle.

If the island uses road markings only, without raised kerbs or other physical obstructions, it is called a **painted island**. Traffic islands can be used to reduce the speed of vehicles driving through.

Types of Traffic Islands:

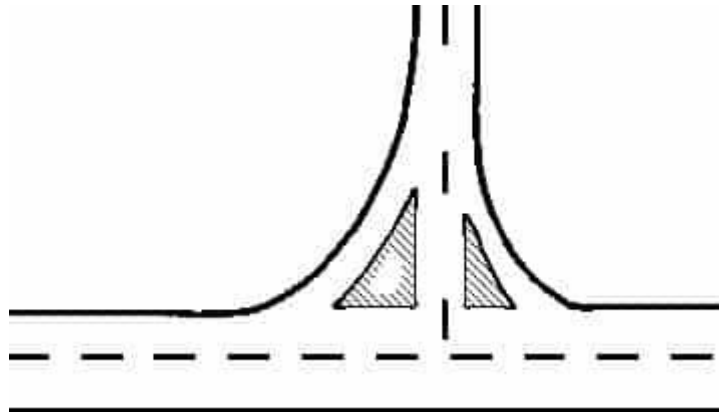
Based on function, Islands are classified as

- Channelizing Islands
- Divisional Islands
- Pedestrian loading Islands
- Rotary Islands

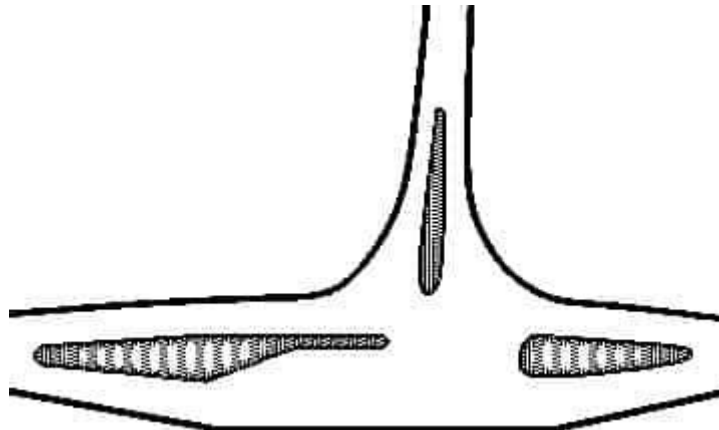
Channelizing Islands:

- Channelizing islands guide the traffic into proper channel through the intersection area.
- The most prominent use of this type is at the turning points, these allow smooth and easy turning of traffic and prevents interference with the other straight moving vehicles.

- These are also found where the roads converge or diverge as they help in reducing conflict points and allow easy merging and diverging of traffic.

**Divisional Island:**

- Divisional islands are dividing the highway in two one-way roadways so that head-on collisions are eliminated and accidents are reduced.
- These are used along the roads.
- These are elongated structures, which can be considered as a median or divider but used for the traffic moving in the same direction.
- These also provide slip roads, which are meant to bypass the traffic signal for straight-moving vehicles.
- These are not meant to aid turning but help in the orderly movement of vehicles and might form a part of a channelizing island, which further assists in reducing conflict points.

**Pedestrian loading Islands / Refuge Island / pedestrian refuge:**

- They are provided at regular bus stops and similar places for the protection of passengers.
- A pedestrian refuge island is a raised section of pavement between two lanes of traffic moving in opposite directions.

- The Islands normally have yellow and white plastic bollards with a blue arrow to remind motorists to keep left. Kerbs are dropped at both sides of the road, usually with tactile paving where the pavement slopes towards the road.
- Refuge Islands allow pedestrians to stop in the centre of the road, so they can split the crossing into two stages for each direction of traffic.



Rotary Islands:

- Rotary islands is the large central island of a rotary intersection.
- The raised platforms of suitable shapes built on the road intersections are called traffic islands or Rotary Island.
- A rotary intersection or traffic rotary is an enlarged road intersection where all converging vehicles are forced to move round a large central island in one direction before they can weave out of traffic flow into their respective directions radiating from the central island.
- The main objects of providing a rotary are to eliminate the necessity of topping even for crossing streams of vehicles and to reduce the area of conflict.



Intersections:

- Intersection is an area shared by two or more roads.
- This area is designated for the vehicles to turn to different directions to reach their desired destinations.
- Its main function is to guide vehicles to their respective directions.
- Traffic intersections are complex locations on any highway. This is because vehicles moving in different direction want to occupy same space at the same time. In addition, the pedestrians also seek same space for crossing.

Type of intersections

There are two main types of intersection of roads,

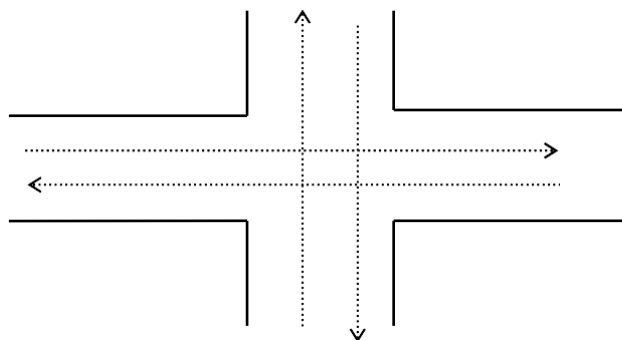
- At-Grade Intersections
- Grade Separated Intersections

At-Grade Intersections:

- At-grade intersections in which all the exchanges between the roads take place on the same plane.
- Roads that cross each other at the same level.
 - i. Uncontrolled junction
 - ii. Priority junction
 - iii. Space sharing junction
 - iv. Time sharing junction
 - v. Channelization

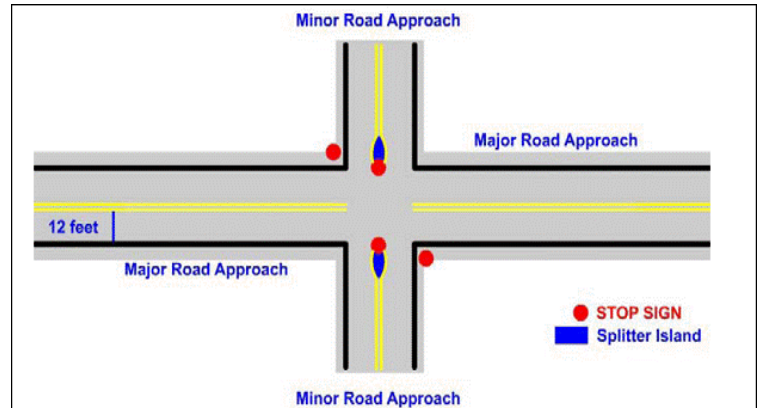
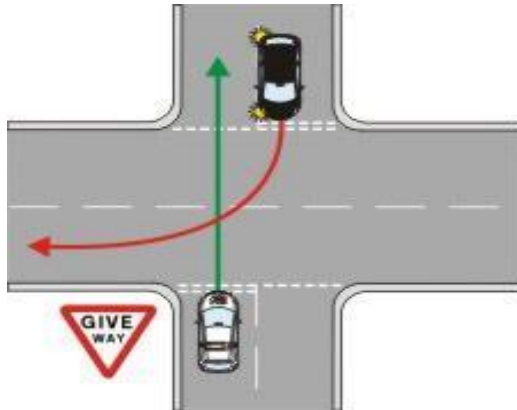
Uncontrolled junction:

Where the join or intersecting roads are more or less **equal important** and there is **no established priority** visibility should be provided, if a driver approaching the intersection from either road must be able to perceive a hazard.

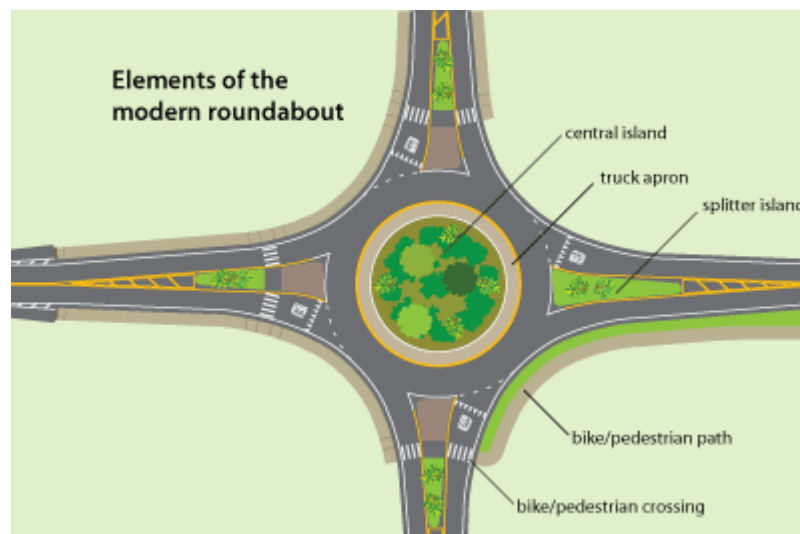


Priority junction:

Intersections involving a **major road and minor road**, it is customary to **control traffic on the minor road** by STOP (when obstructed and poor inter-visibility) or GIVE WAY (when good inter-visibility) signs on road markings.

**Space sharing junction:**

Example: roundabout; – Number of traffic slightly equal at junction; – Traffic streams share spaces at the same time; – Suitable for 3 or 4 highways.

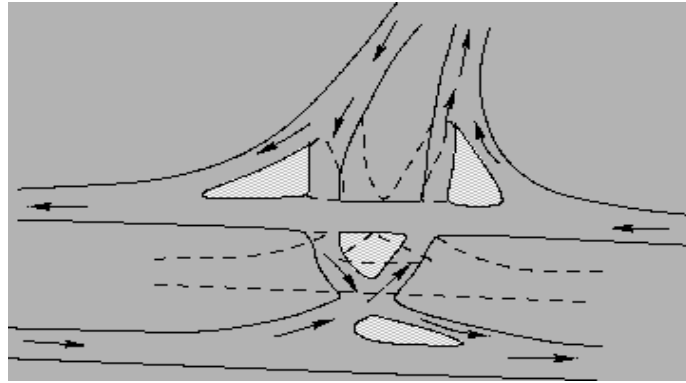
**Time-sharing junction:**

Example: traffic light

Benefits: • Control traffic flow; • Reduce conflict at the junction; • Safer for pedestrian; • Less area used compare to roundabout.

Channelization:

Separation of conflicting movements at intersection to definite paths of traffic flow by means of lane markings islands, road curbs and others.



Functions of Channelization:

- To reduce possible area of conflicts at the intersection
- To control angle of conflict
- To regulate speed of vehicle entering and leaving the intersection
- Protection of traffic and pedestrians
- Location of traffic control devices

Grade Separated Intersection/Interchanges:

Grade separated intersection is the most expensive type of intersection. As such it is recommended in certain situations such as:

- On high type, facilities (expressway) that serve high traffic volume and design speed more than 90km/hr.
- At-grade intersections, which have, reach maximum capacity.
- At locations of bad accident history when functioning as at grade junction.
- At junction where the traffic volume is heavy and it is more economic to provide grade separator compare to the delays.
- At certain specific rolling or hilly topography.
- Road crossing has four through lanes or more.

Types of Grade separated interchanges

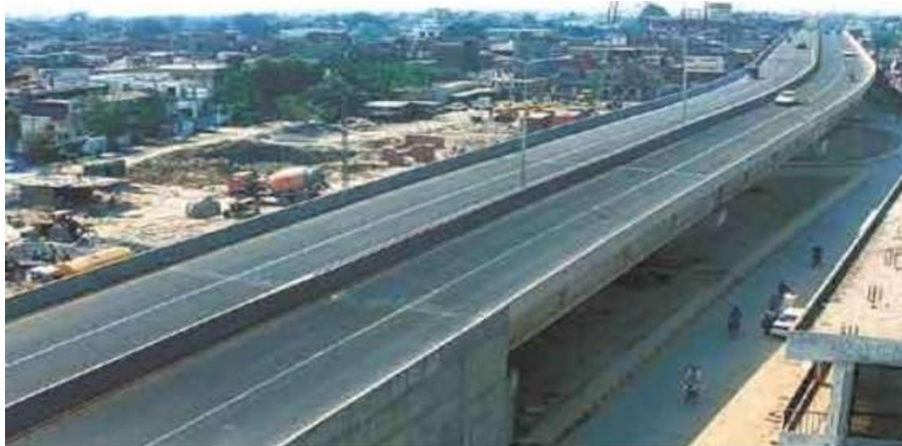
- Underpass
- Overpass
- Trumpet Interchange
- Diamond Interchange
- Cloverleaf Interchange
- Partial cloverleaf Interchange
- Directional Interchange
- Bridged Rotary

Underpass:

- An underpass or a tunnel is an underground passageway, completely enclosed except for openings for ingress and egress, commonly at each end.
- A tunnel may be for foot or vehicular road traffic, for rail traffic.

**Overpass:**

- An overpass also known as a flyover is a bridge, road, railway or similar structure that crosses over another road or railway.
- A pedestrian overpass allows pedestrians safe crossing over busy without affecting traffic.

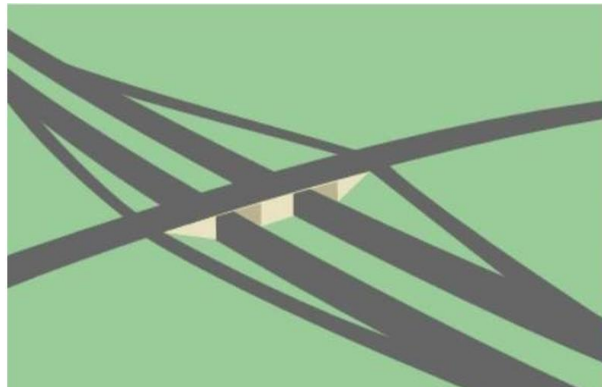
**Trumpet Interchange:**

- Trumpet interchange is a popular form of **three-leg** interchange.
- If one of the legs of the interchange **meets a highway at some angle but does not cross it**, then the interchange is called trumpet interchange.
- The principal advantages are low construction cost and are useful for highways as well as toll roads.



Diamond Interchange:

- Diamond interchange is a popular form of **four-leg** interchange found in the urban locations where major and minor roads crosses.
- The important feature of this interchange is that it can be **designed even if the major road is relatively narrow.**
- The diamond interchange **uses less space than** most types of freeway interchange, and avoids the interweaving traffic flows that occur in interchanges such as the cloverleaf.
- Diamond interchanges are **most effective in areas where traffic is light.**

**Cloverleaf interchange:**

- It is also a **four-leg** interchange and is used when two highways of high volume and speed intersect each other with considerable turning movements.
- The main advantage of cloverleaf intersection is that it **provides complete separation of traffic.**
- In addition, high speed at intersections can be achieved.
- However, the disadvantage is that **large area of land is required.**
- Therefore, cloverleaf interchanges are **provided mainly in rural areas.**

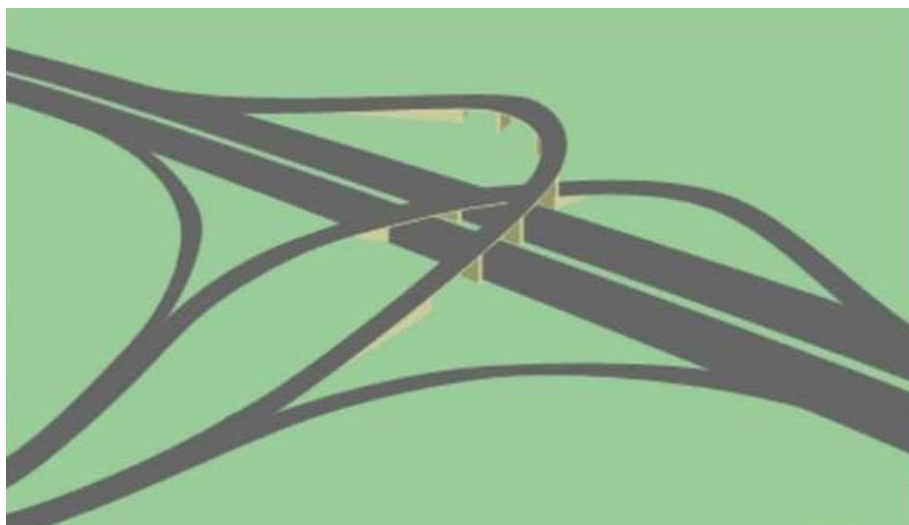


Partial Clover Leaf Interchange:

- Partial cloverleaf is a modification that combines some elements of a **diamond interchange** with one or more loops of a cloverleaf to eliminate only the more critical turning conflicts.
- It provides more acceleration and deceleration space on the freeway.

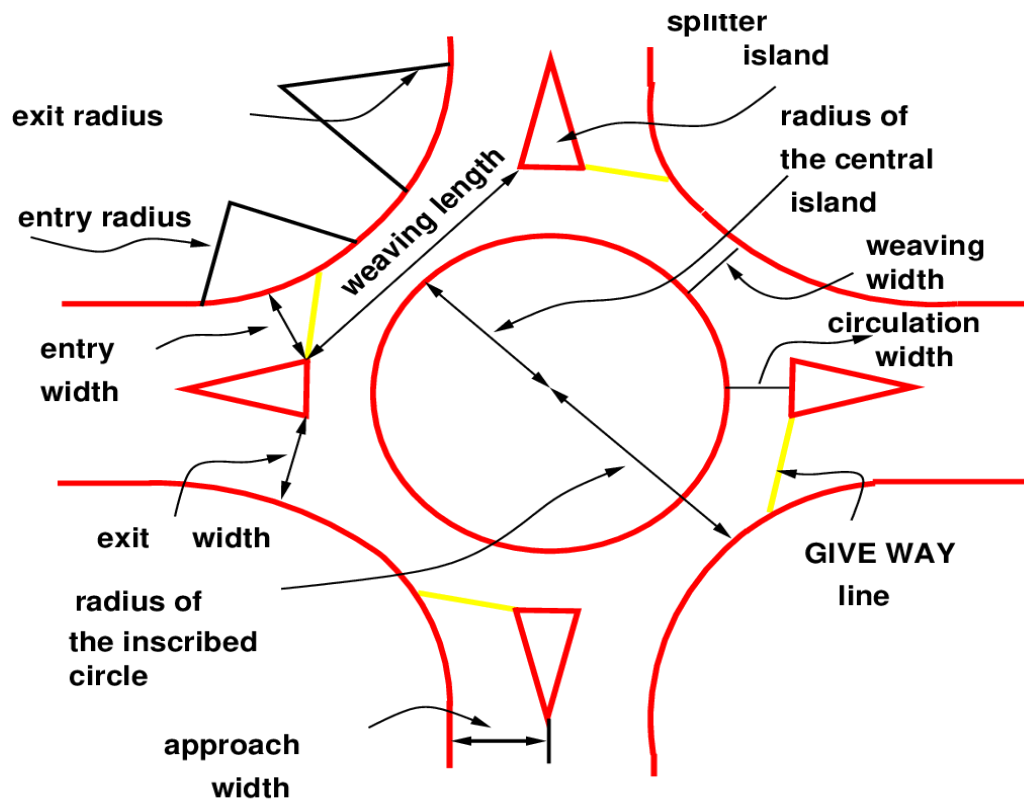
**Directional Interchange:**

- A Directional interchange provides **direct for left turns**.
- These interchanges contain ramps for one or more direct or semi direct left turning movements.
- Interchanges of two freeways or interchanges with one or more very heavy turning movements usually warrant direct ramps, which have higher speeds of operation and higher capacities, compared to loop ramps.



Rotary Intersection:

- Specialized form of at grade intersection laid out for movement of traffic in one direction round a central island.
- Major conflicts at an intersection collision between through and right turn movements.
- All vehicles coming from different roads move in single direction around the central island and diverges into required exit.

**Advantages:**

- Traffic flow is regulated to only one direction of movement, thus eliminating severe conflicts between crossing movements.
- All the vehicles entering the rotary are gently forced to reduce the speed and continue to move at slower speed. Thus, none of the vehicles need to be stopped, unlike in a signalized intersection.
- Because of lower speed of negotiation and elimination of severe conflicts, accidents and their severity are much less in rotaries.
- Rotaries are self-governing and do not need practically any control by police or traffic signals.
- They are ideally suited for moderate traffic, especially with irregular geometry, or intersections with more than three or four approaches.

Disadvantages:

- All the vehicles are forced to slow down and negotiate the intersection. Therefore, the cumulative delay will be much higher than channelized intersection.
- Even when there is relatively low traffic, the vehicles are forced to reduce their speed.
- Rotaries require large area of relatively flat land making them costly at urban areas.
- 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.

Design Factors for Rotary Intersection of Roads

There are many factors to be considered while designing traffic rotary as follows:

- Design speed
- Shape of central island
- Radius of rotary roadway
- Weaving angle and weaving distance
- Width of carriageway at entry and exit
- Width of rotary roadway
- Curves at entrance and exit
- Capacity of rotary
- Channelizing islands
- Camber and super elevation
- Sight distance
- Lighting
- Traffic signs
- Pedestrian ways

Design speed:

- At rotary intersections, the vehicle can be moved without any breaking. Therefore, there is no chance to stop the vehicle while other vehicles can change their direction or cross each other without stopping. However, the speed of vehicular movement should be reduced.
- Standard highway speed is not applicable at rotary intersection. It should be passed with low speed, which will results the safe carrying towards one's direction without any collision. Speed restriction board should be provided on the road towards rotary intersection.

Shape of Central Island:

- The shape of Central Island provided for rotary intersection should not contain any corners. It should be formed by curves to allow the comfortable rotations around it.
- The shape is particularly dependent upon number of roads meeting at that particular junction. The shapes generally provided are circular, elliptical, turbine and tangential. Circular shape island is shown below:

**Radius of Rotary Roadway:**

- The radius of roadway or pavement around the central island is dependent of shape of Central Island. If it is circular shape, radii are similar at all points and if it is elliptical or tangent radii is different at different points. The radius of rotary roadway should be designed by just considering the friction force and super elevation should be neglected.
- Normal radius of roadway in curves

$$R = \frac{V^2}{127(f)}$$

But super elevation (e) is neglected i.e., $e = 0$

Hence, radius of rotary

$$R = \frac{V^2}{127(e+f)}$$

Where f = coefficient of friction = 0.43 to 0.47

Entry Radius:

- This is determined by the design speed, super elevation and coefficient of pavement friction. This should be such as to result in the drivers lowering their speed to the design speed of the rotary.
- IRC recommends an entry radius of 20 to 35 m for rural areas and 15 to 25 m for urban rotaries.

Exit Radius:

- This should be larger than that of the rotary island for the drivers to leave the rotary rapidly. The recommended practice is to keep the exit radius 1.5 to 2 times more than that of the entry radius.
- However, the exit radius may be kept similar to the entry radius in case the pedestrian traffic across the exit road is high, in order to limit the exit speed and allow for pedestrian safety.

Weaving Length:

- The ease with which the traffic can merge and diverge will be dependent on the weaving length. This is decided based on entry width, the width of weaving section, total traffic volume, and the proportion of weaving traffic in it. If the weaving length is made at least four times the weaving width, direct traffic cuts may be prevented.
- IRC: 65-1976 recommends a minimum weaving length of 45 m for a design speed of 40 km/h and 30 m for 30 km/h.
- A maximum limit to weaving length is also considered desirable to discourage speeding near the rotary. For this, twice the above values can be taken to be the upper limits.

Entry and Exit Angles:

- A desirable value for entry angle is 60°; the exit angles should be small for smooth exit from the rotary – it can be 30° or less.

Width of Rotary Roadway

- Vehicles coming from all directions may meet at a time at least for shorter distance at rotary intersections. The width should be equal to the effective width of weaving section. So, the width provided for rotary roadway should be as follows

$$W = \frac{(e_1 + e_2)}{2} + 3.5 \text{ m}$$

Where e_1 = width at entrance

e_2 = width of non-weaving section

Capacity of Rotary Intersections:

- The capacity of rotary is derived from the below formula and it is mainly dependent upon capacity of individual weaving section.

$$Q_p = \frac{280 W (1 + \frac{e}{W})(1 - \frac{p}{3})}{(1 + \frac{W}{L})}$$

Where W = width of weaving section

e = average width of entry and width of non-weaving section for the range of e/W

L = weaving length for the range of W/L

Where p = proportion of weaving traffic = $(b+c)/(a+b+c+d) = (0.4 < p < 1.0)$

a = left turning traffic moving along left extreme lane

b = weaving traffic turning toward right while entering the rotary

c = weaving traffic turning toward left while leaving the rotary

d = right turning traffic moving along right extreme lane

Channelizing Islands:

- Channelizing islands are provided at entrance or exit of roadway to prevent the vehicle from undesirable weaving.

Sight Distance:

- The sight distance provided at rotary intersections should be as higher as possible and in no case; the value must be less than the stopping sight distance.

