Chapter 33

Grade Separated Intersection

33.1 Overview

An intersection is the area shared by the joining or crossing of two or more roads. Since the main function of an intersection is to enable the road user to make a route choice, it is a point of decision. Hence the problems that are encountered by the motorist while passing through an intersection must be recognized and the design should be in such a way that the driving task is as simple as possible.

Intersection is also a point of large number of major conflicts, besides a point of decision. These conflicts may be due to the crossing maneuvers of vehicles moving in different directions. Good intersection design results from a minimization of the magnitude and characteristics of the conflicts and a simplification of driver route selection process.

33.2 Classification of Intersection

Intersections are classified depending upon the treatment of crossing conflicts as follows (i) At Grade Intersection and (ii) Grade Separated Intersection.

33.2.1 Grade Separated Intersection

It is a bridge that eliminates crossing conflicts at intersections by vertical separation of roadways in space. Grade separated intersection are otherwise known as Interchanges. Grade separated intersections cause less hazard and delay than grade intersections. Route transfer at grade separations is accommodated by interchange facilities consisting of ramps. Interchange ramps are classified as Direct, Semi-Direct and Indirect. Interchanges are described by the patterns of the various turning roadways or ramps. The interchange configurations are designed in such a way to accommodate economically the traffic requirements of flow, operation on the crossing

facilities, physical requirements of the topography, adjoining land use, type of controls, right-of-way and direction of movements.

The ultimate objective of grade separated intersections is to eliminate all grade crossing conflicts and to accommodate other intersecting maneuvers by merging, diverging and weaving at low relative speed. The relative speed of the conflicting vehicle streams is an important factor affecting the significance of a conflict. The benefit of providing for low relative speed is twofold. First, events unfold more slowly allowing more judgement time and second, in case of an impact the total relative energy to be absorbed are less and hence, the damage is less. In addition, when relative speed is low, the average motorist will accept a smaller time gap space between successive vehicles to complete his move. This condition increases roadway capacity.

33.2.2 Classification of Grade Separated Intersection

One of the distinctions made in type of interchange is between the directional and the non directional interchange. Directional interchanges are those having ramps that tend to follow the natural direction of movement. Non directional interchanges require a change in the natural path of traffic flow. A comprehensive classification plan for grade separated intersection design which includes all possible geometric patterns has not yet been developed. The design and operational characteristics of each of the major interchange types are mentioned as follows and are discussed in the following sections.

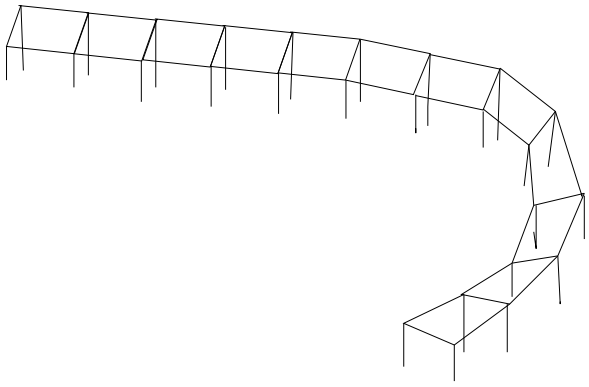
1. Underpass
2. Overpass
3. Trumpet Interchange
4. Diamond Interchange
5. Cloverleaf Interchange
6. Partial Cloverleaf Interchange
7. Directional Interchange
8. Bridged Rotary

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. If an underpass is constructed for pedestrians and/or cyclists beneath a road or railway, allowing them to reach the other side in safety, then such a construction is termed as a Subway. These are constructed when it is necessary for pedestrians to cross a railroad or a limited-access highway. Subways may also be constructed for the benefit of wildlife

Overpass

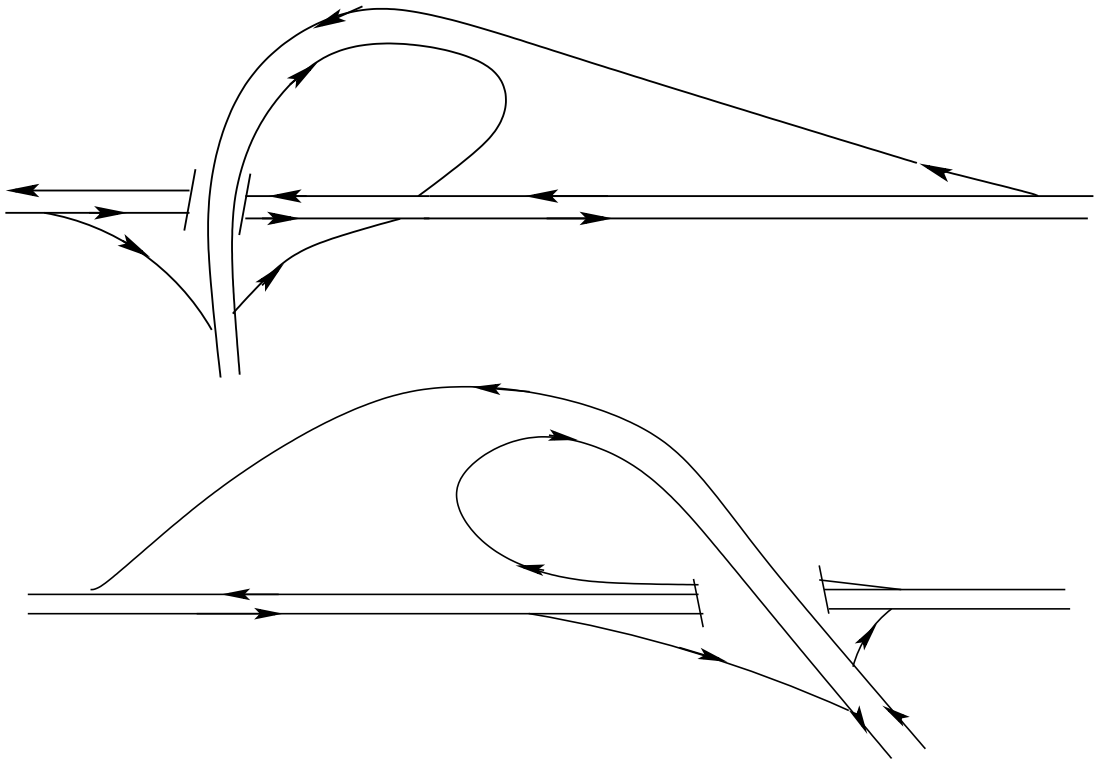
An overpass also known as a flyover, is a bridge, road, railway or similar structure that crosses over another road or railway. A pedestrian overpass allows pedestrians safe crossing over busy roads without impacting traffic. And Railway overpasses are used to replace at-grade crossing as a safer alternative. Overpasses allows for unobstructed rail traffic flow from mixing with vehicular and pedestrian traffic. Stack interchanges are made up of many overpasses.



Trumpet Interchange

Trumpet interchanges have been used where one highway terminates at another highway. These involve at least one loop ramp connecting traffic either entering or leaving the terminating expressway with the far lanes of the continuous highway. These interchanges are useful for highways as well as toll roads, as they concentrate all entering and exiting traffic into a single stretch of roadway, where toll booths can be installed. Trumpets are suitable at the locations where the side road exists on only one side of the freeway, and traffic is relatively low. Each entrance and exit consists of acceleration or deceleration lanes at each end. It requires only one bridge and is the most traditional way of grade separating a three way junction. The principal advantages are low construction cost and are useful for highways as well as toll roads. But

the limitations in employing trumpet interchanges are it leaves a redundant patch of the land within the loop, Disorienting to navigate for those driving in the direction that uses the loop. Moreover scaling down the interchange often results in a more dangerous suffers congestion from articulated lorries that have tipped over.

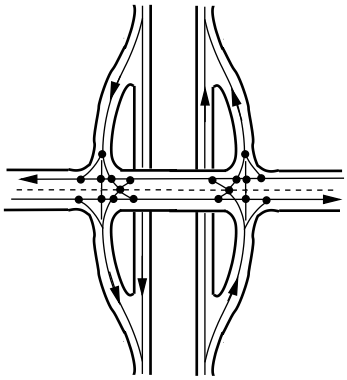


Diamond Interchange

The diamond Interchange is the simplest form of grade separated intersection between two roadways. The conflicts between through and crossing traffic are eliminated by a bridge structure. This particular intersection has four one way ramps which are essentially parallel to the major artery. The left turn crossing movement conflicts are considerably reduced by eliminating the conflict with the traffic in opposite direction. All the remaining left turn conflicts, merging and diverging maneuver conflicts take place at the terminal point of each ramp. Limitation in application of this design depends on the operations of these terminals. So, it is suitable for locations where the volume of left turn traffic is relatively low.

The diamond interchange requires a minimum amount of land and is economical to construct. Also,a diamond interchange generally requires less out-of-the-way travel and vehicle operating costs are less than those on most other types of interchanges. The single point of exit from the major roadway eases the problem of signing. This type of interchange requires the

least of right-of-way. With these advantages, the diamonds appear to be the ideal solution to an intersection problem. But there might be chances of occurrence of conflicts at the locations where ramps meet the grade separated cross street are to be considered foe high ramp volumes. Improper design of signal timings at cross streets may result in the inadequacy of capacity for certain flows.



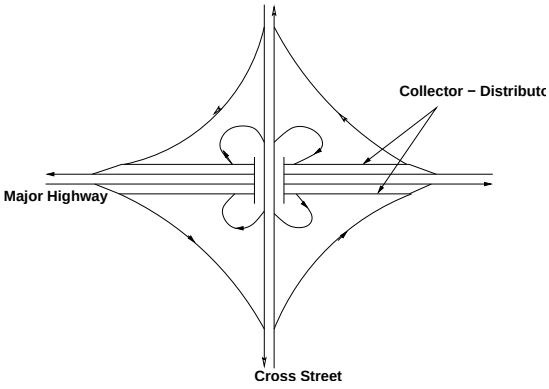
Cloverleaf Interchange

The full clover interchange eliminates all crossing movement conflicts by the use of weaving sections. This weaving section is a critical element of cloverleaf design. It replaces a crossing conflict with a merging, followed some distance farther by a diverging conflict. There are two points of entry and exit on each through roadway. The first exit is provided before the cross road structure allows right turn movements. The second exit, immediately after the cross road structure, allows for left turn movements. A weaving section is created between the exit and entry points near the structure. Sufficient length and capacity is to be provided to allow for a smooth merging and diverging operation.

Cloverleaf design requires only one bridge. In this respect, it is the cheapest form providing for elimination of all crossing maneuvers at grade. Although full cloverleaf interchanges eliminate the undesirable crossing movements of diamond interchanges, they have the disadvantages of greater travel distances, higher operating costs, difficult merging sections, circuity of travel, large areas for loops, sight distances to exits at the other side of the bridge, confusion caused by turning right to go left and large rights-of-way occasioned by the radius requirements necessary for satisfactory speeds on the ramps.

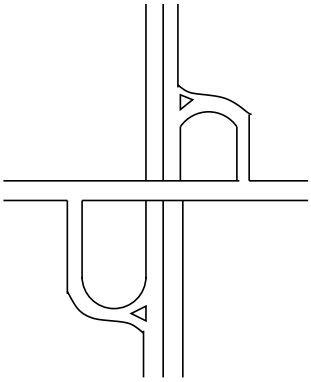
A variation of the cloverleaf configuration is the cloverleaf with collector-distributor roads. With the collector-distributor roadway, main roadway operations are much the same as in diamond interchange. For each direction of travel, there is a single point for exits and a single point for entrances. Speed change, detailed exit directional signing and the storage and weaving

problems associated with a cloverleaf are transferred to the collector-distributor road, which can be designed to accommodate greater relative speed differences or encourage smaller ones. Although this configuration improves the operational characteristics of a cloverleaf interchange, the disadvantages of greater travel distances and the requirement of extra right-of-way are still present. The use of a cloverleaf with collector-distributor roads is appropriate at junctions between a freeway and an expressway where a diamond interchange would not adequately serve traffic demand.



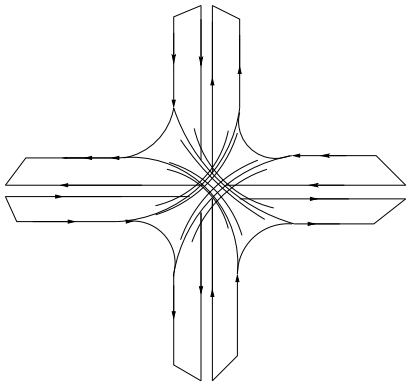
Partial Cloverleaf Interchange

This is another variation of the cloverleaf configuration. Partial clover leaf or parclo 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. This is the most popular freeway -to- arterial interchange. Parclo is usually employed when crossing roads on the secondary road will not produce objectionable amounts of hazard and delay. It provides more acceleration and deceleration space on the freeway.



Directional Interchange

A Directional interchange provides direct paths 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. Some designers do not favor entrance of merging traffic in the left lane, which is a characteristic of most direct-connection bridges. The principal limitations of this type of interchange is higher cost of construction and requirement relatively large amount of land when compared to the diamond interchanges and in some cases than cloverleaf interchange. Various combinations of directional, semi directional and loop ramps may be appropriate for certain conditions. They are the basic patterns that use the least space, have the fewest or least complex structures, minimize internal weaving and appropriate for the common terrain and traffic conditions.



33.2.3 Design Components

Acceleration Lane

An acceleration lane is defined as extra pavement, of constant or variable width, placed parallel or nearly so, to a merging maneuver area to encourage merging at low relative speed. The major difference in opinion concerning acceleration design stems from lack of information on driver performance. Field observations have indicated that drivers desire to follow the direct path even though extra width or tapered section is provided. The length of acceleration lanes are determined by two factors: (1) Time required for drivers to accelerate to the speed of the preferential flow from the speed of entry into the acceleration lane and (2) Maneuvering time required as a supplement to the sight distance which is provided in advance of the acceleration lane. Taper distances are based upon a lateral transition time of about 1/3 sec/ft of displacement.

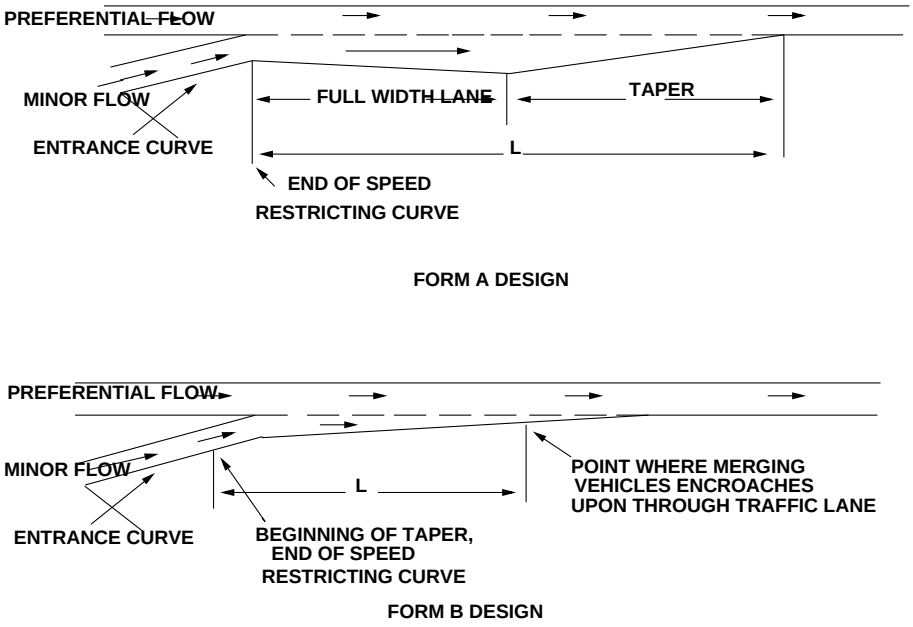


Figure 33:1: Different forms of Acceleration lanes

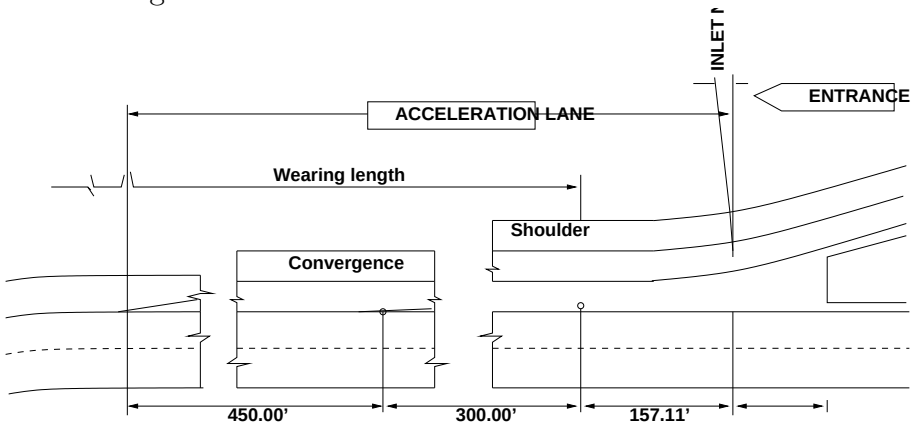


Figure 33:2: details of length of acceleration lane

Deceleration Lanes

Deceleration lanes are defined as extra pavement of constant or variable width, placed parallel or nearly so, to a diverging maneuver area to encourage diverging at low relative speed. The lengths of deceleration lanes are based on the difference in the speed of traffic of the combined flow (in advance of the collision area) and the speed at which drivers negotiate the critical diverging channel curve, as well as the deceleration practices of drivers. These deceleration lane lengths are based on the assumed performance of passenger vehicles only. Extra allowance must be made for grades and for trucks with different deceleration characteristics. In the figure

below, Form A design is more economical when large speed differentials are to be overcome. Form B could be advantageous by contrasting pavement colors and Form C design is more convenient for drivers when small speed differentials are to be eliminated.

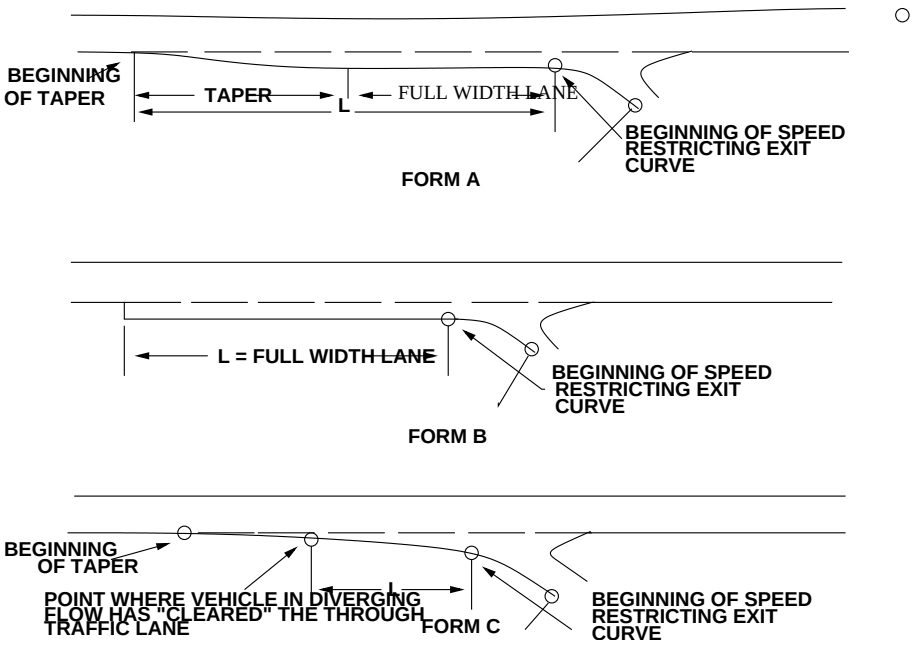


Figure 33:3: Different forms of Deceleration lanes

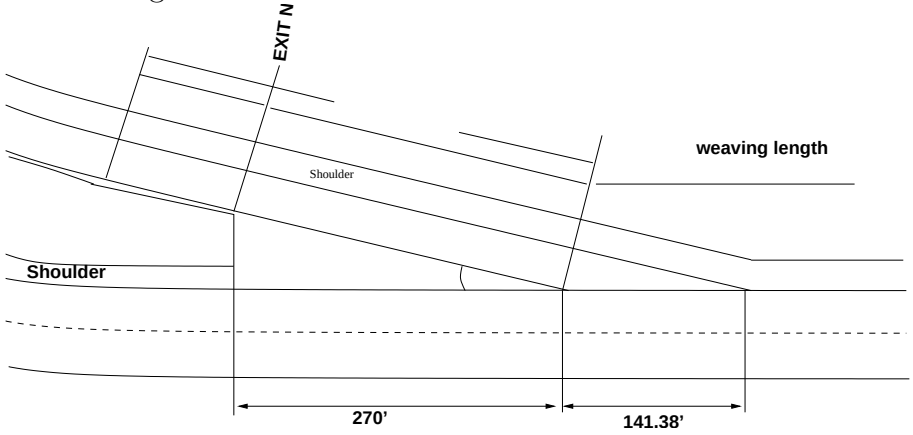


Figure 33:4: details of length of deceleration lane

33.3 Grade separated intersections

As we discussed earlier, grade-separated intersections are provided to separate the traffic in the vertical grade. But the traffic need not be those pertaining to road only. When a railway

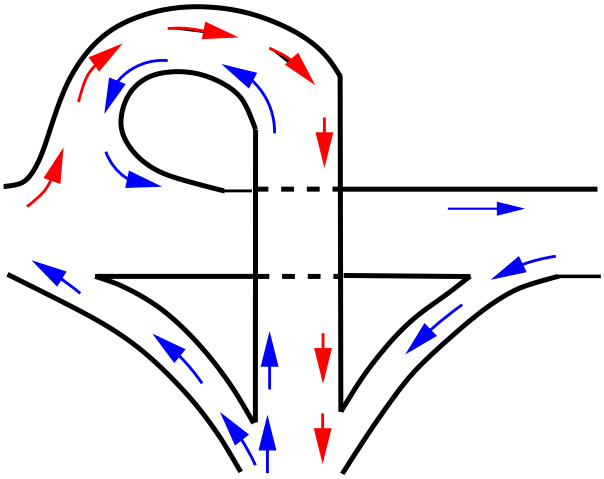


Figure 33:5: Trumpet interchange

line crosses a road, then also grade separators are used. Different types of grade-separators are flyovers and interchange. Flyovers itself are subdivided into overpass and underpass. When two roads cross at a point, if the road having major traffic is elevated to a higher grade for further movement of traffic, then such structures are called overpass. Otherwise, if the major road is depressed to a lower level to cross another by means of an under bridge or tunnel, it is called under-pass.

Interchange is a system where traffic between two or more roadways flows at different levels in the grade separated junctions. Common types of interchange include trumpet interchange, diamond interchange , and cloverleaf interchange.

1. **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. A typical layout of trumpet interchange is shown in figure 33:5.

2. **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. A typical layout of diamond interchange is shown in figure 33:6.

3. **Clover leaf 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

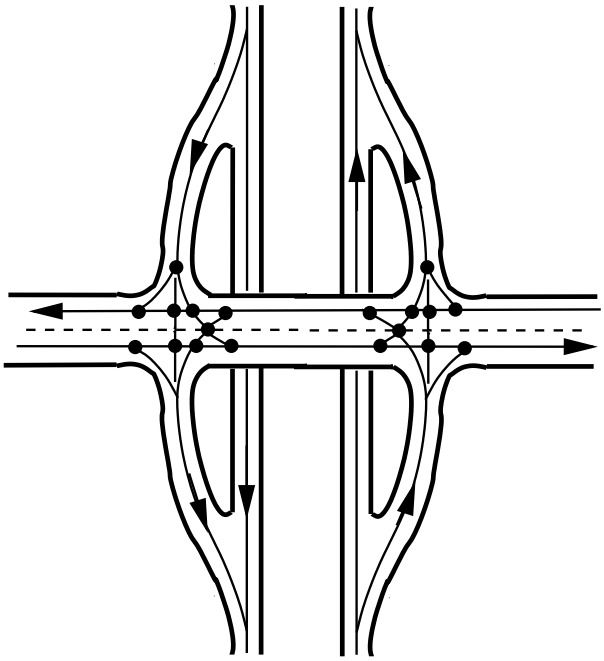


Figure 33:6: Diamond interchange

that large area of land is required. Therefore, cloverleaf interchanges are provided mainly in rural areas. A typical layout of this type of interchange is shown in figure 33:7.

33.4 Summary

Traffic intersections are problem spots on any highway, which contribute to a large share of accidents. For safe operation, these locations should be kept under some level of control depending upon the traffic quantity and behavior. Based on this, intersections and interchanges are constructed, the different types of which were discussed in the chapter.

33.5 References

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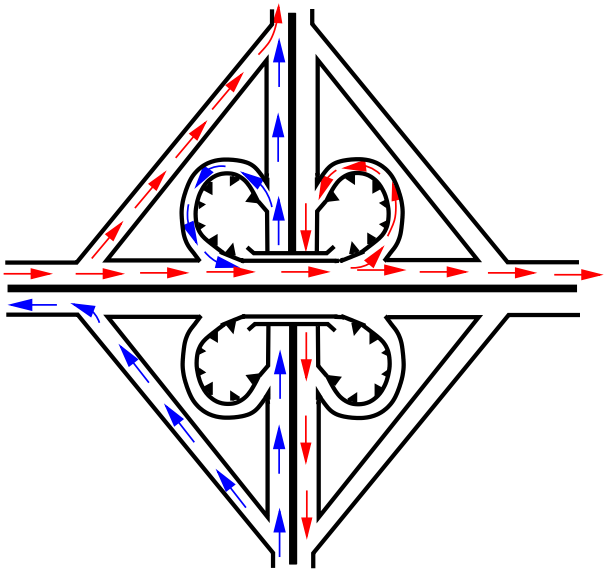

Figure 33:7: Cloverleaf interchange

4. Theodore M Matson, Wilbure S smith, and Fredric W Hurd. Traffic engineering, 1955.