

TRAFFIC OPERATIONS

For the safe traffic operation on highways, it is essential to impose adequate traffic regulations and traffic control devices. The public should be assured that these regulations and controls are for their interest.

1. Traffic Regulations

Need: The motor vehicle is a machine in charge of a human being. It is necessary to formulate the suitable regulations for safe and efficient movement of traffic and pedestrians. Most of the countries have uniform traffic laws operating in all parts of the country so that the laws are understood everywhere and are obeyed.

(i) Regulation of Speed: High speeds are always associated with accidents. Speed limits selected should be 'realistic' e.i. should be appropriate to the conditions at site so that they are not disregarded by the drivers. In Bangladesh, the traffic is mixed in character. In many towns, streets are narrow and pedestrian traffic is heavy. Speed limits in urban areas are 25 to 30 km/hr. (heavy to medium vehicles). Speed limits in rural areas are 50 km/hr. for vehicles with one trailer & 60 km/hr. for heavy vehicles (Bus/Truck) without trailer. Before selecting any particular speed limit, the following factors should be considered: (a) Speed of traffic, (b) Road conditions, (c) Environment of the road (d) Traffic and (e) Traffic accident rates, For success of speed regulation measures, strict enforcement of law is needed. Motorists who violate the speed limit must be arrested and penalties must be imposed. A distinctive coloured motor cycle with speedometer used to follow the violator for detecting the speed violation.

(ii) Regulation of Vehicles: The regulation of vehicles broadly covers the aspects are -

(a) Vehicle Registration (b) Construction and equipment of vehicles (c) Size, weight and loads of vehicles (d) Lighting of vehicles (e) Inspection of vehicles (f) Insurance.

(iii) Regulations Concerning the Driver: cover the following aspects - (a) Licensing of the driver (b) Age of drivers (c) Requirements of physical fitness of drivers (d) Disqualification and endorsement of licenses.

(iv) Regulations Concerning Traffic: Any city will have to develop a system of rules and enforce them strictly to regulate mixed traffic: Cycles, Motor cycles, Scooters, Rickshaws, Animal vehicles, Pedestrians.

(v) General Rules Concerning Traffic: (a) "Keep to the left" rule (b) Overtaking rules (c) Priority rules at intersection (d) Turning rules (e) Hand signals (f) Rules intended to promote pedestrian movement on footway.

(vi) Parking Regulations: It is said that proper parking policy is the key to the traffic problems of a town.

(a) Space controls (b) Time controls (d) Restrictions on loading and unloading (e) Curb space for bus stops (f) Exclusive parking spaces for taxis (g) Peak hour parking prohibitions (h) Parking control by fees.

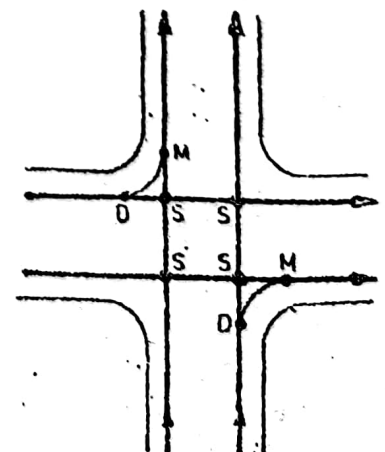
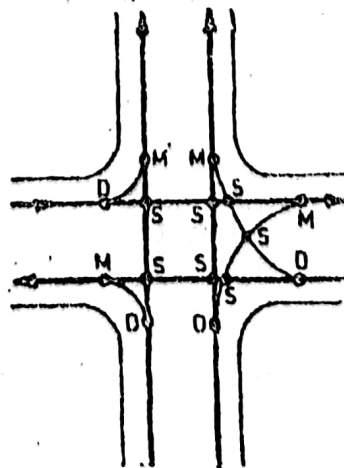
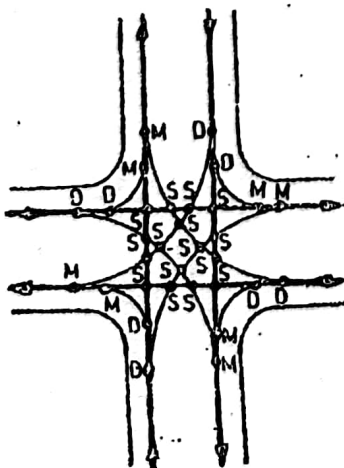
(vii) Enforcement of Regulations: (a) Traffic police forces have a vital role to play in traffic law enforcement (b) The courts have the final say in the matter of punishing the offenders by interpreting the law.

(viii) Regulations Concerning Traffic Flow: Traffic movements at junctions involve a number of points of conflict. These generate delay, congestion and accident hazards. One-way road system can overcome these problems.

S → Cross conflict point

M → Merging conflict point

D → Diverging maneuvering point



32 conflicts with Two-way traffic

15 conflict, with One-way Regulation on One Road

8 conflicts with One-way Regulation on Both Roads

2. Traffic Controls

The various aids and devices used to control, regulate and guide the traffic are called traffic control devices. Requirements of traffic control devices are: attention, meaning, time for response and respect to road users.

In order to facilitate people traveling from one country by road in another country where the language may be different, standardization of traffic signs assumes considerable importance. Realizing the need for such standardization, the U.N (1949) has evolved a code of system for signs, signals and markings to convey messages, rather than lettered messages. The most common of these devices are:

(i) **Traffic Signs:** Traffic sign is a device mounted on a fixed or portable support to convey a specific information by means of words or symbols. The signs should be placed such that they could be seen and recognized by the road users easily and in time.

Importance of Traffic Signs:

- (i) They give timely warning of hazardous situations where they are not self evident.
- (ii) They help in regulating traffic by imparting messages to the drivers about the need to stop or give-way.
- (iii) They give information as to highway routes, directions and points of interest.

Types of Traffic Signs: Traffic signs have been divided into three categories according to Motor Vehicle Act.

(a) **Warning Signs (Danger signs):** These signs convey to the drivers, the conditions ahead where some cautions is required. The shape of the sign is equilateral triangle with one point upward as shown below.



RIGHT HAND CURVE



ZIG-ZAG ROAD



NARROW BRIDGE



SCHOOL

(b) **Regulatory Signs (Mandatory signs):** These signs are used to inform the drivers of certain laws, regulations and prohibitions. Violation of signs is a legal offence. Shape of sign is circular as shown below.



DIRECTION SIGN



SOUND HORN



LEFT TURN PROHIBITED



HORN PROHIBITED

(c) **Informatory Signs:** These signs are used to guide the drivers with information to make travel easier, safe and pleasant. These signs are displayed on rectangular boards of specific size as shown below.



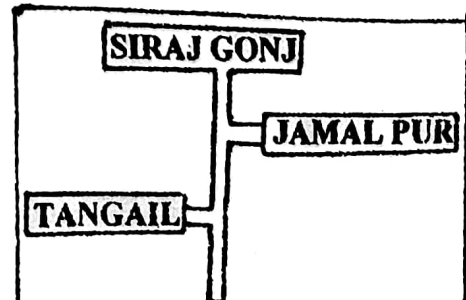
EATING PLACE



LIGHT REFRESHMENT



REST HOUSE



ADVANCE DIRECTION SIGN

(ii) **Traffic Signals:** Traffic signals are such control devices which can alternately direct the traffic to stop and proceed at level intersections (place of accidents & congestion) using red and green traffic light signals. Yellow period is a transition interval between red to green & green to red. The main requirements of traffic signals are to draw attention, provide meaning and time to respond and to have minimum waste of time.

The **cycle length** is the time required for one complete sequence of signal indications as shown figure.

Phase is a part of the cycle length allocated for specific traffic movement.

Interval is the time for which any division of the signal cycle continues to reflect the same coloured light.

1. Traffic control signals

- (a) **Manually operated signals:** A police man from his cabin gives red & green lights to the traffic as needs.
- (b) **Fixed-time signals:** are set to repeat regularly a cycle of red, amber and green lights. Phase time is fixed.
- (c) **Traffic actuated signals:** Timings of the phase and cycle can be changed according to the traffic needs.

2. Pedestrian Signals: They are meant to give right of way to the pedestrians to cross a road during the walk period when the vehicles shall be stopped by red signal. The green walking man represents cross indication.

Example: An isolated signal with pedestrian indications is to be installed at right-angled intersection with Road 1 of 18 m wide and Road 2 of 12 m wide. The peak volume (V) per hour for each lane of Road 1 and Road 2 are 275 PCU and 225 PCU respectively. The approach speeds are 55 kmph and 40 kmph, for Road 1 and Road 2 respectively. Design the timings of traffic and pedestrian signals on the basis of pedestrian crossing time.

Solution:

Design of traffic signals

(i) Based on the approach speed; yellow periods:

For Road 1 with 55 kmph, yellow period $Y1 = 4$ sec For Road 2 with 40 kmph, yellow period $Y2 = 3$ sec.

(ii) Based on the pedestrian walking speed of 1.2 m/sec, the pedestrian clearance time is calculated:

Pedestrian clearance time (interval) for Road 1 = width of road/walking speed = $18/1.2 = 15$ sec and pedestrian clearance time for Road 2 = width of road/walking speed = $12/1.2 = 10$ sec.

(iii) Adding 7 sec for initial walk-period, minimum red time for Road 1 = $(15+7)$ sec and that for Road 2 = $(10+7)$ sec.

(iv) Minimum green times based on pedestrian criterion: Road 1 = $(10+7) - 4 = 13$ sec & Road 2 = $(15+7) - 3 = 19$ sec

(v) Based on approach volume, the green time (G) calculated is increased for Road 1 with higher volume as $G1/G2 = V1/V2$, here green time for vehicles on Road 2 = $G2 = 19$ sec, therefore, $G1 = (275/225) \times 19 = 23.2$ sec

(vi) Total cycle length = $G1 + Y1 + R1 = G1 + Y1 + G2 + Y2 = 23.2 + 4 + 19 + 3 = 49.2$ sec. Signal cycle time should be multiples of 5 sec and so the cycle time (length) = 50 sec. The extra $(50 - 49.2) = 0.8$ sec distributed proportionally as:

Corrected green time $G1 = 23.2 + (275 \div 500) \times 0.8 = 23.64$ sec & corrected $G2 = 19 + (225 \div 500) \times 0.8 = 19.36$ sec

Red time for Road 1, $R1 = G2 + Y2 = 19.36 + 3 = 22.36$ sec & that for Road 2, $R2 = G1 + Y1 = 23.64 + 4 = 27.64$ sec

Design of pedestrian signals

Do not walk (DW) period of pedestrian signal at Road 1 (PS1) is red period of traffic signal at Road 2.

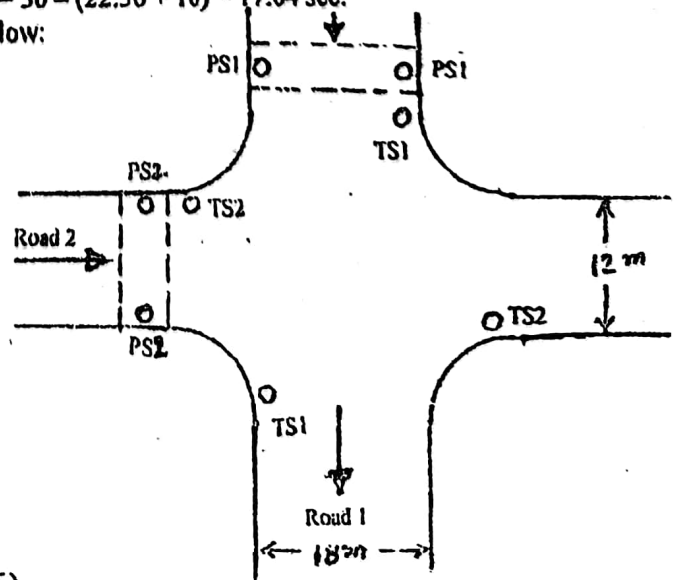
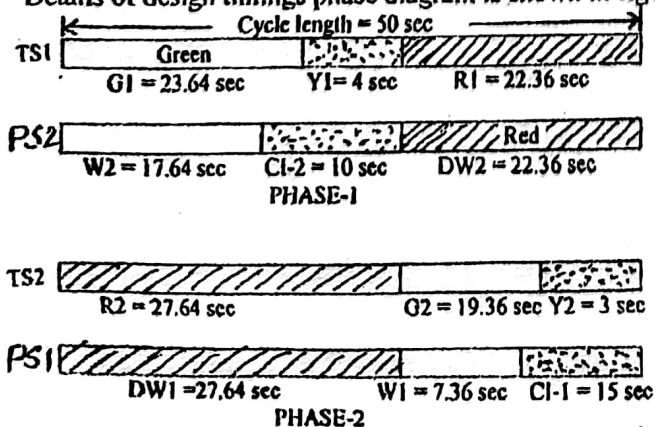
For PS1, $DW1 = R2 = 27.64$ sec and for PS2, $DW2 = R1 = 22.36$ sec.

Pedestrian clearance intervals (CI) are of 15 and 10 sec respectively for Road 1 & Road 2 for crossing from (ii) above.

The walk time (W) is calculated from total cycle length.

For PS1, $W1 = 50 - (27.64 + 15) = 7.36$ sec and for PS2, $W2 = 50 - (22.36 + 10) = 17.64$ sec.

Details of design timings phase diagram is shown in figure below:



Example: At right angled intersection of two roads, Road 1 has four lanes with a total width of 12.0 m and Road 2 has two lanes with a total width of 6.6 m. The volume of traffic approaching the intersection during design hour are 900 and 743 PCU/hour on the two approaches of Road 1 and 278 and 180 PCU/hour on the two approaches of Road 2. Design the signal timings as per IRC guidelines.

Solution:

Design traffic on Road 1 = higher of the two approach volume per lane = $900/2 = 450$ PCU/hour

Design traffic on Road 2 = higher of the two approach volume per lane = $278/1 = 278$ PCU/hour

(i) Pedestrian green time for Road 1 = width of road/walking speed + initial walking time = $12/1.2 + 7 = 17$ sec/person
 Pedestrian green time for Road 2 = width of road/walking speed + initial walking time = $6.6/1.2 + 7 = 12.5$ sec/person

(ii) Green time for vehicles on Road 2, $G_2 = 17$ seconds i.e. pedestrian green time for Road 1.
 Green time for vehicles on Road 1, $G_1 = 17 \times 450/278 = 27.5$ seconds.

(iii) Total cycle time required for each phase = (amber + G_2 + inter-green period) + (amber + G_1 + inter-green period)
 = $(2 + 17 + 2) + (2 + 27.5 + 2) = 52.5$ sec. Signal cycle time should be multiples of 5 sec & so cycle time = 55 sec
 The extra 2.5 sec (55 - 52.5) per cycle apportioned to the green time for vehicles of Road 1 and 2, as 1.5 and 1.0 sec and so corrected $G_1 = 27.5 + (450/728) \times 2.5 = 29.0$ sec and corrected $G_2 = 17.0 + (278/728) \times 2.5 = 18.0$ seconds.

(iv) Vehicle arrivals per lane per cycle on Road 1 = $450/55 = 8.2$ PCU

Minimum green time for clearing vehicles on Road 1 = $6 + (8.2 - 1.0)2 = 20.4$ sec < green time $G_1 = 29.0$ sec. OK.

Vehicle arrivals per lane per cycle on Road 2 = $278/55 = 5.1$ PCU

Minimum green time for clearing vehicles on Road 2 = $6 + (5.1 - 1.0)2 = 14.2$ sec < green time $G_2 = 18.0$ sec. OK.

Optimum cycle time, $C_o = (1.5L + 5)/(1 - Y)$ where L = Lost time per cycle and $Y = y_1 + y_2$.

Approach road width (Curb to median or centre line), m	3.0	3.5	4.0	4.5	5.0	5.5	>5.5
Saturation flow values, PCU/hr. per meter width	1850	1890	1950	2250	2550	2990	525

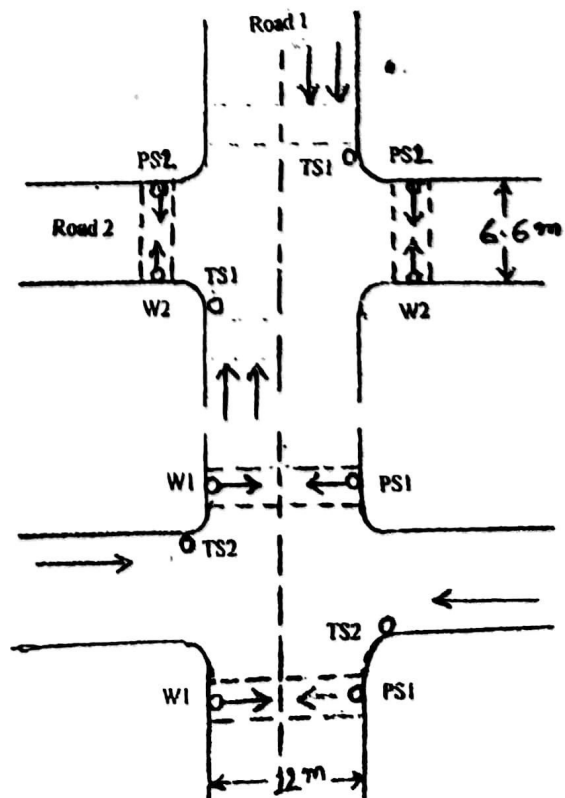
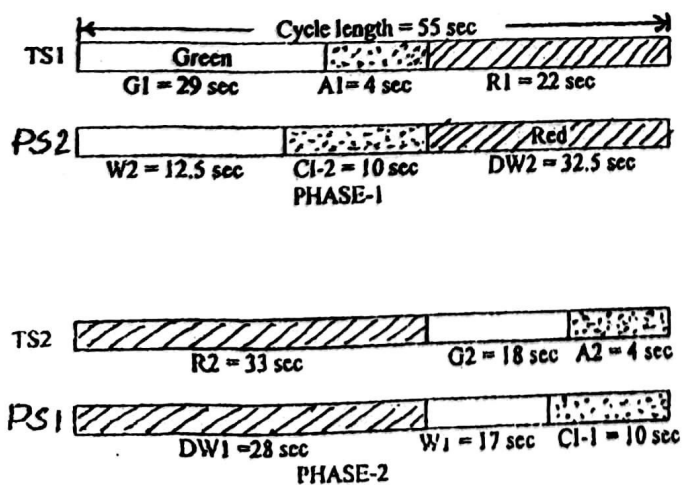
L = Amber time + inter-green time + time lost for initial delay of first vehicle = $[2 + 2 + (6 - 2)]2 = 16$ sec

Saturation flow S_1 for Road 1 = $525 \times 6 = 3150$ PCU/hr. Saturation flow S_2 for Road 2 = $1850 + 40(0.3/0.5) = 1874$ PCU/hr.

For Road 1, y_1 = Normal flow/Saturated flow = $900/3150 = 0.286$ & for Road 2, $y_2 = 278/1874 = 0.148$, then $Y = 0.434$

$C_o = (1.5L + 5)/(1 - Y) = (1.5 \times 16 + 5)/(1 - 0.434) = 51.2$ sec. Therefore the designed cycle time 55 sec is acceptable

The details of the signal timings are given below: Pedestrian clearance intervals (CI) = 10 sec from (i) e.i $12/1.2 = 10$.



(iii) Road Markings

Road or traffic markings are made of lines, patterns, words, symbols or reflectors on the pavement, kerb, sides of islands or on the fixed objects within or near the roadway. This special signs are used to control, warn, guide or regulate the traffic. The markings are made using paints in contrast with colour and brightness of the pavement or other back ground.

(a) Colour of Road Markings (given in Table 14.1)

(b) Types of Road Markings

1. Pavement or Carriageway Markings: Some common types of pavement markings are:

(i) **Centre Lines**:- These broken line are meant to separate the opposing streams of traffic on undivided two-way roads. On rural highway, line width 0.1 m, segment length 4.5 m & gaps 7.5 m. These lengths reduced to 3m and 6 m at horizontal curves and approaches to intersections. On urban roads, line width 0.10 m to 0.15 m, segment length 3 m and gap 4.5 m. On undivided roads with at least two traffic lanes for each direction of traffic flow, the centre line marking shall consist of two solid continuous lines (Fig. 14.1).

(ii) **Lane Lines**:- These broken line are drawn to designate traffic lanes. These are used to guide the traffic and to properly utilize the carriage way. It is offence to cross such a line (Fig. 14.1).

(iii) **Route Direction Arrows**:- are used to guide effectively the traffic in the correct direction and lanes. Arrows must be elongated in the direction of traffic to be properly legible (Fig. 14.11)

(iv) **Stop Lines**:- are solid white lines provided transversely to the carriageway and used to indicate the point behind which vehicles are required to stop in compliance with a STOP sign as shown in Fig. 14.7.

Table 14-1
Colour of Roads Markings as per Indian Practice

Colour	Uses
White	All carriageway markings except those intended for parking restrictions.
Yellow	(i) Markings intended for parking restrictions (ii) Continuous centre and barrier line markings.
Alternate bands of white and black.	Kerb and object markings.

10 cm THICK LINE	3 m 6 (3) m	CENTRE LINE MARKING FOR TWO-LANE RURAL HIGHWAY
10-15 cm THICK LINE	3 m 4.5 (3) m	CENTRE LINE MARKING FOR TWO-LANE URBAN ROAD
10 cm THICK LINE	3 m 4.5 (3) m	LONGITUDINAL TRAFFIC MARKINGS FOR SIX LANE DIVIDED URBAN ROAD
10 cm THICK LINES WITH 10 cm GAP	— — — — —	

NOTE FIGURES IN BRACKETS TO BE USED ON CURVES AND APPROACHES TO INTERSECTIONS

Fig. 14.1. Centre line and lane markings.

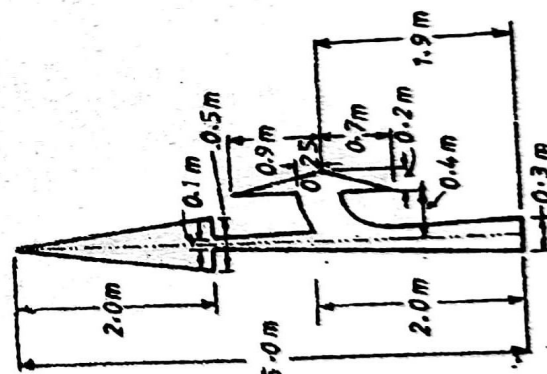


Fig. 14-11. designs for route direction arrows.
EDGE OF CARRIAGE WAY AND FOOTPATH

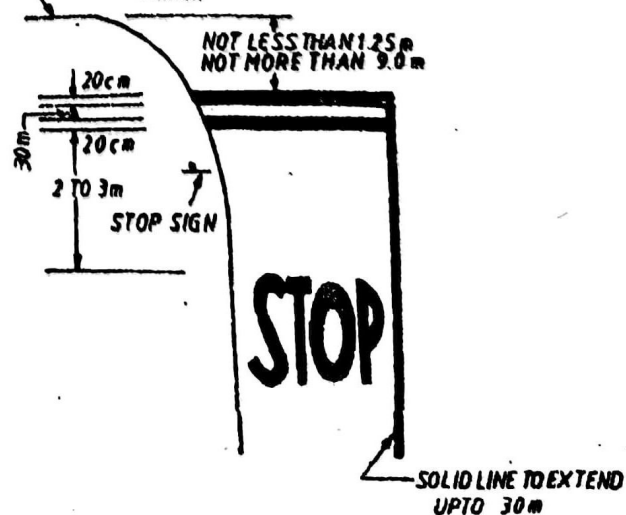


Fig. 14.7. Details of a stop line.

(v) **Cross Walk Lines:-** Pedestrian crossings (2m wide) are very important for their safety as shown in Fig. 14.9

(vi) **Parking Space Limits:-** For proper utilization of parking facility, markings are made.

(vii) **Bus Stops:-** Kerb length reserved for buses to stop are marked by continuous yellow line on kerb indicating 'parking prohibited' or marked by the word 'BUS'.

2. Kerb Markings: These may indicate certain regulations like parking regulations. Also the markings on the kerb and edges of islands with alternate black and white line increase the visibility from a long distance. During night time they prove very helpful.

3. Object Markings: Hazardous obstructions near the road, like supports for signs & signals, level crossing gates, traffic islands, narrow bridges culvert head walls, trees etc.

4. Reflector Unit Markings: Hazardous obstructions are indicated by fixing reflector units reflecting yellow light at night. Reflector unit should be visible from 150 m distance

(iv) Traffic Islands

Traffic islands are raised areas constructed within the roadway to establish physical channels through which the vehicular traffic may be guided to travel and avoid conflict. Based on the function, islands are classify as :

1 Divisional Islands:- are provided to separated opposing flow of traffic in a road having four or more lanes. It reduces the possibilities of head on collision and other accidents. The width should be large to reduce the head light glare during night driving.

2 Channelizing Islands:- are normally of triangular shape and used to guide the motorists at turning points. Channelizing islands are very useful as a traffic control device, particularly, at intersections having large areas. Minimum area desirable size of this island should be 5 sqm in area and preferable length of one side of triangle should be 4 m. The various uses of properly designed channelizing islands are listed below :

- (i) The area of possible conflicts between traffic stream is reduced.
- (ii) They establish the desired angles of crossing and merging of traffic streams.
- (iii) They are useful when the direction of the flow is to be changed.
- (iv) They serve as refuge islands for pedestrians.

3 Central Island or Traffic Rotary:- Rotary (Central) island is an enlarged highway intersection where all the approaching vehicles from all the converging roads are forced to move around a large centrally situated island before they weave out into the desired radiating road. It is usually circular in shape but can be elliptical or any other shape. ** in clockwise direction*

Functions : (i) They segregate vehicular traffic from pedestrian traffic. (ii) They segregate traffic into specified paths. (iii) They reduce the conflict area (iv) They increase the traffic capacity of the road and (v) They increase traffic safety.

(V) Highway Lightings

To promote the safe and efficient movement of vehicular and pedestrian traffic along the roadway proper lighting is essential. The rate of highway accidents and fatalities that occur during night travel is many times higher than that during day time travel. One of the many reasons of increased accident rate during night may be due to the poor visibility at night. Highway lighting is more important at intersection, bridge site & level crossings.

During night driving, the visibility of objects on road varies with the absolute level of brightness of the object and the relative brightness of the road surface and the object. During night objects are discerned (উদ্ভাৱন - হ'ল সৰ্ব্বোচ্চ দেখা দিয়া বস্তু) by three ways:

Silhouette (সিলুইট) :- When the brightness of the object is less than that of the background.

Reverse Silhouette :- When the brightness of object is more than that of the background.

Surface Detail :- When the variations in brightness and colour of the object surface without regard to its background.

The various factors that influence the night visibility are:

1. Size of the object
2. Brightness of the object
3. Brightness of the background
4. Reflecting characteristics of the pavement surface
5. Glare on the eyes of the driver
6. Time available to see the object
7. Amount and distribution of light flux from the lamp.

Design factors of highway lighting

1. Lamps:- Road lighting lamps may be as follows :

Tungsten filament lamps: It is the cheapest lamp but have low light producing efficiency.

Fluorescent lamps: Long life, good visibility, least dazzling but low output per lamp.

Sodium vapour lamps: Yellow coloru, costly but these are preferred at large intersections

Mercury vapour lamps: Bluish white colour, costly but more pleasing to the eye.

2. Luminaire distribution of light:- should be downward so that higher percentage of lamp light is utilized and should cover the pavement between the kerbs and the adjacent area. The unit of illumination in the metric system is lux or lumen per square metre. It is suggested the average level of illumination on road side should be 20 to 30 lux on urban roads carrying fast traffic, about 15 lux for mixed traffic and 4 to 8 lux on secondary road

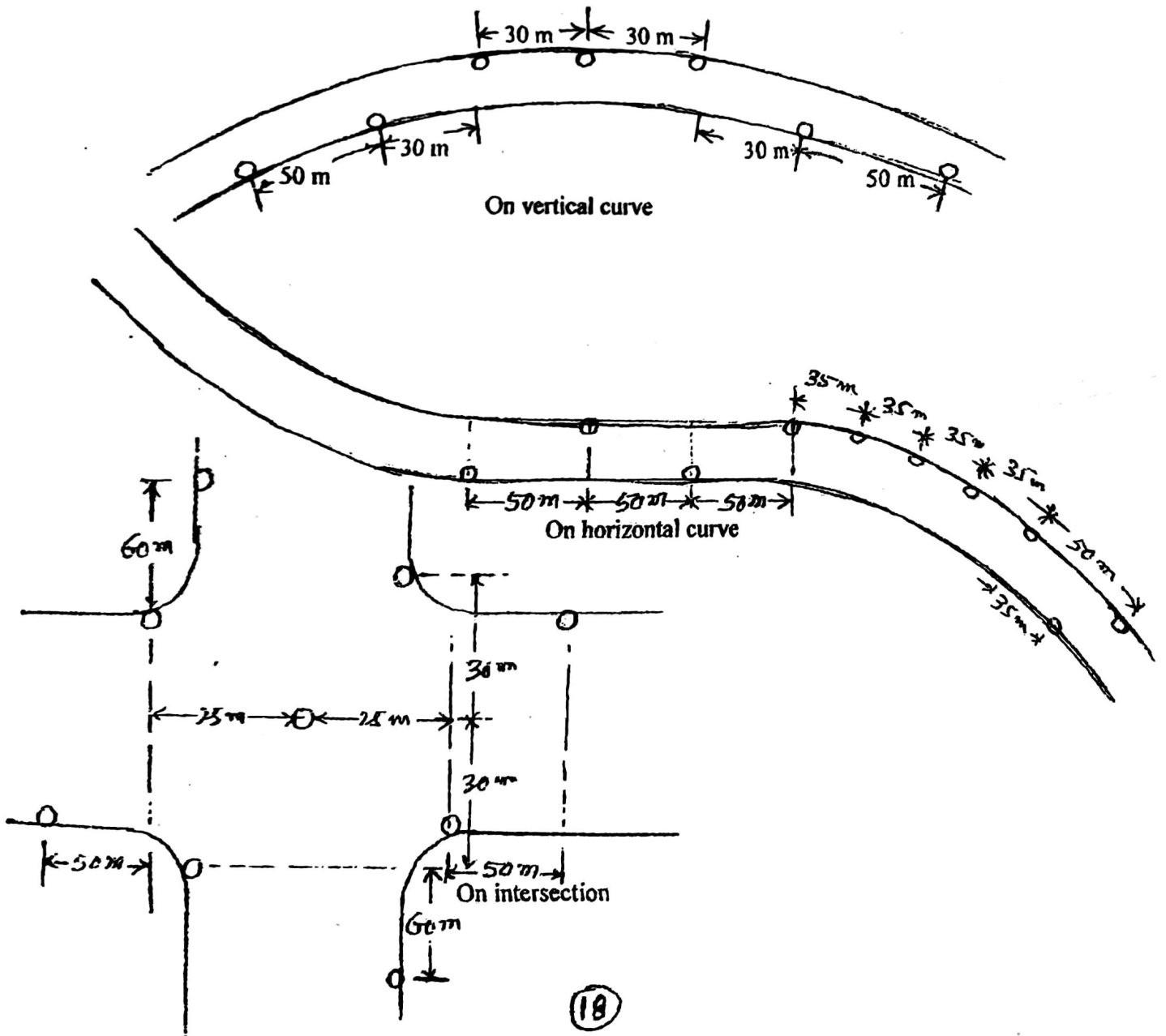
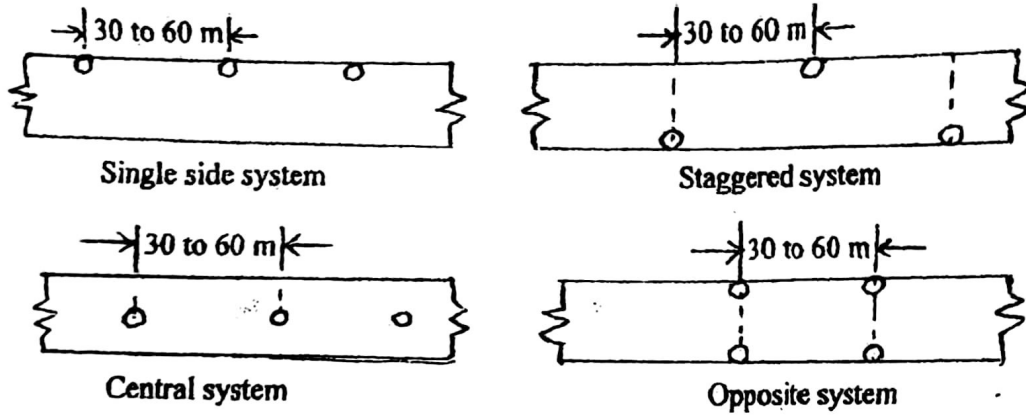
3. Spacing of lighting units:- The spacing of lighting units is influenced by the electric distribution poles, road layout and type of side features. Spacing should be 3 to 5 times the mounting height on straight roads and less than this on sharp curves. From economy point of view, large lamps with high mounting and greater spacing should be used.

4. Height and over hang of mounting:- The mounting height of lamp governs the distribution of light, shadow and the glare effect. Usually the mounting height varies from 6m to 10m. Over hangs (≤ 2 m) would keep the poles away from the road edges.

5. Lateral placement:- If poles are too close to the carriageway, free movement of traffic is obstructed, decreasing the capacity of the road. The horizontal clearance required for lighting poles are given below:

- (a) For roads with raised kerbs > Minimum 0.3 m and desirable 0.6 m from the edge of raised kerb.
(as in urban roads)
- (b) For roads without raised Kerb (as in rural roads) > Minimum 1.5 m from the edge of carriageway. or minimum 5.0 m from the centre line of carriageway.

6. Lighting layout:- On straight roads the lighting layout may be of the following types:

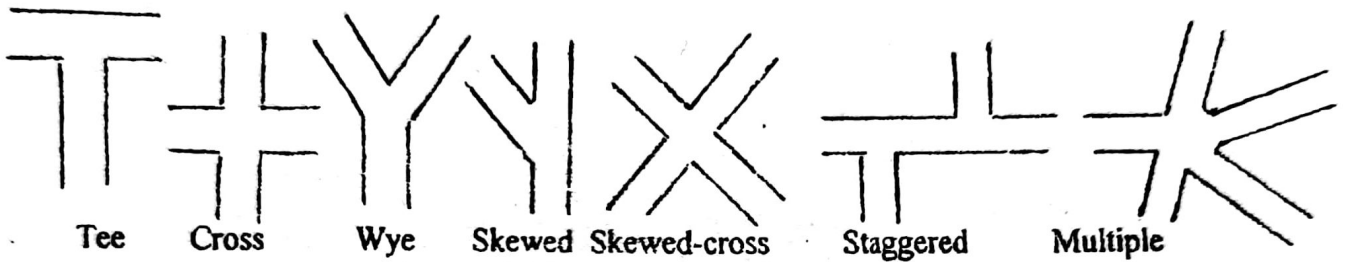


1.5 Road Intersections

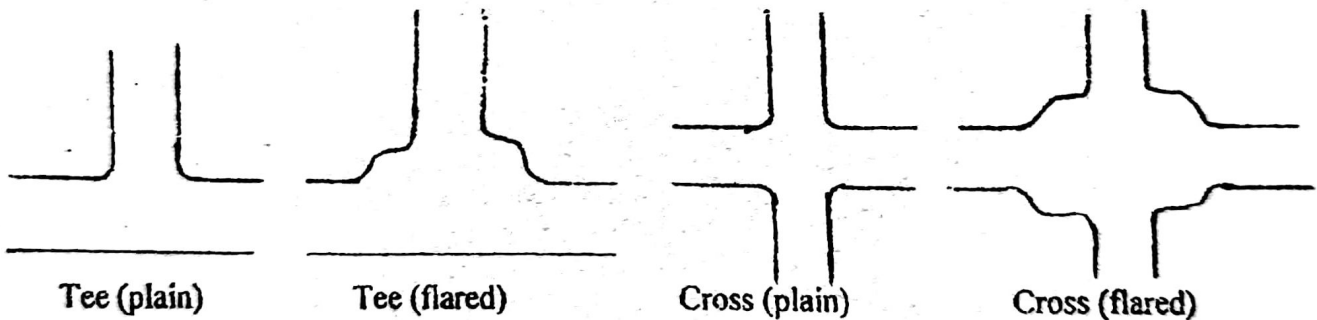
Road Junctions or Road Intersections are the places where two or more roads cross each other at different angles. Different types of movements (through, turning and crossing) are involved at road intersections. There is no problem in traffic movements on straight roads. But intersections are points of traffic hazards which affect safety, speed, efficiency, capacity and cost of operation of the whole road. Pedestrian movements at intersection produce increased potential hazards and delays.

1.5.1 Intersection at grade or level: These include all roads which meet at more or less the same level. The traffic manoeuvres like merging, diverging & crossing are involved here.

Types of level intersection according to the system of intersecting roads at intersection are:

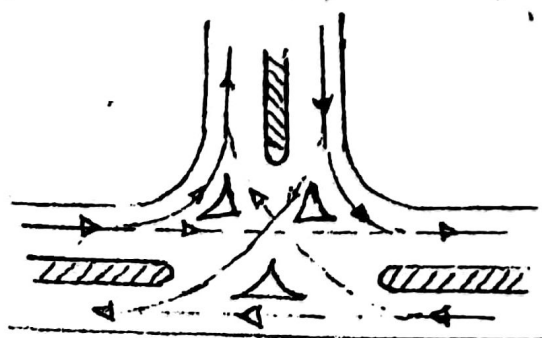


1.5.2 Unchannelized Intersection:- There is no provision of any direction island or central island. To avoid frequent accidents, heavy traffic at such intersections can be controlled by installing traffic signals or with the help of traffic police. No additional pavement width for turning is called plain intersection and with additional pavement width is called flared intersection.

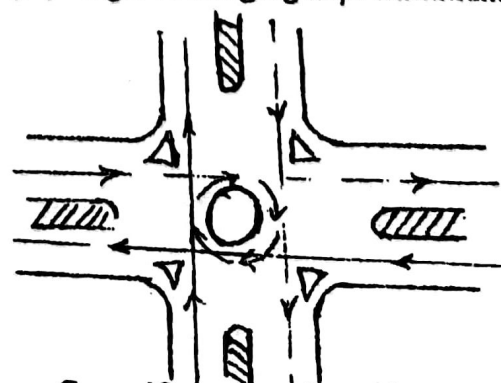


1.5.3 Channelized Intersection:- is achieved by introducing islands into the intersectional area, thus reducing the total conflict area available in the unchannelized intersection. Channelization may be either partial or complete with *divisional* and *directional* island and medians. The advantages of channelized intersection are as follows:

- (i) Vehicles can be confined to definite paths.
- (ii) Points of conflicts can be separated.
- (iii) Refuse islands can be provided for pedestrians.
- (iv) Angle of merging kept minimum.

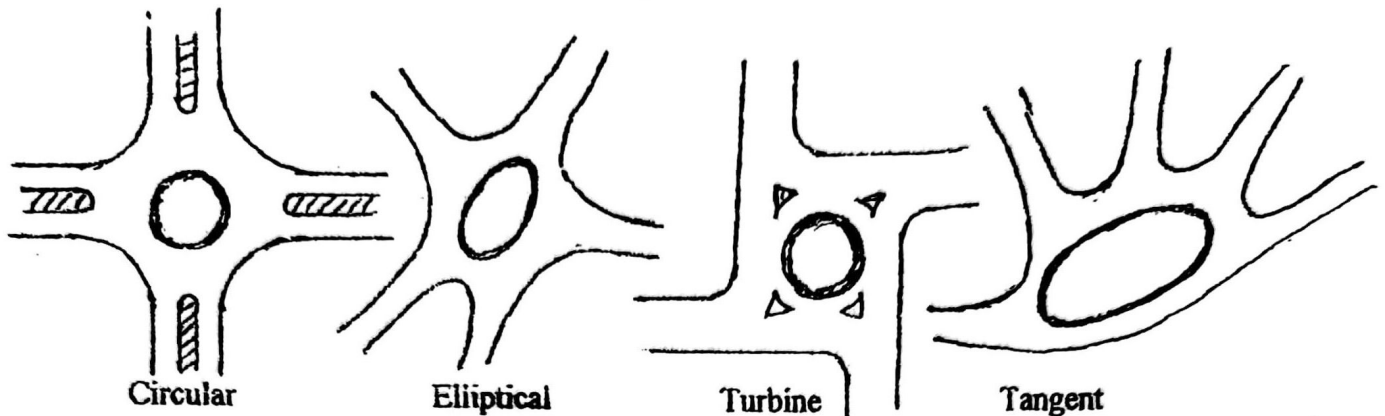


Tee (Complete channelization)



Cross (Complete channelization)

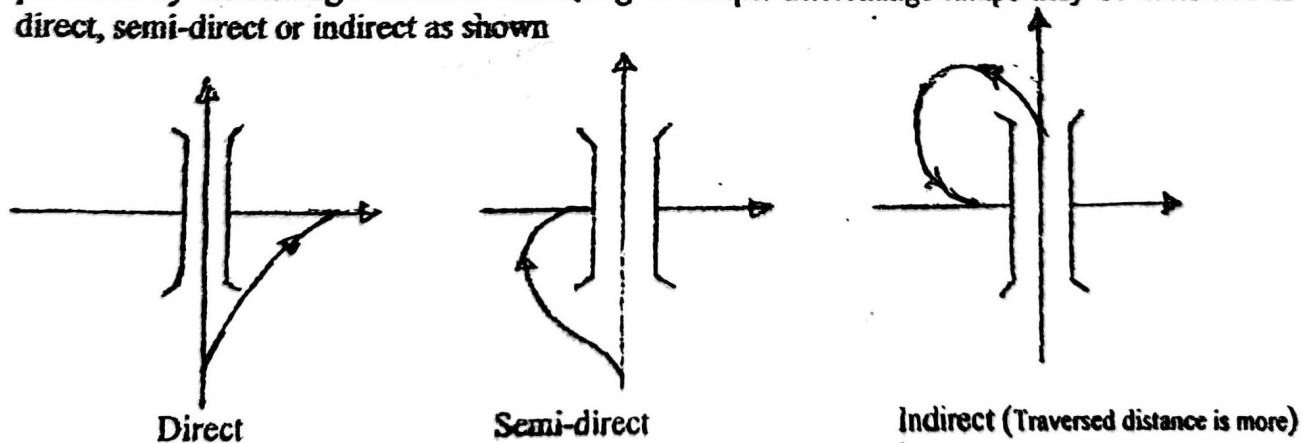
1.5.4 Rotary Intersection:- By provision of rotary, necessity of stopping at road intersection is eliminated. Traffic from all the converging roads keeps on moving round the central island in clock wise direction and adopts its road of desire to move out of rotary without stopping anywhere. On rotary, crossing conflicts are completely eliminated.



Advantages: (i) Traffic handling capacity is the highest (ii) It is more safe (iii) All vehicle get equal preference (iv) Operational cost of vehicle is less (v) There is no need of traffic police or signal (vi) Number of accidents are low.

Disadvantages: (i) Requires a large area of land and hence it is costly in built up area. (ii) If the vehicular traffic have to stop to allow pedestrian to cross, the main purpose of rotary is defeated. (iii) If large number of pedestrians and cyclists are involved, design and operation of rotary becomes very complicated. (iv) When there are more than seven intersecting roads, rotaries are unsuitable and unjustified for very low traffic volume.

1.5.5 Grade separated intersection:- The intersecting roads are separated by passing one road over or below the other and thus eliminating the crossing manoeuvres. This intersection causes least delay and hazard to the crossing traffic and much superior to intersections at grade from the point of view of traffic safety and efficient operation. Transfer of route at the grade separation is provided by interchange facilities consisting of ramps. Interchange ramps may be classified as direct, semi-direct or indirect as shown



Advantages : (i) Maximum facility is given to the crossing traffic. (ii) There is increased safety for turning traffic. (iii) They provide comfort and convenience to the driver and saving the travel time & operation cost. (iv) It is essential part of controlled access highway like expressway and freeway. (v) It can be designed for any angle of intersection

Disadvantages : (i) It involves very large areas. (ii) It involves lot of expenditure in providing bridges under passes and interchange ramps. (iii) Unnecessary rising grades and sags are introduced in vertical alignment.

1.5.6 Over-pass:- When the major highway is taken above by raising its profile above the general ground level by embankment and an over-bridge across another highway.

Advantages: (i) Drainage problem may be reduced (ii) Cost of bridge structure is less for small span of cross road. (iii) There is aesthetic preference and less feeling of restriction (iv) Future expansion or construction of separate bridge structure is possible.

Disadvantages: (i) In rolling terrain, the vertical profile of major road will also have rolling grade line. (ii) Embankment with steep gradient increase the grade resistance (iii) Long vertical curve required for clear sight distance.

1.5.6 Under-pass:- When the highway is taken by depressing it below the ground level to cross another road by means of an under-bridge.

Advantages: (i) If main road is retained at ground level and cross road is depressed, under pass proves advantageous. (ii) If main road is depressed, below cross road, traffic from cross road will reach main road with increased acceleration and traffic from main road will reach cross road with retardation.

Disadvantages: (i) Drainage problem is very troublesome. (ii) Rise of underground water table during monsoons may further complicate the drainage problem. (iii) There is a feeling of restriction to traffic at the sides. (iv) The over head structure may restrict the vertical sight distance. (v) There is no possibility of stage construction for the bridge.

1.5.7 By-pass:- is an arrangement for diverting a traffic flow to avoid unnecessary hazards.

1.5.8 Fly-over:- is a bridge over a large road intersection for safe traffic flow avoiding conflict.

1.5.9 Interchanges:- Grade separated intersection with complete interchange facilities is essential to develop a highway with full control of access. Some of the types of interchanges are shown in Figure 5.39. Of all these complete *full clover leaf* fulfils all the requirements of turning traffic involving the simplest traffic manoeuvres, viz; diverging to the left and merging from the left by providing four indirect ramps.

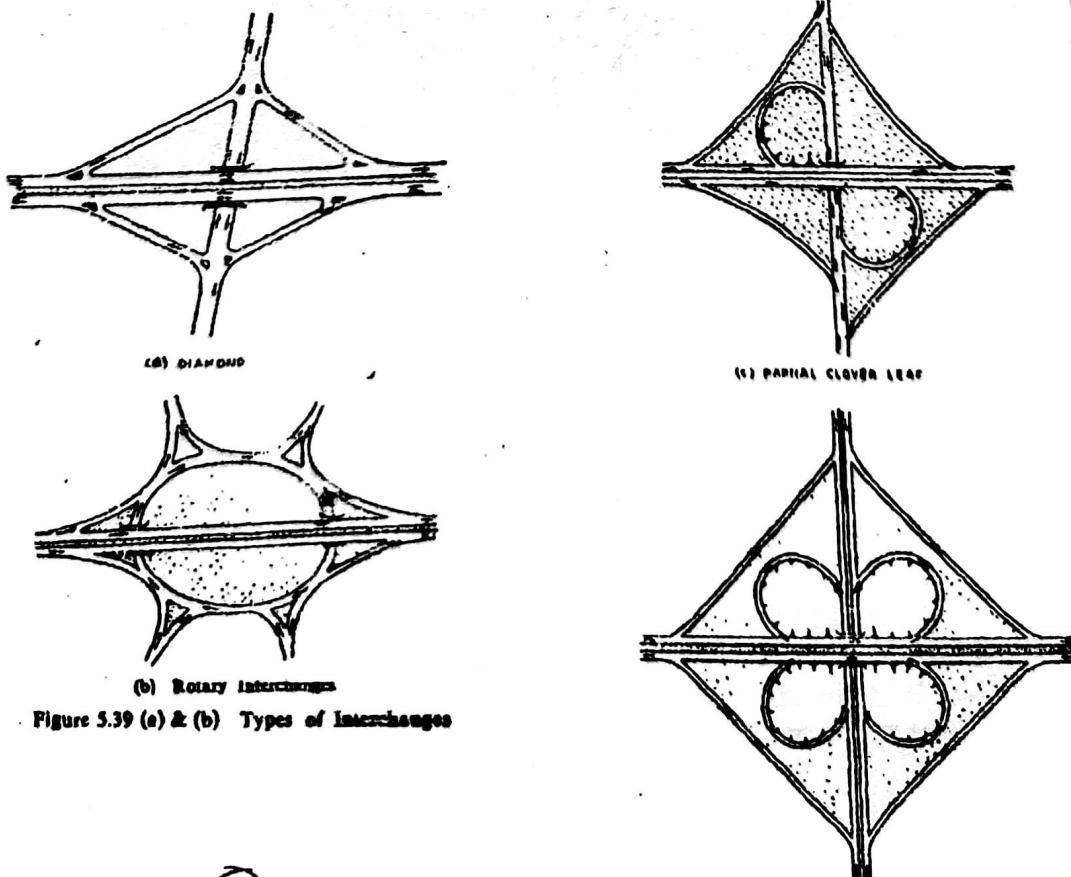


Figure 5.39 (a) & (b) Types of Interchanges

Traffic and the Environment

The automobile is the outstanding (*Prominent*) inventions of man. Problems of traffic have a direct impact on the environment in which we live. The traffic engineer has a great responsibility in ensuring that the road traffic does not spoil this environment. The **environmental area** is an area having no extraneous (වෙනාමාලික) traffic, and within which considerations of environment predominate over the use of vehicles. The areas should be safe, reasonably free from noise and generally agreeable.

The detrimental effects of traffic on our surroundings are discussed below:

(i) **Road safety:** Everybody wants a road safety i.e, movement on roads should be free from accidents. Safety of road users has been seriously endangered by the motor vehicle and because of its great importance this subject is discussed in separate chapter as *Road Safety*.

Factors involved in road accidents are (1) Road Factors (2) Vehicle Factors (3) Road Users (driver, scooter and motor-cycle riders, cyclists, passengers, pedestrians etc.). (4) Environmental Factors (5) Other Factors.

(ii) **Noise:** Noise is unwanted sound intruding (වැනැහිනු ලබන ශබ්දය) upon the quiet life and privacy of the urban dwellers. The detrimental effects of traffic noise can be considered under the following major groups:

(a) **Subjective effects:** Such as annoyance (discomfort), dissatisfaction, disturbance, bother and noisiness.

(b) **Behavioural effects:** Such as interference in speech, T.V. programs, studies, student mind in class room.

(c) **Physiological effects:** The startle (වැනැහිනු ලබන) phenomena that can results in harmful effects on body.

The generation of noise by traffic (1) Noise generated by various parts of the vehicle; (2) Noise contributed by the interaction between vehicles and road surfaces (3) Noise dependent on speed, flow & traffic density.

Motor cycles and scooters are noisier than car; commercial trucks & old vehicles are a main source of noise

Sound level is recorded by the sound level meter and expressed as the decibel (dB). In order to account for

the ear's response at low and high frequencies, different weighing filters, A, B and C are used. Normally,

noise having a level of not more than 60 dB (A) will be rated by many as quiet. Noise level of 90 dB (A)

and above will be rated by many as extremely noisy. Acceptable noise levels inside the building in

suburban and busy urban areas are 45 dB(A) & 50 dB(A) for day time and 35 dB(A) for night respectively.

Control of Traffic Noise: (i) Changes in design of vehicles and tyres (ii) Elimination of noisier vehicles, etc.

(iii) **Air Pollution:** Pollution of the atmosphere by fumes and smell emitted by the motor vehicles makes the urban streets extremely unpleasant. The source of the pollutant: (1) The major source is the exhaust gas emitted by the internal combustion engine (2) Evaporative losses from the fuel tank & the carburetor and (3) losses from the crank case.

Small doses of carbon monoxide, oxides of nitrogen and lead compounds does not appear to be a danger to health but the increase in the concentration may ultimately affect the well-being of the residents. Smog is a result of the combination of smoke and fog and can cause hazards to driving and irritation to the eyes.

Measures for Controlling Air Pollution:

(1) Reducing the pollutants at the source by improving the vehicle design and maintenance.

(2) Use of small cars instead of bigger ones and patronage of public transport system (tubes and railways).

(3) Use of alternative fuels, bypasses and ring roads (4) Staggering work hours, to reduce peak hour traffic.

(iv) **Vibration:** A vehicle moving on road surface induces following types of vibration in the surroundings:

(1) Vibrations generated in the contained air between the buildings may be annoying to the people.

(2) Surface vibrations set up on the superstructures (3) Underground vibrations set up in the substructures.

(4) Vibration due to irregular road surface causes of cracking of plaster, rattling of doors, windows & glass.

Vibrations with 10-15 mm/sec (peak particle velocity in the vertical direction) (i) considered unpleasant by people & unacceptable to some people walking on bridges (ii) cause architectural damage and possible minor structural damage.

Ameliorative (වැඩිදියුණු කිරීමේ) Measures: (1) Improvement of road surface (2) Reducing the number of heavily loaded vehicles (3) Enforcing a minimum space between adjacent buildings (4) Provision of wider roads.

(v) **Visual Intrusion and Degrading the Aesthetics:** Buildings seem to be rise from a plinth of cars.. Service stations, garages and petrol filling stations have sprung up along the road and added their mite to the degradation of the general scene.

(vi) **Severance (විච්ඡේදනය):** is the psychological, cultural and physical disturbance caused by a traffic facility on the neighborhoods, the land, the society and its life style. Land crisis is problem of rehabilitation.

Hierarchy of Roads

Road: is a convenient way for communication from one place to another and may be bituminous or concrete.
Street: is a road within the town, which has defined by buildings constructed along one or both of its sides.
Highway: is a roadway of standard width, meant for all sorts of traffic & include all public roads and streets.
Bypass road: is an arrangement for diverting a traffic flow to avoid congested areas of towns or cities.
Boulevard (Avenue): is a very wide road in a city with trees on either side and used as processional roads.

Needs of highway classification: (i) For a designer, it enables him to relate the geometric and structural design standards. (ii) For a planner, this provides a basis for long-term planning. (iii) Also it serves various administrative needs.
 Based on location and function, two broad categories of road are:
 (i) Urban – falling within the municipalities and (ii) Non-urban (Rural) – located in areas other than urban.

Urban roads are classified as under:

Expressways: A divided arterial highways for heavy volume of motor traffic at high speeds, with full control of access and provided with grade separation at intersections. Parking & pedestrian are not permitted.

Arterial Streets: A divided highways for through traffic with fully or partially controlled access. Parking, loading and unloading activities are usually restricted. Pedestrians are allowed to cross only at intersections.

Sub-arterial Streets: A street with lower level of mobility & access to adjoining areas is more than arterial streets. Parking, loading-unloading are restricted & regulated. Pedestrians are allowed to cross at intersection

Collector Streets: A collector street provided for collecting and distributing the traffic to and from local streets. Full access is allowed from abutting properties. A few parking restrictions except during peak hours.

Local Streets: A local street provided for access to residence, business or other abutting property. A local street may be residential, commercial or industrial. It allows unrestricted parking and pedestrian movements.

Rural roads are classified as under:

National Highways: are the main highways running through the length and breadth of the country connecting ports, foreign highways, capitals of States large towns and industrial areas and roads for strategic value.

State Highways: are the other main trunk or arterial roads of a State, connecting up with the National highways or highways of adjacent State and linking the district headquarters and important cities within the State.

District Roads: are roads traversing each district, serving areas of production & markets & connecting these with each other or with NH/SH. M.D.R. is for higher order of traffic and O.D.R. is for lower order of traffic.

Village Roads: are roads connecting villages or groups of villages with each other and to the nearest district road, NH or SH or Railway or navigational routes. They are in essence road from the village to a market.

Based on construction materials, classifications of road are:

- (1) Earth road (2) Gravel road (3) Brick road (4) Soil stabilized road (5) Water Bound Macadam (WBM) road (6) Bituminous road (7) Cement concrete road.

THE ROAD IN BANGLADESH

S	Category	Length	Definition
1	National Highway (NH)	3163 Km	Connecting capital city with district headquarters, ports & international highways
2	Regional Highway (RH)	2911 Km	Connecting different regions with each other which are not connected by the NH
3	Feeder Road Type-A (FRA)	9996 Km	Connecting Thana headquarters to the arterial network ()
4	Feeder Road Type-B (FRB)	17058 Km	Connecting growth centers to the RHD network or to the Thana headquarters
5	Rural Road Category-1 (R ₁)	56136 Km	Connecting Union headquarters/local markets with the Thana headquarters
6	Rural Road Category-2 (R ₂)	48874 Km	Connecting villages and farms to local markets/Union headquarters
7	Rural Road Category-3 (R ₃)	61286 Km	Roads within villages