MODULE 5

CE 308 Module V

Types of road intersections, Traffic control devices, Traffic signs, Road markings and Traffic signals, Design of Isolated signals by Webster's method.

Introduction to Airport Engineering, Aircraft characteristics and their influence on planning of airports, Components of airport, Selection of site for airport

Intersection

An intersection is defined as the general area where two or more highways join or cross

Can be mainly classified into two

a. Intersection at Grade

b. Grade seperated intersection.

a. Intersection at Grade

→ An intersection where all roads join or cross at the same level.

→ Traffic operations like Merging, diverging and crossing involved

Types of At grade I/n.

i) Unchannelised i/n

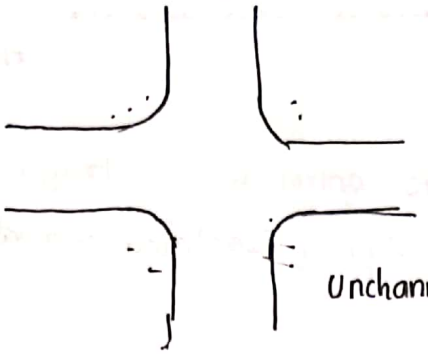
ii) Channelised i/n

iii) Rotary i/n.

Unchannelised i/n

- Lanes are not seperated by channel ~~dashes~~. divider.
- Vehicles have no restriction to use any part of intersection
- One of the crossing vehicle have to stop while other proceeds

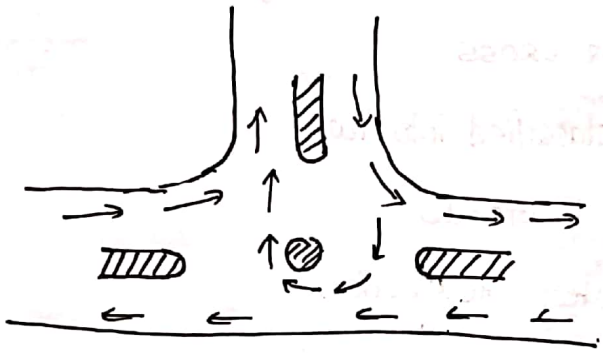
- Here more conflit between vehicle occue.



Unchannelised Iln.

ii) Channelised iln

- Lanes are sepeated by channel divides
- Vehicles have restriction to use any past of intersection
- Less conflict or collision than unchannelised.



channelised iln.

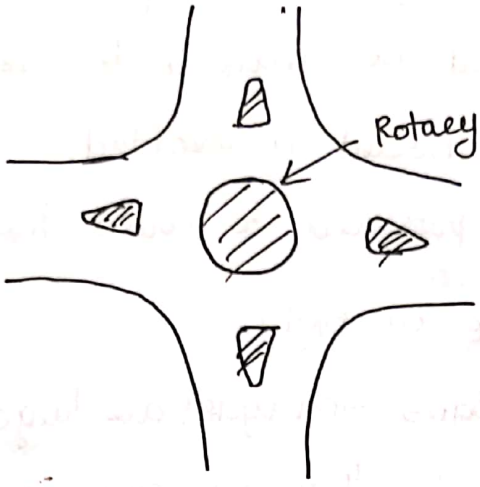
iii) Rotary or Round about

- All converging vehicles are forced to move around a large central island in clockcoise direction and they can move out into respective direction
- Eliminate stopping of vehicle
- Reduce conflict.
- Suited for iln with 5 or more intersection legs, where heavy right turning.

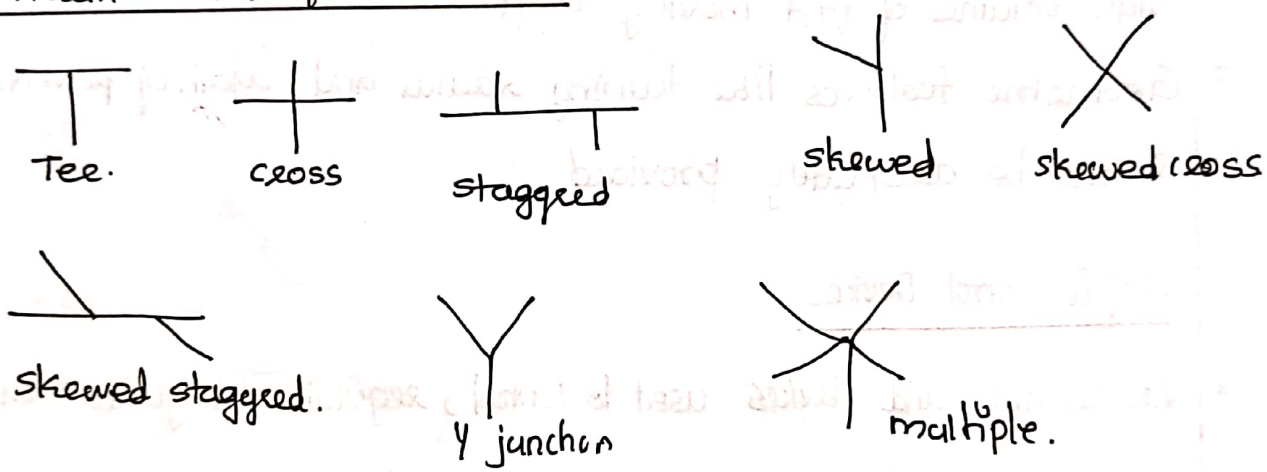
Disadvantages : More land

→ for high speed - require large size

→ Require many warning and direchonal sign.



Different forms of Intersechon at Grade



Grade seperated Intersechon

→ Intersecting roads are seperated by difference in level

→ Intersecting roads are seperated by overpass or underpass

Overpass : when highway is taken above ground level by an over bridge

Underpass : When highway is taken below ground level by an under bridge.

KTU Previous

Basic Requirements of Intersection at grade

1. At intersection the area of conflict should be as small as possible
2. Relative speed and angle of approach of vehicle should be small
3. Adequate visibility should be available for vehicles approaching
4. Sudden change of path should be avoided.
5. Proper signs should be provided to warn the drivers,
6. Good lighting is desirable at night
7. If the number of pedestrians and cyclist are large, seperate provision should be made for their safe passage in the areas with high volume of fast moving traffic.
8. Geometric features like turning radius and width of pavement should be adequately provided.

Traffic Control Devices

→ Various aids and devices used to control, regulate and guide traffic may be called traffic control devices. It include

→ Traffic sign
→ Traffic signal
→ Markings
→ Island.

Traffic Sign

Functions:

→ They give timely warning of hazardous situations
→ Help in regulating traffic by imparting messages to drivers.
→ Give information of highway routes, directions etc.

General principles of Traffic Signing.

→ Traffic signs should be installed only by the authority of laws
→ Proper enforcement measures should be undertaken
→ Sign should be put up only after traffic engg studies
→ Excess use of sign should not be promoted
→ Signs should be designed for foreseeable traffic conditions.
→ High visibility during night and day
→ Lettering or symbols should be of adequate size
→ Simplicity and uniformity in design, position and application.
→ located at position to be able to be seen by drivers

Traffic Sign - classification.

3 types

a. Regulatory Sign.
b. Warning Sign.
c. Informatory Sign.

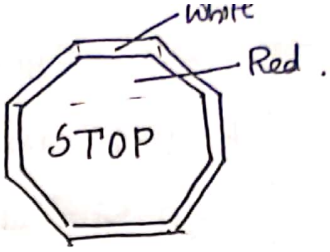
Regulatory Sign or Mandatory Sign.

→ These are mandatory signs
→ It inform certain laws, regulation and prohibitions
→ Violation of regulatory sign is an legal offence

Regulatory signs classified as.

i) Stop and Give way Signs
ii) Prohibitory sign.
iii) No parking - no stopping sign
iv) Speed limit and vehicle control sign.
v) Restriction end sign
vi) Compulsory direction control sign.

i) Stop and Give way sign.



Stop sign : To stop the vehicle

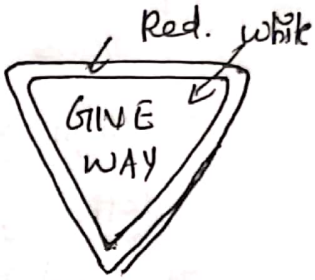
→ Octagonal in shape

→ Red in colour with white Border.

Give way sign : Control vehicle on road so as to assign right of way to other roadways.

→ Triangle in shape with apex downward.

→ White in colour with red border.



Give way.

ii) Prohibitary Sign

→ To prohibit certain traffic movement, use of horn or entry of certain vehicle

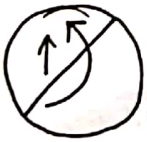
→ Circular in shape - white in colour and red border.

One way Sign.

Vehicle Prohibited in both dln.

Right turn Prohibited.

U turn Prohibited.



Overtaking Prohibited.

iii) No parking - No stopping sign

No parking : To prohibit parking at that place.

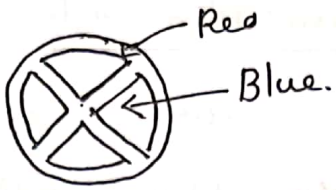
No stopping : Prohibit stopping of vehicle at that place.

Circular in shape - blue background, red border, 2 oblique red bar @ +5°

along main road

at 45°

No parking

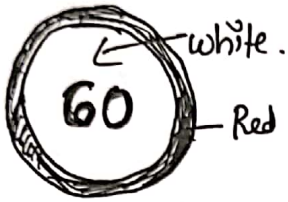


No stopping Sign.

iv) Speed limit and Vehicle control Sign.

→ To restrict speed of vehicle on a stretch of road

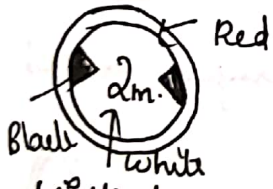
→ Circular in shape - white background, red border and black numerals indicating speed limit.



→ Vehicle Control Signs :

→ Control load, length, height etc.

→ Circular in shape : White background, red border, black symbol



Width limit

Height limit

Weight limit.

v) Restriction end Sign.

→ Indicate the point at which all restrictions indicated by signs end here.

→ Circular in shape with white background and a black diagonal band at 45°

vi) Compulsory Direction Control Sign.

→ To direct vehicle in appropriate direction

→ Circular in shape with blue background and white direction arrows

Compulsory Turn left

Compulsory Turn right ahead

Compulsory ahead only.

b) Warning Sign. or Cautionary Signs

→ To warn the road users of certain hazardous conditions that exist on the roadway

→ Equilateral Δle in shape with apex pointing upwards.

→ white background, red border, black symbols

→ Eg: Hairpin bend, curve, narrow bridge, School zone Pedestrian crossing

Side Road Right

T Intersection

Hair pin bend left

Narrow bridge.

c) Informatory Signs

→ Guid road users along routes, inform about destination, distance and provide information to make travel easier.

Direction and Place Information Sign.

→ Rectangle with white black ground, black border and black arrows and letters

→ eg: Destination Sign, Place Identification Sign

→ Facility Information Sign.

Public telephone, Petrol pump, Hospital etc.

First aid post

Road Marking

→ Special signs intended to control, coarse, guide or regulate the traffic

→ Made of lines, patterns, coords, symbols or reflectors on pavement, kerb, or fixed object etc.

Types - Marking

a.) Pavement markings
b) Kerb markings
c.) Object Markings
d) Reflector unit marking.

a.) **Pavement marking.**

→ white or yellow paints are used.

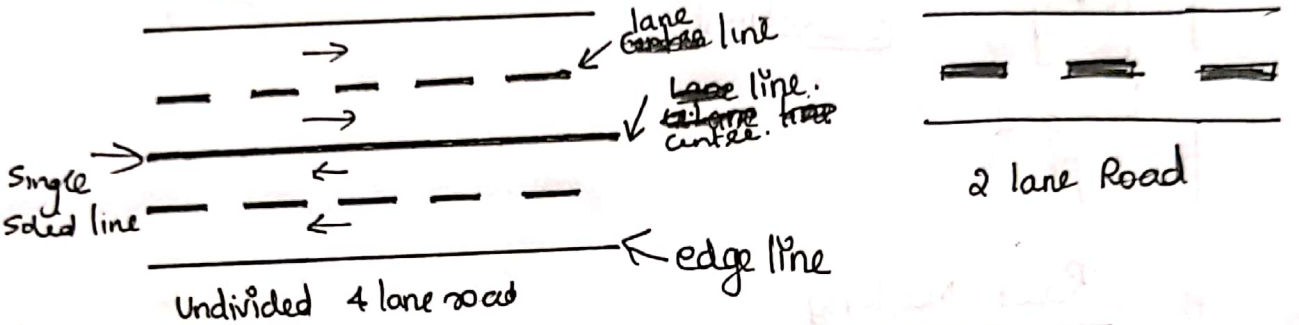
Some common types are center line, lane line, walk line, parking space, bus stop etc.

i) Centre line : To seperate opposing streams of traffic on undivided two-way traffic.

- white, single broken lines, single solid line, double broken like or solid lines based on road and traffic requirements

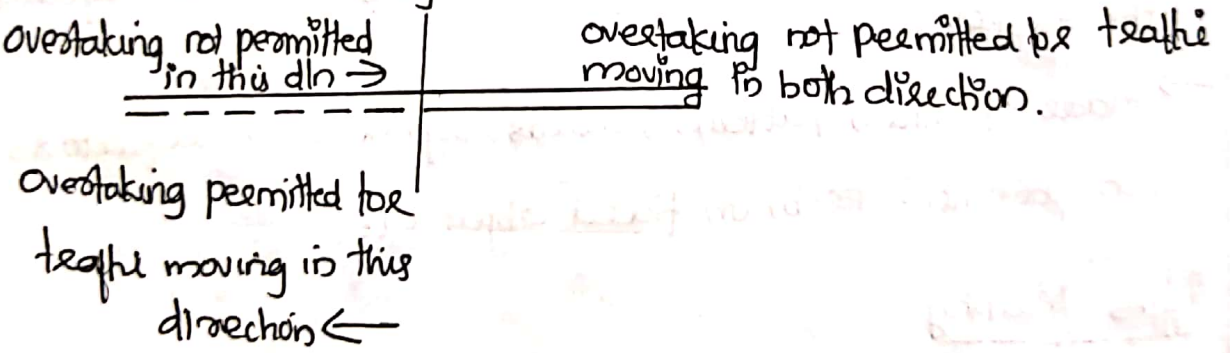
ii) Lane line : To designate traffic lane

- used to guide the traffic and to properly utilize the carriageway



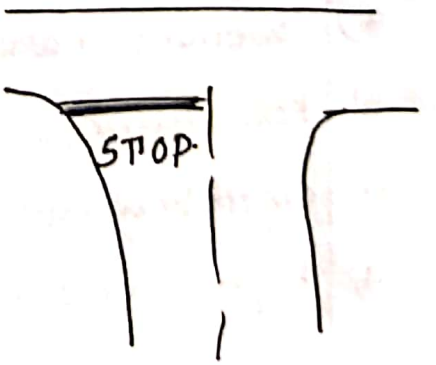
iii) No passing zone marking :

To indicate overtaking is not permitted.



iv) Stop line :

To stop vehicle near pedestrian crossing



v) Pavement edge line

Indicate edges of rural roads

vi) Cross walk line or pedestrians crossing line.

Used at places where pedestrians need to cross.

Pedestrian cross marking.

v) Bus stops

Indicate space reserved to stop buses.

b.) Kerb Marking

Indicate certain regulation like parking regulation.

c) Object Marking

Physical obstruction on or nearby roadway which are hazardous should be marked.

- Obstructions : bridge supports, signs and signal, level crossing gates, traffic island etc.

d) Reflector unit marking

Used as guide markers for safe driving during night.

- Hazard markers reflecting yellow light should be visible from an long distance of about 150m.

Traffic Signal.

Traffic signals are control devices which alternately direct the traffic to stop and proceed at intersections using red and green traffic light signals automatically.

Advantages - Traffic Signal.

→ They provide orderly movement of traffic and increase traffic handling capacity of intersection at grade.

→ Reduce certain types of accidents - right angled collision.

→ Pedestrians can cross the road safely at signalised intersection

→ Signals allow crossing of heavy traffic flow with safety.

→ When signal system is properly co-ordinated, there is a reasonable speed along the major road traffic.

→ Automatic traffic signal more economical compared to manual control

→ They can be coordinated to provide continuous movement of traffic at a definite speed along a given route

Disadvantages - Traffic Signal

→ Rear end collision may increase

→ Excessive delay to vehicle may be caused in off peak hours

→ Failure of signal due to electric power failure or any other defect cause confusion to road users

→ Improper design and location of signals may lead to violation of the control system.

Types of Traffic Signal

i) Traffic control signals
   a) Fixed time signal
   b) Manually operated signal
   c) Traffic actuated signal

ii) Pedestrian signal

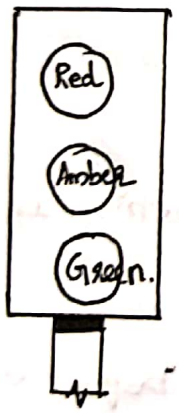
iii) Special traffic signal

Traffic control signals have 3 coloured light facing each direction of traffic flow.

Red light – STOP

Green light – GO

Amber / Yellow light – Allows clearance time for vehicles which enter the intersection area by the end of green time, to clear off



Fixed time signal or pretimed signal are set to repeat regularly a cycle of red, amber and green lights.

→ Timing of each phase of cycle is predetermined based on traffic studies

→ Simplest type of automatic signal

→ Draw back: Sometimes traffic flow on one road may be almost nil and traffic on cross road may be quite heavy. Yet as the signal operate with fixed timings, traffic in heavy streams will have to

stop at red phase.

Traffic actuated signal :

Timings of phase and cycle changing according to traffic demand to
In fully actuated traffic signal, detectors and computers assign
right of way for various traffic on the basis of demand
and predetermined programming. Adv: Flexible
Delay held to minimum
Max. capacity achieved

Manually operated signal

Disadv: Requires costly equipments such as detectors.

Traffic police watches traffic demand and varies timings
of phases and cycle accordingly.

Pedestrian signal.

→ Provide right of way to pedestrians to cross a road during walk period.

Special signal or Flashing Beacons.

→ To warn the traffic

→ Flashing of yellow signal : Direct drivers of vehicular traffic to proceed with caution

→ Red flashing signal : Drivers must stop before entering the nearest cross walk at the intersection

Signal coordination

Principle of linking adjacent signals so as to secure maximum benefits to flow of traffic is called co-ordinated control of signals.

objectives or need:

→ To pass maximum amount of traffic without enforced halt.

→ To have minimum overall delay to traffic streams, both in main and side roads.

→ To prevent queue of vehicles at one intersection

Types of co-ordinated Signal system

a. Simultaneous system
b. Alternate system
c. Simple progressive system
d. Flexible progressive system.

a. Simultaneous system

All signals along a given road always show same indication (green, red etc) at same time.

→ overall speed often reduced.

→ Does not work satisfactorily

b. Alternate system

→ Alternate signals show opposite indications in a route at same time.

→ satisfactory than simultaneous system.

c. Simple Progressive System.

→ A time schedule is made to permit, as nearly as possible, a continuous operation of vehicle at a reasonable speed along main road is obtained.

→ Signal phases controlling 'Go' direction is scheduled to work at predetermined time schedule

d. Flexible Progressive System.

→ modification of simple progressive

→ It is possible to automatically vary the length of cycle and time schedule at each intersection with help of computer

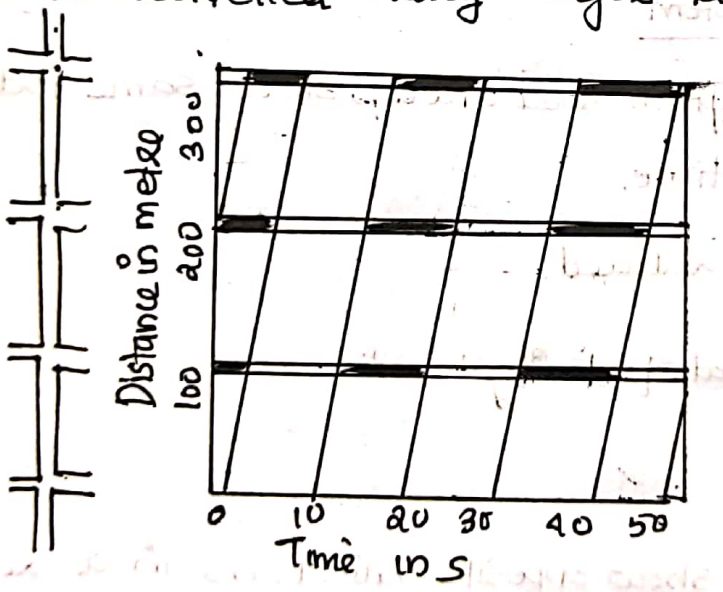
→ most efficient system.

Time and Distance Diagram

→ In planning a system of co-ordinated signal control, it is necessary to prepare Time distance diagram

→ Time and signal settings along x axis

→ Distance travelled along major route on Y axis.



Warrants for Traffic Signal

Traffic control devices Signals should not be installed unless one or more of the following warrants.

1. Minimum Traffic Volume

→ Average traffic volume on major street should be 650 veh/hr (for single lane) and 800 veh/hr on 2 or more lane.

→ Average traffic volume on minor street should be 200 veh/hr (for single lane) and 250 veh/hr on road with 2 or more lane

2. Interception of Continuous traffic

→ Affect continuous movement of traffic

→ Traffic volume on major street - 1000 to 1200 veh/hr.

→ Traffic volume on minor street - 100 to 150 veh/hr.

3. Minimum Pedestrian Volume

→ Minimum 150 or more pedestrians/hour cross a major street with over 600 veh/hour.

4. Accident Experience

→ other measures have failed to decrease accident ~~frequency~~ frequency

→ 5 or more accidents occured within 12 months period

5. Combination of warrants when no single warrant is satisfied but indicating 2 or more warrants above are satisfied to the extent of 80% or more

Traffic Signal Design

Definitions

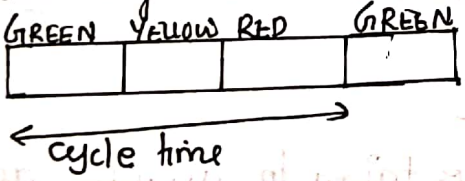
Green time or Green Interval (G): Amount of time for which a movement receives a green indication.

Yellow time (Y): Amount of time for which a movement receives Yellow indication

Red Time or Red interval (R): Amount of time for which a movement receives Red Indication.

Cycle: 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 b/w starting of green for one approach till the next time green starts. Denoted by C.



Lost time: It indicates the time during which the intersection is not effectively utilized for any movement.

For eg: when signal for an approach turns from red to green, the driver of vehicle which is in front of queue, will take some time to perceive the signal (reaction time) and some time will be lost there before he moves. This is known as start up lost time.

Interval : Indicate change from one stage to another.

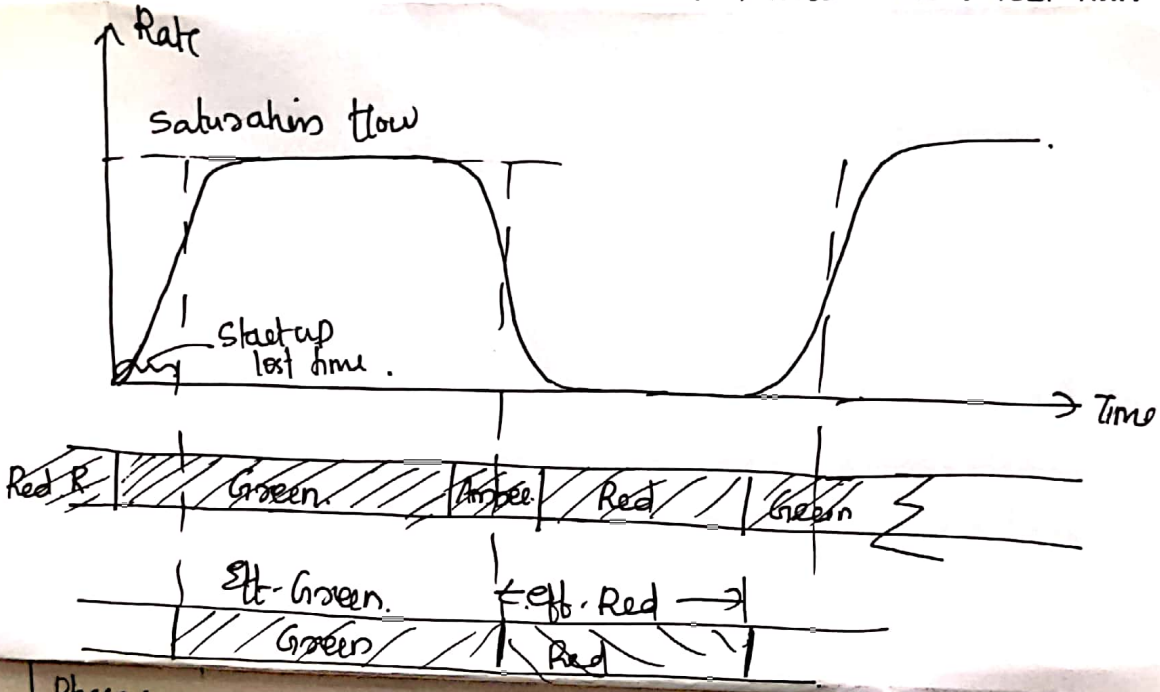
change interval also called yellow time indicate interval b/w green and red signal indication

clearance interval also called all red. - period during which all signal faces show red and is used for clearing off the vehicles in intersection.

Effective Green Time is the actual time available for the vehicles to cross the intersection. It is the sum of actual green time (G_i) plus the yellow time minus lost times.

$$g_i = G_i + Y_i - t_L$$

Effective Red time = Actual Red time + Yellow time + lost time



Phase :

Part of a cycle allocated to any combination of traffic movements receiving right of way simultaneously during one or more intervals.

→ The objective of phase design is to seperate the

=67.5

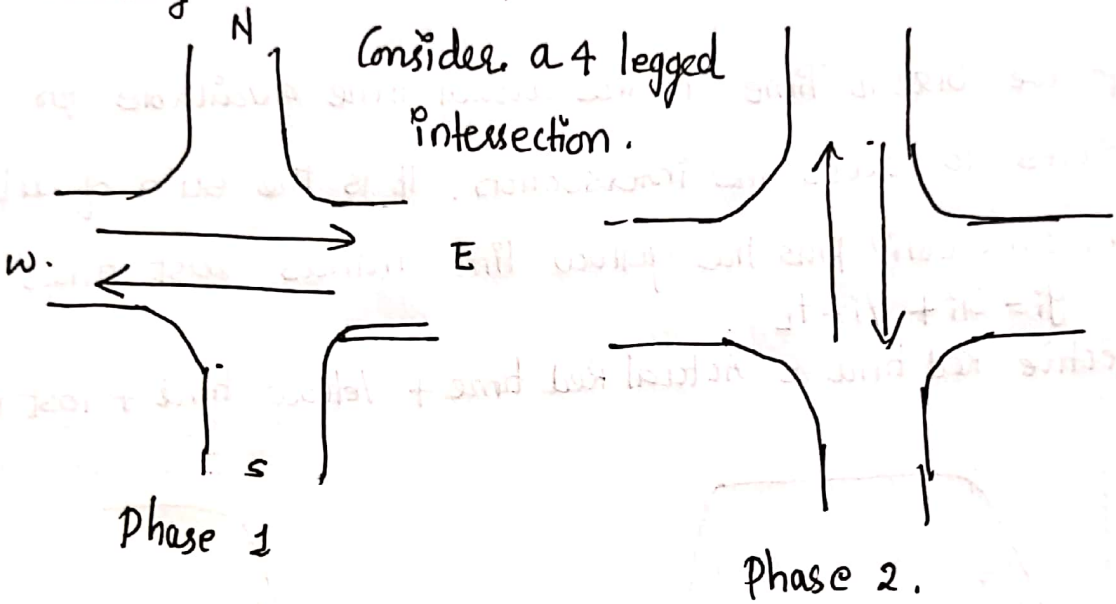
1.5 secon

conflicting movements in an intersection into various phases

→ Design phases with minimum conflict or with less severe conflicts.

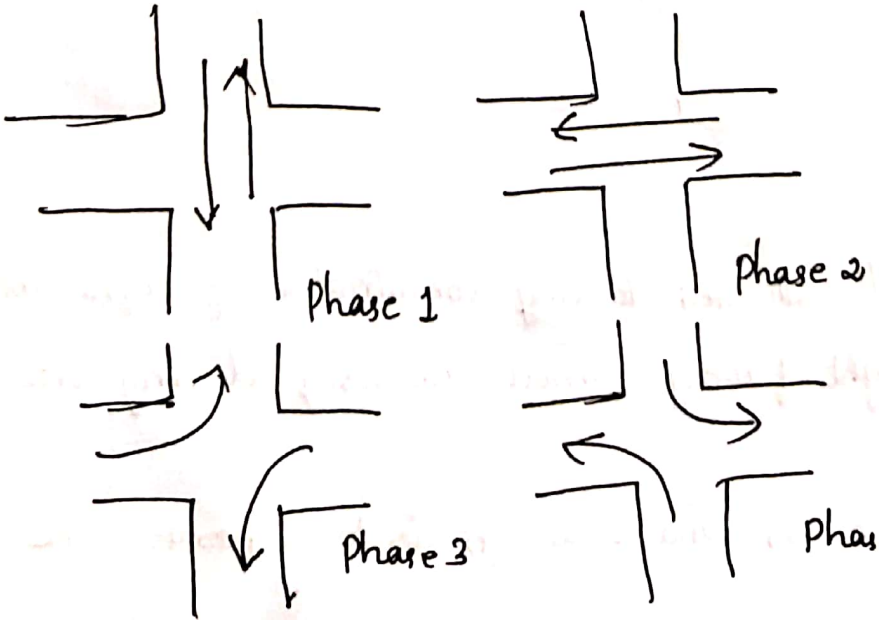
Two phase system

→ Adopted if through movement is significant compared to turning movements.



Four phase signal

- Suited in urban areas where turning movements are comparable with through movement



Saturation flow

→ Most important factor in Traffic signal design.

→ It is the maximum flow that can pass through an intersection without impedance by the signal

→ Different factors affecting saturation flow are

- Traffic composition
- Road alignment (approach width, gradient, radius of right & left turning)

Design of Isolated Signal

a. Trial Cycle method.

b. Approximate method

c. Webster's method (✓)

d. As per IRC

V.Imp Webster's Method of Signal Design

S_i – Saturation flow on each approach

q_i – Normal flow on each approach

→ Calculate critical flow ratio, $y_i = q_i/s_i$ for each approach and take the highest and find the sum

$$Y = y_1 + y_2 + \ldots$$

→ Calculate Total lost time (L)

$$L = 2n + R$$

n = No. of Phases

R = All red time

→ Optimum cycle Time, $\boxed{C_o = \frac{1.5L + 5}{1 - Y}}$

Effective green time per cycle = $C_o - L$

Effective green time per phase = $\frac{y_i}{y}(C_o - L)$

Question 1

The average normal flow of traffic on cross roads A and B during design period are 400 and 250 pcu/hour. Saturation flow values on these roads are estimated as 1250 and 1000 pcu/hour respectively. The all red time required for pedestrian crossing is 12 seconds. Design a phase traffic signal by webster's method.

Solution:

Given,

All red time $R = 12$ s

Normal flow on A, $q_a = 400$ pcu/hr.

Normal flow on B, $q_b = 250$ pcu/hr.

Saturation flow on A, $S_a = 1250$ pcu/hr.

Saturation flow on B, $S_b = 1000$ pcu/hr

Critical flow ratio $y_a = \frac{q_a}{S_a} = \frac{400}{1250} = 0.32$

$$y_b = \frac{q_b}{S_b} = \frac{250}{1000} = 0.25$$

$$Y = y_a + y_b = 0.32 + 0.25 = 0.57$$

Total lost time $= 2n + R = (2 \times 2) + 12 = 16$ seconds.

Optimum cycle time, $C_o = \frac{1.5L + 5}{1 - Y} = \frac{(1.5 \times 16) + 5}{1 - 0.57} = 67.4$ sec $= 67.5$

Effective green time per cycle $= C_o - L = 67.5 - 16 = 51.5$ seconds

Effective green time per phase $= \frac{Y_i}{Y}(C_o - L)$

Effective green time for phase 1 (A) $= \frac{g_a}{Y}(C_o - L)$

$= \frac{0.32}{0.57}(67.5 - 16) = 29$ seconds

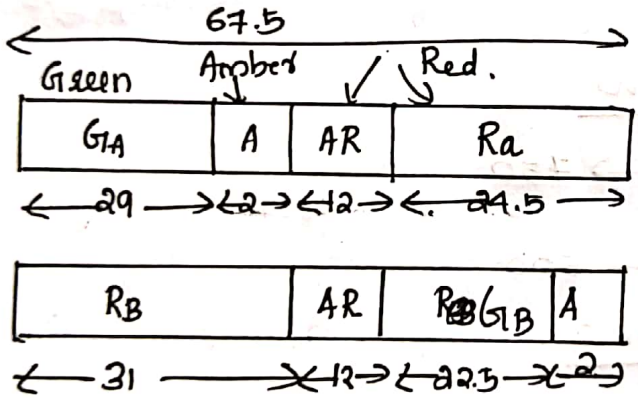
Effective green time for phase 2 (B) $= \frac{g_a}{Y}(C_o - L)$

$= \frac{0.25}{0.57}(67.5 - 16)$

$= 22.5$ seconds

Provide amber time = ~~2~~ 2 seconds

Draw phase diagram (Imp)



$R_a = 67.5 - G_A - A - AR$

$R_B = 67.5 - G_B - A - AR$

G - Green
A - Yellow / Amber
AR - All red
R - Red.

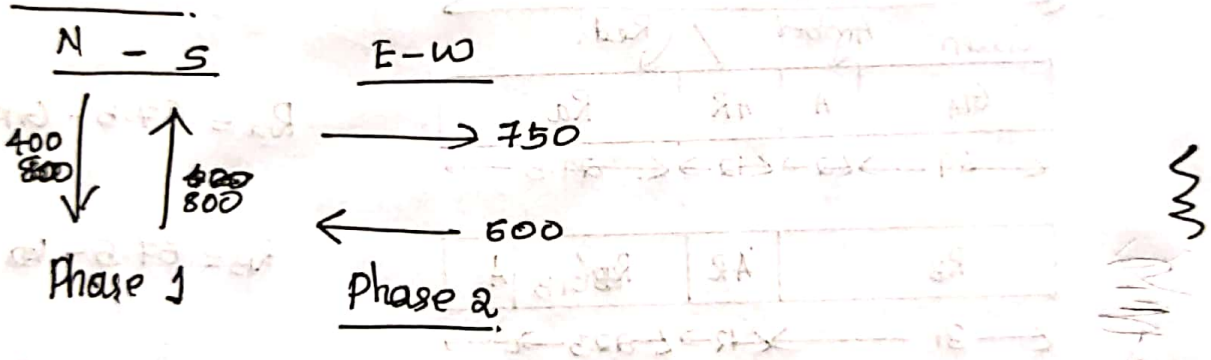
Question 2.

A fixed time Two-phase signal is to be provided at an intersection having four arms. The design hour traffic and saturation flow are.

	North	South	East	West
Design hr flow pcu/hr	800	400	750	600
Saturation flow pcu/hr.	2400	2000	3000	3000

Time lost per phase due to starting delay is 2 sec and All red period is 4 sec. Design 2 phase traffic signal using Webster's method. Draw phase diagram also

Solution.



Critical flow ratio for N-S phase

$$y_N = \frac{q_N}{S_N} = \frac{800}{2400} = 0.33$$

$$y_S = \frac{q_S}{S_S} = \frac{400}{2000} = 0.2$$

Maximum value of critical flow ratio (y) in N-S direction
$= 0.33$

Critical flow ratio for E-W Phase

$$y_E = \frac{q_E}{S_E} = \frac{750}{3000} = 0.25 \;,\; y_W = \frac{q_W}{S_W} = \frac{600}{3000} = 0.2$$

Maximum value of critical flow ratio (y) in E-W direction
$= 0.25$

$$Y = y_{NS} + y_{EW} = 0.33 + 0.25 = 0.58$$

Total lost time per cycle in second

$$L = 2n + R = (2 \times 2) + 4 = \underline{8 \text{ seconds}}$$

Ophmum cycle time, $C_o = \dfrac{1.5L + 5}{1 - Y}$

$$= \frac{(1.5 \times 8) + 5}{1 - 0.58} = \underline{40 \text{ seconds}}$$

Effective green time per cycle $= C_o - L$

$= 40 - 8 = \underline{32 \text{ seconds}}$

Effective green time per phase

N-S phase $G_{NS} = \dfrac{y_{NS}}{Y}(C_o - L) = \dfrac{0.33}{0.58}(40 - 8) = \underline{18 \text{ sec}}$

E-W Phase $G_{EW} = \dfrac{y_{EW}}{Y}(C_o - L) = \dfrac{0.25}{0.58}(40 - 8) = \underline{14 \text{ sec}}$

Provide amber period = 2 sec.

$G_{NS} = 18$ sec	A = 2s	AR = 4s	$R_{NS} = 16$ sec

← 40s →

$$R_{NS} = 40 - 18 - 2 - 4 = \underline{16 \text{ sec}}$$

$R_{EW} = 20$ sec.	AR = 4s.	$G_{EW} = 14$s	A = 2s.

CE 308 TRANSPORTATION ENGINEERING I

MODULE V

Types of road intersections, Traffic control devices, Traffic signs, Road markings and Traffic signals, Design of isolated signals by Webster's method

Introduction to Airport Engineering, Aircraft characteristics and their influence on planning of airports, Components of airport, Selection of site for airport

Road Intersection

- Intersection is an area shared by two or more roads.
- Main function: Guide vehicles to their respective directions
- Traffic intersections are complex locations on any highway

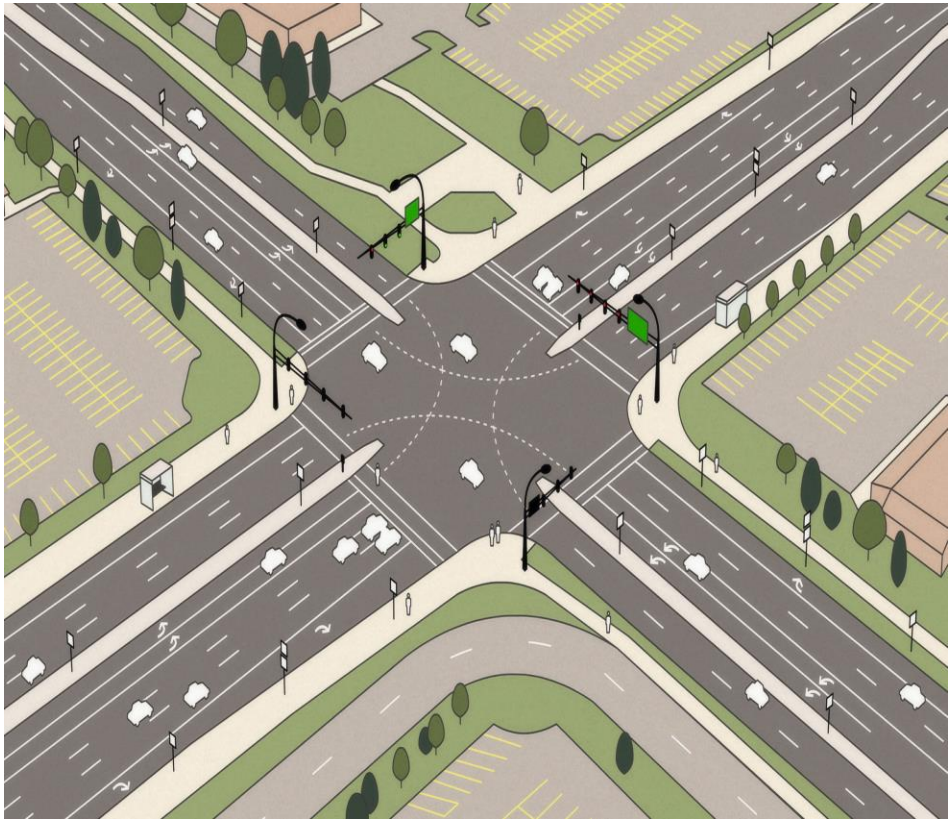
Road Intersection - Types

Two types

- Intersection at Grade
- Grade separated Intersection

Intersection at Grade

- Road meet at same level



Grade separated Intersection

- Intersecting roads are separated by difference in level

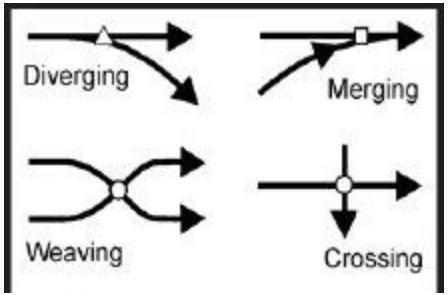
Intersection at Grade

- Road meet at same level
- Merging, diverging and crossing involved
- Types of intersection at grade

✓ **Unchannalised**

✓ **Channalised**

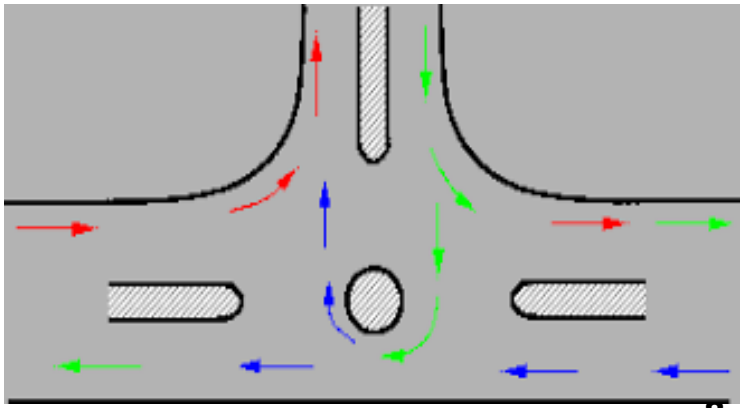
✓ **Rotary**



Intersection at Grade

Channalised Intersection

- ✓ Lanes are separated by channel divider
- ✓ Vehicles have restriction to use any part of intersection
- ✓ One of the crossing vehicle have to stop while other proceeds
- ✓ Less conflicts than unchannalised



Intersection at Grade

Unchannalised Intersection

- ✓ Lanes are not separated by channel divider
- ✓ Vehicles have no restriction to use any part of intersection
- ✓ One of the crossing vehicle have to stop while other proceeds
- ✓ More conflicts

Intersection at Grade

Rotary

- All converging vehicle are forced to move around a large central island in clockwise direction and they can move out of flow into their respective direction
- Eliminate stopping of vehicle
- Reduce conflict

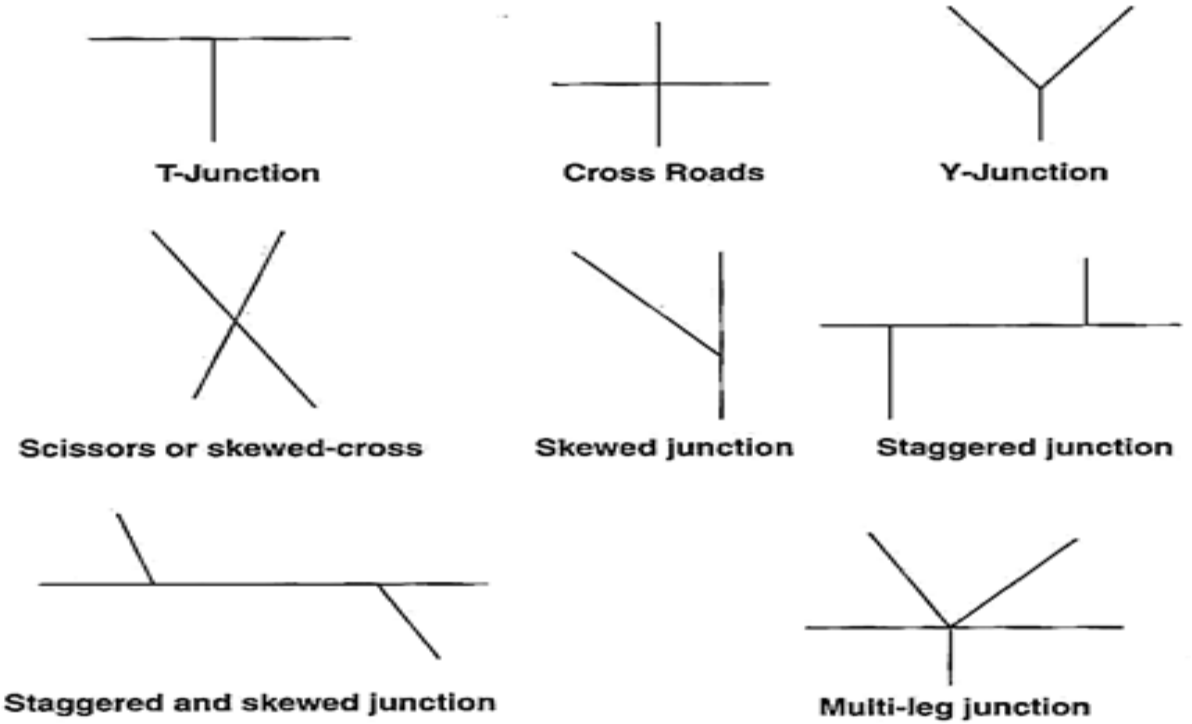
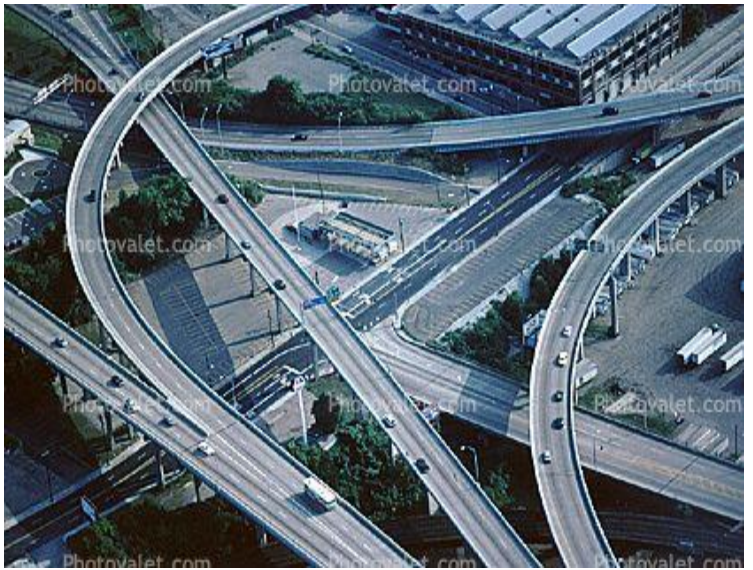


FIG. 5.2 *Basic forms of At-grade intersections*

Grade separated Intersection

- Intersecting roads are separated by over pass or under pass
- **Overpass** – when highway is taken above ground level by an over bridge
- **Underpass** – when highway is taken below ground level by an under bridge



Basic requirements of Intersection at Grade (KTU-2018)

- At the intersection area of conflict should be minimum
- Relative speed or the angle of approach should be as small as possible
- Adequate visibility should be available for vehicle approaching the intersection
- Sudden change in path should be avoided
- Proper sign should be provided to warn drivers
- Good lighting at night
- Safe passage for pedestrians and cyclist
- Geometric features like turning radius and width of pavement should be provided

Traffic Control Devices

- Traffic signs
- Traffic signals
- Markings
- Island

Traffic Sign

- Regulatory Sign
- Warning Sign
- Informatory Sign

Regulatory Sign

- These are mandatory signs
- It inform certain laws, regulations and prohibitions
- Violation of regulatory sign is an legal offence

Classified as

- ✓ Stop and give way signs
- ✓ Prohibitory sign
- ✓ No parking – no stopping sign
- ✓ Speed limit and vehicle control sign
- ✓ Restriction end sign
- ✓ Compulsory direction control signs

Stop and give way signs

Stop sign – to stop the vehicle

- Octagonal in shape and red in colour with a white border

Give way sign – control the vehicle on a road so as to assign right of way to other roadways

- Triangle in shape with apex downward – white in colour with red border

Give way Sign
900mm Triangle

Stop Sign
900mm Octagon

Prohibitory sign

- To prohibit certain traffic movement, use of horn or entry of certain vehicle
- Circular in shape – white in colour and red border

No parking – no stopping sign

No parking – to prohibit parking at that place

Circular in shape – blue background, red border and an oblique red bar at an angle of 45o

No stopping – prohibit stopping of vehicle at that place

Circular in shape – blue background, red border and two oblique red bar at 45o and right angle to each other

Speed limit and vehicle control sign

- To restrict the speed of vehicle on a stretch of road
- Circular in shape – white background, red border and black numerals indicating the speed limit

Vehicle control sign

- Control load, length, height etc
- Circular in shape – white background, red border and black symbol

Restriction end sign

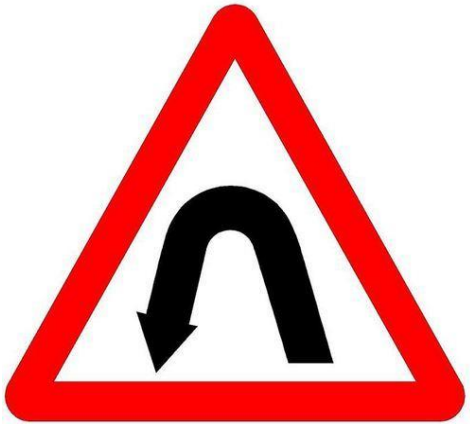
- Indicate the point at which all restrictions indicated by signs ends here
- Circular in shape with white background and a black diagonal band at 45degree

Compulsory direction control signs

- To direct the vehicle in appropriate direction
- Circular in shape with blue background and white direction arrow

Warning signs

- To warn about certain hazardous conditions
- Equilateral triangle in shape with apex pointing upwards.
- White background red border and black symbols
- Example: curve, hair pin bend, narrow bridge, pedestrian crossing, school zone



Informatory signs

- To guide the user along the roads, inform about destination, distance and provide information to make travel easier

Direction and place identification signs

- Example: destination sign, place identification sign

Facility information sign

- Example: public telephone, petrol pumb, hospital

Parking sign

- Square shape with blue background and white coloured letter P

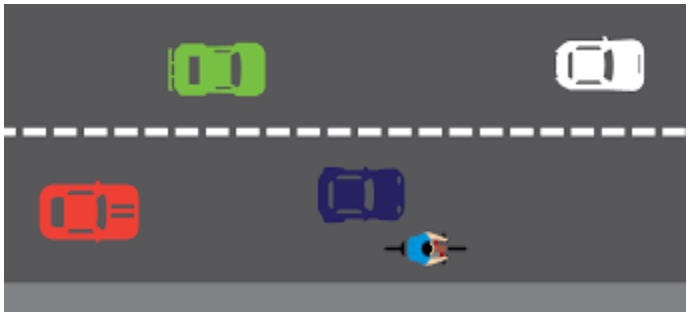
Road Marking

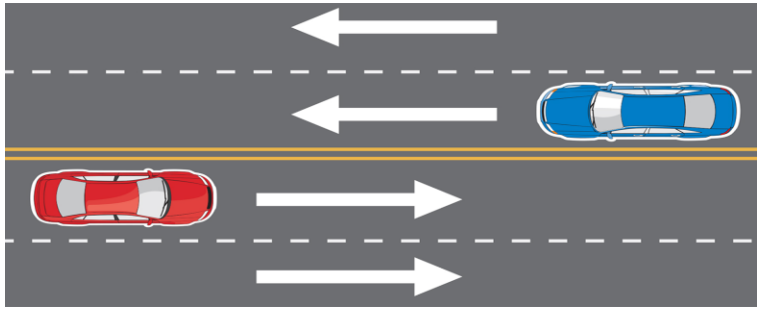
- Road marking made of lines, patterns, words, symbols or reflectors
- Used to control, warn, guide or regulate traffic
- Made using paints in contrast with the pavement

1. Pavement marking

Centre line

- To separate opposing streams of traffic
- Depends on whether road is in urban or rural region
- On roads with less than four lane – single broken line
- On undivided highway with at least two traffic lane in each direction- solid continuous line





Pavement marking

Lane Line

- To designate traffic lanes
- To guide traffic and properly utilize the carriageway

No passing Zone Marking

To indicate that overtaking is not permitted

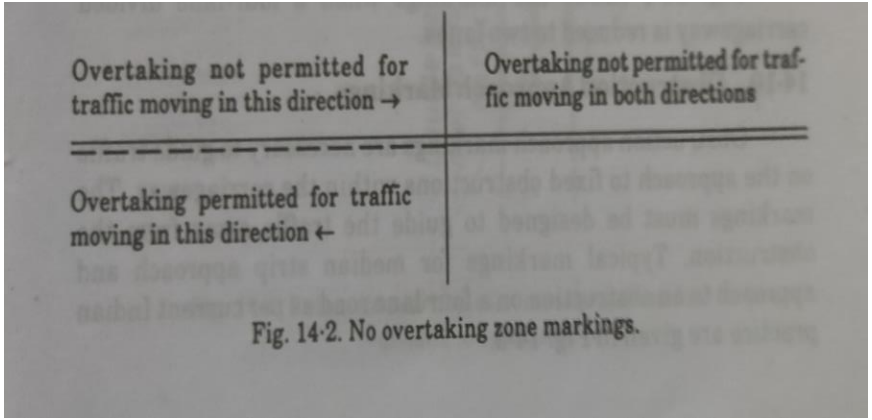


Fig. 14·2. No overtaking zone markings.

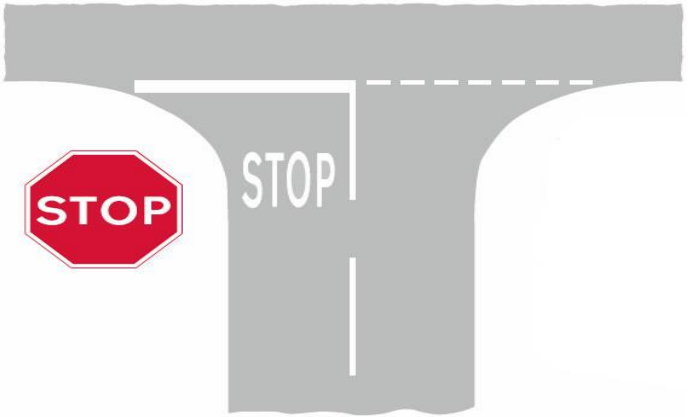
Pavement marking

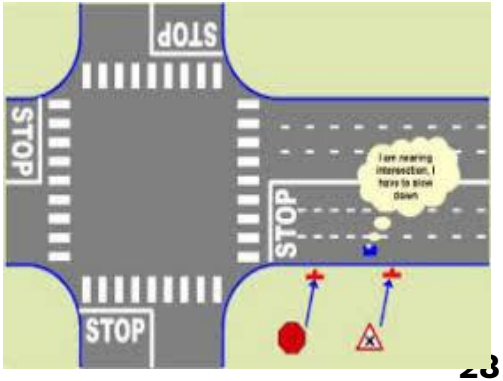
Edge line

Indicate carriageway edges of rural road which have no kerb stones along edges

Stop line

Stop near pedestrian crossing , signalized intersection etc





Pavement marking

Cross walk line or pedestrian crossing

- Safe passage for pedestrians to cross road or intersection

Bus stop

- Space meant for bus stop

2. Kerb Marking

- Indicate certain regulation like parking regulation
- Marking or painting with black and white increase visibility from long distance

3. Object Marking

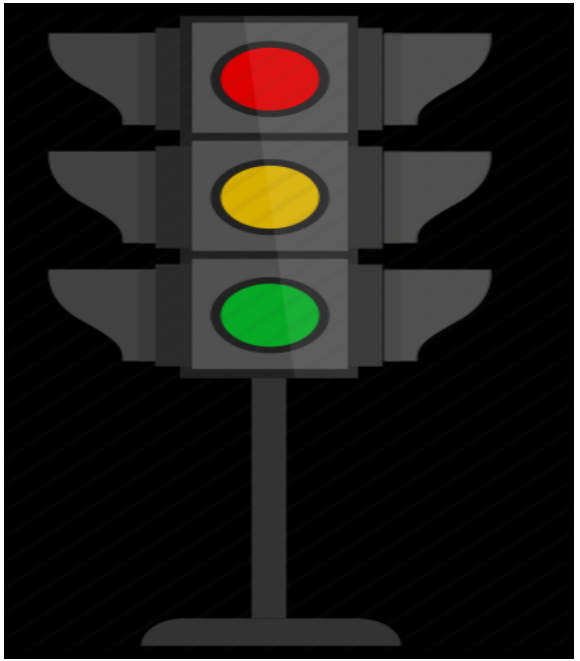
- Physical obstruction on or near roadway which are hazardous marked
- Bridge support, level crossing gate, traffic island etc

4. Reflector Unit Marking

- Guide markers for safe driving during night driving

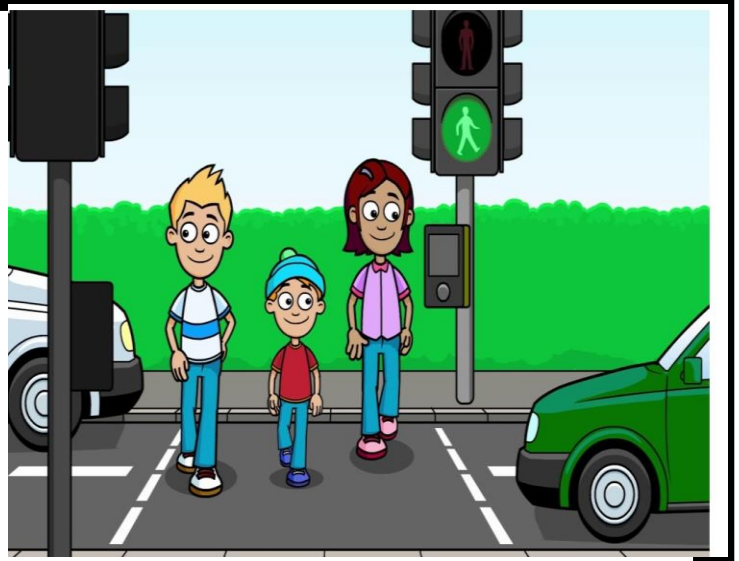
Traffic Signal

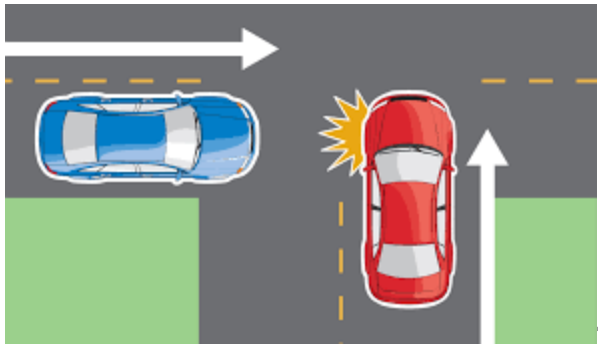
- Control devices which alternately direct traffic to stop and proceed at intersection using red, green and amber light signal



Advantages

- Provide orderly movement of traffic and increase traffic handling capacity of intersection
- Reduce certain types of accidents
- Pedestrians can cross the road safely at signalized intersection





Advantages-Traffic signal

- Allow crossing of heavy traffic flow with safety
- They can be coordinated to provide continuous movement of traffic
- When properly coordinated- reasonable speed along major road traffic
- Quality of traffic improves

Disadvantages- Traffic signal

- Rear end collision may increase
- Excessive delay to vehicle may caused in off peak hour
- Failure of signal due to electric power failure or any other cause- confusion to road users
- Improper design and location of signals lead to violation of control system

Warrants for Traffic signal

Traffic signal should not be installed unless one or more of the following signal warrants are met

- Minimum vehicular volume
- Interruption of continuous traffic
- Minimum pedestrian volume
- Accident Experience
- Combination of warrant

Warrants for Traffic signal

1. Minimum vehicular volume

- Average traffic volume on major street should be 650 veh/hour (for single lane) and 800 veh/hour on road with two or more lane
- Average traffic volume on minor street should be 200 veh/hour (for single lane) and 250 veh/hour on road with two or more lane

Warrants for Traffic signal

2. Interruption of continuous traffic

- Affect the continues movement of traffic
- Traffic volume on major street- 1000 t0 1200 veh/hour
- Traffic volume on minor street- 100 to 150 veh/hour

3. Minimum pedestrian volume

- Minimum 150 or more pedestrians/hour cross a major street with over 600 vehicles/ hour

4. Accident Experience

- Other measures failed to decrease accident frequency
- Five or more accidents occurred within 12 months period

5. Combination of warrant

Types of traffic signal

- Traffic control signal
    - Fixed time signal
    - Manually operated signal
    - Traffic actuated signal
- Pedestrian signal
- Special traffic signal

Traffic control signal

- Have three coloured light facing each direction of traffic flow
- Red light- **STOP**
- Green light- **GO or PROCEED**
- Amber or yellow- **CLEARNCE TIME**

Traffic control signal

1. Fixed time signal

- Set to repeat regularly a cycle of red, amber and green light
- Timing of each phase of cycle is predetermined based on traffic studies
- Simplest type
- Limitation: Inflexible- may cause unavoidable delay
- Require careful setting

2. Traffic actuated signal

- Timings of each signal phase according to traffic demand
- Detectors and computers assign right of way for traffic based on demand bases on predetermined programming

Advantages: Flexible

- Delay minimum
- Maximum capacity achieved

Disadvantages: Require costly equipment such as detectors

Traffic control signal

3 Manually operated signal

- Traffic police watches traffic demand and varies timing of phases and cycles accordingly

Pedestrian signal

- Provide right of way to pedestrians to cross a road during walk period

Special type signal or flashing beacons

- To warn traffic
- Flashing of yellow signal: direct drivers of vehicular traffic to proceed with caution
- Red flashing with caution: Driver must stop before entering the nearest cross walk at the intersection

Signal Coordination

- Principle of linking adjacent signals so as to secure maximum benefits to the flow of traffic

Objectives or Need of Signal Coordination

- To pass maximum amount of traffic without enforced halt
- To have minimum overall delay to traffic streams, both in main and side roads
- To prevent queue of vehicles at one intersection from extending and reaching the next intersection

Types of Signal Coordination System

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

Simultaneous System

- All signals along a given street always show same indication at the same time
- Does not give continuous movement
- Overall speed often reduced

Alternate System

- Alternate signal or group of signal shows opposite indication in a route at same time
- Operated by a single controller
- Satisfactory than simultaneous system

Simple Progressive system

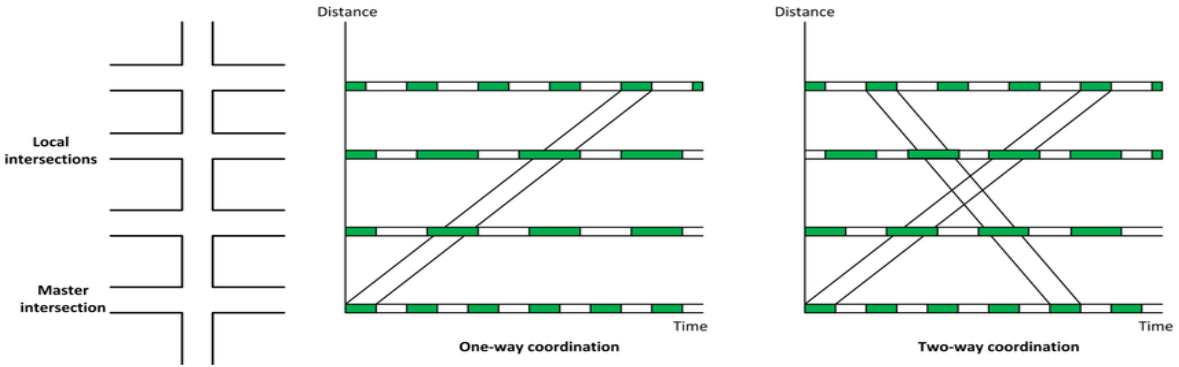
- Time schedule is permitted as nearly as possible continuous operation vehicles along a main road at reasonable speed
- Green indication along the road scheduled to work at predetermined time schedule

Flexible progressive

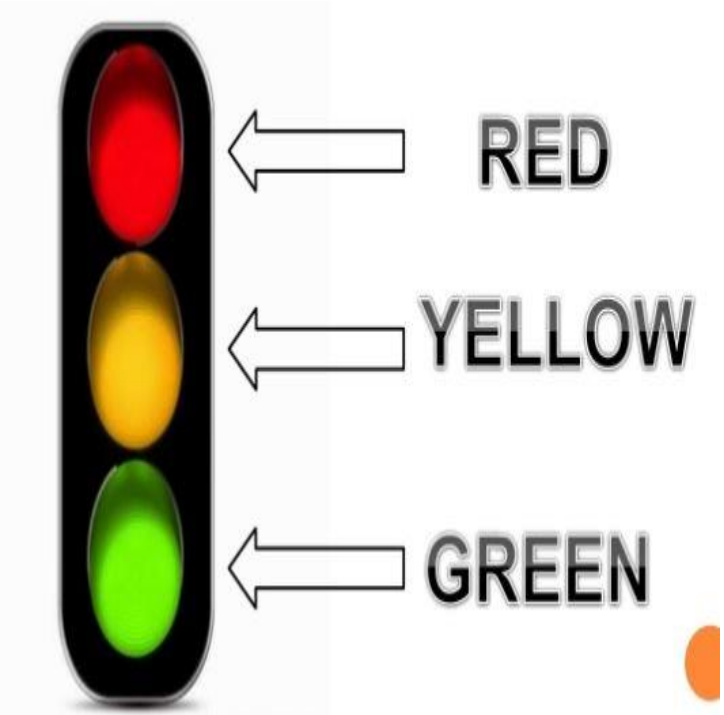
- Improvement of simple progressive system
- Possible to automatically vary the length of cycle and time schedule at each intersection with help of a computer
- Most efficient system

Time and Distance Diagram

- Time and signal settings indicated along horizontal axis to a suitable scale
- Distance travelled along major route plotted on Y axis



TRAFFIC SIGNAL DESIGN



DEFINITIONS

Green Time (G) or Green Interval -The amount of time for which a movement receives a green indication.

Yellow Time (Y) -The amount of time for which a movement receives a Yellow indication. (Change Interval)

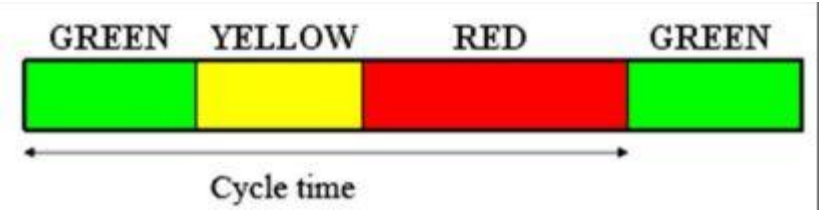
Red Time (R) -The amount of time for which a movement receives a Red indication.

All Red Interval (AR) : All red interval the display time of a red indication for all approaches. (for wide intersection and for pedestrian crossing)

DEFINITIONS

Cycle: 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 of green for one approach till the next time the green starts. It is denoted by C

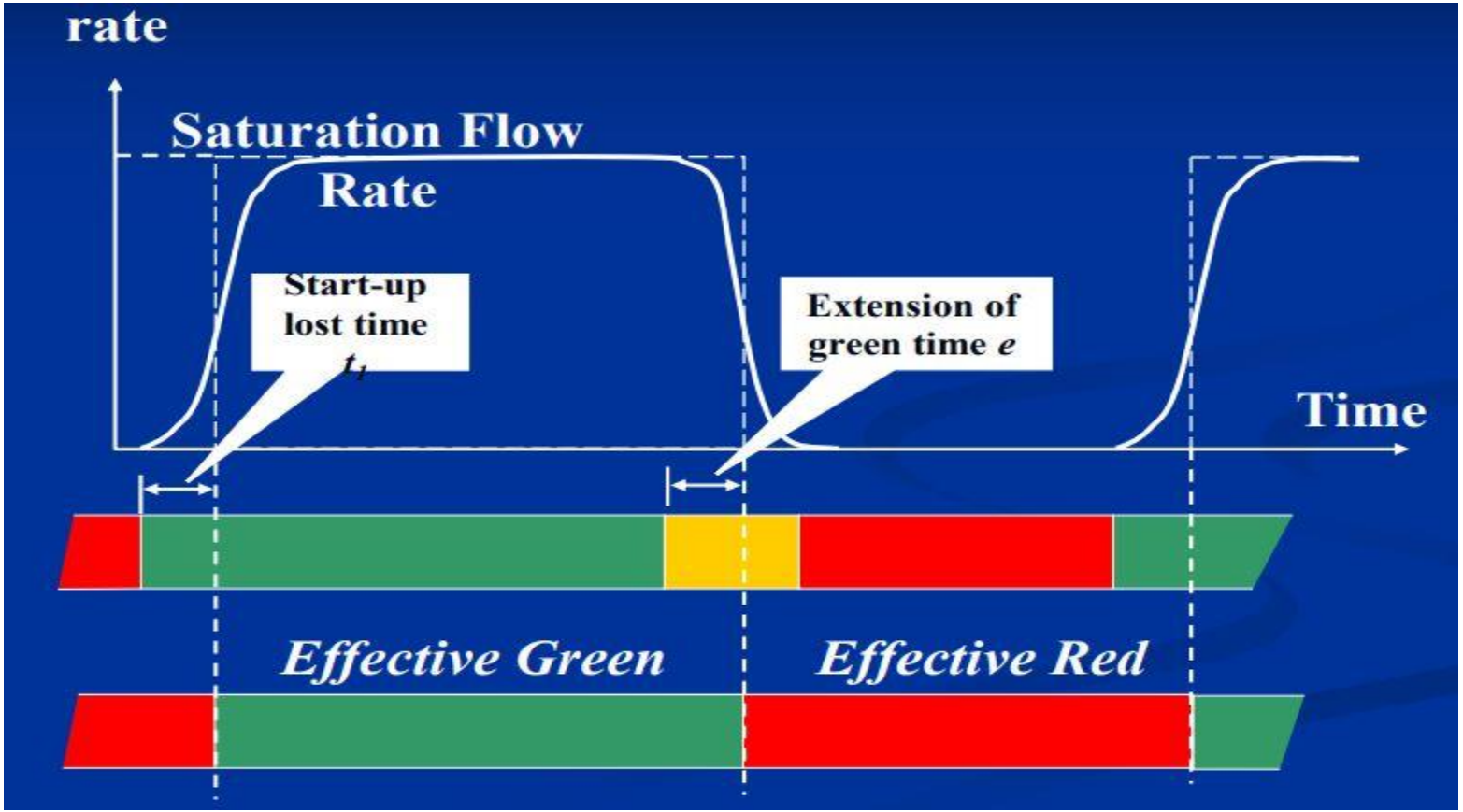


DEFINITIONS

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 here before he moves (**Start up lost time**)


rate
Saturation Flow
Rate
Start-up
lost time
t_l
Extension of
green time e
Time
Effective Green
Effective Red

Interval: Thus it indicates the change from one stage to another.

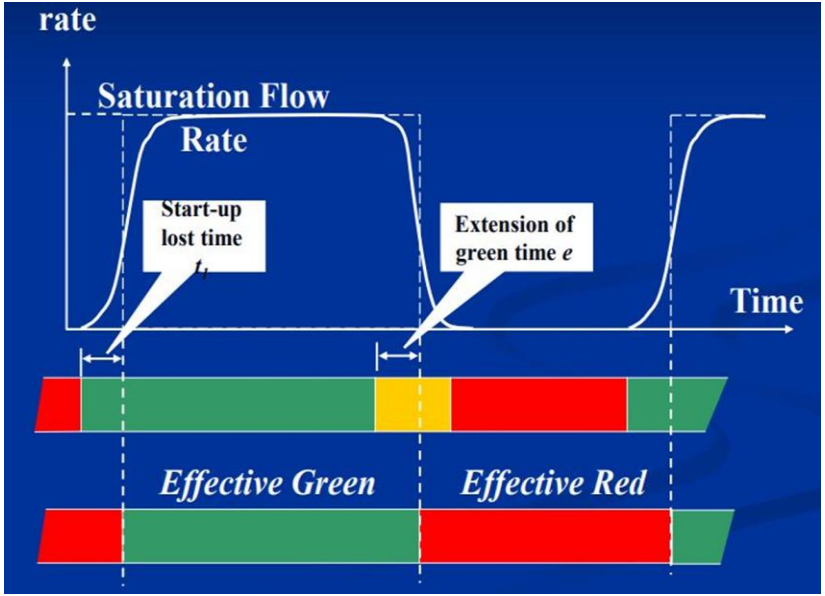
Change interval is also called the yellow time indicates the interval between the green and red signal indications for an approach

Clearance interval is also called all red is included 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

DEFINITIONS

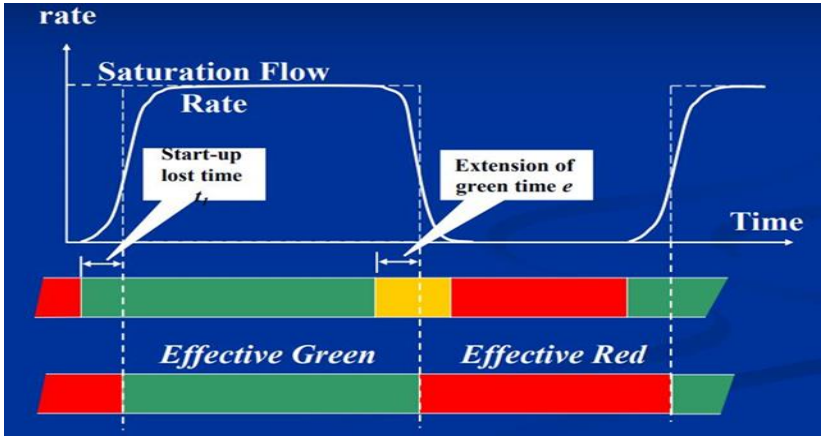
Effective green time is the actual time available for the vehicles to cross the intersection. It is the sum of actual green time (Gi) plus the yellow minus the applicable lost times.

$$g_i = G_i + Y_i - t_L$$



DEFINITIONS

Effective Red Time = Actual Red Time + Yi + lost time



Phase: The part of a cycle allocated to any combination of traffic movements receiving right of way simultaneously during one or more interval

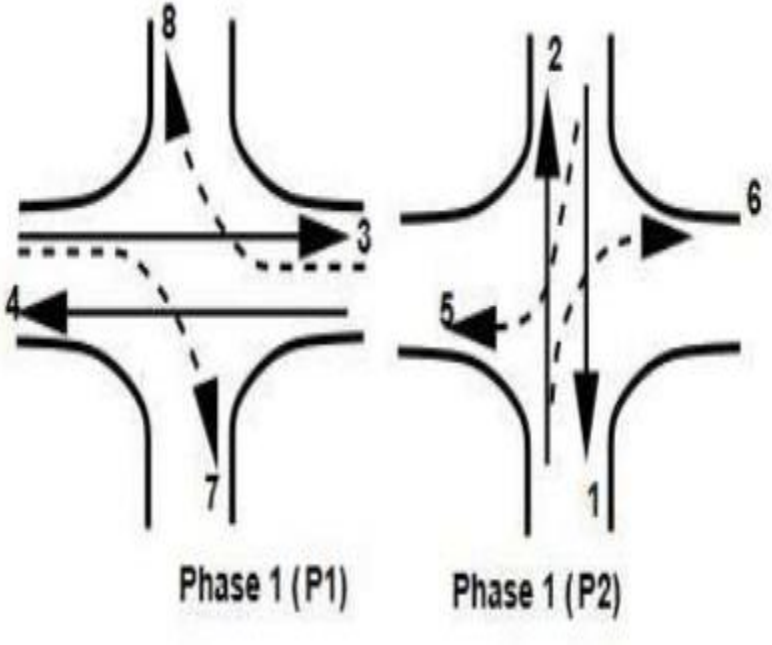
The objective of phase design is to separate the conflicting movements in an intersection into various phases, so that movements in a phase should have no conflicts

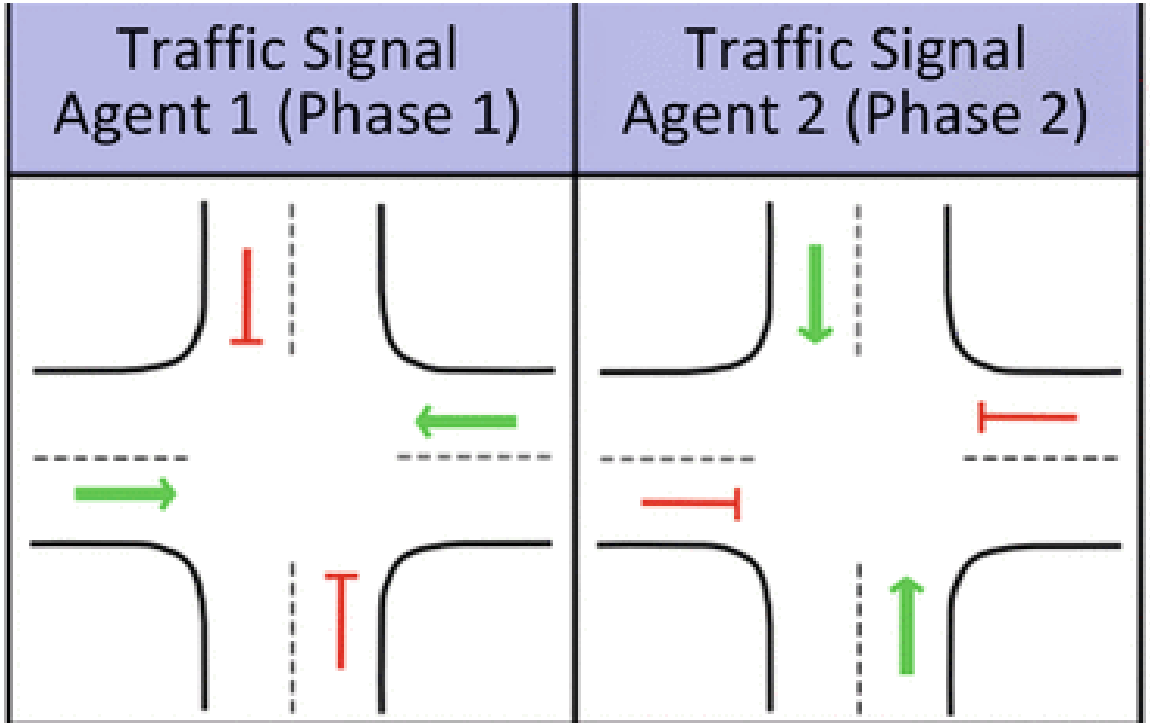
Design phases with minimum conflicts or with less severe conflicts

Two phase system is usually adopted if through traffic is significant compared to the turning movements.

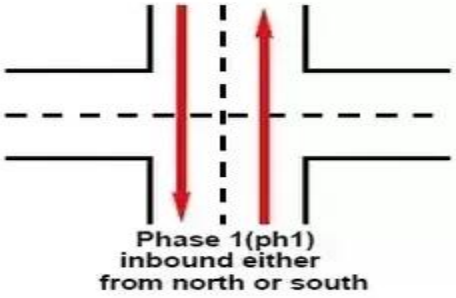
Non-conflicting through traffic 3 and 4 are grouped in a single phase and non-conflicting through traffic 1 and 2 are

grouped in the second phase

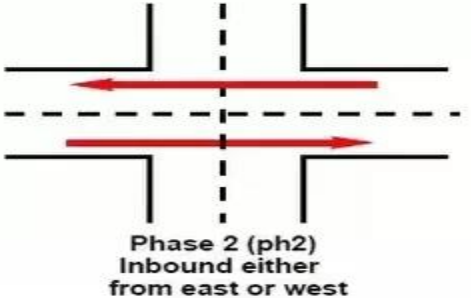



Traffic Signal
Agent 1 (Phase 1)
Traffic Signal
Agent 2 (Phase 2)

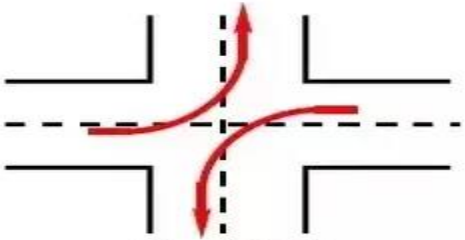
FOUR PHASE SIGNAL



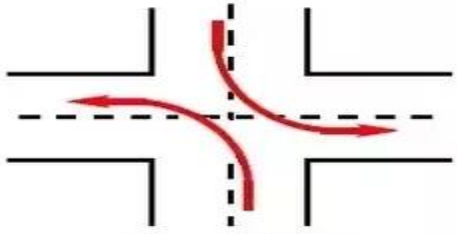
Phase 1(ph1)
inbound either
from north or south



Phase 2 (ph2)
Inbound either
from east or west



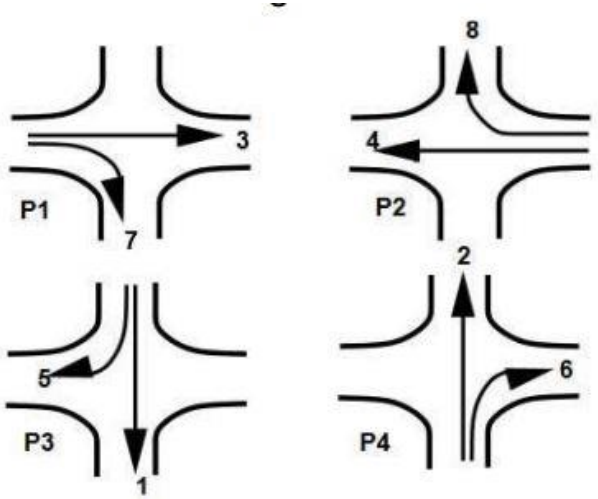
Phase 3 (ph3)
Inbound either from east to south
or west to north



Phase 4 (ph4)
Inbound either from south to east
or north to west

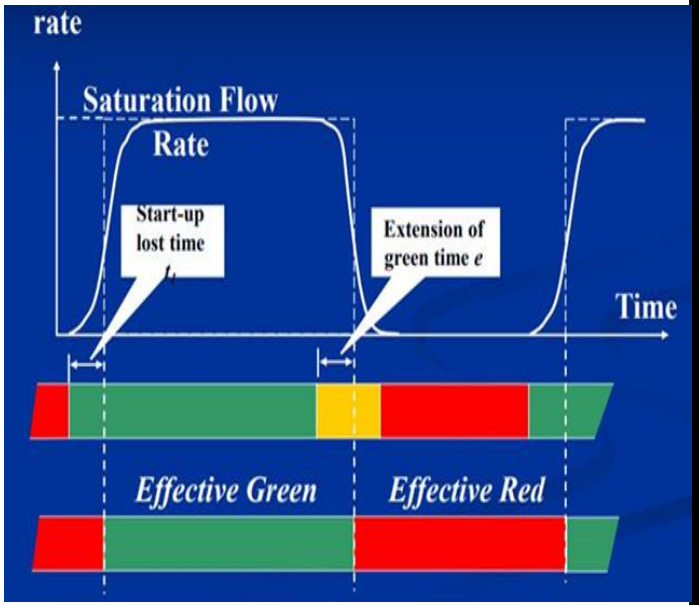
Four Phase Signal

- 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



Saturation flow

- Most important factors in the signal setting calculation is the saturation flow of an approach
- Maximum flow that can pass through an intersection without impedance by the signal
- Different factors affect the saturation flow of an approach: - The traffic composition, and - Road alignment (approach width, gradient in %, radius for right- and left-turning).



Design of Isolated Signal

- Trial cycle method
- Approximate method
- **Webster's method**
- As per IRC

Webster's Method of Signal design

- Si – Saturation flow on each approach
- q_i - Normal flow on each approach
- Calculate Critical flow ratio $y_i = q_i / Si$ for each approach and take the highest and find the sum
- $Y = y_1 + y_2 + \ldots..$
- **Optimum cycle time, $C_0 = \frac{1.5L+5}{1-Y}$**
- **Effective green time per cycle = $C_0 - L$**
- **Effective green time per phase = $\frac{y_i}{Y}$ $(C_0 - L)$**

L= Total lost time per cycle = 2n+R
R= All red time
n = Number of phases

Question 1

The average normal flow of traffic on cross roads A and B during design period are 400 and 250 pcu per hour. Saturation flow values on these roads are estimated as 1250 and 1000 pcu per hour respectively. The all red time required for pedestrian crossing is 12 seconds. Design two phase traffic signal by Webster's method

Given,

All red time. R= 12 sec

Normal flow on A, q_a = 400 PCU/hr

Normal flow on B, $q_{b`}$ = 250 PCU/hr

Saturation flow on A, Sa = 1250 PCU/hr

Saturation flow on B, Sb = 1000 PCU/hr

Critical flow ratio $y_a = \frac{q_a}{Sa}$ = 400/1250 = 0.32

$y_b = \frac{q_b}{Sb}$ = 250/1000 = 0.25

$Y = y_a + y_b$ = 0.32+0.25 = 0.57

Total lost time L= 2n+R = (2 x 2) + 12 = 16 seconds

Optimum cycle time, $C_0 = \frac{1.5L+5}{1-Y}$

$$= \frac{(1.5 \times 16)+5}{1-0.57} = 67.4 \text{ seconds} \sim 67.5 \text{ seconds}$$

Effective green time per cycle = C_0 – L

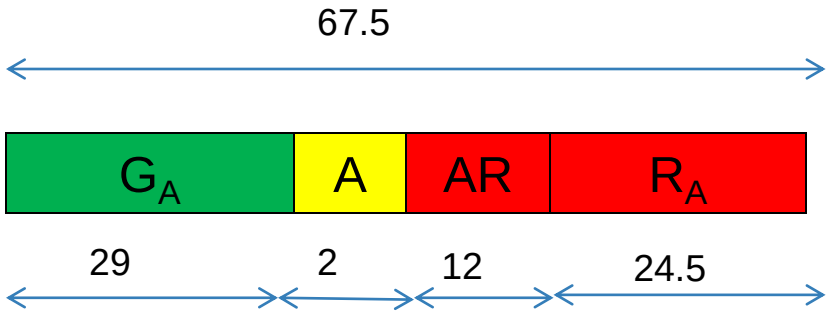
= 67.5 – 16 = 51.5 seconds

Effective green time per phase = $\frac{y_i}{Y}$ **$(C_0 - L)$**

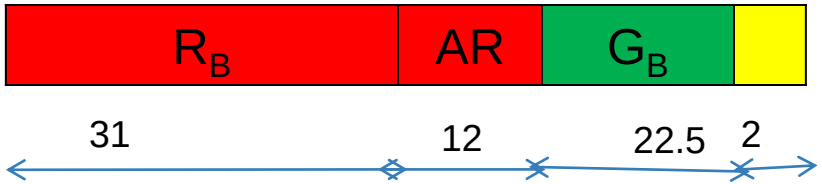
Effective green time for Phase 1 = $\frac{y_a}{Y}$ **$(C_0 - L) = \frac{0.32}{0.57}$ (67.5 –16) = 29 seconds**

Effective green time for Phase 2 = $\frac{y_b}{Y}$ **$(C_0 - L) = \frac{0.25}{0.57}$ (67.5 –16) = 22.5 seconds**

Provide amber time = 2 second



Phase 1



Phase 2

Question: 2

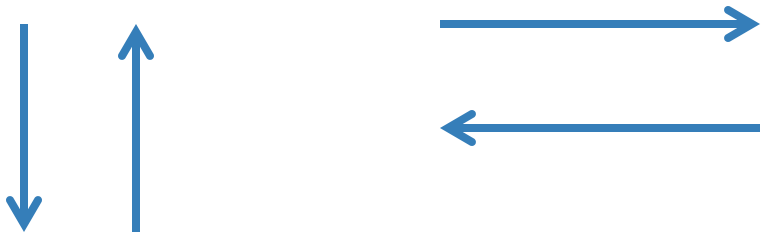
A fixed time 2-phase signal is to be provided at an intersection having four arms. The design hour traffic and saturation flow are

	North	South	East	West
Design hour flow PCU/hr	800	400	750	600
Saturation flow PCU/hr	2400	2000	3000	3000

Time lost per phase due to starting delay is 2 sec and All red period is 4 sec. Design two phase traffic signal using Webster‟s method. Draw the phase diagram also

N - S

E - W



Critical flow ratio for each arm

$$y_N = \frac{q_N}{S_N} = \frac{800}{2400} = 0.33 \qquad y_S = \frac{q_S}{S_S} = \frac{400}{2000} = 0.2$$

$$y_E = \frac{q_E}{S_E} = \frac{750}{3000} = 0.25 \qquad y_W = \frac{q_W}{S_W} = \frac{600}{3000} = 0.2$$

The maximum value of critical flow ratio (y) in N-S direction = 0.33

The maximum value of critical flow ratio (y) in E-W direction = 0.25

Total critical ratio

$Y = y_{NS} + y_{EW} = 0.33+0.25 = 0.58$

Total lost time per cycle in second L= 2n+R = (2 x 2) + 4 = 8 seconds

Optimum cycle time, $C_0 = \frac{1.5L+5}{1-Y}$

$$= \frac{(1.5 \times 8)+5}{1-0.58} = 40 \text{ seconds}$$

Effective green time per cycle = C_0 –L

= 40– 8 = 32seconds

Effective Green time is given by

$$G_{NS} = \frac{y_{NS}}{Y}(C_0 - L) = \frac{0.33}{0.58}(40 - 8) = 18\ sec$$

$$G_{EW} = \frac{y_{EW}}{Y}(C_0 - L) = \frac{0.25}{0.58}(40 - 8) = 14\ sec$$

Provide amber as 2 second

Phase diagram

AIRPORT ENGINEERING

- Air Transport - Fastest mode of transport – more than 300 kmph

Advantages of air Transport

- **Accessibility** – reach inaccessible area with other modes
- **Continuous journey** – can fly over both land and water – do not require any track
- **Demand for technical skill** – manufacture, maintenance and operation have opened up opportunities for technical man power
- **Emergency use** – serving flood, war affected areas
- **Save time** – save time due to high speed

Disadvantages

- Flight rules – rules should be strictly followed
- Operating expense – most expensive mode and high fare
- Safety – psychological fear among passengers about the safety
- Weather condition – can operate only under favourable conditions

SITE SELECTION FOR AIRPORT

1. **Atmospheric and metrological conditions**

- Study of weather records
- Presence of fog, haze and smoke reduces visibility
- Wind data should be studied and should have minimum blowing of smoke
- Airport should be located on the windward direction

2. **Availability of land for expansion**

- Field of aviation is expanding day by day
- Acquire more land in advance
- As volume increases, runway length should be increases and expand the terminal facilities

SITE SELECTION FOR AIRPORT

3. Availabilities of utilities

- Utilities like electric power, water, telephone, sewer, etc. should be available

4. Development of surrounding area

- Proximity to residential area, schools and hospital should be avoided as it cause noise

5. Economy of construction

Site which is more economic to construct should be selected

- Waterlogged areas and uneven terrains are very costly to construct

SITE SELECTION FOR AIRPORT

6. Ground accessibility

- Airport should be accessible for passengers, employees and it should be located at a considerable distance from the center of population

7. Presence of other airports

- Airports should be located at a sufficient distance apart.
- To prevent the interfering of aircraft movement for landing

8. Soil Characteristics

- Soil should be sufficiently strong
- Soil should be self-drained

SITE SELECTION FOR AIRPORT

9. Surrounding obstructions

- Airport site should be clear of the obstructions which interfere the landing and take off Obstructions like tall trees, sloping ground, man-made structures, towers, etc. should be cleared

10. Topography

- Topographical features like contours, hills, streams, etc. should be studied
- Raised ground like a hill top is an ideal site

11. Use of airport

- Site selection depends on the purpose of airport. That is civil or military

AIRCRAFT CHARACTERISTICS

AIRCRAFT CHARACTERISTICS

- Aircraft capacity
- Aircraft speed
- Aircraft weight
- Fuel spilling
- Jet blast
- Minimum circling radius
- Minimum turning radius
- Noise
- Range
- Size of aircraft
- Take off and landing distances
- Type of propulsion
- Tyre pressure and contact area

AIRCRAFT CHARACTERISTICS

1. **Aircraft capacity**

- Number of passengers, baggage, cargo and fuel that can be accommodated in the aircraft
- Terminal facilities should be planned to receive aircraft of highest capacity

2. **Aircraft speed**

- Speed of aircraft
- Air speed – speed of aircraft relative to the speed of air
- Ground speed – speed relative to the ground

AIRCRAFT CHARACTERISTICS

3. Aircraft weight

- Governs length and thickness of runway
- **Maximum gross take off weight** – maximum load the aircraft is certified to carry during take off – pavements are designed for this
- **Maximum structural landing weight** – difference between gross take off weight and weight of fuel consumed during the trip
- **Operating empty weight** – weight of an aircraft including crew. It does not include pay load and fuel
- **Pay load** – revenue producing load. Includes passengers, baggage, mail and cargo
- **Zero fuel weight** – weight other than fuel

AIRCRAFT CHARACTERISTICS

4. Fuel spilling

- Spilling of fuel and lubricant
- Affect the bituminous pavement

5. Jet blast

- Ejecting of hot exhaust gas at high velocity
- Affect the pavement

6. Minimum circling radius

- Minimum radius in space required for smooth turn in space before landing
- Affect the distance between two adjacent airport

AIRCRAFT CHARACTERISTICS

7. Minimum turning radius

- Minimum turning radius of aircraft in ground Affect radius of taxiways

8. Noise

- Noise due to machinery and jet
- During Take off – noise due to jet
- During landing – Noise due to machinery

AIRCRAFT CHARACTERISTICS

9. Range

- The distance that fly without refueling

10. Take off and landing distances

- Distance required for take off and landing
- Affect the minimum runway length

11. Type of propulsion

- Affect the size, speed, weight carrying capacity, circling radius, etc.

12. Tyre pressure and contact area

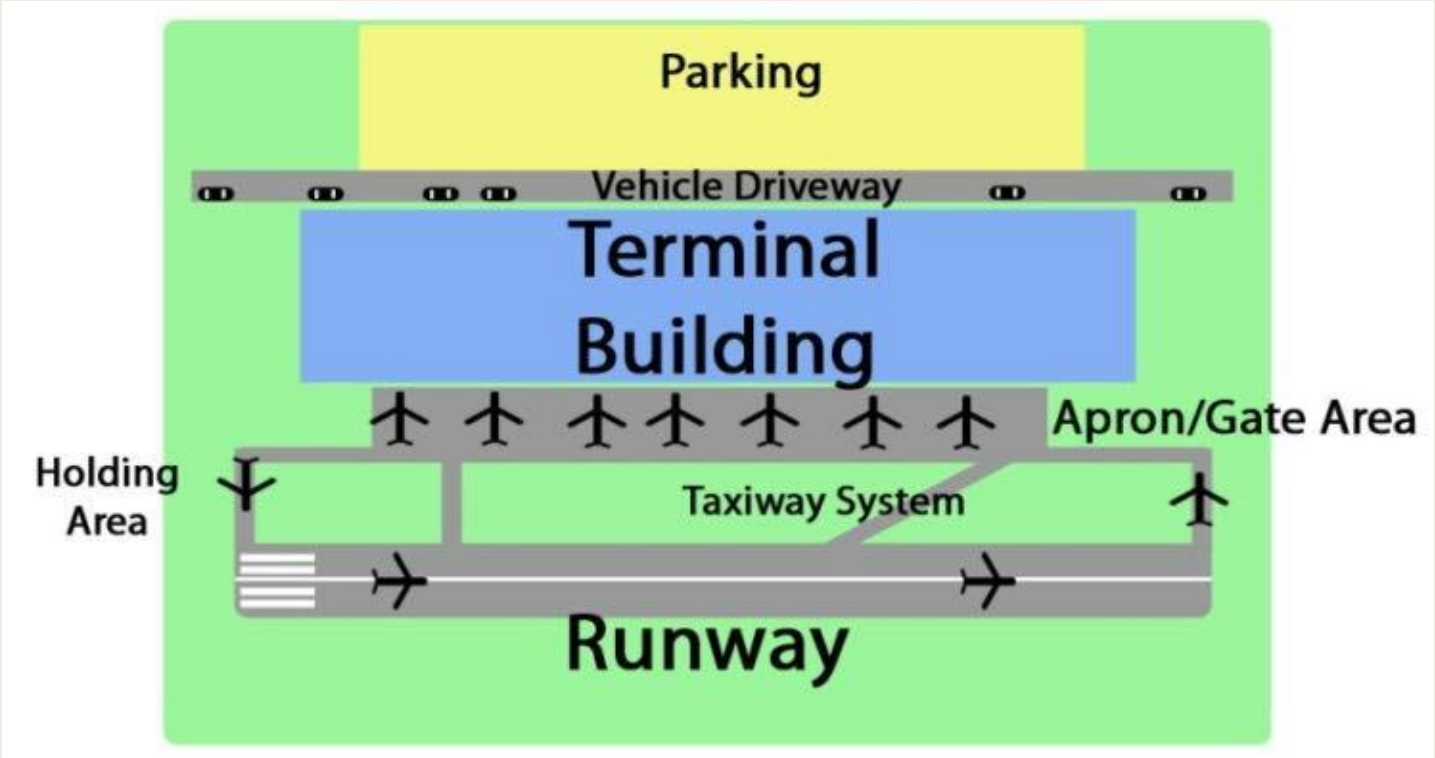
- Affect the type and strength of pavement required

AIRCRAFT CHARACTERISTICS

13. Size of aircraft

- **Fuselage length** – affects the widening of curves, size of apron and hangars
- **Gear tread** – distance between main gears-govern minimum turning radius
- **Height** – Affect the height of hangar gate
- **Tail width** – affect the size of parking and apron
- **Wheel base** – affect the minimum radius of taxiway
- **Wing span** – govern the width of taxiway, size of apron and hangar, etc.

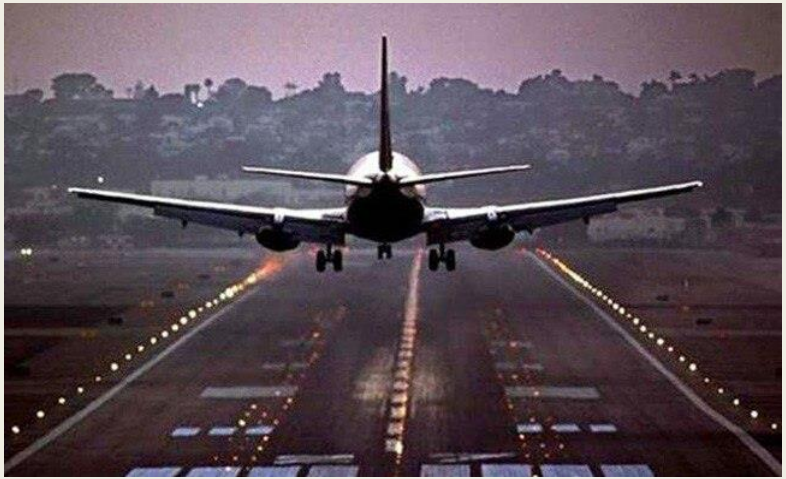
COMPONENTS OF AIRPORT



RUNWAY

- Runway is a paved land strip on which landing and takeoff operations of aircrafts takes place. It is in leveled position without any obstructions on it.

- Special markings are made on the runway to differ it from the normal roadways. Similarly, after sunset, specially provided lightings are helped the aircrafts for safe landing.



Basic runway length is the length based on the following conditions

- No wind is blowing on runway
- Aircraft loaded to its full capacity
- Airport situated at sea level
- No wind blowing on the way to destination
- Runway is leveled in the longitudinal direction. That is the effective gradient is zero
- The standard temperature along the runway is 15oC

Basic runway length

Basic runway length is determined from the performance characteristics of the aircrafts using the airport

- Normal landing case
- Normal take-off case
- Engine failure case

✓ For jet engine aircrafts all 3 cases are considered

✓ For the piston engine aircraft only 1st and 3rd cases are considered

✓ The case which works out the longest runway length is finally adopted.

Basic runway length

Normal landing case

The landing case requires that aircraft should come to stop within 60% of the landing distance. The runway of full strength pavement is provided for the entire landing distance

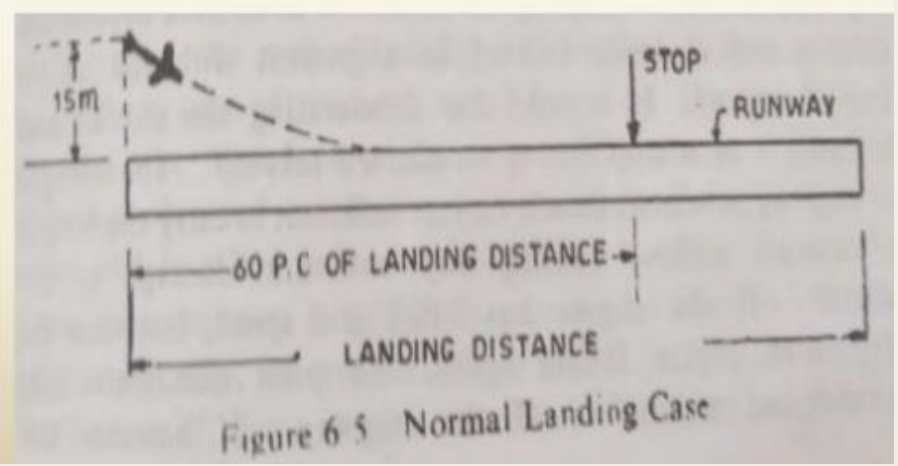


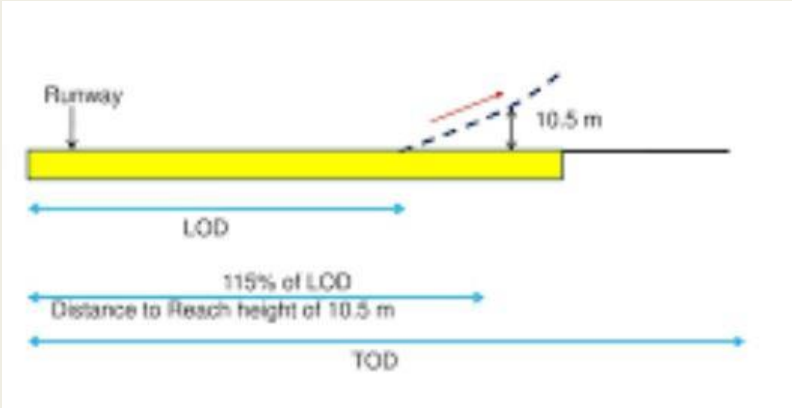
Figure 6.5 Normal Landing Case

Basic runway length

Normal take off

The distance required to reach a height of 10.5 m is 115% of lift of distance (LOD)

Take of distance (TOD) including clear way is twice the distance of 115% of LO



Basic runway length

Stopping in emergency

- In case of engine failure, sufficient distance should be available to stop the airplane
- This distance is known as accelerate – stop distance
- TOD is twice the LOD

THANK YOU