CE8702 - RAILWAYS, AIRPORTS, DOCKS AND HARBOUR ENGINEERING

UNIT- 1 RAILWAY PLANNING AND CONSTRUCTION

i) Elements of Permanent Way

What is Transportation?

Transportation is regarded as an index of economic, social and commercial progress of a country.

RAILWAYS

Role of Indian railways in National Development:

Political Advantages:

Unites the people of different castes, religions and different places and helpful in mass transport of people from one place to other.

Social Advantages

Convenient and safe mode of transport.

Economic Advantages:

Mobility of labor and goods has contributed to industrial development.

## Permanent Way:

The combination of rails, fitted on sleepers and resting on ballast and sub grade is called as "railway track" or "permanent Way".

Rails are joined in series by fish plates and bolts.

The rails transmit the wheel load to the sleepers.

Rails are fixed to sleepers by different types of fastenings.

The sleepers properly spaced and resting on ballast.

The sleepers hold the rails in proper position with respect to the proper tilt, gauge and level.

Sleepers transmit the load from rails to the ballast.

Sleepers are suitably packed and boxed with ballast.

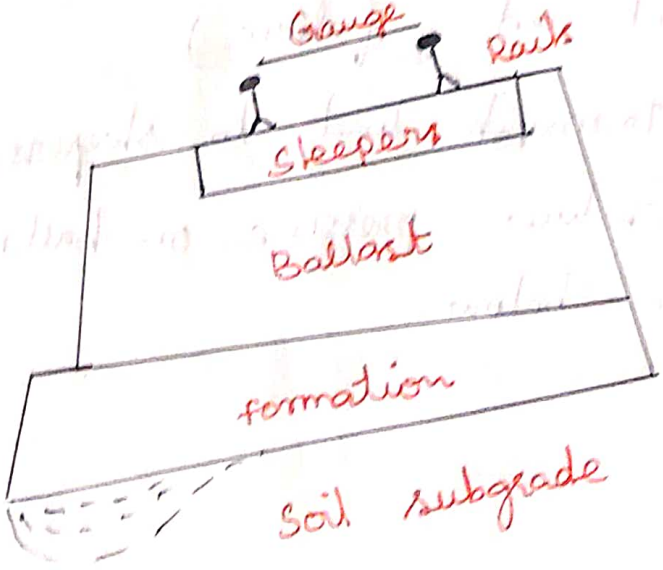
The ballast distributes the load over the formation and holds the sleepers in position.

* The layer of ballast rest on the prepared sub grade is called as formation."

The layer of

on curved tracks, super elevation is maintained by ballast and the formation is levelled.

On curved Tracks



## Rails:

The rail on the track can be considered as steel girders for the purpose of carrying axle loads.

They are made of high carbon steel to withstand wear and tear.

Flat - footed rails are mostly used in railway tracks.

## Functions of rails:

Hard, smooth & unchanging surface for heavy moving loads with minimum friction b/w steel rail and wheels.

Bears stresses developed due to heavy vertical loads, lateral & thermal stresses.

Material - minimum wear (avoid - replacement and failure.)

Transmit load to sleepers - in turn reduces pressure on ballast & formation below.

## Composition of Rails:

1) Carbon
2) Manganese
3) Silicon
4) Sulphur
5) Phosphorus

## Requirements of Rail:

Composition of steel must be proper.

Must be capable of withstanding lateral forces.

Wearing surface must be hard.

Web of rails should be thick - adequate flexural rigidity.

Foot should be wide enough - avoid overturning.

Tensile strength of rail should not be less than 72 kg/mm².

C.G must be approximately at mid height so that maximum tensile and compressive stresses are equal.

# Types of rail

Flat bottom

Bull head

Double headed

Double Headed Rail:

The rails having their head and foot of same dimensions are known as "double headed rail".

Flat footed rail:

The rail section having their foot rolled to a flat are known as "flat footed rail".

Bull headed rail

The rails sections having their head of more dimension then that of their foot are known as "bull headed rail".

## Gauge

The clear distance between inner or running faces of two rails in a track is called as "Gauge".

## Types of gauge

- Standard gauge / broad gauge - 1.676m
- Meter Gauge - 1m
- Narrow Gauge - 0.762m
- Light Gauge - 0.61m

## Selection of Gauge:

1) Cost of construction
2) Volume & Nature of traffic
3) Development of the Areas
4) Physical Features of the country
5) Speed of movement.

## Coning of wheels

The flanges of wheel is never made flat, but they are in the shape of cone with a slope of 1 in 20.

The coning of wheels is mainly done to maintain the vehicle in the central position with respect to the track.

## Advantages of coning the wheels.

To reduce wear, & tear of the wheel flanges and rail, which is due to rubbing action of flanges with inside face of the rail head.

To provide a possibility of lateral movement of the axle with its wheels.

To prevent the wheels from slipping to some extent.

## Creep of Rails:

Creep is the longitudinal movement of rails with respect to sleepers in a track.

## Indication:

Closing of successive spaces at rail joints.

Marks on flanges and web of rails made by spikes.

## Effect of Creep:

- Buckling of track
- Movement of sleepers out of its position.
- Difficult to fix removed rails in proper position.
- Points and crossings get distorted.
- Smashing of fish plates and fish bolts.

## Theory of Creep:

- Wave action theory
- Percussion theory
- Drag theory

## Remedies for Creep:

- Pulling back the rails
- Provision of anchors
- Use of steel sleepers.

## Measurement of Creep:

Creep Indicator is used

Maximum creep limit is 15cm

No creep is permitted at points and crossings.

## Sleepers

A sleeper is a member laid transversely under the rails which are meant to support the rails over them and transfer the load from rails to ballast.

## Function of sleepers

To distribute the load from the rails to ballast.

They add to the lateral and longitudinal stability of the permanent track to support the rails at a proper level in straight tracks and at proper super elevation on curves.

To hold the rails to correct gauge.

To act as an elastic medium in between the ballast and rails to absorb the vibrations of moving loads.

## Requirements of sleepers

a) Economical

b) Lifting, packing, Removal and Replacement of sleepers should be easy.

c) It should have moderate weight.

d) High strength.

e) Proper spacing between sleepers.

## Classification of Sleepers:

Sleepers are classified into the following categories:

i) Wooden sleepers

ii) Metal sleepers

a) Cast Iron sleepers

b) Steel sleepers.

iii) Concrete sleepers

a) Reinforced Concrete sleepers

b). Pre - stressed Concrete sleepers

## Wooden sleepers:

Wooden sleepers are the ideal type of sleeper. Hence they are universally used. The life span of timber sleeper is depend on,

Wear
Decay
Attack by vermin
Quality of timber

## Steel sleepers:

Due to the increasing shortage of timber in the country and other economic factors have led to the use of steel and concrete sleepers on railways.

## cast iron railway sleepers:

- Service life is very long.
- Less liable to corrosion
- Scrap value is high

## concrete Railway sleepers

RCC and prestressed concrete sleepers are now replacing other types of sleepers except in some special circumstances like bridges etc. where wooden sleepers are used.

## Track Fittings and Fastenings

Track fittings and rail fastening are used to keep the rails in the proper position and to set the points and crossings properly.

They link the rails endwise and fix the rails either on chairs fixed to sleepers or directly on the sleepers.

The important fittings commonly used are :

- Fish plates
- Spikes
- Bolts
- chairs
- Blocks
- keys
- Plates

## Fish plates

These are used in rail joints to maintain the continuity of the rails and to allow expansion and contraction

## Requirements of Fish plates:

Fish plates should maintain the correct alignment both horizontally and vertically.

They should support the underside of the rail and top of the foot.

Provide proper space for the expansion and contraction.

They should be made up of such a section to withstand shocks and heavy stresses due to lateral and vertical B.M

## Fish Bolt

Dia of fish bolt = 3.2 cm

Spacing blw bolts = 11.4 cm

Edge distance = 5.7 cm

## Spikes:

For holding the rails to the wooden sleepers, spikes of various types are used.

## Requirement of spikes

Spikes should be enough to hold the rail in position and it should have enough resistance against motion to retain its original position.

The spikes should be deep for better holding power.

It should be easy in fixing and removal from the sleepers.

The spikes should cheap in cost and it should capable of maintaining the gauge.

**Blocks:**

When two rails run very close as in case of check rails etc. small blocks are inserted in between the two rails and bolted to maintain the required distance.

**Bolts:**

It used for fixing various track components in position.

**Keys:**

Keys are small tapered pieces of timber on steel to fix rails to chairs on metal sleepers.

**Bearing plates:**

Bearing plates are rectangular plates of mild steel or cast iron

used below F.F rails to distribute the load on larger area of timber sleeper.

## Ballast:

Ballast is the granular material packed under and around the sleeper to transfer loads from sleeper to ballast. It helps in providing elasticity to the tracks.

The different materials that are used vary from broken stone to sometimes earth. A few commonly used types of ballast are the following

a) Broken stone
b) Gravel or shingles
c) Ashes or cinders
d) Moorum
e) Blast furnace slag
f) Kankar

## Functions of Ballast:

Provide a hard and level bed for sleepers.

Hold sleepers in place during passage of trains.

Transfer and distributes load from sleepers to larger area.

Provides effective drainage and keep sleeper dry.

Prevent vegetation growth

Prevent water from percolating

Provide track stability.

## Characteristics of Good Ballast:

It should have sufficient strength to resist crushing under heavy loads of moving trains.

It should be durable enough to resist abrasion and weathering action.

The have enough and angular surface to provide good lateral and longitudinal stability to the sleepers.

She have good workability have easy spread of formation.

She be cheaply available.

She not have any chemical action on metal sleepers and rails.

## Ballast size:

For wooden sleepers – 5.1 cm

For steel sleepers – 3.8 cm

Under point and crossings – 2.54 cm

## Minimum Depth of ballast section:

$$D_b = \frac{(S.S - W.S)}{2}$$

$D_b$ = Depth of ballast

S.S = Sleeper spacing

W.S = Width of sleeper

## Need for ballast less Track

The three basic requisites of laying a good railway track are economy safety and comfort.

Traditional tracks on wooden and metal sleepers with good ballast cushion satisified all these requirements in the normal traffic conditions

Increased traffic density and increased speeds on railways became necessary to suit growing economy and competition.

In such cases the conventional tracks were found lacking.

## Geometric Design of Railway Track

Geometric design should be such as to provide maximum efficiency in the traffic operation with maximum safety at reasonable cost.

**Gradient** - any departure of track from the level is known as grade or gradient.

## Purpose of providing gradient:

To provide uniform rate of rise or fall.

To reduce cost of earth work

To reach different stations at different level.

## Types of Gradient

### 1) Ruling gradient

The steepest gradient allowed on the track section.

It determines the max load that the locomotive can haul that section.

The steep gradient needs more powerful locomotives ~~can~~ smaller train loads, lower speed resulting in costly hauling.

In plain: 1 in 150 to 1 in 200.

In hilly region: 1 in 100 to 1 in 150

### 2) Momentum Gradient:

The gradient on a section which are steeper than the ruling gradient acquire sufficient momentum

to negotiate them are known as "Momentum Gradient".

3) Pusher Gradient:

As stated above a ruling gradient limits the maximum weight of a train which can be hauled over the section by a locomotive.

If the ruling gradient is so severe on a section that it needs the help of extra engine to pull the same load than this gradient is known as pusher of helper gradient.

4) Gradient at stations:

At stations gradient are provided sufficient low due to following reason:

To prevent movement of standing vehicle.

To prevent additional resistance due to grade.

Grade compensation on curves

If a curve is provided on a track with ruling gradient the resistance

of the track will be increased.

In order to avoid resistance beyond the allowable limits the gradients are reduced on curves.

The reduction in gradient is known as grade compensation for curves.

## CANT / Super Elevation

To counteract the centrifugal force, the level of the outer rail is raised above the inner rail by a certain amount to introduce the centripetal force.

The raised elevation of outer rail above the inner rail at a ~~hzt~~ curve is called super elevation or cant.

The term cant is frequently used as a synonym for super elevation but truly speaking cant should be used to represent the angle of a transverse slope.

## Function of super elevation

Neutralised the effect of lateral force.

It provides better load distribution on the two rails.

It reduces wear and tear of rails and rolling stock.

It provides smooth running of trains and comforts to the passengers.

## Curves

To bypass the natural or artificial obstacles.

To provide easier gradients by diversion from the straight route

To route the line through areas having traffic potentialities

To balance the earth work in excavation and cutting thereby minimizing cost of construction.

## Types of curves:

1) Horizontal curves – change in direction parabolic transition curves

2) Vertical curves – change in gradient – parabolic curves

3) Simple curve

4) Compound curve – more than 2 simple curve

5) Parabolic curves – Vertical curves

6) Transition curves – change in curves.

## Modern methods of surveys for Track Alignment:

Railway planning needs precions and cost effective methods of surveying. Modern method like GIS, GPS etc were incorporated for effective surveying.

## Different Features:

- Survey of India map
- Village map
- Ward / block map
- Updating of map

## Application of modern survey equipments for railway alignment surveying:

### 1) Global positioning system (GPS)

It measures co-ordinates of any point anywhere on the globe. This survey is possible at any weather conditions and a minimum of 24 no of satellites at a distances of 10,000 km from earth's surface will be involved in surveying.

### 2) Electronic Distance Meter

EDM works on electromagnetic waves travel between the given origin and destination. Typical EDM can measure a distance upto 5-10 km.

### 3) Total stations

It works on same procedure of EDM but it also measures the angle along with the distance. It is more accurate than EDM and has a least count of one second. Also reduces human interventions and measurements.

4) Geographical Information System (GIS)

It is a system of software and hardware. It is used to prepare highway. Railway alignment.

Techniques of GIS such as buffering and network analysis are widely applied in highway and railway planning.

5) Remote sensing data products

a) Aerial photos
b) Satellite imageries
c) High resolution satellite imageries.

Merits of Modern

Rapid process of surveying
Optimum resources planning
Acceleration construction programming
More accuracy
less time consuming
Updating and correction of old map will be much easier

## Demerits of modern methods:

Applies only for skilled workers.

Exact boundaries cannot be determ on satellite imageries.

Procurement of equipment such as GPS, EDM, GIS, stereo potters are cost intensive.

## Cant Deficiency

When a train moves around a curve at a speed more than the equilibrium speed, then deficiency in cant occurs. Thus the cant deficiency is the difference between the theoretical cant required for high speed and the actual cant provided.

## Cant Excess:

When a train moves around a curve at speed less than the increases in the cant occurs. Thus cant excess is the difference between the actual cant provided and the theoretical cant required.

## Cant gradient :

Cant gradient and deficiency gradient express the increase or decrease in the cant or the deficiency of the cant in a given length of transition.

## Requirements of Ideal Rail Joints :

Two rails are connected by a joint which forms the weakest part of the track Different fastening are used to make this joint as much efficient as possible. The characteristics of a good ideal rail joint are as follows.

The rail joint should hold the two ends of rails as nearly as possible and should be at same level in a straight line.

It should have the same strength and stiffness with rails.

It should provide space for expansion and contraction of rails due to changes in temperature.

It should be arranged in such a way that any rail while repair.

It should be durable, cheap in initial cost and maintenance.

It should provide sufficient elasticity to absorb vibrations and shocks.

It should provide resistance to the longitudinal forces developed due to acceleration, deceleration.

The joint fittings should be simple and universal type so that it can be used for all types of sleepers.

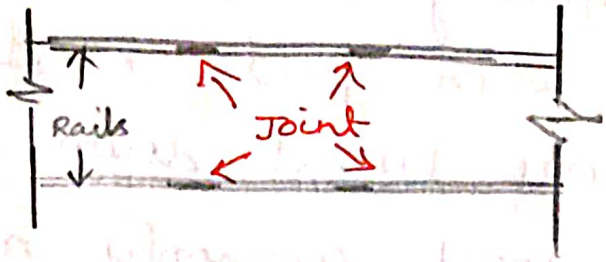
## Types of Rail Joint:

Depending upon the position of joints or sleepers, rails are classified as

1) According to position of Joints:
   - ⇒ Square joints
   - ⇒ Staggered joints

### Square Joints

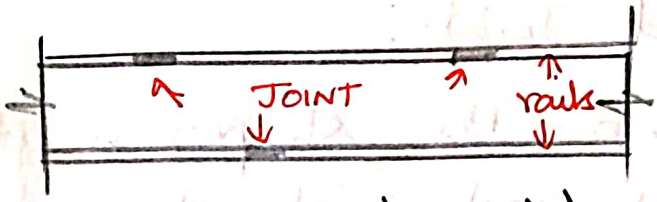
When a joint in one rail is exactly opposite to the joint in the parallel rail, It is known as a square joint and it is very common in straight track.




a) Square Joint

Staggered Joint:

When a joint is one rail is exactly opposite to the centre of the parallel rail length it is known as staggered Joint.




b) Staggered Joints

2) According to position of sleepers:

⇒ Suspended Joints

⇒ Supported Joints

⇒ Bridge Joints

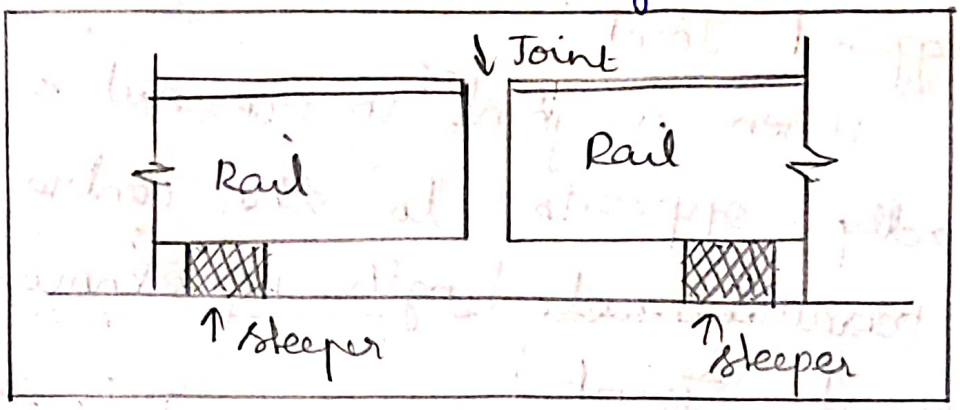
1) Suspended Joints:

The rail joint when placed at the center of two consecutive sleepers is known as "Suspended Joint".

In this type of joint, load

will be equally distributed on sleepers and also when joint is depressed rail ends are pressed down evenly

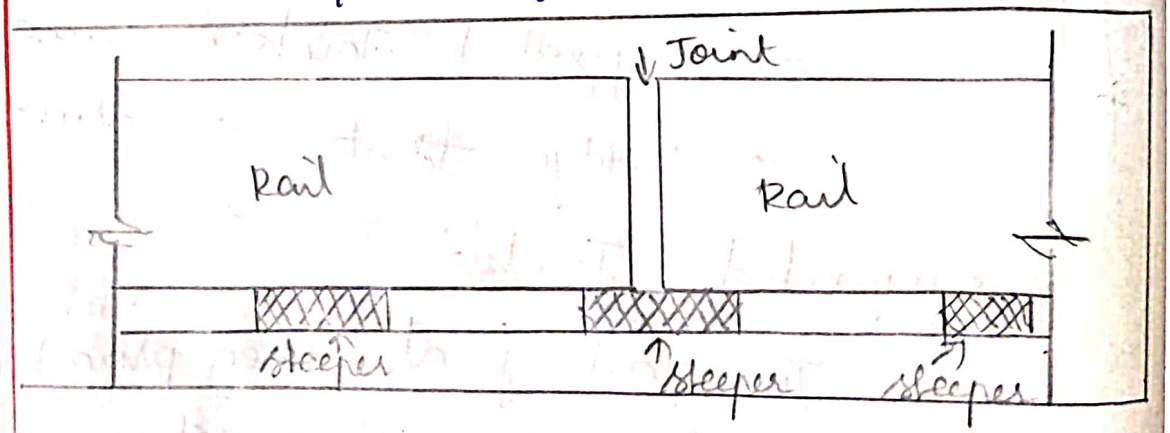
It is most commonly adopted since it provides greater elasticity




## Supported Joint:

When the sleeper is placed exactly below the rail joint, it is known as supported Joint.

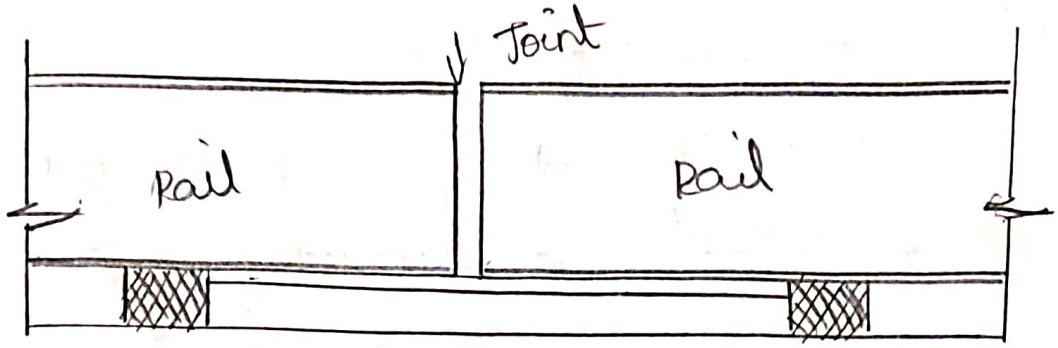
These types of joints are not used at present.




Supported Joint

## Bridge Joint

When a suspended joint is bridged by a metal piece so as to connect the ends of the two rails and thereby preventing bending stress in the rail.




Bridge Joint

### Sleeper Density:

It is indicated by (n+x)

n = the length of rail in meters

X = number of sleepers.

For standard 13 m

m+7 → density would mean 20 sleepers per rail length.

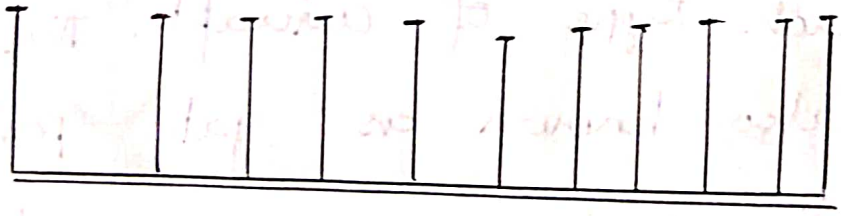
# UNIT-3 . AIRPORT PLANNING

## Airport Layout :

For determining the size and types of parking facility necessary a traffic survey should be conducted.

FAA suggest that the size of the public parking facility should be based on 1.5 to 2 cars for each peak hour passenger.

The pattern of parking is dictated by the shape and size of the parking area available.



Right angle parking

Angle parking

Parallel Curb Parking

## Basic Vehicular Parking Patterns

**Apron:**

It is a paved area for parking of aircrafts, loading and unloading of passengers and cargo. It is usually located to the terminal building or hangers. The size of apron depends upon:

i) size of loading area required for each type of aircraft. This area is also known as gate position

ii) Number of gate positions

iii) Aircraft parking system.

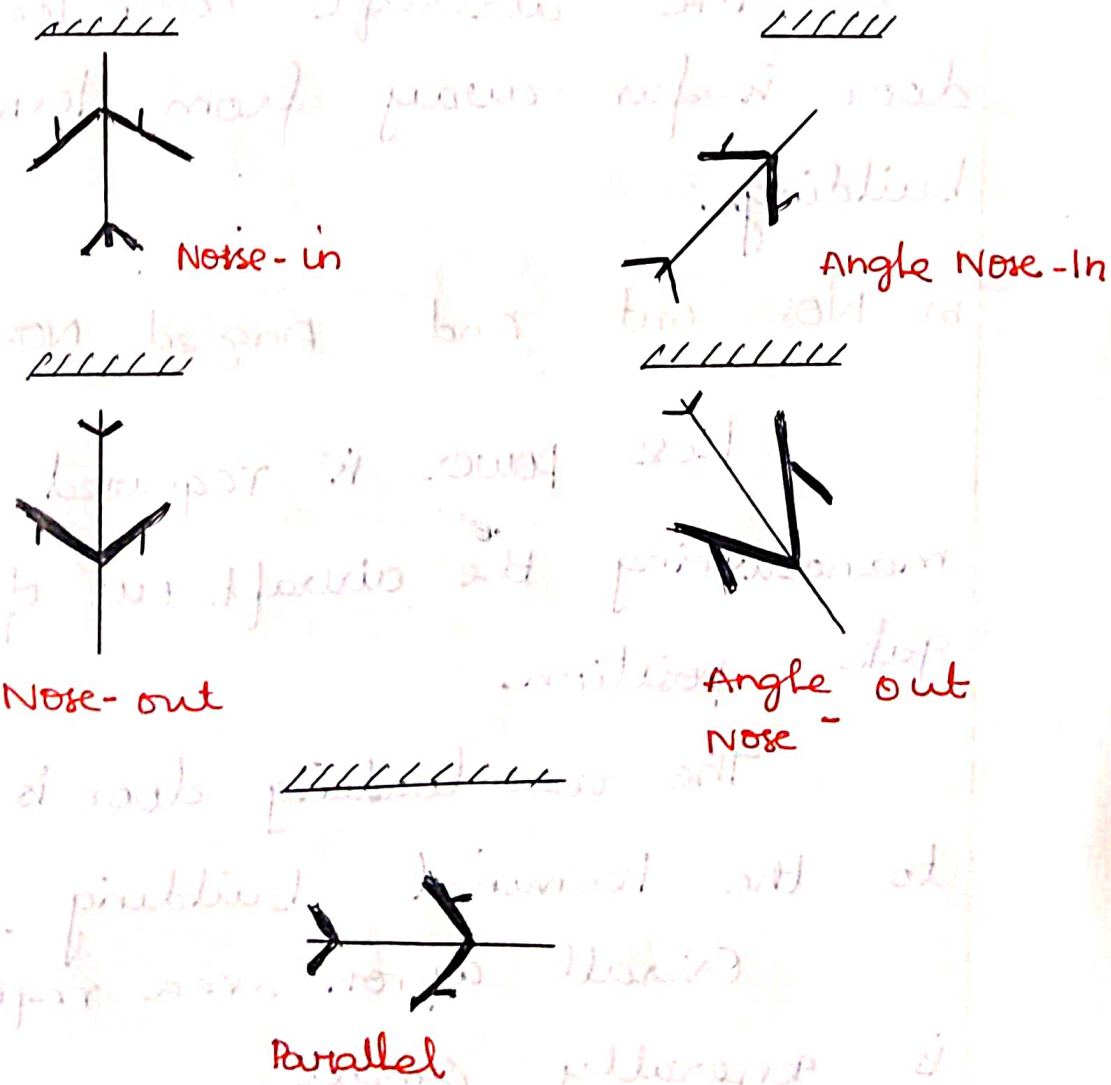
**Size of Gate position:**

i) size of the aircraft and its minimum turning radius.

ii) The manner in which the aircraft enters and leaves the gate position under its own power or when pushed by a tractor.

iii) Aircraft Parking configuration

Aircraft are parked causing the least interference due to heat, fumes and blast during manoeuring into and out of the gate position.




Basic parking configurations of Aircrafts

# Terminal Area And Airport Layout

a) Nose-IN and Angle Nose-IN

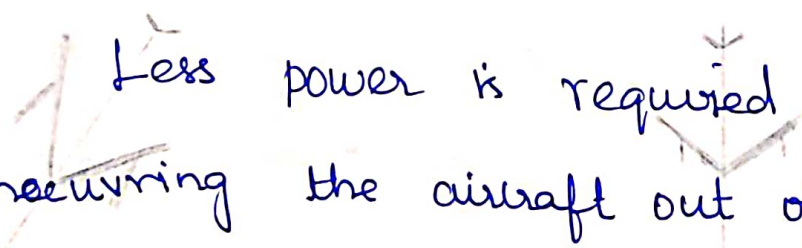
Less noise while taxiing is because no turning is required.

Hot blast is not directed towards the terminal building.

The aircraft forward door is close to the terminal building.

The aircraft rear loading door is far away from terminal building.

b) Nose out And Angled Nose out



Less power is required while manoeuvring the aircraft out of its gate position.

The rear loading door is close to the terminal building.

Overall apron area required is generally small.

The main disadvantage is that the hot blast is directed towards the terminal building.

C) Parallel system

The main advantage of this system is that, both the front and the rear doors are adjacent to the terminal building.

But this type of parking configuration requires more space. Further, the noise and the hot blast are directed towards the adjacent gate position.

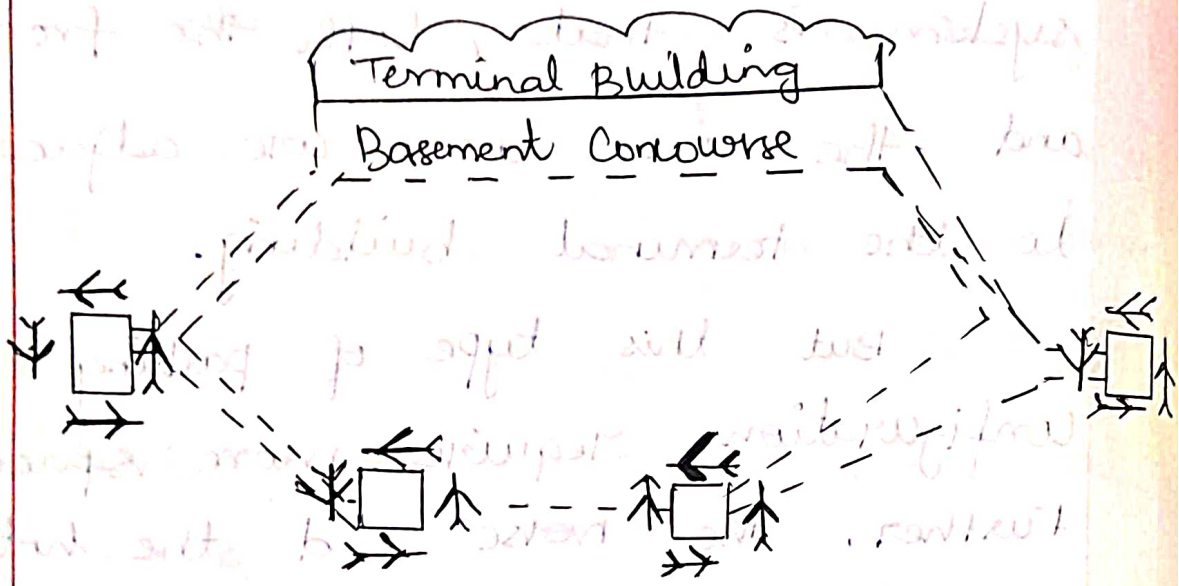
## Aircraft Parking System:

Aircraft can be grouped adjacent to terminal building in various ways

- Frontal system
- Open apron system
- Finger system
- Satellite system

i) Frontal system:

It is very simple and economical system. But its use is limited only to small airports requiring few gate positions.




Satellite System

ii) Open apron system

In this system the aircrafts are parked in rows. If the number of aircrafts is too large, passanger may have to walk long distances or reach the aircrafts parked in the outermost row.

iii) Finger system:

Processing of passengers and their baggage is mainly done within the terminal building. But the facilities for passengers for entering and leaving the aircraft, often require extensions of the terminal building

iv) Satellite system:

Satellite system are small buildings located on the apron. Aircrafts are parked around the satellite buildings which are connected to the main terminal building by underground tunnel. This system is in use at the international airport of Los Angeles.

## Airport Planning

Airport planning requires more intensive study and fore thought as compared to planning of other modes of transport.

This is because aviation is the most dynamic industry and its forecast is quite complex.

## Aircraft characteristics:

Aircraft characteristics are of prime importance to the airport planning and design. The following characteristics need to be studied.

1) Type of propulsion
2) Size of aircraft
3) Minimum turning radius
4) Minimum circling radius
5) Speed of Aircraft
6) Capacity of aircraft
7) Aircraft weight & wheel configuration
8) Jet Blast
9) Fuel spillage

# Airport Classification

1) Based on Take off & Landing

⇒ Conventional Take off & Landing Airport

⇒ Reduced Take off & Landing Airport

⇒ Short Take-off & Landing Airport

⇒ Vertical Take-off & Landing Airport

2) ICAO classification: Based on Geometric Design

ICAO classification: Based on length of Runway

FAA classification: Based on Aircraft Approach speed.

3) Based on Function:

⇒ civil Aviation: International and Domestic

⇒ Military Aviation

4) Classification Based on Pavement Strength

## Airport Layout

### Landing Area:

An airport consists of landing area and terminal area. Landing area is used for landing & take off of an aircraft.

1) Runway
2) Taxiway

### Runway

It is paved long & narrow rectangular strip which is actually used for landing & take-off of aero-planes.

### Taxiway

It is a paved way over which an aero-plane may taxi

while going to & from runway and loading apron.

Taxiway also connect two neighbouring runway, runway with a service and maintenance hangar.

## Terminal Area:

It includes the following

1. Runway
2. Terminal building
3. Apron
4) Taxiway
5) Aircraft stand
6) Hanger
7) Control Tower
8) Parking

## Airport site Selection:

The selection of site for a new airport has to be based on certain criteria which will serve as a guide for the determination of its proper

location and size.

Following are the factors which influence the location or site selection of an airport:

1) Atmospheric and meteorological conditions:

The presence of fog, haze and smoke reduces the visibility and the poor visibility lowers the traffic capacity of an aircraft.

The lack of wind is caused by the topographical features of the surrounding locality.

In a similar way, the smoke and haze are present at sites very near to the large industrial areas.

2) Availability of land for expansion:

The field of aviation is expanding day by day. It is therefore necessary to acquire land in advance or to be able to acquire sufficient

Real estate in the future for expanding the airport.

3) Availability of utilities:

An airport especially a large one has to be provided with the utilities like water, electric power, telephone, sewer etc.

For a new site located far away from available sewers, the sewage disposal plant may have to be constructed.

4) Development of the surrounding Area:

The study of the type of development of the surrounding area is very importance because the airport activities, particularly from the standpoint of noise are often quite objectionable to the neighbours of the airport.

5) Economy of construction

It is clear that if alternative sites are available and equally well-suited, the site which is more economical to construct should be given preference.

6) Ground Accessibility:

The location of airport should be such that it results in the shortest ground access time. This is especially true in case of short-haul operations.

7) Presence of other airports:

The airport should be located at a sufficient distance apart. This is necessary to prevent the aircraft which are manoeuvring for a landing at one airport from interfering with the movements of the aircraft at the other airports.

8) Regional Plan:

The airport site should be selected in such a way that it fits appropriately in the regional plan. Such an airport will form an integral part of the national airport network.

9) Soil characteristics:

The airport site with the favourable soil characteristics is desirable, because it reduces the cost of grading and drainage to a considerable extent. The area should as far as possible be self drained.

10) Surrending Obstructions:

The airport site should be clear of the obstruction likely to interfere with the landing and taking off operation of the aircraft.

11) Topography:

It grants better visibility due to less fog.

It permits easy natural drainage

The approach and turning zones are less obstructed.

There is natural drainage.

12) Use of Airport:

The airport site is decided also by the use of airport.

Incase of an emergency like war, the civilan airports are taken over by the military.

## ICAO Recommendation for Masterplan

A planner operating outside the united states probably may have to use ICAO Manual obstructions to Airspace.

The ICAO procedure for airport master planning is very similar to that recommended by the FAA and is summarised.

However, since member countries of the organization range from highly industrialized to quite under developed nations the procedures outlined are less specific environmental impact and the manner in which economic analysis is to be carried out.

It reveals heavy emphasis on physical planning.

Obviously these procedures need modification in terms of existing planning and fiscal legislation for the area in which the study is conducted.

# UNIT-II - Railway Construction And Maintenance

## Track Construction:

Steps involved in Track construction

Step 1: Earthwork - Formation and consolidation

Step 2: Plate laying

Step 3: Laying of Ballast

### Earthwork - Formation and consolidation

Formation

Depending upon the rail level and general contour of the area, the formation may be laid in an embankment or in a cutting.

A formation laid in an embankment is normally preferred because it affords good drainage.

The ~~drainage~~ height of the embankment also depends on the high flood level of area and a reasonable free board should be given above the HFL.

consolidation

the primary consolidation results from the expulsion or extraction of water from the voids in fine grained soil causes settlement in structures and embankments over a period of time.

The methods of accelerating consolidation include placing a surcharge and installing sand columns or wick drains can be done.

Secondary consolidation is the rearrangement of cohesive soil grains and to pack the track so that the larger quantities of stone ballast are not lost by sinking into loose earth formation.

Step 2 : Plate laying:

Laying the rails and sleepers over the ready formation.
There are three distinct methods of construction of railway track. These are:

1) Telescopic Method
2) Tramline Method
3) American / Mechanical Method

## 1) Telescopic Method:

In this method, rails, sleepers and fastenings are unloaded from the material train as close to the rail head as possible.

The sleepers are carried by carts or men along the adjoining service road and spred on the ballast. The rails are then carried on pairs to the end of last pair of connected rails and linked.

To carry rails manually over a long distance is a tedious job, so certain carriers called Anderson rail. Carriers are used to carry rails to the ends of the rail head.

It can also take rails up to a head last pair linked with the help of temporary track consisting

of 3" x 3" angle irons of the same angle length as rails and fastened to the sleepers.

A further consignment of the materials is deposited at the advances rails head and the procedure is repeated.

## 2) Tramline Method Railway Track Construction:

This method is used where train carrier are installed for carrying earth work or in rainy season due to difficult in movement of cart.

Some tramline is established on with a gauge of 2'-2'-6". The basic difference between this and telescopic method lies in the conveyance and spreading of the sleepers.

The track can be assembled at more than one point simultaneously which is the great advantages of this method. Sometimes an additional track

is laid on the side of existing track for which this method is best.

### 3) Mechanical Method Railway Track construction

This method is extensively used in Britain and America by using special Track laying machine. There are two types of machines available.

In first type of machine, the track material carried by the material. Train is delivered at the rail head and laid in the required position by means of projecting arm or mounted on the truck nearest to the rail Read.

The material train moves forward on the assembled track and operation is repeated.

The second type of machines a long cantilevered arm projecting beyond.

The wagon on which is fitted. A panel of assembled track consists

of pair of rail with appropriate number of sleepers on the ballast layer.

This panel is conveyed by special trolley running over the wagons of materia train to the jibs.

It is lowered by the jib in the required position and connected to the previous panel. The track laying machine then moves forwarded and operation is repeated.

### Step 3: Laying of Ballast

Ballast trains also run on the section and unload the ballast on the track which is then packed manually with the help of beaters.

### Calculation of Materials Required For Track Laying:

Requirement of Track material for BG Track

## Rails:

The standard length of the rails is 13m for BG and 12 m for MG lines.

No of rails per km for BG

$$\text{lines} = \frac{1000}{13} \times 2$$

$$= 77 \times 2 = 154$$

wt of 52-kg rails per km $= 52 \times 154$

$= 8008$ kg

## Number of sleepers

The number of sleepers to be used depends upon the sleeper density. Assume sleeper density to be M+7, where M is the length of the rail in metres.

Number of sleepers per rail $= 13+7 = 20$

Number of sleepers per km $= 77 \times 20$

$= 1540$

## Fitting and Fastenings

a) No of fish plates per km $= 2 \times$ no of rails per km

$= 2 \times 154$

$= 308$

b) No of fish bolts $= 4 \times$ no of rails per km

$= 4 \times 154$

$= 616$

c) No of bearing plates = no of steeper x 2

= 1540 x 2 = 3080

d) Number of dog spikes = No of steepers x 4

= 1540 x 4 = 6160

The requirement of track materials for MG lines can also be calculated in the same manner.

## Track Maintenance

Track maintenance become a necessity due to following reasons.

Due to the constant movement of heavy and high speed trains, the packing under the steepers becomes loose and track geometry gets distributed.

The gauge, alignment, and longitudinal as well as cross levels of the track thus get affected adversely and the safety of the track is jeopardized.

Due to the vibrations and impact of high speed trains, the fittings of the track come undone and there is heavy wear and tear of the track and its components.

The track and its components get worn out as a result of the weathering effect of rain, sun and sand.

## Advantages of maintenance

If the track is suitably maintained the life of the track as well as that of the rolling stock increase ~~such~~ since there is lesser wear and tear of their components.

Regular track maintenance helps in reducing operating costs and fuel consumption.

Small maintenance jobs done at the appropriate time such as tightening a bolt or key hammering the dog spike etc., helps in avoiding loss of the

concerned fittings and thus saving on the associated expenditure.

When track maintenance is neglected for a long time it may render the track beyond repair calling for heavy track renewals that entail huge expenses.

## Daily Maintenance:

General inspection of the track

Checking up of all fastening and fittings

Tightening of bolts wherever required.

Reporting by unusual occurrence.

## Periodic Maintenance:

The periodic Maintenance consists of detailed inspection of the track to detect defects in the track which may not be detected during

daily maintenance. They are listed below:

1) Surface of Rails

⇒ Operations involved are

Packing the ballast

i) Through packing
ii) Scissor packing
iii) Shovel packing

⇒ Surfacing the track
⇒ Boxing and Dressing
⇒ Levelling
⇒ Lifting
⇒ Surface defects and remedies
i) High joint / Riding joint
ii) Blowing joint
iii) Pumping joint
iv) Buckling of Track
v) Centre Bound Track
vi) Hogged rails
vii) Corrugated or Roaring rails.

⇒ Spot packing and Track lifting.

2) Track Alignment

⇒ Realignment of Straight Tracks

⇒ Realignment of curved tracks

3) Gauge

4) Proper Drainage

⇒ Cleaning the ballast

⇒ Cleaning of cess

⇒ Surface Drainage

⇒ Underground Drainage

5) Track components

⇒ Maintenance and renewal of rails.

⇒ " Sleepers — spot renewal and thorough Renewal

⇒ " fittings.

6) Bridge and its approaches

⇒ Maintenance of foundation

⇒ " substructure and protection works

⇒ " superstructure

⇒ " Track on bridge & its approaches.

⇒ Rolling stock

⇒ Maintenance of locomotives

⇒ " Passenger coaches

⇒ " Goods Wagons.

8) Points and crossings

9) Level Crossings

10) Tunnels.

## Stations:

Stations and yards are the field control units of the railway communication system. They also provide waiting places and repairing places for the locomotives and wagons.

## Classification of Railway Stations:

Two categories

1) Operational considerations

2) Functional considerations.

## Operational considerations:

As per Indian railways

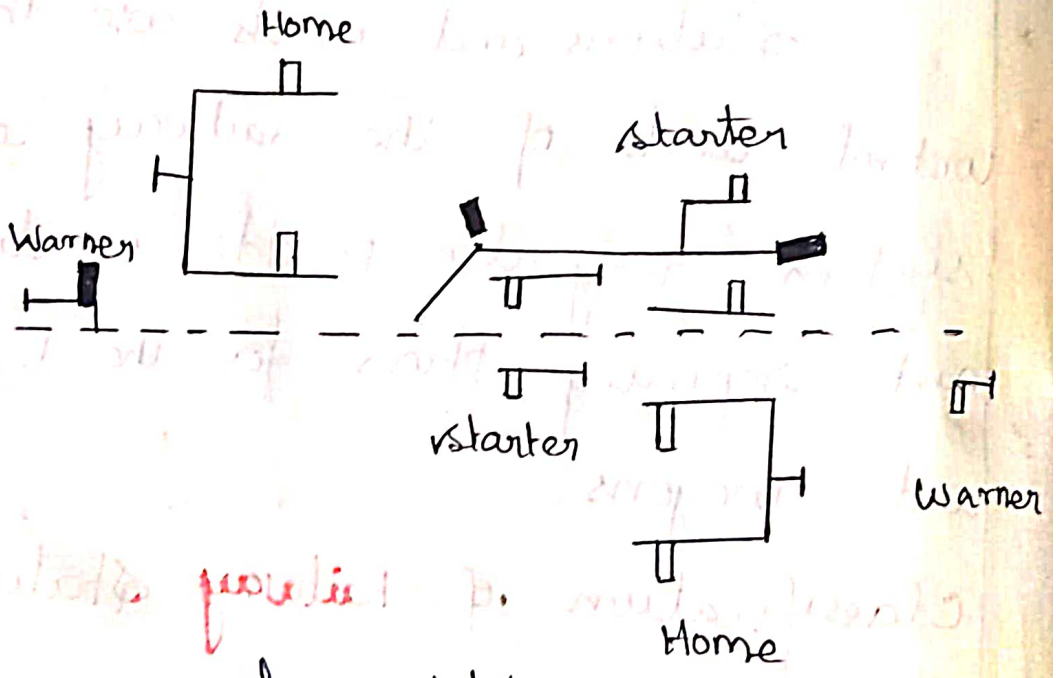
i) Block stations, ii) Non block station

i) Block station.

No traffic is dealt, but trains have to get permission to proceed further. Further classified as A, B, C classes.

⇒ A - class station

Incoming train is received after clearing at least a distance of 400m beyond home signal.

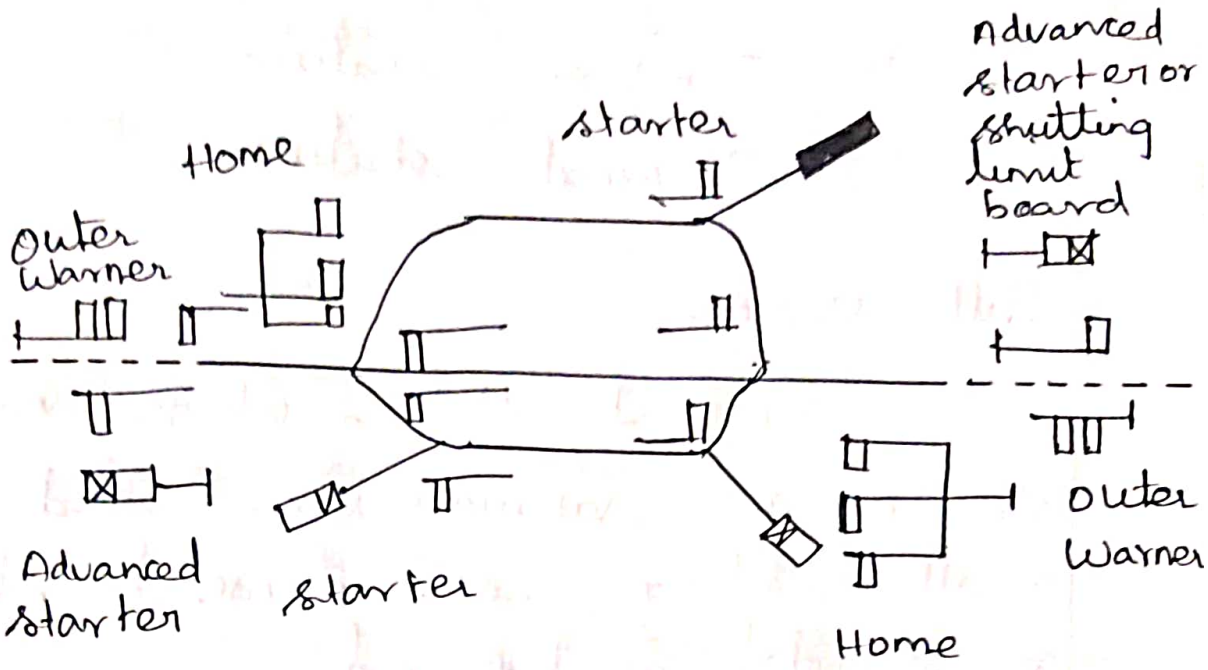



A) class station

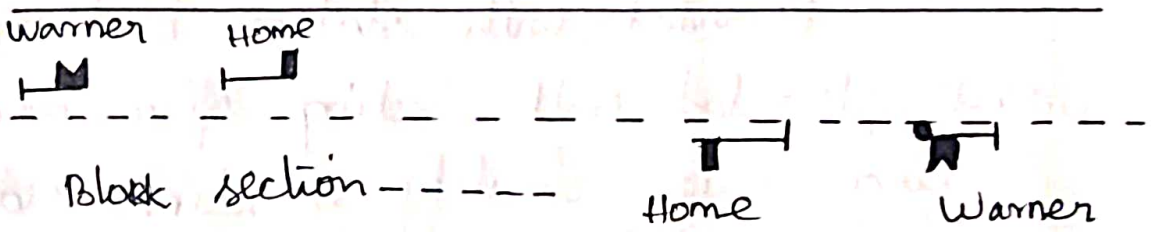
B) - class station:

Permission to the incoming train is given before the receiving line is made clear within the station section.

b) B - class station




c) station where train do not stop




c) C - class station

ii) Non-block station

classified as D-class or flag stations. only traffic is dealt and no arrangements to control the movement of train. Located between two block stations.

Functional classifications:

i) Halt stations

ii) Flag stations

iii) wayside junctions
iv) Junction station
v) Terminal station

Halt station:

Simplest station where trains can stop on a railway line. Provided with small waiting shed, name boards are provided at both end.

Flag station:

Provided with station building and staff. Provided with booking office, benches, drinking water facility. Sometimes siding is also provided for stabling of wagons booked for that stations.

Wayside stations:

It is called as crossing station Provision is made to cross an up and a down train or for over-taking the slow moving trains by the fast-moving trains.

Junction stations:

It is a meeting point of three or more line coming from

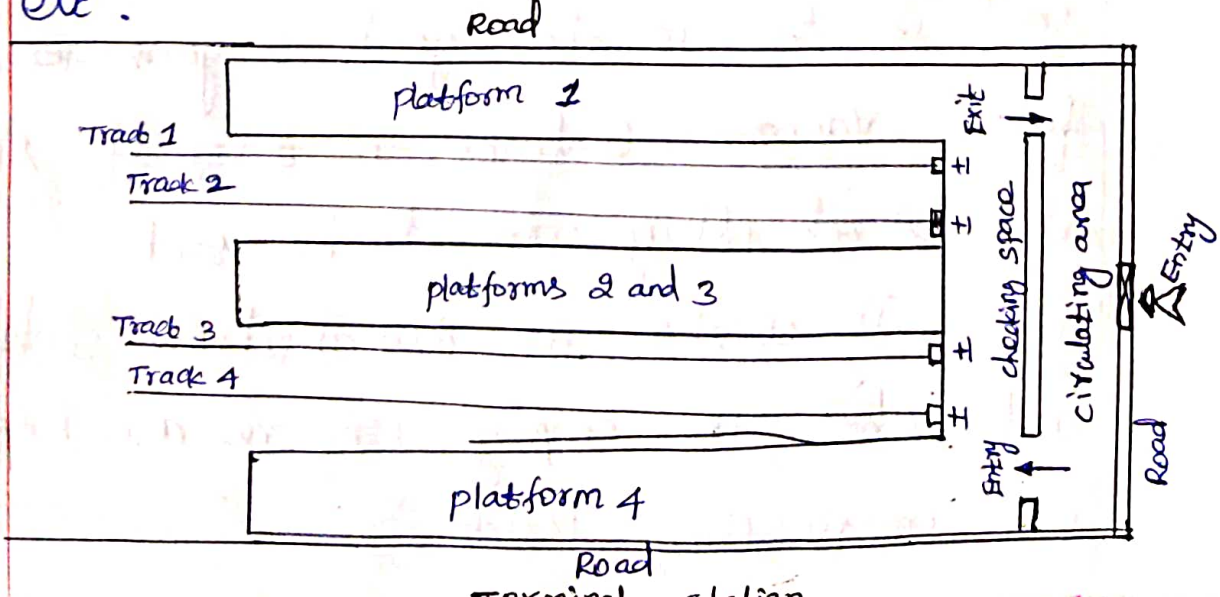
different conditions.

a) Feasibility to interchange of traffic inbetween main and branch lines.

b) Possibility to clean and repair vehicles which terminate at the junctions occur between a single branch line and a single or double main lines or between double branch line and main tracks.

## Terminal station:

Station at which a railway line or one of its branches ends or terminates without further proceeding. Providing with facilities to reverse the locomotive, examination pits, additional sidings, ticket office, restaurant etc.



# Marshalling Yard:

## Yard:

A yard is defined as a system of tracks laid within definite limits for various purposes such as storing of vehicles making up trains, despatch of vehicles etc. It attends to unscheduled movement of trains subjected to rules and regulations.

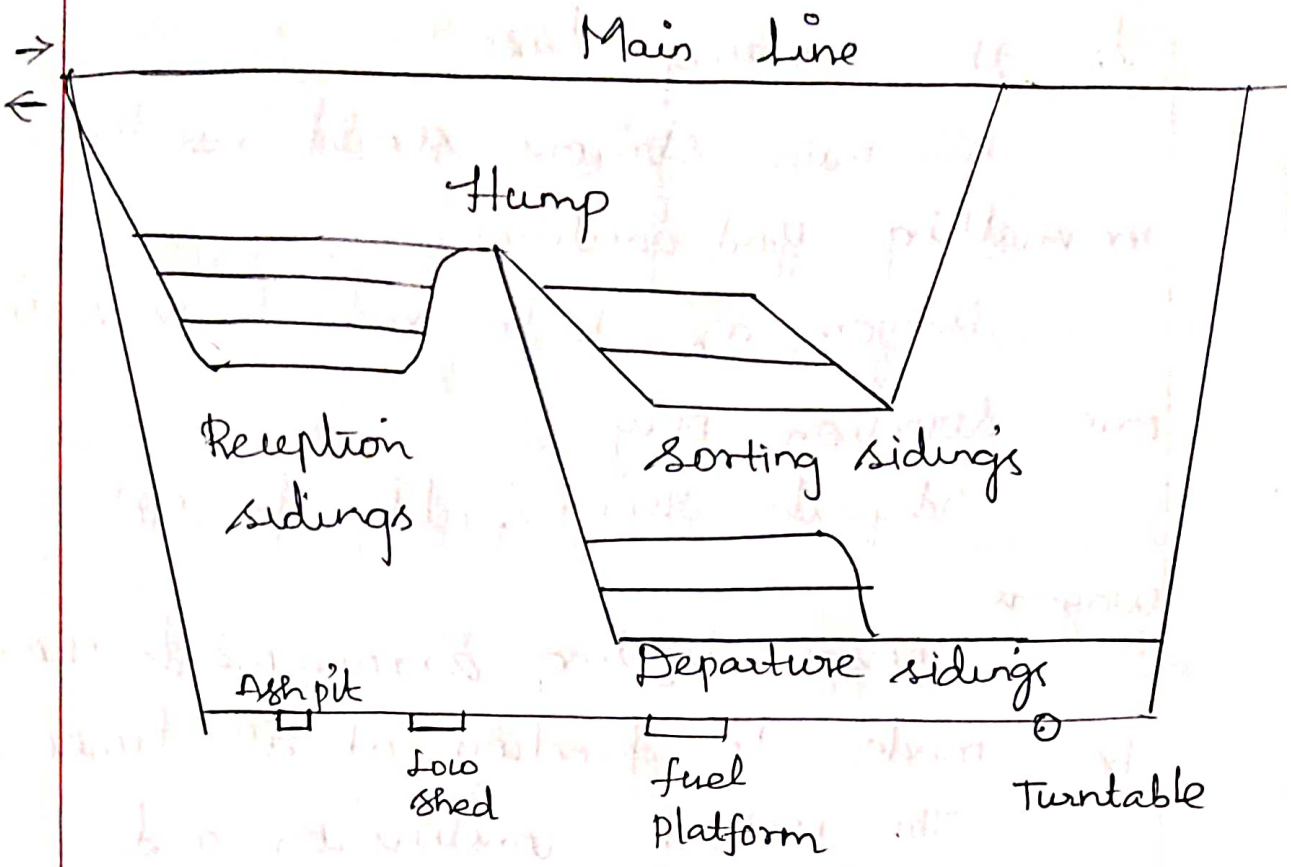
## Types:

- Passenger Yards
- Goods Yards
- Marshalling Yards
- Locomotive Yards

## Marshalling Yards

The main purpose of marshalling yard is to isolate goods wagons received from various centeres in order of station at which they are to be sent.

It works as distribution center and also the empty wagons are kept in marshalling yards.




Marshalling Yard

Design aspects of marshalling yards:

Shunting operations should not disturb the regular movement of trains.

More number of wagons should be despatched rather than storing more wagons.

It should be feasible for future expansion so as to accomodate more goods traffic.

To the maximum extend the marshalling yards should be made parallel

to the running lines.

All main stations should have the marshalling yard facilities.

Wagons are to be made to move in one direction only.

Adequate repair facility for sick wagons.

Enough lighting arrangements should be made to function at all times.

The cost of construction and maintenance should be low.

## Layouts of marshalling Yards:

An ideal layout of marshalling yard consists of three types of sidings:

a) Receptional sidings
b) Sorting sidings
c) Departure sidings

## a) Receptional sidings

These sidings are used to receive incoming trains.

These sidings are laid in the form of parallel grid with equal length.

b) Sorting sidings:

These sidings are intended for shunting operations.

Each sidings is alloted to specific destination wagons.

The sorting sidings are generally laid in the form of a fan or balloon.

c) Departure sidings:

These are similar to reception sidings. If the mainline is not busy their sidings may be omitted.

Types of marshalling yards:

Flat yards
Gravitation yards
Hump yards.

Hump Yard:

Hump or summits or man-made hills are provided and the wagons are pushed upto this point by the engine. Then the wagons are allowed to gravitate down the slope.

The modern trend is to adopt this type of marshalling yard as shunting operations are carried out more quickly than gravity or flat yards.

## Signalling and Interlocking

Signalling is the device by which the movement of trains is controlled.

Highly important in terms of safety.

Trains can be operated efficiently utilization of tracks and tracks can be done at maximum levels.

Signalling includes signals, points blocks and other equipment

Movement of trains is controlled.

Highly important in terms of safety.

Trains can be efficiently

Maintain safe distance between

trains running in the same direction on a single line.

To run the trains at restricted speeds during repair work.

At junctions to prevent the trains from colliding.

## Classification of signals:

Depending on the operational characteristics

- Fog or audible or detonating signals
- Visual indication hand signals
- Visual indication fixed signals

Depending on the functional characteristics

- stop or semaphore type signals
- Warner signals
- Shunting signals
- Coloured light signals

Depending on the location characteristics

- Outer receptional signals
- Home receptional signals
- Starter signals
- Advance starter signals

Special Signals

Routing signals

Calling on signals

Point indicators

Repeater or co-acting signals

Modified lower quadrant semaphore signals

Miscellaneous signals

# SIGNALS

## Function

- Stop
- Warner
- Disc
- Colored

## Location

- Outer
- Home
- Starter
- Advance

## Purpose

- Routing
- Repeater
- Call on

## Operation

- Hand
- Fixed
- Detonating

## Controlling signals

Which are mandatory to observe for train movement

## Indicating signals

Correspond to the traffic signs of highways. Also mandatory to observe.

## Warning signals

They provide a pre-hand warning to the driver about the controlling signals ahead.

These only enhance the efficiency and provide a further safety caution

## Detonating Signals

Used when hand and fixed signals or not visible.

Also used during emergencies.

These are in the form of detonators fixed on the top of rails.

## Hand signals:

Given by the guard using

coloured flags or bare arms

During night times kerosene lamps fitted with movable green, red and yellow coloured glasses are used

Green – proceed

Red – dead stop

Yellow – proceed with caution

## Semaphore signals:

Consist of a Vertical post on which a movable arm is pivoted at the top.

Arm can be kept hzt or it can be inclined at 45° to hzt.

Outer end of arm is controlled by means of levers and cables from the Cabin.

Spectacles of red and green or fixed in the arm.

These are fixed on the left hand side of track with spectacles towards driver.

Horizontal arm indicates "DANGER - STOP and the inclined arm indicates "CLEAR - PROCEED".

In the day time position of arm indicates the signals.

During the night time light of lamp passing through spectacle gives the signal.

# UNIT-IV AIRPORT DESIGN

## Runway Design

The number & orientation of the runways play an important role in the overall arrangement of various components of an airport.

The number of runway will depend on the volume of air traffic while its orientation will depend on the direction of the wind and sometimes on the extent area available for the airport development

In general, the arrangement of the runways and taxiways should comply with the following conditions

i) To avoid delay in the landing, taxiing and take off operations and to cause the least interference in these operations.

ii) To grant the shortest taxi distance possible from the terminal area to the ends of runways.

## Runway Orientation:

### i) Preliminary Information required:

It is necessary to collect the following data before deciding the orientation of the runway.

Maps of the area in the vicinity of the airport showing contours at suitable intervals

Records of direction, force and duration of the wind in the vicinity and fog characteristics of the area for as long a period as possible.

### ii) Head Wind:

During landing it provides a breaking effects and the aircraft comes to a stop in a short

length of the runway.

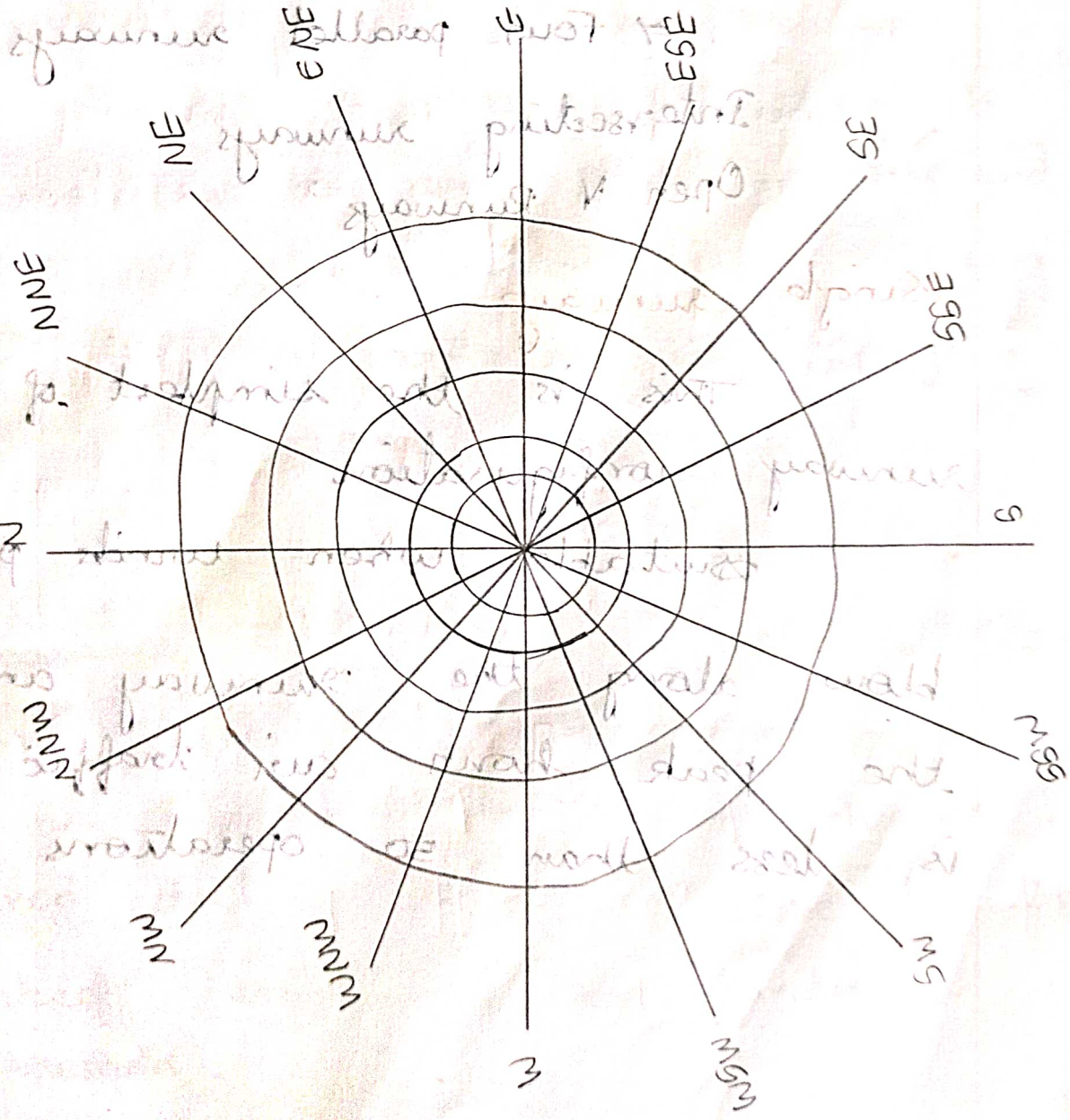
During take off it provides greater lift on the wings of the aircraft.

## Wind Coverage:

The percentage of time in a year during which the cross wind component remains within the limit of 25

| Wind Direction | Duration of wind percent | | | Total in Each Direction Percent |
|---|---|---|---|---|
| | 64 - 25 kmph | 25 - 40 kmph | 40 - 60 kmph | |
| N | 7-4 | 2-7 | 0·2 | 10·3 |
| NNE | 5-7 | 2·1 | 0·3 | 8 1 |
| NE | 2-4 | 0·9 | 0·6 | 3 9 |
| ENE | 1·2 | 0·4 | 0·2 | 1·8 |
| E | 0·8 | 0·2 | 0 | 1 0 |
| ESE | 0·3 | 0·1 | 0 | 0·4 |
| SE | 4·3 | 2·8 | 0 | 7·1 |
| SSE | 5·5 | 3·2 | 0 | 8 7 |
| S | 9·7 | 4·8 | 0 | 14·3 |
| SSW | 6·3 | 3·2 | 0·5 | 10·0 |
| SW | 3·6 | 1·8 | 0·3 | 5·7 |
| WSW | 1·0 | 0·5 | 0·1 | 1·6 |
| W | 0·4 | 0·1 | 0 | 0·5 |
| WNW | 0·2 | 0·1 | 0 | 0 3 |
| NW | 5·3 | 1·9 | 0 | 7·2 |
| NNW | 4·0 | 1·3 | 0 3 | 5·6 |
| | | | Total present | 86 5 |

# Wind Rose Diagram:



## Runway Configurations

Many runway configurations exist Most are combinations of these basic configurations:

- Single runway
- Parallel runway
  - Two parallel runway
  - Two parallel runway with staggered thresholds
  - Four parallel runways
- Intersecting runways
- Open V Runways

### Single runway

This is the simplest of the runway configuration.

Suitable when winds predominately blow along the runway and the peak hour air traffic demand is less than 50 operations.

## Two parallel Runway

suitable when wind predominately blow along the parallel runways and the peak hour air traffic demand is high.

The capacity of two parallel runways depends on the spacing blw them runway usage strategy and air traffic mix.

## staggered parallel Runway

when the terminal building is located in blw the two runways and the other for landing, the taxiing distance for arriving and departing aircraft becomes minimum.

Adjustment to seperation clearance is allowed for simultaneous arrivals and departures.

Highest capacity is achieved when the intersection is close to the takeoff end and the landing threshold.

## Open - V runway:

Runways in divergent directions which do not intersect are referred to as open - V runways.

The runway use strategy where in the operations are away from the "V" yields highest capacity.

## Taxiway system:

The movement of aircrafts to and from the runways and the terminal / cargo and parking areas is provided by a system of taxiways.

This system of taxiways includes:

- Entrances and exit taxiways
- Parallel taxiways
- Bypass taxiways
- Connecting or transverse taxiways
- Apron taxiways and taxi lanes

# Problem on basic and Actual Runway length

① Basic Runway length

length is calculated under the following conditions.

No wind blowing on the runway.

Aircraft is loaded with full loading capacity.

Airport is provided at the sea level.

No wind is blowing on the way to destination

## Factors affecting basic runway length

Aircraft performance characteristics

Landing & Take-off Gross weights of the Aircraft.

Airport Elevation

Maximum Temperature

Runway Gradient

Runway surface conditions.

## Correction for elevation, temperature and Gradient:

### a) Elevation

Basic runway length is increased at the rate of 7% per 300m rise in elevation above the mean sea level.

### b) Correction for Temperature:

$$T_a + \frac{T_m - T_a}{3}$$

$T_a$ = Monthly mean of avg daily temperature.

$T_m$ = Monthly mean of the max daily temperature for the same month of the year.

### c) Correction for Gradient:

Steeper gradient results in greater consumption of energy and as such longer length of runway is required to attain the desired ground speed.

# Aircraft parking system

The type of parking used at the gates affects the gate size because the area required to manuver (a planned movement of an aircraft) in and out of a gate varies depending on the way the aircraft is parked.

## Types of Aircraft parking:

1) Nose - in parking
2) Angled nose - in parking
3) Nose - out parking
4) Angled nose - out parking
5) Parallel parking

### 1) Nose - in parking:

The aircraft is parked at right angles to the terminal building with its nose as close to the building as permissible.

2) Angle Nose - In parking

This is similar to the nose in parking except that the aircraft is not parked perpendicular to the terminal building.

Angled

3) Nose out parking:

This is similar to the nose out parking except that the aircraft is not parked perpendicular to the terminal building.

4) Nose out parking:

The aircraft is parked at right angle to the terminal building with its tail as close to the building as permissible.

5) Parallel parking

It is the easiest to achieve from the stand point of aircraft manouvering.

## Airport Drainage:

An adequate drainage system for the removal of surface and subsurface water is vital for the safety of aircraft and for the long service life of the pavements.

Improper drainage results in the formation of puddles on the pavement surface which can be hazardous to aircraft taking off and landing poor drainage can also results in the early deteriorations of pavements.

## purpose of drainage:

Intercepting and diversion of surface and ground water flow originating from lands adjacent to the aircraft.

Removal of surface run off from the airport.

Removal of subsurface flow from the airport.

## Design storm for surface run off

Federal Aviation Administration (FAA) recommends that for civil airports the drainage system be designed for a storm whose probability of occurrence is once in 5 years.

Rainfall intensity is expressed in inches per hour for various duration of a particular storm.

The FAA adopts the following formula for the calculation of amount of run off.

$$Q = CIA$$

where,

Q = Runoff from the drainage basin (ft/sec)

C = ratio of runoff to rainfall (Coefficient of runoff)

I = rainfall intensity (inch/hr)

A = Drainage area in acres

For drainage basins consisting of several types of surfaces with different infiltration characteristics, the weighted run off coefficient should be computed as,

$$C = \frac{A_1C_1 + A_2C_2 + A_3C_3}{A_1 + A_2 + A_3}$$

## Airport Markings:

Land Marks which are required so as to provide an aid to the pilots.

⇒ Ensures the smooth operating of the aircraft.

Required both in good weather and bad weather as well as during day and night.

The runways of the conventional aircraft appears as long and narrow strip with straight sides and free of obstacles.

These are available in different forms of marking in the airport and airfield

1) Airport Markings
2) Airport lighting
3) Signage

1) Airport Markings

Markings are provided on any of the component of airport in different forms mentioned below

- Strips
- Patches
- Solid lines
- Hollow lines
- Coat lines

Arrangement can be inclined, perpendicular to runway or a component or any other shape.

Airport marking can be divided into the following groups

a) Apron marking

b) Landing direction indicator
c) Runway marking
d) Shoulder Marking
e) Taxiway Marking
f) Wind direction indicator

## Runway Marking

These are provided with different purpose like,

Runway center line marking
Runway edge stripe
Runway numbering
Touch down or landing zone marking
Threshold marking
Two or more parallel runways

## Apron Marking

a) Shoulder Marking
b) Taxiway Marking

a) How aircraft is going to take a turn?
b) At what particular location it has to stop?

c) where there can be a loading and unloading, everything is defined by using apron markings?

Landing direction Indicator:

To indicate the landing direction an arrow or a Tee is placed at the center of a segmented circle.

It is painted in orange or white colour.

It is lighted for viewing during night time

It is fixed at a distant place.

Shoulder Marking:

Markings are in the form of yellow stripes, 90 cm wide and 30 m apart.

the Markings extend up to a max 1.5 m from the outer edges of shoulder.

Helps pilot in knowing whether they are moving towards runway

or moving away from runway.

## Wind direction Indicator

The direction from which the wind blows is indicated by a wind cone.

It is placed in a segmented circle together with the landing direction indicator.

It should be placed away from building so that it is not effected by eddies.

Panels are painted white

It should be visible from a height of 30 m.

## closed runways or taxiways.

For temporarily closed runways or taxiways, yellow crosses are placed at the two ends that defines it is temporarily closed.

If the runway is closed permanently yellow crosses are placed at both ends

and also at 300 m intervals then threshold markings provided are erased.

## Airport lighting:

To achieve uniformity and to guide pilots for unfamiliar airports colours and general arrangement of airport lights are standardized.

Airport lights are kept clean, well maintained checked regularly for faultly bulbs and replacements.

Tough and laborious job, major airport contains 30,000 lights.

Provision of emergency power supplies, which can take over in seconds in case of any power failure

## Airport lighting Affecting factors.

Airport classification
Amount of traffic
Availability of power

Nature of aircraft using the airport.

Type of night operation plans

Type of landing surfaces provided

Weather conditions

## Elements of Airport lighting

Airport beacon

Approach lighting

Apron and hanger lighting

Boundary lighting

Lighting of landing direction indicator.

Lighting of wind direction indicator.

Runway lighting

Taxiway lighting

Threshold lighting.

## Runway lighting

After crossing the threshold the pilot complete a touchdown and

roll out on the runway.

The planning of runway lighting is carried out in such a way that the pilot gets enough information on alignment, lateral displacement, roll and distance.

The lights are so arranged so that they form a visual pattern which the pilot can interpret easily.

During night landings flood lights were used in olden days. But now runway edge lights are adopted.

## Taxiway lighting

The pilots have to manoeuvre the aircrafts on a system of taxiways to and from the terminal and hangar areas either after landing or on the way to take off.

The taxiway system is much complicated on large airports and therefore it is necessary to provide

adequate lighting at night and at day time when the visibility is very poor.

For normal exists - centerline terminated at the edge of the runway.

There should be adequate guidance along the taxiway.

The taxiway edge lights are blue and the taxiway center lights are green.

The taxiway should be clearly identified so that they are not confused with the runways.

## Design standards And Planning of Airport as per Indian Conditions.

The ICAO uses a two-element code, the aerodrome reference code to classify the geometric design standards at an airport.

The code elements consist of a numeric and alphabetic designation

The aerodrome code numbers 1 through 4 classify the length of the runway available the reference field length which includes the runway length and if present the stop way and clearway.

The reference field length is the approximate required runway takeoff length converted to an equivalent length at mean sea level 15°C and zero percent gradient.

5. Harbour

## Water Transportation:

The water transportation can further be subdivided into two categories

i) Inland Transportation

ii) Ocean Transportation

## Harbour

It can be defined as a sheltered area of the sea in which vessels could be launched, built or taken for repair; or could seek refuge in time of storm or provide for loading and unloading of cargo and passengers.

| Harbour | Port |
|---|---|
| A Harbour is either natural or manmade | Ports are mostly manmade and are bigger and have many facilities |
| Harbours provide safe anchorage to ships in conditions of bad weather. | Ports are mainly used for loading and unloading of ships. |

## Docks:

A dock is the area of water between or next to a human-made structure or group of structures involved in the handling of boats or ships usually on or close to a shore.

## Harbour classification

Natural harbours
semi-natural harbours
Artificial harbours.

## Natural Harbour:

Natural formations affording safe discharge facilities for ships on sea coasts in the form of creaks and basins are called natural harbour.

## Semi-Natural Harbour

This type of harbour is protected on sides by headlands protection and it requires man-made protection only at the entrance.

## Artificial Harbours:

Where such natural facilities are not available, countries having a seaboard had to create or construct such shelters making use of engineering skill and methods and such harbours are called Artificial or Man-made Harbour.

From their Utility and situation, harbours are further classified into three major types:

Harbours of refuge including naval bases.

Commercial harbours, connected with ports.

Fishery harbours.

## Harbour planning:

It is necessary to carry out a thorough survey of the neighborhood including the foreshore and the depths of water the vicinity

The borings on land should also be made so as to know the

probable subsurface conditions on land.

The nature of the harbour, wheather sheltered or not should be studied.

## Terminologys

### Mooring

- a place to tie a boat.
- Examples include quays, wharfs jetties, piers anchor buoys and mooring buoys.

### Quay

A stone or metal platform lying alongside or projecting into water for loading and unloading ships.

### Wharf

A level quayside area to which a ship may be moored to load and unload.

### Jetties:

A structure that projects from the land out into water.

## Piers :

A platform on pillars projecting from the shore into the sea, typically incorporating entertainment arcades and places to eat.

## Bouy :

A bouy is a floating device that can have many purposes. It can be anchored or allowed to drift with the sea wave.

## Classification of ports :

Depending upon the location, the ports can be classified as

- Canal ports
- River ports
- Sea ports

The term free port is used to indicate an isolated enclosed and policed area for handling of cargo etc. for the purpose of reshipping without the intervention of customs.

Depending upon the commodities dealt with or their use the ports can also be classified as grain ports coaling ports, transshipment ports, ports of call etc.

Depending upon the size and location, the ports can also be grouped as major ports, intermediate ports and minor ports.

A major port is able to attract trade and it commands a really pivoted position for the extension of communication.

## Port Design:

The entrance channel should be such that the ships can come in and go out easily.

The ships should be able to turn in the basin itself.

The alignment of quays should be such that the ships can come along side easily even

when there is an on-shore wind

## Navigational Aids:

The term "Aid to Navigation" means any object or device, external to a vessel that is intended to assist a navigator in fixing his position or determining a safe course past hazards to navigation.

It includes both fixed and floating objects such as lights, light ships buoys, beacons, fog signals, plus electronic aids to navigation such as radio beacons.

## Types of navigational Aids:

Depending upon structure

There are two types of navigational Aids

1) Fixed structures
2) Floating structures

Depending upon service and visibility

There are four types of navigational aids,

1) Coast approach light station
2) Obstruction light station.
3) Approach channel lighting
4) Harbour light signal.

1) Navigational lights of piers:

For the navigational purpose at the port or harbour locate the light system the pier.

2) Beacon lights:

A beacon is an intentionally conspicuous device designed to attract attention to a specific location.

Types of navigational beacons.

1) Radar reflectors
2) Radio beacons
3) Sonic & Visual signals

1) Radar reflector:

Radar reflectors is an object detection system that uses radio waves to determine the range, angle or velocity of objects.

2) Radio beacons:

A radio beacon is a transmitter at a known location on specified radio frequency.

3) Sonic and visual signals:

Visual beacons range from small single-pipe structure to large lighthouse or light station and can be located on land or water.

there are also used of lights in navigation of ships at harbour like fixed light, occulting light, flashing light and coloured light.

Light house:

It is a lofty structure popularly built of masonry or reinforced concrete in the shape of a tall tower on a high pedestal.

The tower is divided into convenient number of floors, the topmost floor containing powerful lighting equipment and its operating machinery.

The lower floors are used as stores and living rooms necessary for the maintenance and working of the light station.

The main parts of a typical lighthouse tower are illustrated in fig

Lighthouse may be located on shore or on islands away from the mainland as in the case of warning light station.

## Floating Navigational Aids:

There are two types

1) light ships
2) Buoys

## Light ships:

Lightship is a ship which is act as light house.

They are used in waters they are to deep or unsuitable for lighthouse.

Maintenance cost is very high for light ships when compare to

light house.

## Buoys:

Buoys are floating structures moored to the bottom of the sea

Used to mark channels and fairways, shoals, rocks, wrecks and other dangers to navigation.

Buoys are floating objects heavily anchored to the bottom that are intended to convey information to a navigator by their shape and colour by the characteristics of a visible or audible signal or a combination of two or more such features.

## Types of Buoys:

1) Can buoy
2) Spar buoy
3) Nun buoy
4) Lighted buoy
5) Bell buoy

# Docks and their classification

## Defin Docks:

Docks are enclosed areas for berthing the ships to keep them afloat at a uniform level to facilitate loading and unloading cargo.

A dock is a marine structure for berthing of vessels for loading and unloading cargo & passengers.

## Classification of Docks

Docks can be classified into following two categories:

Wet docks
Dry Docks

## Wet Docks:

Docks required for berthing of ships or vessels to facilitate

the loading and unloading of passengers and cargo are called wet docks.

These are also known as harbour docks.

## Dry Docks:

The docks used for repairs of ships are known as dry docks.

Shape may be adopted as per site conditions:

Rectangular dock
Diamond dock
Inclined Quay type

### 1) Rectangular Dock

The length and breadth should be adjusted in such a way as to give maximum quayage.

2) Diamond Dock:

For the same perpendicular distance b/w long sides, the long side could be extended conveniently.

3) Inclined Quay dock:

It consist of a no of projecting quays into the dock or basin.

Location of dock:

Docks can be located on inland ports of rivers or at estuaries or open sea coasts.

A proper piloting service is necessary.

The river approaches to the dock have to be maintained.

Classification of Dry Docks:

Dry Docks are classified in the following

1) Gravity or dry Docks
2) Floating dry Dock
3) Marine railway dock
4) Ship lift dry dock
5) Slip ways

## 1) Gravity Dock

A dry dock is also known as gravity dock.

It is long excavated chamber having side walls a semi circular end wall and a floor.

The open end of the chamber is provided with a gate & acts as the entrance to the dock

## 2) Floating dry Docks.

It may be defined as a floating vessel, which can lift ship out of water and retain it above water by means of

its own buoyancy.

It is a hollow structure made of steel or RCC consisting of two walls and a floor with the ends open.

## Marine railway dock

The marine railway or slip dock or slip way is an inclined railway extending from the shore well into the water as the off there.

This railway track is used to draw out a ship needing repair out of the water.

## Lift dry dock:

This is a constructed platform capable of being lowered into and raised from water.

Lowering and raising is achieved by means of hydraulic

power applied through cylinders supporting the ends of cross girders carrying the platform.

## Ship lifts:

As the name suggests in the ship lift, the ships are lifted bodily out of water.

The ship lifts may be either electric hydraulic or pneumatic.

These lifts are used for launching as well as for dry docking the ships.

## Slip ways:

This technique is used for repairs as well as for building of Vessels.

In its simplest form a slip way consists of a inclined path of timber or stone laid on a firm ground.

On this inclined path a series of rails are fixed.

The rails run up from a sufficient depth of water to the required height above the high water level to a point at which the longest vessel to accomodated is completely out of range of tide.

The lower end of slip is tidal and open to water.

## Tides And Waves:

Coastal currents and evidences of silting, including littoral drift or coast erosion.

Tides and tidal range

Wind, wave and their combined effect on harbour structures.

## Tides:

Tides on the coast-line are caused by the sun and moon.

The effect of tides is to artificially raise and lower the mean sea level during certain stated periods.

## Waves and Wind:

The "sea wave" is by far the most powerful force acting on harbour basins and against which the engineer has to contend.

The wave has the impulse of a huge battering ram and equipped with the point of a pick axe and chisel edge.

It is the most incompressible natural phenomena.

## Break Waters.

The protective barrier constructed to enclose harbours and to keep the harbour waters undisturbed by the effect of heavy and strong seas are called break waters.

## Design of break water:

Character of coastal currents.

Cost and availability of materials of construction.

Directions and force of prevailing winds.

Nature of the bottom or foundation

## Detrimental forces acting on break waters:

### Hydrostatic force:

This force reduces the apparent weight and hence, the marine structure suffer these loses to a great extent unless the foundations are absolutely impervious.

## Classification of break water:

Heap or mound breakwater

Mound with superstructure

Upright wall break water.

## Wharves:

Platforms or landing places are necessary for ships to come, close enough to the shore, for purpose of embarkation, disembarkation etc at the same time.

These platform location should give sufficient depth of water for the ship to float.

Such platforms are called "Wharves".

## Piers:

The structure which are built perpendicular or oblique to the shore of a river or sea are known as piers.

In the sea the piers are constructed where the sea is not deep and the natural harbour is not convenient for allowing the ships to berth adjacent to the shore.

## Fenders:

The cushion which is provided on the face of jetty for ships to come in contact is known as fender.

It is provided for various forms and is made of different materials.