CE6604 - RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING.

UNIT - I - RAILWAY PLANNING:-

Significance of Road, Rail, Air and Water transports - Co-ordination of all modes to achieve sustainability - elements of Permanent way - Rails, Sleepers, Ballast, rail fixtures and fastenings - Track stress, Coning of wheels, Creep in rails, defects in rails, Route alignment surveys, Conventional and modern methods - soil suitability analysis - Geometric design of railways, gradient, super elevation, widening of gauge on curves - Points and crossings.

Introduction

Transportation is regarded as an index of economic, social and commercial progress of a country. The transport industry, which undertakes nothing more than mere movement of persons and things from one place to another.

An adequate transporation is indispensible for economic and social progress of nation and the world as a whole.

Land, Water and Air have been used by mankind for developing the transport modes like Railways, Highways, Water

Airways, etc.

The various modes of Transport can be classified in the following ways.

→ Land Transport
eg: Highways, Railways, Cable ways, Ropeways etc.

→ Water Transport
eg: Canal ways, Riverways, Oceanways Lakeways, etc.

→ Air transport, eg: Airways.

Characteristics of Different modes of Transport:-

Co-ordination of all modes to achieve sustainability:

Transporation modes provide following 2 basic Utilities

→ Place Utility, → Time Utility.

Railways Transport

The Railways have their greatest Utility in the Utilization in the transport of large Volumes of heavy and bulk commodities over long distances and in very long distance journeys of passengers with safety, comfort and convenience.

Road Transport:

Road Transport provides greater utility in transport over short and long hauls of lighter weight commodities and of lesser volumes, as also for passenger transport for short and medium hauls.

It is especially for passenger transport due to flexibility in operation and door to door service.

Air Transport:

Air Transport attains maximum utility where savings of time in transport is of utmost importance rather than money.

Water Ways:

Water ways provide facilities of transport of heavy and bulk commodities where time may not be of much importance. This is the most economical mode of transport.

Route Alignment Survey:

Factors controlling Alignment :-

Introduction :-

Alignment may be defined

Road Transport:

Road Transport provides greater utility in transport over short and long hauls of lighter weight commodities and of lesser volumes, as also for passenger transport for short and medium hauls.

It is especially for passenger transport due to flexibility in operation and door to door service.

Air Transport:

Air Transport attains maximum utility where savings of time in transport is of utmost importance rather than money.

Water Ways:

Water ways provide facilities of transport of heavy and bulk commodities where time may not be of much importance. This is the most economical mode of transport.

Route Alignment Survey:

Factors controlling Alignment :-

Introduction :-

Alignment may be defined

as the layout of the centre line of a railway track. The alignment is of horizontal and vertical.

Basic requirements of an ideal alignment are, it should be economic, easy for construction, operation & maintenance, safe.

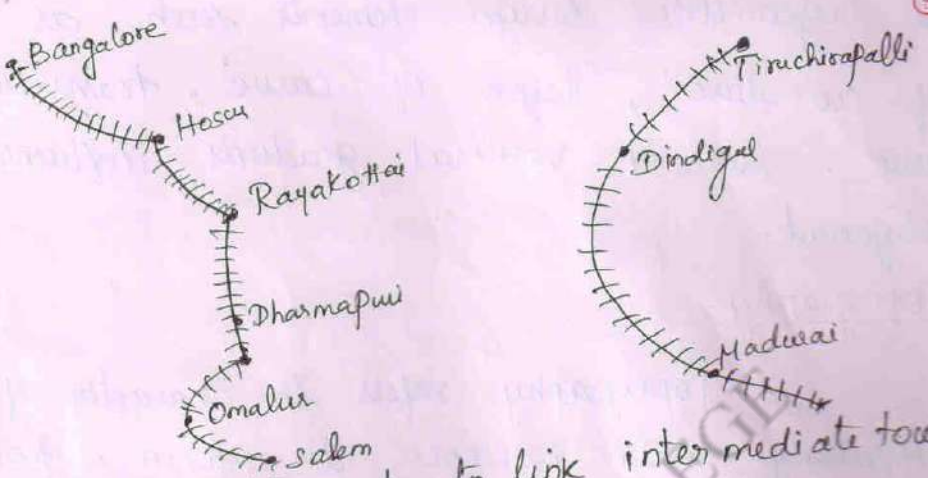
Factors Controlling alignments

- → Obligatory Points
- → Traffic Potential
- → Geometric design standards
- → Topography
- → Economic viability
- → Techno - economic characteristics.
- → Other considerations.

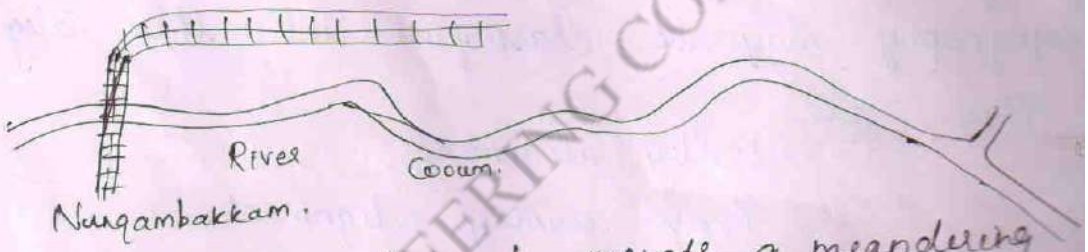
Obligatory Points:-

Obligatory Points are Controlling Points which govern the alignment of railway tracks. The obligatory points through which alignment has to necessarily pass through are.

- ⇒ Important towns and cities
- ⇒ Shortest width and Permanent path of rivers.
- → Hill Passes.



⇒ Railway alignment to link intermediate towns.



⇒ Straight alignment across a meandering river.

Traffic Potential

Traffic Potential is the capability of Catchment areas to generate or to attract traffic. Traffic Potential of the area through which alignment passes has to be assessed to ensure adequate demand.

Geometric design standards:

Geometric design deals with the layout of visible features of railway tracks,

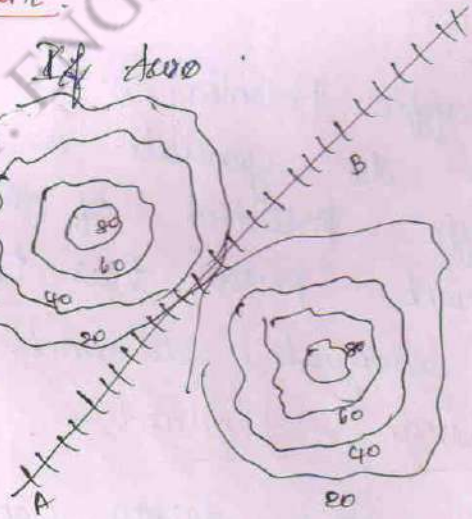
The geometric design elements such as 'radius of curvature', 'degree of curve', transition curve, and vertical gradients influence the alignment.

Topography.

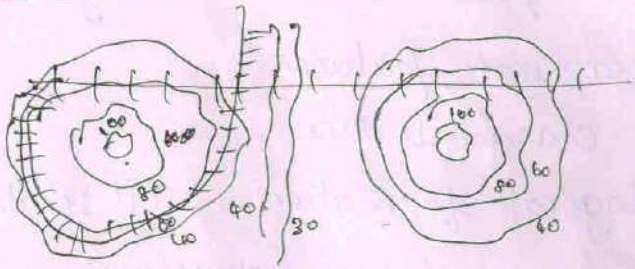
Topography refers to character of a place, Particularly, with reference to form, geometric design, slope and height. for this purpose topography may be classified into three categories. They are

Valley alignment.
Cross country alignment.
Mountain alignment.

Valley alignment:



Cross country alignment:



Other considerations:-

→ Geological formation such as dip of strata, faults, slips and slides.

⇒ Proximity to sources of construction materials such as quarries and water resources.

Engineering Surveys for Track Alignment:-

Introduction:

Alignments are provisionally fixed and firmed up through engineering surveys at different stages.

Objective of this Survey.

⇒ Obtain data for mapping

⇒ designing of alignment.

* Traffic Survey
* Map Study for fixing Provisional alignments
* Reconnaissance Survey.
* Preliminary Survey.
* Detailed Survey.
*

Data collected from various Surveys:-

⇒ Topographical features
⇒ Soil characteristics
⇒ Geological formation - Soil strata, rocky, structure
⇒ Hydrological data → high flood loco flood levels rainfall
⇒ Cross drainage structures — bridges Culverts.
⇒ Proximity of construction materials.

Engineering Surveys through modern methods

Railways planning needs precious and cost effective methods of surveying. Innovative techniques like remote sensing and advancement in hardware and software technology have led to sophisticated and scientific methods.

Remote sensing data products such as aerial photos and high resolution satellite imageries, modern surveying equipment / systems such as Electronic Distance Meter (EDM)

Total Station

Global positioning System (GPS)

Geographical Information System (GIS)

Application of Modern survey equipments / Techniques for railway Alignment Surveying.

Modern equipments and techniques make the process expeditious and economic.

⇒ Global positioning system (GPS)

→ This instrument measures co-ordinates of any point any where on the globe. This system uses a set of satellites at a distance of about 10,000 km above earth.

All weather and day and night surveying is possible with the instrument. It is capable of measuring distances even up to thousands of kilometers.

⇒ Electronic distance Meter :- (EDM)

EDM works on the principle of time taken for electromagnetic waves to travel between the given Origin and destination. Typical EDM equipment can measure a distance up to 5 - 10 km with an accuracy of one to two centimeters

Total station (TS):

Total station works on the same principles as that of EDM. Total station measures distances and angles with very great accuracy.

Total stations can provide angle measurement with a least count of one second (1/3600th of a degree). They are also provide with software for automatic recording and printing of measurements.

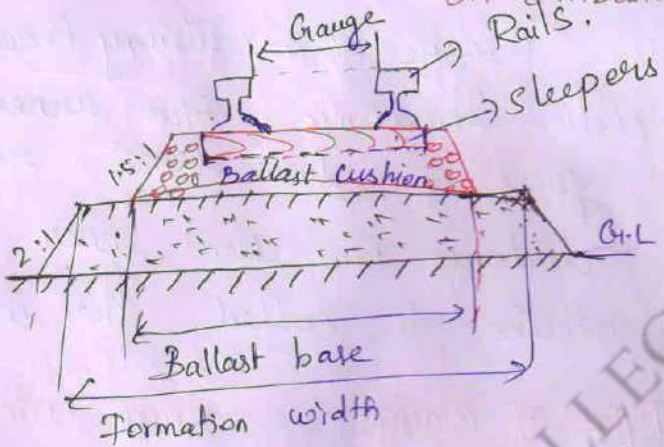
Total stations can provide angle measurement, simultaneous provide horizontal and vertical angle measurements. This reduces human intervention and eliminate human errors.

Elements of Permanent Ways:

The combination of rails, fitted on sleepers and resting on ballast and sub grade is called the railway or permanent way.

Sometimes temporary tracks are also laid for conveyance of earth and materials during construction.

Typical Cross-section of Permanent Way on Embankment.



In a Permanent way, the rails are joined in series by fish plates and bolts and then they are fixed to sleepers by different types of fastenings.

The sleepers properly spaced, resting on ballast, are suitably packed and boxed with ballast.

The layer of ballast rests on the prepared subgrade called the formation.

The rails act as girders to transmit the wheel load to the sleepers. The sleepers hold the rails in proper position with respect to the proper position with respect to the proper tilt, gauge and level, and transmit the load from rails to the ballast.

Gauges in Railway Track

Def:

The 'Gauge' of a railway track is defined as the clear distance blw inner or running faces of two track rails.

The distance blw the inner faces of a pair of wheels is called the 'wheel gauge'.

Type of Gauge	Gauge width.
Broad gauge.	(India) 1.676m 1.676m to 1.524 m 5'6" to 5'0"
Standard gauge	1.435 m to 1.451 m 4'-8.5"
Metre gauge	1.067, 1m & 0.915 m (3'-6")
Narrow gauge	0.762m & 0.610m 2'6" - 2'0"

Rails:

The rails on the track can be considered as steel girders for the purpose of carrying axle loads. They are made in high

carbon steel to with stand wear and tear. Flat Footed rails are mostly used in railway track.

Functions of Rails:

⇒ Rails provide a hard, smooth and unchanging surface for passage of heavy moving loads, with a minimum friction between the steel rails and steel wheels.

⇒ Rails bear the stresses developed due to heavy vertical load, lateral and braking forces and thermal stresses.

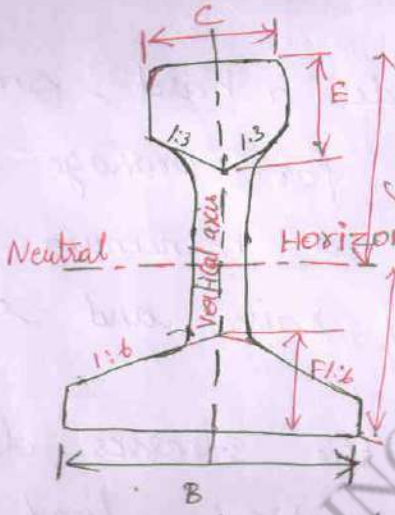
⇒ Rails transmit the loads to sleepers and consequently reduces pressure on ballast and formation below.

Types of Rail Sections:

The three types of rail sections which have been tried so far for the construction of railway track. are

⇒ Double headed rails
⇒ Bull headed rails
⇒ Flat Footed rails.

Typical Cross section of Flat footed rails.



Flat footed rails could be directly fixed to sleepers with the help of spikes.

Length of Rails.

The rails of larger length are preferred to smaller length of rails, because they give more strength and economy for a railway track.

Indian railways adopt a standard rail length of 13m for B.G and 12m for M.G. Joints are the weakest points in railway tracks.

Indian Railway adopt →

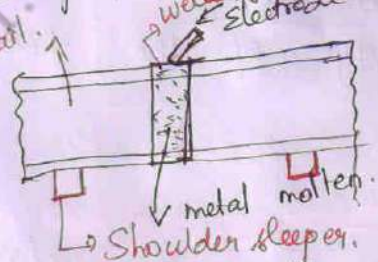
Standard rail length of 13m. for B.G
12m for M.G

Joints are the weakest points in railway tracks. However, with technological advancement, the theory of keeping gaps in joints no longer holds goods.

Welding of rail into 3 rails, 5 rails & 10 rails was started.

Short welded Rails (SWR)
Long welded Rails (LWR)
Continously welded Rails (CWR)

Welded rail have certain advantages over conventional rails. by way of cost, maitenance, reduction in creeps, increased stability.



Welded rail joint.

Sleepers :-

Sleepers are members generally laid transverse to the rails on which the

rails are supported and fixed, to transfer the loads from rails to the ballast and subgrade below. (16)

Functions of Sleepers:

⇒ To hold the rails to correct gauge.
- exact in straight and flat curves
- loose in sharp curves.
- tight in diamond crossings.

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

⇒ To support the rails at the proper level in straight tracks and at proper superelevation on curves.

⇒ Sleepers also add to the longitudinal and lateral stability of the permanent track on the whole.

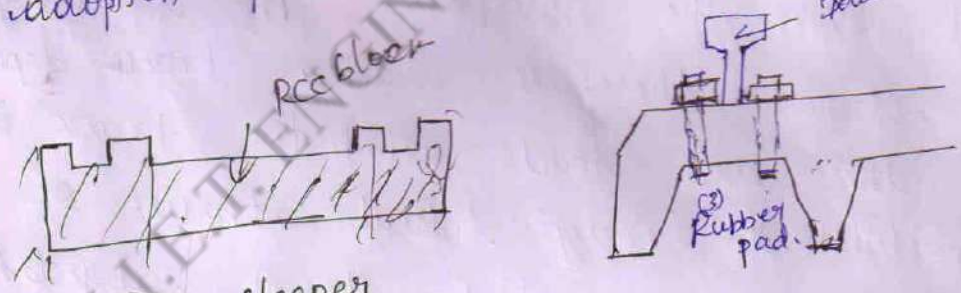
Types of Sleepers:

Sleepers can be classified according to the materials used in their construction, in the following categories

⇒ Wooden sleepers
⇒ Metal sleepers
  Cast iron sleepers
  steel sleepers
⇒ Concrete sleepers.
  → Reinforced concrete stupers
  → Pre stressed Concrete sleepers

Traditionaly wooden sleepers are wooden sleepers are easy to cut and drill. They are also cheaper.

Heavier and longer rails (CWR / CWR) coupled with economic considerations resulted in adoption of concrete sleepers.



RCC sleeper

RCC sleeper contains two block of RCC. Pre stressed concrete sleepers may be pre tensioned and post tensioned.

In post tensioned concrete sleepers, the steel is tensioned after concrete has hardened.

In the pre-tensioned type, steel is tensioned before placing concrete. In both cases, very high tensile strength is developed.

Pre-stressed concrete sleeper industries in India has very good expertise and technical know-how in design, fabrication laying and maintenance of psc sleepers.

Sleeper Density:

The space between two adjacent sleepers determines the effective span of the rail over the sleepers. The spacing of sleepers therefore, in a track depends on the axle load which the track is expected to carry lateral thrust of locomotives to which it is subjected.

Sleeper density is the number of sleepers per rail length and it is specified as (M+x or N+x), where M is the length of rail in metres x is a number, varying

according to the following factors and is fixed by the Railway Board for various axle loads.

Density of sleepers depends upon.

⟹ Methods of providing rail joints.

⟹ Speed of trains.

⟹ Maximum axle load expected on track.

Thus, if M is the length of a rail in metres, the sleeper density is expressed as M, (M+1), (M+2) ...

The number of sleepers per rail varies in India from M+4 to M+7 for main tracks.

While in America, M+9 to M+11 sleepers are used. This large no of sleepers in America is due to use of very heavy axle loads.

Ballast:

Ballast is the granular material usually broken stone or brick, shingle or kankar, gravel or sand placed and packed below and around the

sleepers to transmit load from sleepers, to formation and at the same time allowing drainage of the track. (20)

Functions of Ballast:

⇒ It transfers the load from the sleeper to the subgrade and then distributes it uniformly over a larger area of the formation.

⇒ It holds the sleepers in position and prevents the lateral and longitudinal movement, due to dynamic loads and vibration of moving trains.

⇒ It provides easy means of maintaining the correct levels of the two lines of a track and for correcting track alignment.

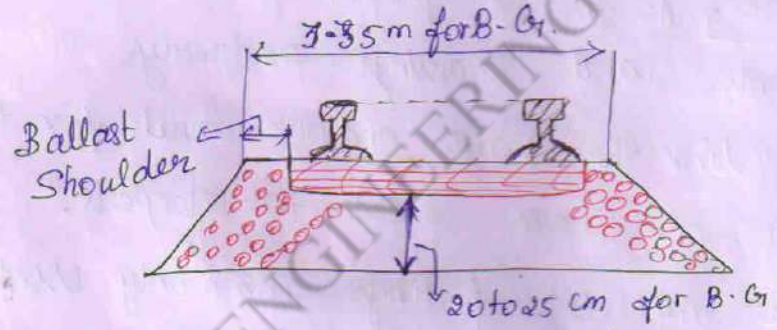
Ballast Materials:

⇒ Broken stone
⇒ Gravel
⇒ Sand
⇒ Brick bats
⇒ Blast furnace slage

Details of Ballast Sections

Dimensions	B.G	H.G	N.G
1. Width of ballast	3.35m	2.25m	1.83m
2. Depth of ballast	20 to 25cm	15 to 20cm	15cm
3. Quantity of Stone ballast per Metre length	$1.036 m^3$	$0.71 m^3$	$0.53 m^3$

Ballast Sections for Railway Tracks



For curves with super elevation, the quantity of ballast is slightly more, because as per the Indian standards, recommended depth at level is provided under the inner edge of the sleeper.

Speed, Sleeper Density and Ballast Cushion for different Category of lines

Group	Sanctioned Speed	Sleeper density	Ballast Cushion
A	160 Km/h	1660 No/Km	1600 No/km	30cm

B	130 km/h	1660 Nos/km	25 cm
C	Suburban sections of delhi, Mumbai, kolkatta	M+7 (1540 Nos/km)	25 cm.
D	100 km/h	M+7 (1540 Nos/km)	20 cm
E	< 100 km/h	M+7 (1540 Nos/km)	15 cm.

Rail Fixtures and Fastenings :-

Track fittings and Rail fastenings 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.

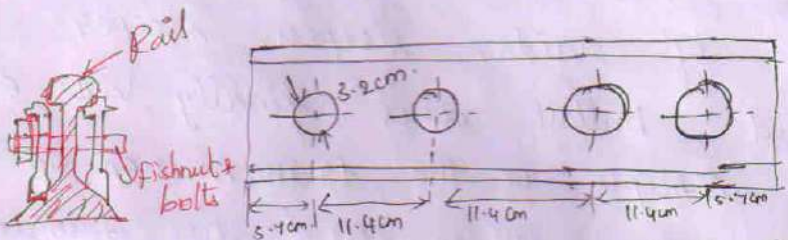
The important fittings commonly Used in a permanent way are the following :-

- Fish Plates :-
- Spikes
- Bolts
- Chairs
- Blocks
- Keys

Fish Plates :-

Fish plates are Used in rail joints to maintain the continuity of the rails

and to allow for any expansion or contraction of the rail caused by temperature variations.



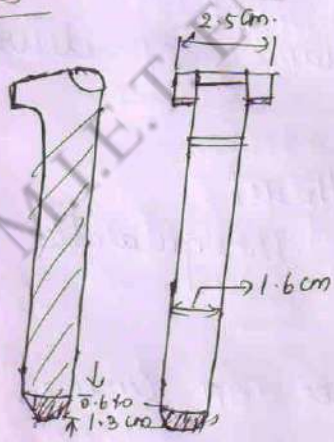
Fish Plates with Rails (longitudinal section).

Spikes

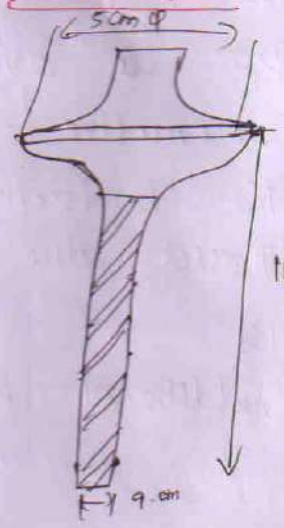
For holding the rails to the wooden sleepers spikes of various types are used.

- → Dog spikes
- → Screw spikes
- → Round spikes
- → Standard spikes.

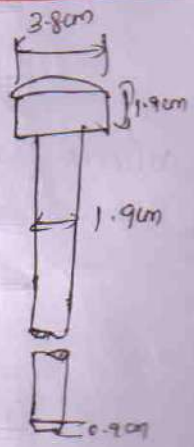
Dog Spikes



Screw spikes



Round spikes



Track Stress:

A railway track is a composite structure which consists of rails, sleepers, sleeper fastenings and ballast and finally rests on the sub-grade. Concepts of the transmission of pressure through a railway track are founded upon the principles of elasticity modified by simplifying assumptions and test results.

Track stresses:

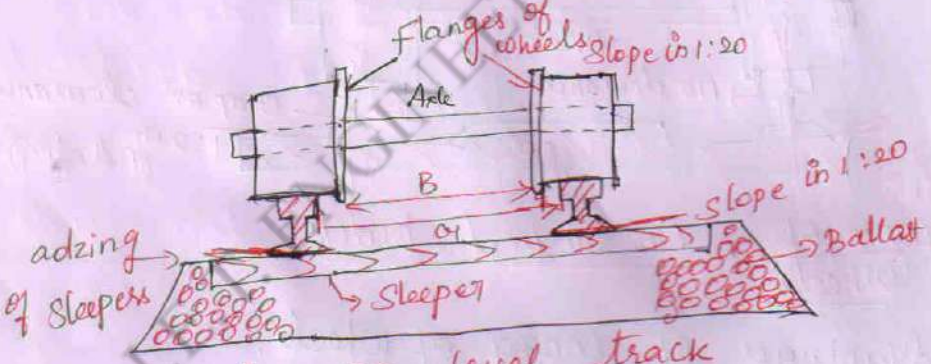
Stresses in railway track are produced due to many causes listed below:-

- ⇒ The wheel loads
- ⇒ The dynamic effect of wheel loads
- ⇒ Due to overbalance of driving wheels of locomotive.
- ⇒ The horizontal thrust.
- ⇒ Stresses due to irregularities of the tracks
- ⇒ Additional stresses on curves.

Coning of wheels:

Wheels are shaped like a cone or made as a conical segment. The distance between the inside edges of wheel flanges is generally kept less than the gauge of the track.

Normally the tread of wheels is absolutely dead centre of the head of the rail, as the wheel is coned to keep on Keep it in this central position automatically These wheels are coned at a slope of 1 in 20



Coning on level track

Coning of wheels

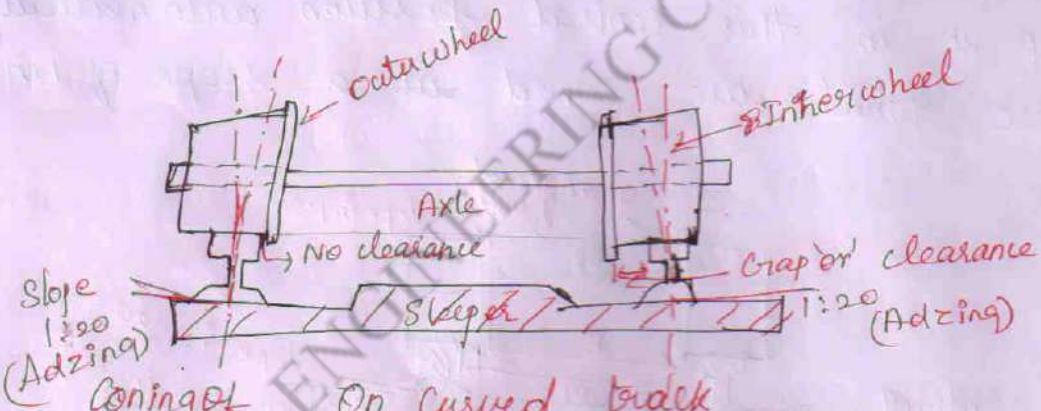
Purpose of coning of wheels:

⇒ It helps outer wheels to travel longer distance than inner wheels and helps to negotiate curves smoothly.

⇒ Wheels generally remain central on a straight track. However, when vechicles move on a curved track, the outer wheels move outward due to centrifugal force

⇒ It reduces slipping and skidding of wheels.

⇒ It gives smooth riding.



Coning of Wheels On Curved track

Disadvantages of Coning of wheels:

⇒ Pressure of horizontal component near the inner edge of rails has a tendency to accelerate wearing of rails.

⇒ It tends to turn rails outwardly and consequently, the gauge is widened.

Canting Of Rails:

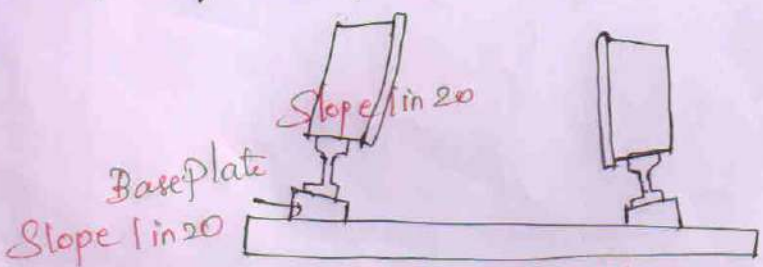
In order to minimise eccentric loading at inner edge due to coning, rails are tilted towards. This is called Canting of rails

The most common method adopted for tilting of rails is to use inclined base plates. Tilting helps to maintain gauge properly.

Adzing Of Sleepers:

Due to coning of wheels, pressure from wheels is always towards inner edge of rails. This tends to accelerate wearing of ~~same~~ rails slope. For this purpose, Wooden sleepers are cut at top under rail seats.

Cutting of top of the sleepers to provide tilting of the rail is known as adzing of sleepers.



Cant in railway track.

UNIT-II - Railway construction and Maintenance.

Earthwork - Stabilization of track on poor soil - Tunneling methods, drainage and ventilation - calculation of materials required for track laying construction and maintenance of tracks - Modern methods of construction & maintenance - Railway stations and yards and passenger amenities - Urban rail - Infrastructure for Metro, Mono and underground railways.

Earthwork and consolidation:-

(i) construction of formation
(ii) Height of embankment above highest water should be atleast 60cm.
(iii) Economical limit of moving the earth in long direction is decided by mass Haul curve.

cost depends on:-

(i) Type of soil used
(ii) Hauling distance
(iii) Lift required.

Purpose of consolidation is pack the track, so that larger quantities of stone ballast are not lost by sinking into loose earth formation.

After completion of embankment, small earthen walls are built of 15cm high and across the edges of formation at an interval of

Tunneling methods:-

Necessity of Tunnels:-

(i) Reduce the length of the railway line and also economical.

(ii) The use of tunnel under a river bed is often economical and convenient than providing a bridge over the river.

(iii) The costs of excavation for providing an open cut in a mountain are excessive and maintenance costs are also high. It is therefore, better to use a tunnel.

Size and Shape of Railway tunnels:-

The size of the railway tunnels depend upon whether it has to carry a single line (or) a double railway line.

Polycentric (or) horse shoe type sections are commonly used for railway tunnels.

It represents a compromise between polycentric and circular sections and has become extensively popular due to its simplicity in construction.

After fixing size, shape and ends of the tunnel, its centre line should be located exactly on ground to find the exact length of the tunnel.

The following operations are involved in the survey work for the

(i) Locating the centre line on the ground.
(ii) Transferring centre line to the inside of tunnels
(iii) Providing the required grade at the bottom of tunnel
(iv) checking tunnel c/s details as per requirements

Tunneling methods in rocks differ from that of soft ground tunnel construction in the following aspects:
(i) The operation of tunneling in rock is costly.
(ii) in rocks, for drilling and ~~drafting~~ blasting, it requires a power plant to operate machinery and excavating tools.
(iii) cutting operation in rocks is very expensive.
(iv) Rocks being self supporting, require less timbering for supporting.

Methods of tunnel construction in rocks:-
For tunnel driving in rocks, the following operations are involved.
(i) Setting up the section of tunnel and drilling.
(ii) Loading of holes and shooting of explosive.
(iii) ventilation and removing dust of explosion.
(iv) Loading and hauling of muck.
(v) Removal of ground water (if any)

sides and roofs if necessary.

(vii) Placing reinforcing steel if required.

(viii) Placing of concrete lining.

(i) Full Face method:-

The whole section of the tunnel is attacked at the same time. It is suitable for tunnels of same C/S area say upto 8m diameter.

This method is frequently used for larger diameter tunnels also.

(ii) Heading and Bench method:-

(i) This method involves the driving of the top portion in advance of the bottom portion.

(ii) It is used when tunnel section is very large and quality of rock is not very satisfactory.

(iii) Drift method:-

Rock tunneling is sometimes carried out first in smaller section of the proposed tunnel and then widened. The method is called drift method

A drift may be classified as centre, bottom, side (or) top drift depending upon its relative position with reference to the main bore

Drilling and Blasting of Rocks:-

Most commonly used drill in tunnelling is the drifter equipped with

that can be used are the following Types:-

(i) Percussion Drills.
(ii) Abrasion Drills.

Types of Explosives:-

A variety of explosives are available to meet particular requirement some common type of explosives are the following.

(i) Power Explosives
(ii) Disruptive Explosives
(iii) Liquid Air.

Methods of tunnel construction in soft ground:-

It depends upon the following factors

(i) Size of tunnel
(ii) Type of ground
(iii) Available equipment, machinary and tools.
(iv) Method of excavations.

The tunneling in soft ground broadly involves the following operations.

(i) Mining (or) Excavation,
(ii) Timbering (or) Strutting the excavated section.
(iii) Mucking removal of excavated materials
(iv) Placing of lining.

(a) methods requiring use of timbers:-

(i) Forepoling method, (ii) Needle beam method.
(iii) Belgian method, (iv) Austrian method
(v) American method, (vi) English method

(b) Other methods:-

(i) Linear plate method,
(ii) Shield method
(iii) Compressed air method.

Ventilation and Drainage for tunnels

The use of drilling machine, detonators, large explosive charges, loading machine, dust etc, require the provision of an efficient system for ventilation in view of the large no of men working at the tunnel face.

The most efficient ventilation system relies upon a combination of blower and exhaust fan.

Immediately after blasting, exhaust system is used for 15-30 mins. to drive smoke and dust.

Drainage:-

In tunnel driving, control of water consists of the following two operations

(i) Prevention of excess quantities of water, entering the tunnel.
(ii) Removal of water that enters the tunnel

The ground water can be removed by either.

(i) open ditch drainage system (or)
(ii) By pumping system

Railway Construction:-

First Stage - Earthwork → Formation and consolidation.

Second Stage - plate laying → laying of a railway track.

Third Stage - laying of ballast on track.

Second Stage (plate laying).

Operation of laying out the rails and sleepers over ready formation is known as plate laying.

The point where laying of track starts is known as base and point upon which the new track is carried out is known as rail-head.

Methods:-

(i) Tramline method (or) Side method.
(ii) Telescopic method.
(iii) American method.

Third Stage - laying of ballast:-

(i) Taken up after two (or) three monsoons.
(ii) Loaded in wagons and transport to site unload etc. no of heaps at suitable interval.
(iii) Packing of ballast.

Materials required per 'Km' of Railway track:-

An Engineer-Incharge should work out the exact quantities of all the materials required for the proposed railway track.

The excess materials will lead to

may delay the work. The exact quantities of various materials are calculated as follows for one Km track.

(i) Rails:-

$$\text{No of rails per Km} = \frac{1000}{\text{length of rail in m}} \times 2$$

For B.G when rail length = 12.8m.

$$\therefore \text{No of rails per Km} = \frac{1000}{12.8} \times 2 = 156.2$$

$$= 157.$$

(ii) Weight of rails in tonnes per Km:-

$$= \text{No of rails} \times \text{length of rail in m} \times \frac{\text{wt of rail in kg/m}}{1000}$$

$$\therefore \text{Weight of rails per Km} = \frac{157 \times 12.8 \times 44}{1000}$$

$$= 90 \text{ metric tonnes}.$$

Sleepers:-

$$\text{No of sleepers per Km} = \frac{1}{2} \times \text{no of rails per Km} \times (M + a)$$

where,

M = Length of rail in 'm'

a = Density factor.

Sleeper density = (M + a).

a = Density factor, is any no. which when added to a length of rail, will give sleeper density.

In India a = 4, 5, 6 or 7.

For B.G 12.8m rail length and a = 4

$$\text{No of sleepers per Km} = \frac{157}{2} \times (12.8 + 4)$$

$$= 1276$$

Fish plates:-

No of fish plates per km of track
= 2 x No of rails per km.

when, no of rails per km = 157 for BG.

No of fish plates per km of track
= 314.

Fish bolts:-

No of fish bolts per km of track
= 4 x No of rails per km.

when no of rails per km = 157 for BG

= 4 x 157 = 628.

Bearing plates:-

No of plates per km of track depends upon design.

No of bearing plates per km of track is = 2 x No of sleepers per km of track.

= 2 x 1319 = 2638 Nos.

(or) = 4 x No of rails per km of track

= 4 x 157 = 628.

Dog spikes:-

For use with timber sleepers.

No of Dog spikes per km of track
= 4 x No of sleepers per km of track

= 4 x 1319 = 5276.

Maintenance of track:-

Necessity:-

(i) Strength of track structure gets deteriorating.

(ii) other deteriorating effects like rain water, action of sun and wind.

surface levels of rails.

Therefore it is essential to maintain the track in good condition so that it may run over it safely.

Classification:-

(i) Daily maintenance

(ii) Periodic "

Daily maintenance:-

It is carried out by the year. The railway track is divided in suitable sections of 5 to 6 km length. one gang is allotted for each section.

Periodic maintenance:-

It is carried out after an interval of 2 (or) 3 years. It includes the maintenance of

(i) Surface of rails:-

In this the top surface of two rails should be maintained properly on straight lengths. It involves the following operations.

(i) Packing, (ii) Surfacing the track

(iii) Boding and dressing the track

(iv) Levelling of the track

(v) Lifting of the track

(vi) Surface defects and remedies.

(vii) Spot packing and track lifting.

(ii) Track Alignment:-

If the track goes out of alignment due to following causes,

(i) Increased hammering action of wheels.

(ii) Variation of centrifugal force by

temperature variations in hot weather. thermal stresses and heavy creep of rails.

The checking of perfectness of alignment is made either through eyes (or) by instruments such as theodolite and string line method.

(iii) Gauge :-

The variations in the gauge may occur due to the following case.

(i) Loosening of track fittings.
(ii) Widening of gauge
(iii) Keys are not tight
(iv) loose fittings lack of attention to packing.

It can be maintained by tightening of track fittings and proper maintenance of correct joints, creep, anchor etc.

(iv) Maintenance of Proper Drainage :-

It can be achieved by,

(i) clearing of ballast
(ii) clearing of weeds
(iii) clearing of cess
(iv) Provision of surface drainage and underground drainage.

(v) Maintenance of track components :-

Renewal of rails and sleepers.

It can be done by,

(i) Spot renewal, (ii) Through renewal.

(vi) Maintenance of Fittings :-

Graphiting of fish plates :

It is done for the following purposes.

(i) To protect the fish-plates against corrosion.

(iii) To increase the life of fish plates and bolts.

(vii) Maintenance of points and crossings:-

(i) Gauge should be perfect at all places

(ii) Creep should be prevented.

(iii) Periodic displacement of sleepers should be corrected.

(iv) Proper tightening of bolts should be done daily.

(v) Ballast should be repacked and screened periodically.

(vi) Fouling mark should be cleaned and painted.

(viii) Maintenance of Level crossings:-

(i) Rails and fittings should be tarred once a year.

(ii) Area of crossing should have wear bound macadam (or) bituminous pavement.

(ix) Maintenance of Tunnels:-

(i) Track materials should be examined for corrosion.

(ii) Ventilation should be clear of any obstruction.

(iii) Light arrangement in the tunnel should be checked.

(iv) Level and alignment and its approaches should be checked.

(v) Portals at the ends should be checked.

Modern methods of construction:-

India, max speed - 130 Km/ph.

For achieving speeds higher than 250 kmph conventional track replaced by a new ballast less track consisting of concrete slabs fastened to rails with elastic fastening.

Modernization of existing track:-

Development of super high speeds:-

(i) Limitations of super high speeds.
(ii) Power requirement for different speeds
(iii) Concepts for developing high speeds.

Limitations of super high speeds:-

(i) Wave formation
(ii) Adhesion between wheel and rails
It decrease with increase of speed of vehicle.
(iii) Vibrational limitations
(iv) Special problems on curved track

Power requirement for different speeds on straight track:

(i) Resistance to movement,

$$R = 2.8 + 3\left(\frac{V}{100}\right)^3 \text{ Kg/ tonne.}$$

(ii) Value of specific power,

$$P = 6V + 0.817\left(\frac{V}{10}\right)^3.$$

(iii) Resistance on gradient 'j' (per thousand)

$$R = 2.2 + 3\left(\frac{V}{100}\right)^3 + j$$

(iv) Specific power in watt (P)

$$= (6 + 2.78j + 278f)V + 0.817\left(\frac{V}{10}\right)^3.$$

Concepts for developing high speeds:-

(ii) Linear motor and Air cushion vehi
(iii) Gas turbine and Air cushion (tracked air cushion vehicle).
(iv) Magnetic levitation vehicle (MAGLEV)

Modernization of track for high speed

Structural (or) Strength requirements of track components:-

(i) Rails and Rail joints
(i) Section should be heavy.
(ii) Economical, strength, stiffness & durabi
(iii) Weight 60kg/m and 52kg/m.

(ii) Sleepers:-
(i) CST-9 and CST-13 are used for high speed track
(ii) Having high sleeper density.

(iii) Fastenings and Fittings:-
Use of elastening fastenings for greater stability and it have the follo characteristics:
(i) Maintain correcte uniform gauge.
(ii) Held the rail in position
(iii) Enough resistance
(iv) Economical and require less maint

Types:-
(i) Pandrol clip
(ii) Pandrol clip with wooden sleepers / steel sleepers
(iii) Pandrol clip with C.C sleepers, concre sleepers.
(iv) Spring steel clip
(v) Sigma clip
(vi) ZRN -202 clip
(vii) Lock spike
(ix) Double shank elastic spike.

(iv) Ballast:
(i) Adequate in thickness
(ii) Proper gripping to sleepers.
(iii) Proper tamping and consolidation.
(iv) Enough resistance
(v) Min thickness 25cm and 27cm.
(vi) Shoulder width - 35cm (straight)
50cm (curves)
(v) Formation:-
(i) Increase in depth of ballast
(ii) Increase density of sleepers.
(iii) Increase section of rail and no of sleepers.
(vi) Track Assembly:-
(i) Check the stability of materials design and fittings.
(ii) Proper joints and periodic checking.
LWR give more safety, efficiency and economy compared to conventional fish, jts. track
(vii) Points and crossings:-
(i) Speeds limited on turn outs
(ii) Use manganese cast steel for crossings.
(iii) High cant defeciency rather than no S.E on turnouts.
(viii) Economic design of modern track:-
Balance in design of track, locomotive type, steam, Diesel (or) Electric goods.
(i) Rail Requirements → quality and stress sustainability
(ii) Wheel dia, and Axle loading.
(iii) Fastenings, weight of sleeper.

Modern methods of track maintenance

The following are the main modern methods of track maintenance

(i) Mechanized Maintenance (or) Mechanical tamping
(ii) Measured shovel Packing.
(iii) Directed Track Maintenance.

Methods of Mechanical Tamping :-

(i) Off track Tamping
(ii) On " "

Off track tamping :-

These are portable and can be taken off the track within a short period of time are used.

It requires no blocking of the traffic

Types :-

(i) Self contained (Percussion type, Vibratory type).
(ii) Off track tampers worked from a common power unit.

On track tamping :-

These are self propelled vehicles, used to tamp the sleepers automatically through various controls provided in the operator's cabin.

Automatic aligning, lifting, cross and longitudinal levelling and packing are simultaneously possible.

Types :-

(i) Light on track tampers
(ii) Heavy " "

Measured Shovel Packing :-

In this method, unevenness and voids are accurately measured, the track is lifted by means of jacks and measured quantities of small broken stone chippings are placed under the sleeper, to bring the track to the predetermined level.

Directed Track Maintenance (DTM)

It is a method to maintain the track as directed by day to day requirements but not as prescribed routine.

It is also called as Track Maintenance System (or) TMS. It consists of 3 stages.

Railway Stations :-

Place where trains are halt

(i) For exchange of passengers.
(ii) Exchange of goods.
(iii) control of train movements
(iv) enable the route
(v) For detaching engines.

Site selection :-

(i) Acquisition of land
(ii) Proximity to town (or) village.
(iii) Nature of land area.
(iv) Approach road to station site
(v) Station site alignment
(vi) site drainage
(vii) Station Amenities.
(viii) Type of station and yard.
(ix) Role of authorities.

Requirements :-

(iii) Train requirements.
(iv) Requirements of locomotives.
(v) Requirements for development of railways.

Operational classification:-

(i) Block stations:

place on railway line at which "permission to approach and authority to proceed are granted.

(i) A class station - (400m from home sig
(ii) B class station → (530m " " ")
(iii) C class station - block hut (where no passengers are booked)

(ii) Non block stations:

It is also called D class (or) flag Stations situated bwn two consecutive block stations.

Special class stations:

Stations not covered under A, B, C and

Functional classification:-

(i) Non junction (or) way side stations -

Arrangement for crossing up and down train for overtaking the slower moving trains.

Three ways:

(i) A way side station on single line
(ii) " " " on double line
(iii) " " " on triple line

(ii) Junction Stations:-

branch line joins a main line the following arrangements to be made

(i) Interchange of traffic bwn main

(ii) Engine should be released for servicing.

(iii) Terminal stations / Junctions:-

Stations at which a railway line (or) branches terminate (or) continuity of a line stops is known as terminal station.

It provides facilities like servicing of engines and vehicles, reversing of engines are provided.

Platforms:-

Raised level surface, where passengers board, and loading and unloading of goods is done.

Types:-

(i) Passanger platform.

(ii) Goods platform

Length of platform depends on longest train running on that platform.

Station Yards:-

System of tracks laid on level within defined limits, for receiving, storing, sorting, making up new trains and despatch of new trains.

(i) Passanger bogie yards:-

Safe movement of passangers and vehicles.

(i) Goods yards:

Receiving, loading, unloading, delivery of goods and movement of goods vehicles.

(ii) Marshalling yards:-

Machine to receive, break up, reform and despatch train onwards.

In otherwords where trains and other

Types!-

(i) Flat yards, (ii) Gravitational yards
(iii) Hump yards.

Locomotive yards!-

Locomotive are housed and all the facilities for coaling, watering, repairing oiling, cleaning etc are provided for servicing and stability.

Passanger Amanities!-

As stations and their environments are the first point of contact bwn Railways and their customers; special importance is required to be given to the facilities provided to passangers in regard to their adequacy, quality and maintenance

While planning for provision / augmentation of stations, due considerations needs to be given to the importance of station from point of view of passanger traffic

Facilities :-

(i) Booking offices.
(ii) Waiting Halls
(iii) Platforms
(iv) Shady trees on platforms.
(v) Lighting
(vi) Drinking water supply.
(vii) Latrines, Urinals and Dustbins.
(viii) Platform covers.
(ix) Foot over Bridges (or) Sub ways.
(x) Waiting Rooms.

(xii) Vending Trollies / Stalls
(xiii) Retiring Rooms.
(xiv) Facilities for physically Handicapped.
(xv) Station Name boards.
(xvi) Platform sign Boards.
(xvii) Timetable Boards and Fare lists
(xviii) Pictogram.
(xix) Station Buildings
(xx) Approach Roads and circulating Area.

Urban rail:-

Urban rail transit is an all encompassing term for various types of local rail systems providing passanger service within and around urban (or) suburban areas. The set of urban rail systems can be roughly subdivided into the following categories.

(i) Tram:-

A tram, street car (or) trolley system is a rail based transit system that runs mainly (or) completely along streets with relatively low capacity and frequent stops.

(ii) Light rail:-

A light rail system is a rail based transit system that has higher capacity and speed than a tram. It operation is right of way seperated from automobile traffic.

(iii) Rapid transit:-

A rapid transit system is a railway

and full grade separation from other traffic (including other rail traffic).

It is also called underground, subway, tube, elevated, metro (or) mass Rapid Transit (MRT).

(iv) Monorail :-

A monorail is a railway in which the track consists of a single rail, as opposed to the ~~original~~ traditional tra with two parallel rails.

(v) Commuter rail :-

A commuter rail, regional rail, s urban rail (or) local rail system oper on mainline trackage which may be shared with intercity rail and freig trains.

(vi) Funicular :-

A Funicular is a cable driven incl railway that uses the weight of desc cars to help pull the ascending cars slope.

(vii) Cable car :-

A cable car in the context of r Transit is a system using rail cars are hauled by a continuously moving running at a constant speed.

Individual cars stop and start by releasing and gripping this cable as required.

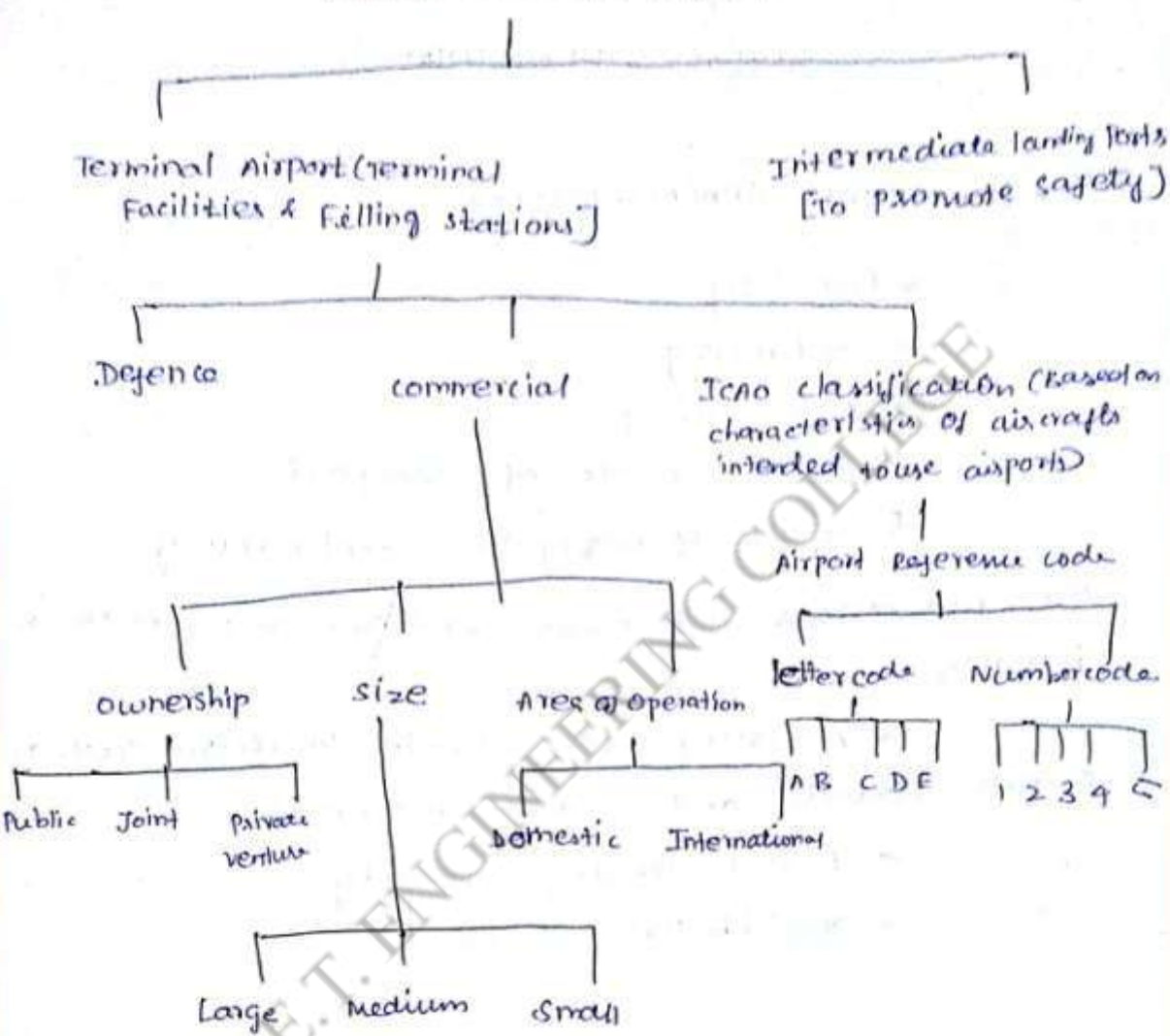
UNIT - III

AIRPORT PLANNING:

AIR TRANSPORT CHARACTERISTICS:

* Rapidity
* continuity
* Accessibility
* Fastest mode of Transport
* capable of navigating continuously over mountains and ocean without any break in jousney.
* Accessing even remote locations such as Forests, islands and snowed mountains
* Lesser carrying capacity
* Prohibitive costs

AIRPORT CLASSIFICATION:



Airport planning:

Airport planning refers to preparation of a scheme beforehand for development of airports. Requirement of airport is to ensure safe and speedy transport of air travel passengers. It has to facilitate reception & departure of aircrafts with least possible delays

OBJECTIVES OF AIRPORT PLANNING:

* Justify the need for an airport
* Formulate a layout plan for the airport and design of runways, taxiways and airport buildings.
* Prepares cost estimation
* Propose institutional arrangements.

Components of airport Planning:

* Assessment of Traffic potential
* Site selection
* Design and drawing of airport components
* cost estimation
* Financial resources
* Evaluation of economic Viability, Engineering Visibility & environmental impact
* Institutional Arrangement

Good Airfield Layout characteristics:

* Landing, Takeoff and Taxing - Independent operation
* Shortest Taxiway
* safe runway length
* Safe Approaches
* Excellent control Tower visibility

* Adequate landing Apron space.
* Adequate Terminal Building facilities
* Land area for future expansion
* cost effective construction, maintenance and operation

Socio Economic characteristics of catchment areas:

(i) Assessment of Traffic potential;

Assessment of Traffic potential for a Proposed airport interms of panenger and cargos is a crucial element in establishing the need for an airport. The first step in assessment of Traffic potential is to delineate catchment area of the proposed airport in the national network of airports After demarcation of imaginary influence area, socio economic characteristics of population are studied.

ii) population:

* Total population
* Rate of growth of population.
* Estimation of future population.

iii) Economic characteristics:

a. Pattern of employment - Industries, Business, Government, Private, others.

b. Income group - Composition of families under high income and middle income group.

c. Average Per capita income of Persons in income groups of HIG and MIG

d. Pattern of expenditure - Proportion of expenditure for different items and more particularly for travel.

iv) Travel characteristics:

* Frequency of air travel
* Modal choice.

site selection for Airports:

Site selection is a critical element in airport Planning. Efficiency, safety and capacity of airports to a great extent depend on suitability of sites.

Factors influencing Size of Airport:

* Type of an airport i.e) domestic or international or defence. Size of an airport depends up on whether it is an international or domestic one.
* Traffic potential of an airport region.
* Aircraft characteristics such as aircraft capacity, aircraft speed, minimum circling radius, minimum turning radius, noise level and take off and landing distances.
* Site characteristics such as topography and land availability

Design and drawing Of Airport Components:

Airport Planning involves the Preparation of following plans

* Topographical Plan
* Layout Plan
* Design of Taxiway, runway & buildings
* Vehicular circulation and parking area plan.

Topographical Plan:

It includes all man made & natural features on a site, besides boundaries of the site.

Boundaries of cleared and graded area, contour lines and acces roads are marked on the topographical plans. Width for which features are incorporated depends upon the type & size of airport.

Layout plan:

It is the process of laying out various elements in a system. It is the manner in which various elements are arranged An airport layout plan shows the various positioning of components of airport.

* Airport landing area - Approach zone
* Airport Terminal area - Runway, Taxiway, Apron, Airport building, vehicular parking area, Airport road network.

Design of Runway:

* Runway orientation
* Length of runway
* Runway width
* width & length of safety area
* Transverse gradient
* Longitudinal & effective gradient
* Rate of change of long. Gradient
* sight distance
* Design of runway Pavement

ICAO stipulations

Federal Aviation agency (FAA) and International Civil Aviation organisation (ICAO) have stipulated norms for various parameters

1) Regional plan;

A region is a larger area consisting of cities, towns and villages. The ICAO stipulates a min. distance of separation b/w airports.

Regional plan is studied to ensure that the proposed airport forms part of the regional network of airports. Min separation is essential from operational & effective potential consideration.

Minimum spacing as per FAA:

Smaller airports under VFR conditions - 3km
Bigger airports " " " - 6km
Airports operating piston Engine aircrafts - 25km
" " Jet " " - 160km

2) Types of airports:

The site suitability depends upon the type of proposed airports such as commercial, domestic international or defence. In case of

airports for defence, special requirements are provided such as natural cover from air raids, sites with thick bushes.

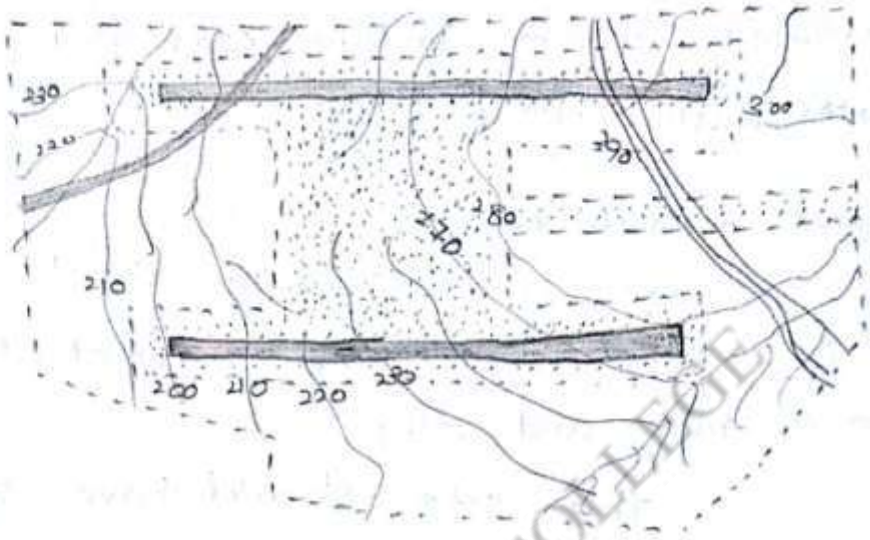
Ground Accessibility:

Location of a site should be such that it is easily accessible by different modes - road, rail and water.

The site should have strategic locations abutting national highway/ Arterials, close to railway stations and harbours/ports. This provides quick access and reduces the time taken for surface travel.

Topography:

It is the description of natural and man made features. It refers to natural features such as ground contours, water bodies, hillocks, forests, bushes, trees and man made features such as Pattern of land use, intensity and height of building An elevated site is considered ideal for an airport.



Graded Area
Boundary cleared Area
Runway
Boundary Airport
Property
Stream Road
~120~ contour
Pole line
Building.

Advantages of Elevated site:

Less obstruction in approach & turning zones

Natural Drainage

Uniform wind intensity

Better visibility.

Soil characteristics:

A site with better soil characteristics is prefarable because it reduces cost of grading, drainage, construction and maintenance. soil containing reasonable composition of

Pervious materials like gravel or sand with a suitable natural binder is considered desirable. A site with expansive soil like clay is considered unsuitable.

Properties of ~~runway~~ soil as runway Material:

* Stability
* Strength
* Minimum change in volume & stability under adverse condition.

Index Properties

* Grain size distribution
* liquid limit
* Plasticity index.

Meteorological Factors:

i) Wind:

Landing & Take off operations take Place in head wind.

wind data greatly influence the site selection.

wind data on direction, duration & intensity are collected atleast for 10 years for available sites and ~~favourable~~ Place which has favourable wind has chosen

Frost and Fog:

Any site selected should be free from fog, frost and smoke.

Fog generally settles in area like valley where wind blow is less.

Smoke exists at sites nearer to industrial areas.

The site located on the leeward direction should be preferred than that on windward direction.

Trend of future development of industries should also be studied and sites should be chosen accordingly.

Temperature:

Temperature influences runway length. Increase in temperature results in decrease in air density

Aircraft requires longer runway in a particular direction.

Sites with temperature at or closed to standard temperature are preferred.

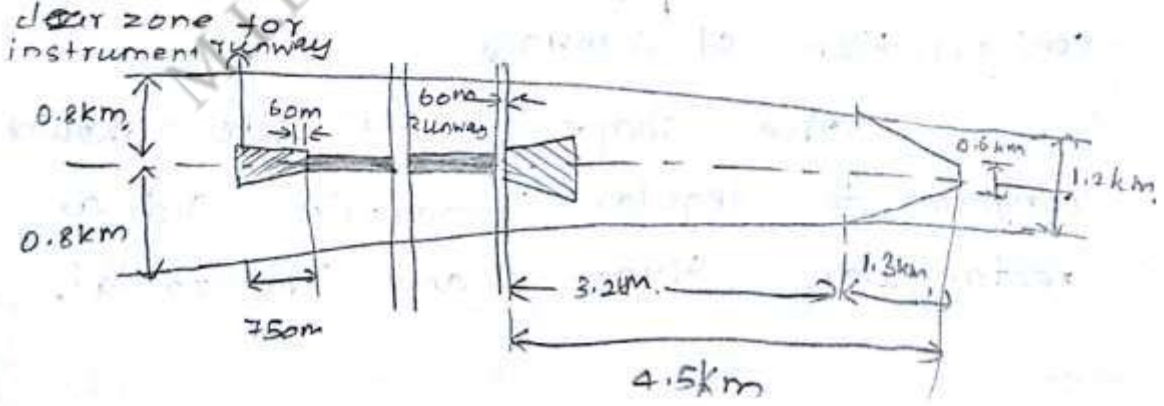
Noise nuisance:

Proximity of airports to areas of human habitation, residential areas & institutional areas such as Schools, hospitals should be avoided.

Intensity of noise nuisance depends upon climb-out paths of aircrafts, types of engines propulsion and gross weights of aircrafts.

A site which is not marked by any developments in general and residential developments in particular is Preferred.

It is practically not possible to provide a buffer zone, acoustic barriers have to be installed.



Buffer zone for noise mitigation.

Onsite and off site infrastructures:

* It refers to basic facilities such as Water supply, Sewer network, electricity communication and roads.

* In case these facilities are not available onsite or off site they may have to be developed exclusively for airports, it may add to the cost of projects

* sites for which facilities are already available should be selected than those which are in isolation or away from existing cities.

shape and dimension of a site:

shape of an airport depends upon the type and class of an airport, prevailing wind direction and configuration of runways

The shape of the site should conform to regular geometrics such as rectangular, square and Trapezoidal.

Scope for future expansion:

Area of a site selected for an airport should be more than that stipulated by ICAO.

It should be adequate not only to meet present demand but also future requirements by way of more number of runways, aprons, terminal buildings, vehicular parking and horizontal expansion to meet future air travel demand.

Comprehensive Evaluation:

A comparative analysis of alternate sites is done with reference to economic viability, environmental impact, technical feasibility, social & political acceptability.

A multi criteria technique is adopted to integrate various evaluation elements ~~such as~~ and arrive at a composite score.

Based on composite score, the best site among alternatives is chosen.

Typical Airport layout:

Runway is the principal element of an airport.

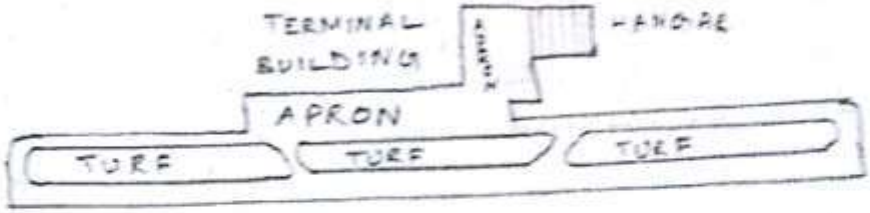
All other components of airports should have good correlation with runway.

Integration of all elements makes efficient and effective airports

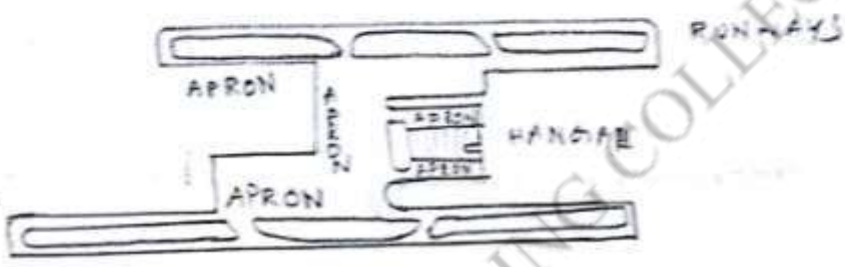
Requirements of well planned airports are

* optimal route from the apron to the runway through the taxiway.
* control tower with a command over entire airfield.
* optimal service to air passengers.
* cost effective construction & maintenance.
* Scope for future expansion

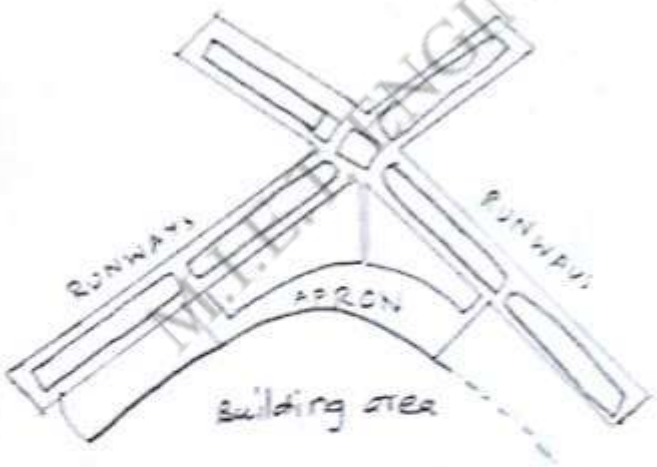
a) single Runway layout.



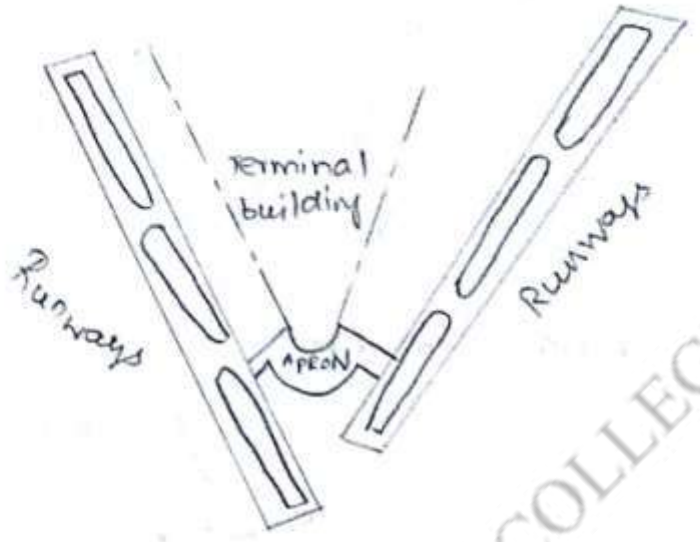
b) Open runway concept.



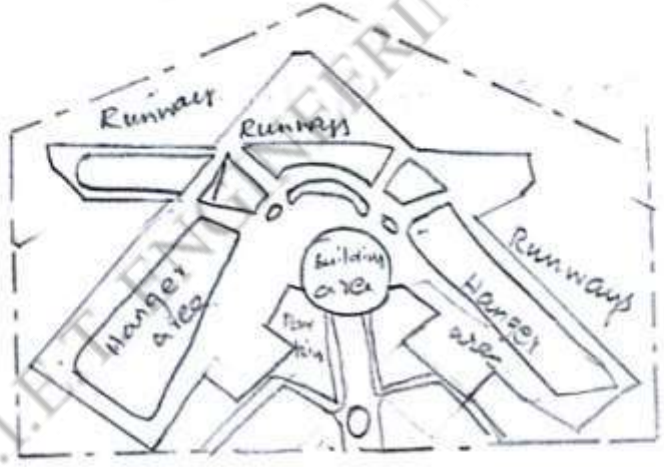
c) Offset Parallel concept:



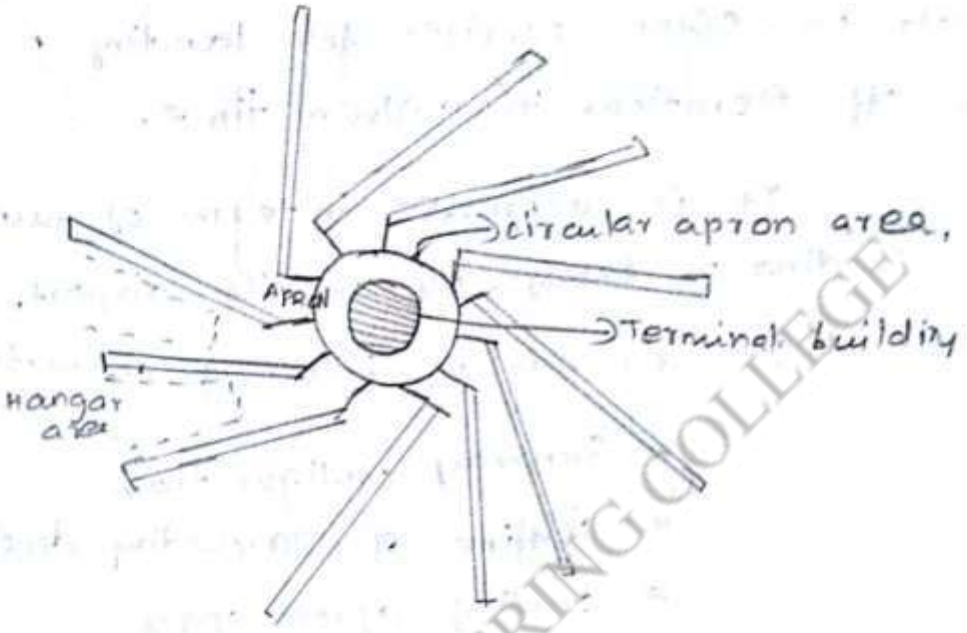
Non intersecting runways.



Three intersecting Runways:



Tangential Runway layout:



Conceptual layout pattern:

Pattern of airport layouts is determined by configuration of runways Secondary elements such as apron, taxiway, Terminal building are positioned ~~under~~ based on orientation of runway.

Airport capacity:

It refers the ability of an airport to offer services for landing / Take off operations in a given time.

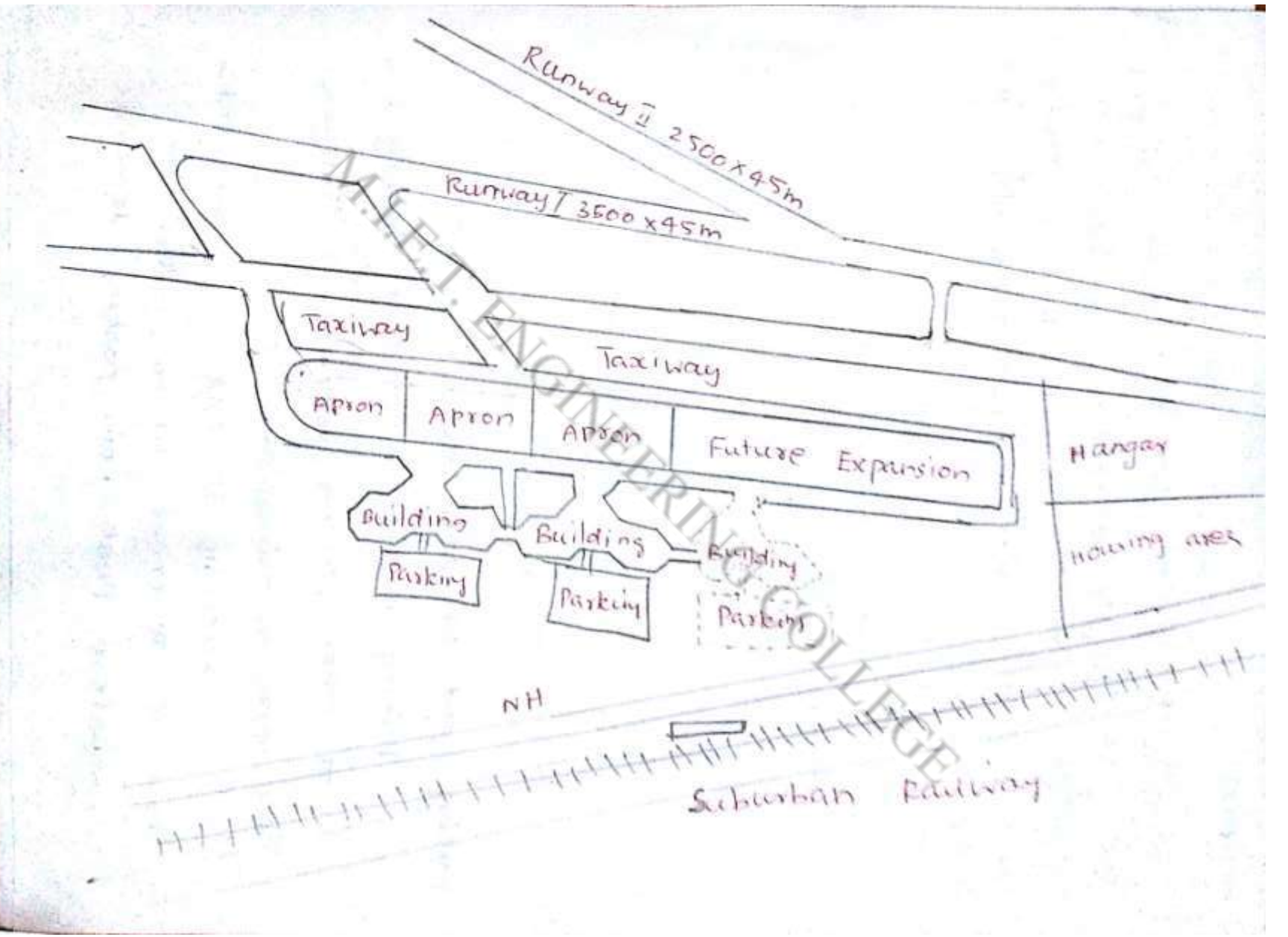
It is expressed in terms of number of landing or taking off in the airport.

It depends on following characters

* Runway configuration
* Skyline of surrounding development
* Loading apron space
* Type of Instrument - landing system.

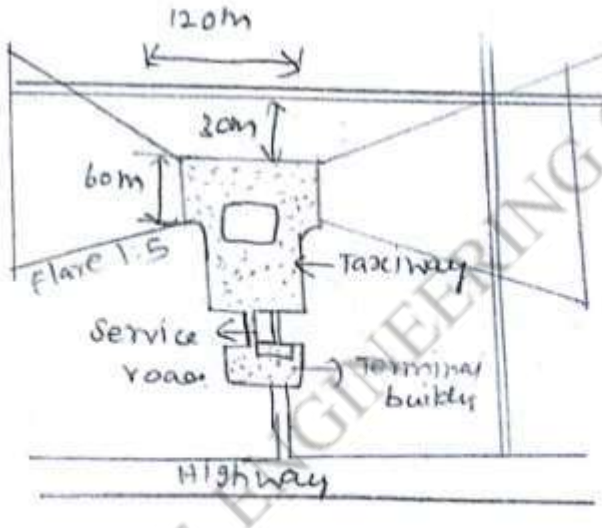
Layout of Airport.

chennai Airport handled around 120 landings a day. The breakup was 95 on St. Thomas mount end of the main runway and 25 on pallavaram side based on wind conditions. With the installation of ILS on pallavaram End, 48 landings could be handled.



Heliport:

It is prepared ground used for landing and take off of helicopters. It have all facilities to that of airports but to smaller scale. landing area maybe range b/w 0.5 to 0.75 hectares.



Parking and circulation area:

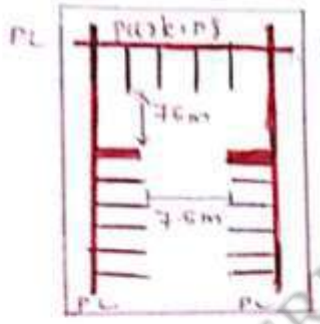
Parking maybe defined as leaving of a car or other personal vehicle in a particular place for certain place time.

According to FAA for each peak hour air passenger 1.5 to 2 cars are assumed as peak hour parking demand.

ii) Access and circulation standards

* An important consideration is parking lot should be easily accessible.

* Should ensure least possible delay during entry and exit.



PL - Parking lot

Driveway standards:

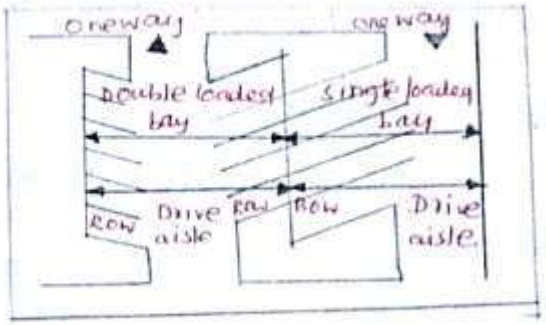
* oneway driveway for parking spaces shall have a min. width of 3.75m

* Twoway driveways for a small width of 6.25m.

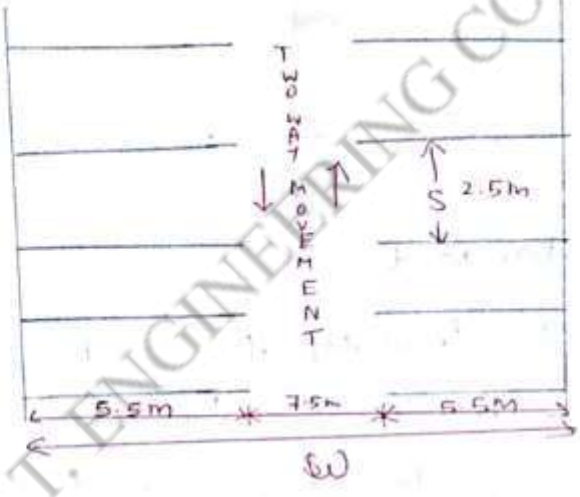
* Driveways or turnaround aisles shall not be dead - end.

* Parking lots must be located close to arrival and departure halls.

Parking slots and Drive aisle:



Standards for parking bays



W - Width
S - Space

Maximum Aisle length:

Maximum length of aisle should not exceed 100m. without a break in circulation.

An aisle width should be sufficient to allow a driver to couple parking and unparking manoeuvres in a single, convenient and smooth turn.

Employees Parking :

It is desirable to seggregate employee's Parking from that of Passengers' Parking. Employees' Parking are normally long term Parking. Based on size and shape of Parking lots, the best parking angle is decided.

* Parallel parking
* 30° angular Parking
* 45° " "
* 60° " "
* Right angle parking.

surface parking lots are provided close to airport buildings. If sufficient spaces are not available, multi storeyed car parking is provided.

* vehicles parked parallel to kerb is Parallel Parking
* If vehicles are parked making angles with a kerb is called angular parking

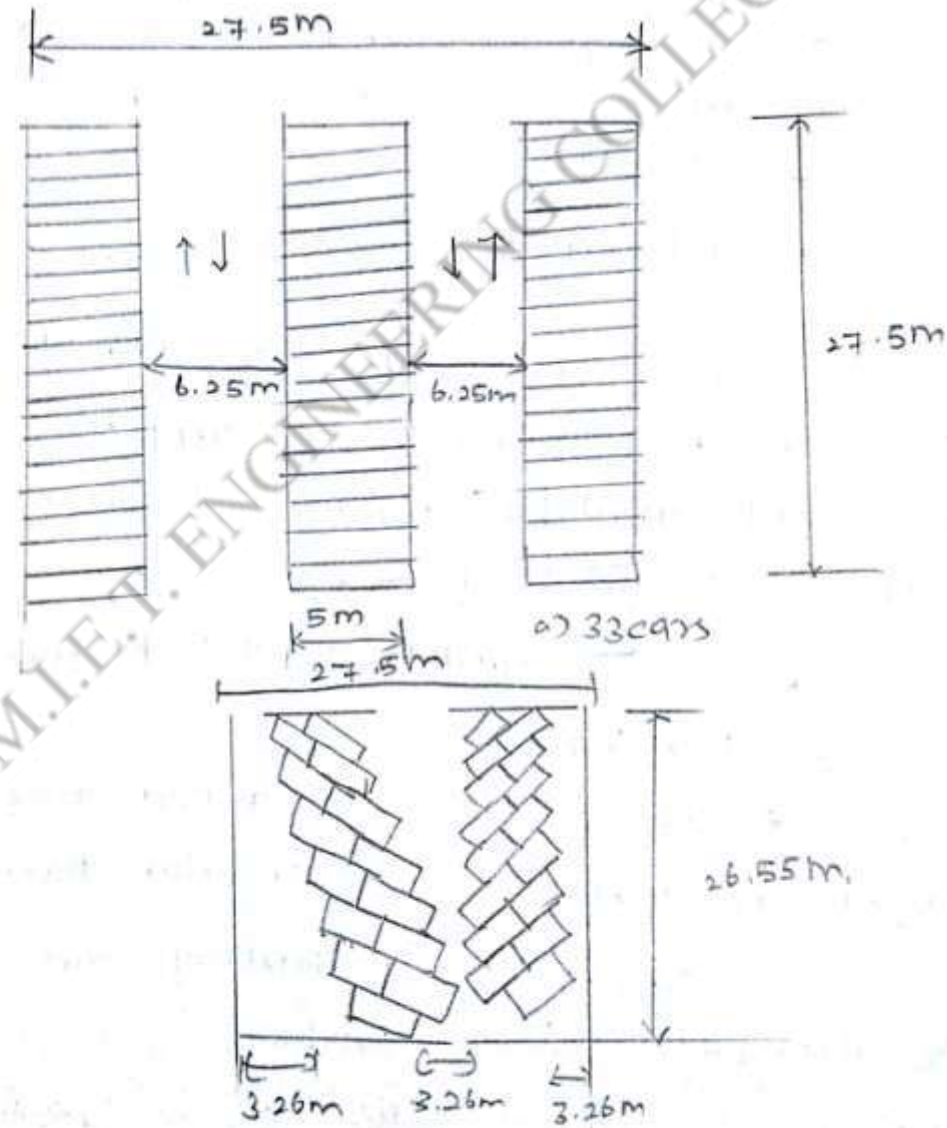
operations of parking and unparking is difficult in Parallel parking.

Parking with 60° is Practicable while 45° parking yields best results

Right angled Parking is adopted only under exceptional conditions

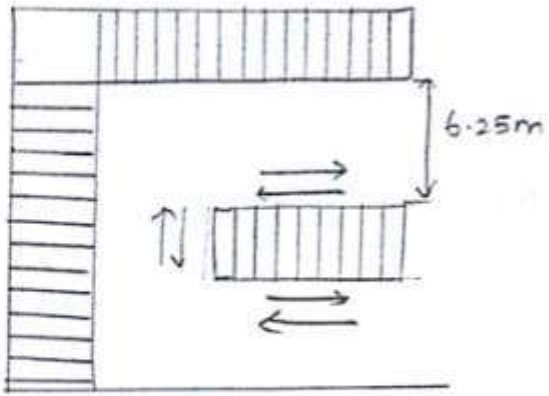
At airports parking for 3hours or less is termed as short term parking

short term parking accounts to 80% Parkers at airports.



33 cars

28 cars



31 cars

UNIT IV

AIRPORT DESIGN:

Runway design:

INTRODUCTION:

* Runway design is Planning for a Pattern and arrangement of runways.

* Components of runway design are runway orientation, wind coverage. Orientation is the position or direction of runway.

* coverage is the percentage of time in a year during which a runway could be put into use. Runway is designed by drawing wind rose diagrams.

* Wind rose diagram is one in which the direction, duration and intensity of wind at a selected airport site is represented to scale.

Elements of Geometric Design of runways:

* Runway length
* Runway width
* Width & length of safety area
* Transverse gradients
* Longitudinal & effective gradients
* Rate of change of Long, gradient

* Sight Distance.

Orientation of runway:

Orientation is positioning of runways. It is usually along prevailing wind direction.

Landing and taking off operations takes place in head wind. It takes place in directions opposite to head wind.

When landing operations take place against wind direction, the head wind provides a braking effect to aircraft and they come to a stop in a smaller length of runway.

When aircrafts take off, the head wind provides greater lift on wings of aircraft and enables it to rise above the ground within a shorter length of runway.

Therefore a runway is oriented in headwinds.

Wind data interms of direction duration and intensity for the selected site is collected for 5 to 10 years

These factors impart orientation of runways.

Cross Wind component:

centre line of a runway is oriented along prevailing wind direction.

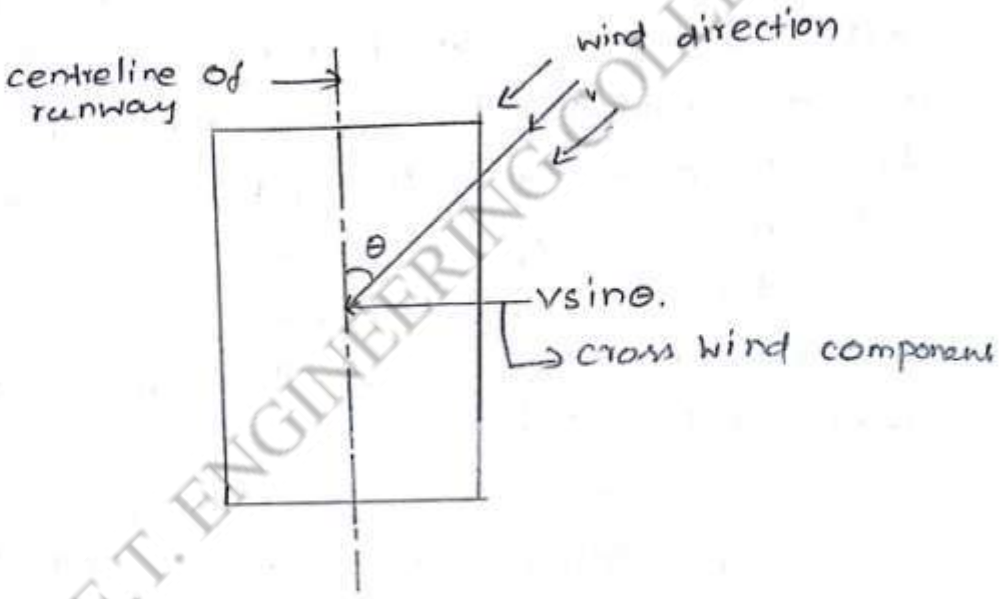
However it is not possible to obtain the direction of wind along the centre line of runway throughout a year.

On some days of a year and few hours of a day, wind may blow making certain angle with a centre line of runway. If an angle b/w the centre line of runway and direction of wind is θ, the component along the direction of runway is $V\cos\theta$, the component normal to the runway is $V\sin\theta$. Where V is wind velocity.

The normal component of the wind is termed as cross wind component. The cross wind component is very dangerous and may interrupt safe landing and take off operations. As per ICAO, the following are permissible cross wind component

Airport/Aircraft Type	cross wind component (velocity)	Field length
Small Aircrafts	14 - 24 km/hr	< 1200 m.
Mixed Traffic	25 - 37 km/hr	1200 to 1500 m
Big Aircrafts	> 37 km/hr	≥ 1500 m.

cross wind component:



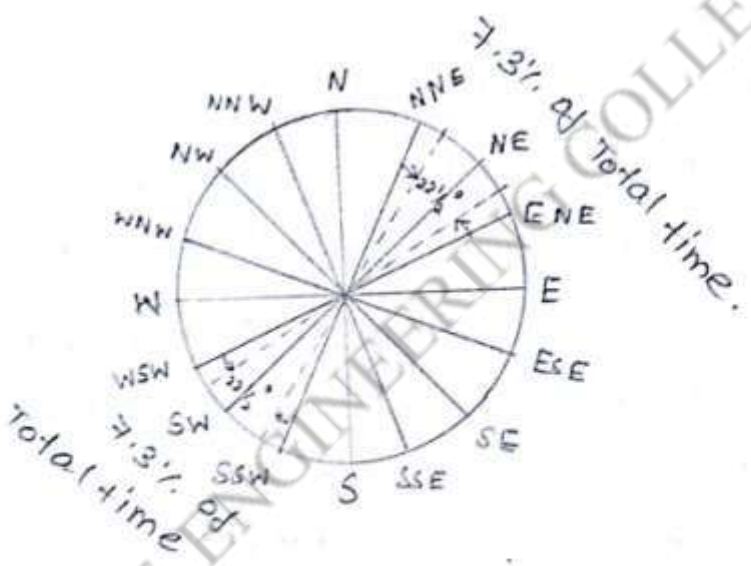
wind coverage:

Coverage is the percentage of time in a year during which a cross wind component remains within permissible limits.

For purpose of calculating coverage, an assumption is made to effect that a deviation in a direction upto

22.5° + 11.25° from directions of landing and take off operations is permissible.

For example if 'NS' is the best orientation, the coverage for orientation is obtained by summing up durations in the directions of N, NNE, NNW, S, SSE & SSW.



Wind directions and coverage.

Calm period:

Percentage of time in a year during which wind intensity is less than minimum intensity is termed as calm period.

It is assumed that during calm period, intensity of wind is negligible and do not interfere with landing &

Take off operations.

∴ The calm period is added to the calculated wind coverage.

Wind rose diagram - Type I:

i) Determination of orientation of runway:

* Past wind data for a selected site of an airport is collected for as many years as possible.

* Data should be collected at least for 5 yrs & preferably for 10yrs.

* Average data is obtained with sufficient accuracy.

* Since wind data is vary considerably from site to site, observations should have been taken at or near a site selected as far as possible.

ii) Direction and duration:

* Radial lines indicate wind directions.

* Avg. wind data are obtained for 16 directions

* Each direction covers an angle of 22.5°.

* It is assumed that wind may blow from any point within 22.5°

::: Best orientation of runway:

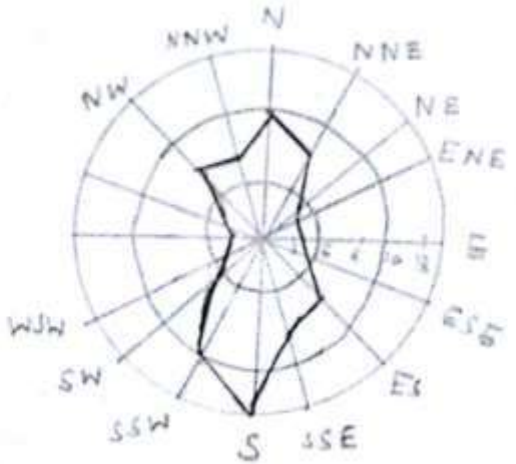
Values of durations from wind data are marked in respective durations.

The best orientation of runway is usually along the direction of the longest line in wind rose diagram.

iv) Wind Coverage:

It is assumed that deviation of direction is permissible is upto 33.75°.

Percentage of time during which a runway can be used for landing & take off in this ex. is obtained by summing percentages of time along NNW, N, NNE, SSE, S, SSW.



Procedure to determine the orientation:

1) Draw three Parallel lines on a transparent paper at the equal distance apart. The distance b/w Parallel lines is equal to Permissible cross wind component. It is drawn to the same scale with which the wind rose diagram. cross wind component is 25 km/hr.

2) Place a transparent paper over the wind rose diagram in such a way that its centre lies over the central line of Wind rose diagram.

iii) With the centre of wind rose, rotate the tracing paper and place it in such a position that the sum of all values of duration of a wind, bound by two outer parallel lines has a maximum value. Thus the direction indicated by the central line is the orientation of runway. Wind coverage is calculated by adding up all percentage of duration shown in segments. The percentage of duration is assumed to be equally distributed over the entire area of segments. If outer parallel lines of transparent strip cross a segment, proposed value is assessed and added.

Second runways:

Runways handling mixed air traffic should be planned so that their coverage is more than 95%.

Airports should be operational atleast for 95% of the time in a year. For busy airports the wind coverage may be increased upto 100%.

However this may be possible only by planning for second & more runways.

orientation of the second runway is the second longest direction in the wind rose diagram.

While calculating additional coverage for the second runway, duration of any direction, already added for the first runway should not be added for second time.

Example 1,

Table below shows a typical wind data for an airport site. Determine the best orientation of the runway and percentage of time during which the runway can be used. Does it require a second runway? If so Determine Total coverage.

Wind direction	Percentage of time		
	6-25 km/h	25-50 km/h	50-80 km/h
N	4.60	1.40	0.10
NNE	3.40	0.75	0.00
NE	1.80	0.03	0.10
ENE	2.80	0.02	0.03
E	2.10	2.20	0.00
ESE	5.40	4.75	0.00
SE	6.40	1.40	0.00
SSE	7.50	0.02	0.00

Wind direction	Percentage of Time		
	6-16 kmph	26-50 kmph	50-80 kmph
S	4·60	1·40	0·10
SSW	2·40	6·75	0·00
SW	1·20	0·02	0·10
WSW	2·60	0·01	0·02
W	1·80	2·20	0·00
WNW	6·00	4·75	0·00
NW	6·30	1·40	0·00
NNW	6·60	4·90	0·30

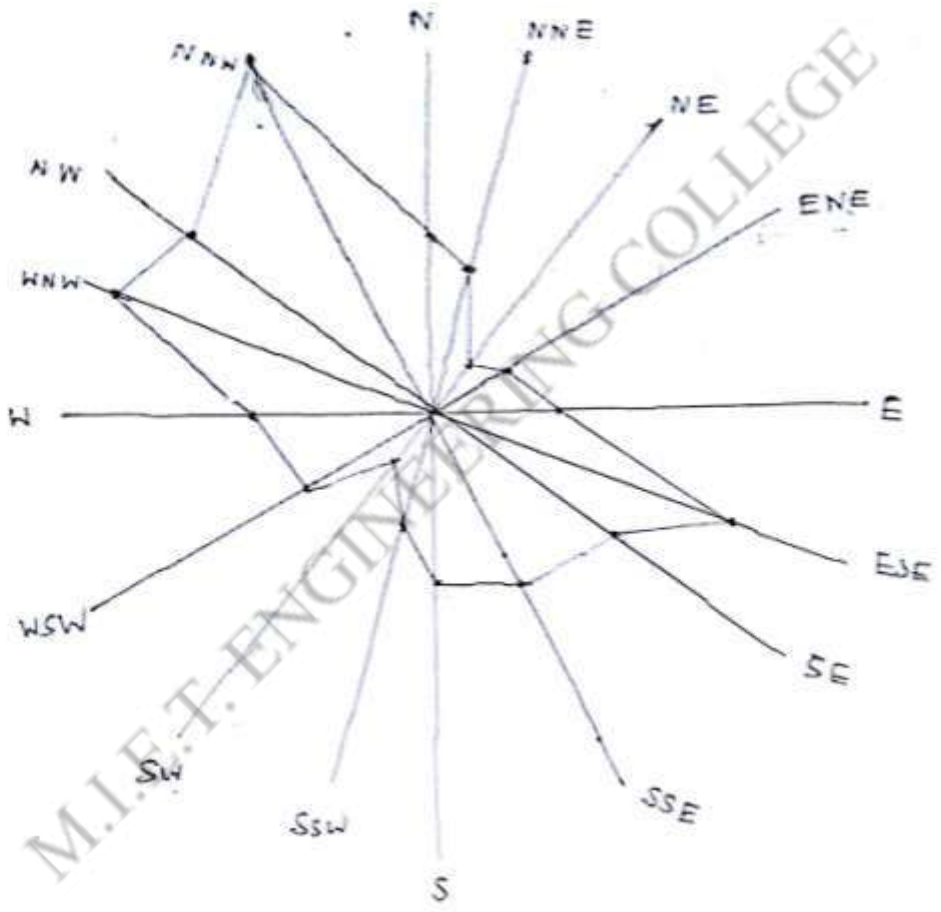
Soln:

Wind direction	Percentage of time
N	6.10
NNE	4.15
NE	1.93
ENE	2.85
E	3.20
ESE	10.15
SE	7.30
SSE	7.5
S	6.10
SSW	3.15
SW	1.33
WSW	3.65
W	4.00
WNW	10.75
NW	7.30
NNW	12.00

Percentage of wind blow = 92.08

Calm period = 100 − 92.08

= 7.92



Best orientation = NW - SE

Total period of operation = SSE + SE + ESE + NW + WNW + NNW + calmperiod

= 7.52 + 7.80 + 10.15 + 7.3 + 10.75 + 12 + 7.92

coverage = 63.44.

The landing and take off operations in the airport can take place on the runway only for 63.44 %. of time in a year. However the percentage is on lower side. ∴ there is need to design a second runway.

Best orientation for a second runway is the second longest line on the wind rose diagram.

orientation for the second runway is WNW-ESE

coverage for II runway = WNW + NW + W + ESE + E + SE

(X) coverage of any direction should not be added for the second time.

coverages for SE, ESE, NW, WNW have already been added.

The coverage for E & W can be added.

ie) 3.30 + 4.00 = 7.30

∴ Total coverage with the second runway

= 63.44 + 7.30 = 70.74 %.

Basic runway length:

Basic runway length is the length of runway under following conditions of an airport.

* Altitude of an airport @ sea level.
* Airport has standard temperature (15°C)
* Runway has no longitudinal gradient
* Wind doesnot blow on the runway.
* Airport is loaded to its full capacity,
* Wind doesnot blow en-route to destination
* Enroute temperature is standard.

Basic runway length is determined based on aircraft performance. Normally following cases are considered

* Normal landing case
* " Take Off "
* Engine Failure case

Actual runway length:

i) corrections for elevation, Temperature, Gradient:

Ideal conditions for an airport is not possible in real world conditions.

In most cases, elevation of airports may not be at mean sea level they may

not have std. atmospheric condition

corrections may be required for actual sites of airports for change in elevation, temperature and gradient.

Corrections for Elevation:

* Air density reduces with increase in elevation. This is turn reduces lift on wings of aircrafts.

* So longer runways are required

* The basic runway length has to be increased by 7 %. for every 300m rise in elevation above Mean sea level.

Correction for Temperature;

Airport Reference Temperature is the sum of monthly mean of average daily temperature (T_a) and the monthly mean of max. daily temperature (T_m) for same month of the year

$$\text{Reference Temperature} = T_a + \left(\frac{T_m - T_a}{3}\right).$$

As per ICAO recommendations, the basic runway length has to be increased at a rate of one percent for every one degree rise of an airport reference Temperature

above standard atmospheric temperature of that elevation. Temperature gradient or std. temperature from mean sea level to an altitude at which temperature becomes 15°c is 0.0065°c / metre. The temperature gradient becomes Zero above an altitude with Std. Temperature of 15°c.

Check for Total correction for elevation plus Temperature:

ICAO recommended that if total correction for elevation plus temperature exceeds 35% of basic runway length, the correction further checked up by conducting specific studies at the site by model Tests.

Correction for Gradient.

Steeper gradients require longer runway.

A runway length needs to be increased, incase of longitudinal gradient

The runway has to be increased at a rate of 20% for every 1% of effective gradient.

Effective Gradient:

It is defined as the maximum difference in elevation b/w the highest and lowest points of runway / unit length of runway.

Actual runway length:

Actual runway length is the corrected length of the runway for actual elevation, temperature and gradient. All these corrections are positive. ∴ Actual runway is longer than Basic runway.

Examples:

Monthly mean of average daily temperature for the hottest month of year at an airport site is 40°c. Monthly mean of maximum daily temperature for the same month of the year is 50°c. Calculate the airport Reference Temperature if the site is at MSL with a level ground determine the actual runway length to be provided.

Mean of max. daily Temperature, $T_m = 50°c$

Mean of avg. " " , $T_a = 40°c$

$$ART = T_a + \left(\frac{T_m - T_a}{3}\right)$$

$$= 40 + \left(\frac{50-40}{3}\right) = 43.33°c.$$

Std. Atmospheric temperature at MSL = 15°C

Rise in temperature = 40.32 − 15 = 25.32

correction = 1% per 1°C rise in temperature

If given basic runway length as L metres

∴ Required correction = $\frac{L}{100} \times 25.32 = 0.253L$

The runway is at MSL ∴, Actual length of runway = L + 25% times the basic runway length

Example :-

Length of a runway at MSL, standard temperature and zero gradients is 1600m. The site has an elevation of 300m, with a reference Temperature 33.6°C, The runway has to be constructed with an effective gradient of 0.2%. Determine the actual length of the runway at site.

Soln:

Std. length = 1600m

Elevation of site = 300m

Ref. Temperature = 33.6°C

Effective gradient = 0.2%

correction for elevation :

Increase in length = 7% for every 300m elevation

$$= \frac{7}{100} \times \frac{320}{300} \times 1600$$

$$= 119.47 \text{ m.}$$

corrected length = 1600 + 119.47 = 1719.47 m.

correction for temperature

1% for every 1°c increase.

Ref. Temperature = 33.6°c.

Std. Temperature at site = 15 - 0.0065 × Elevation

$$= 15 - 0.0065 \times 320$$

$$= 12.92^\circ c$$

Difference in Temp = 33.6 - 12.92 = 20.68°c

Increase in length $= \frac{1}{100} \times 20.68 \times 1719.47$

$$= 355.59 \text{m}$$

corrected length = 355.59 + 1719.47

$$= 2075.06 \text{m}$$

check for total correction of elevation & Temperature

$$= \frac{2075.06 - 1600}{1600}$$

$$= 29.68\%$$

It must be less than 35% as per ICAO standards.

correction for gradient:

20% for every 1% Effective gradient

$$\frac{20}{100} \times 0.25 \times 2075.06 = 103.75 \text{ m}$$

corrected length = 2075.06 + 103.75 = 2178.81m

Runway Geometric Design elements

i) Airport Reference codes:

The ARC composed of two elements. Element 1 is a number based such on Aircraft Reference field length. Element 2 is based on aircraft wing, span, outer main gear wheel span.

ARC

code Element 1		code Element 2		
code NO	Aircraft Reference field length	code letter	wing span	Outer main gear wheel span
1	Less than 800m	A	Less than 15m	Less than 4.5m
2	800 - 1200 m	B	15m to 23.9m	4.5m - 5.9m
3.	1200 - 1800 m	C	24 - 35.9m	6 to 8.9 m
		D	36 - 51.9m	9 to 13.9 m
4	More than 1800 m	E	52 - 64.9m	9 to 13.9m

Runway length:

ACTUAL LENGTH OF PRINARY RUNWAYS:

Length should be adequate for operational requirements of aircrafts for which a runway is intended. It should not be less than the longest length determined by applying corrections.

ACTUAL LENGTH OF SECONDARY RUNWAYS:

It is determined in the same way as that of primary runway. It needs to be adequate both for those aircrafts which require to use the secondary runway in order to obtain a usability factor of 95%.

Runway Width:

width of runways for different class of airports

code NO	code letter				
	A	B	C	D	E
1[a]	18m	18m	23m	–	–
2[a]	23m	23m	30m	–	–
3	30m	30m	30m	45m	–
4	–	–	45m	45m	45m

Longitudinal gradient:

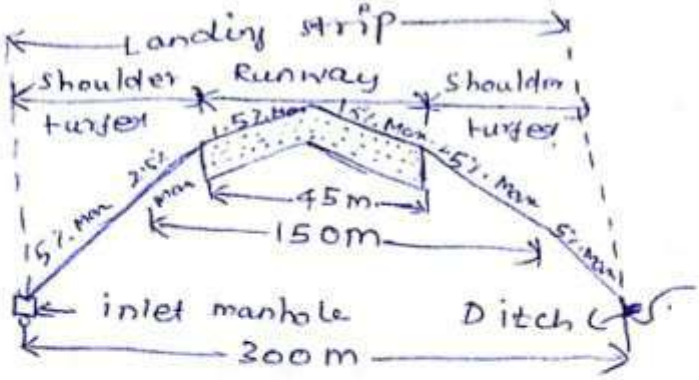
Sudden or abrupt change of longitudinal gradient is undesirable. Such a gradient may restrict height distance and cause premature lift of aircraft during take off operations. Premature lift affect performance of aircrafts and may develop structural defects.

Code NO	maximum longitudinal Gradient	Rate of change.
1 or 2	2%.	2%.
3 or 4	1%.	1.5%.

Transverse gradient.

Class of Airport	Transverse gradient	Remarks
A, B	2%.	Transverse gradient is for runway should be same throughout the length of runway except at an intersection with another runway or taxiway.
C, D, E	1.5%.	

code NO	Rate of change of Transverse gradient	Remarks
4	0.1%./30m	Min. radius curvature 30,0000
3	0.2%./30m	" " " 15000
1.2	0.4%./30m	" " " 7500m



SIGHT DISTANCE:

Type of Airport	condition for sight distance
C, D & E	Any point 3m above the surface of a runway should be mutually visible from a distance equal to half the runway length.
B	There should be an unobstructed length line of sight from any point 2m above a runway, and to all other points, 2m above the runway within a distance of atleast one half the length of runway
A	There shall be an obstructed line of sight from any point 1.5m above the runway to all other points 1.5m above the runway within a distance of atleast half the length of runway.

STRENGTH OF RUNWAYS:

A runway should be capable of withstanding aircrafts the runway is expected to carry.

SURFACE OF RUNWAYS:

* It shall be constructed without irregularities.
* otherwise, it should result in loss in friction characteristics & thereby adversely affect landing and take off operations.
* When the surface of runways are grooved, the grooves should be perpendicular to runway centre lines.

RUNWAY SHOULDERS:

* shoulders are provided for runways where the code letter is D & E & the runway width is less than 60m.
* The surface of a shoulder should be flush with the surface of the runway & its transverse slope should not exceed 2.5%

A runway shoulder should be capable to

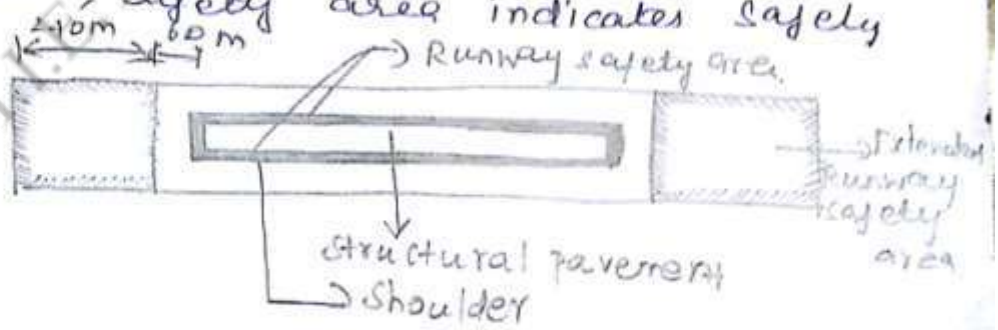
* support an aircraft in the event of the aircraft running off the runway.

* support ground vehicles when they operate on them.

* shoulders are provided with steeper gradient to facilitate effective drainage.

RUNWAY SAFETY AREA:

components of runway safety area are the runway, shoulders on either side of runway, and the area that are cleared, graded and drained. As the name itself indicates safety area indicates safety

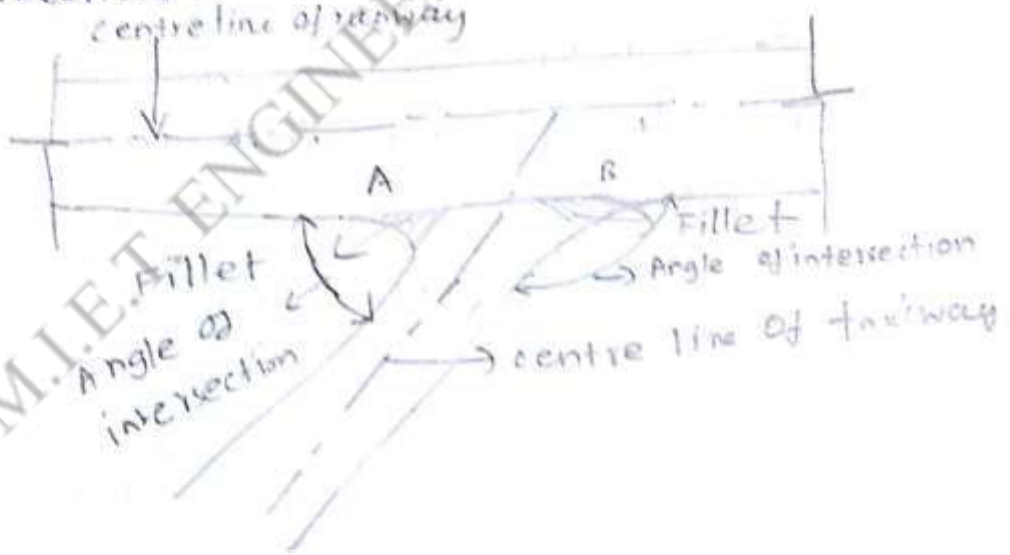


FILLETS (JUNCTIONS) / INTERSECTIONS:

* It refers to small space laid at the junction of two parts at right angles to each other.

* The junction of taxiway and runway provided with corner Fillets. It provides a smooth curve.

* It is provided @ junctions to ensure minimum wheel clearances when aircrafts manoeuvre through junctions & intersection



Runway Pavement Design:

1) Runway & highway Pavement characteristics:

Requirements of runway Pavements are different from that of highways.

Besides heavy dynamic wheel loading of aircrafts, runways have to weather special problems such as fuel spillage, heat and blast of engine exhausts, high type pressure and small contact area.

Effect of fuel spillage, heat & blast loosen pavement Particles & this is hazardous to aircrafts.

This phenomena leads to sudden change in longitudinal grade and in Pavement undulations.

The repetitive load in narrow band along centre line of taxiway cause rutting.

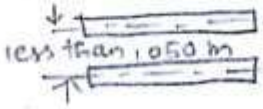
Runway Pavement Design

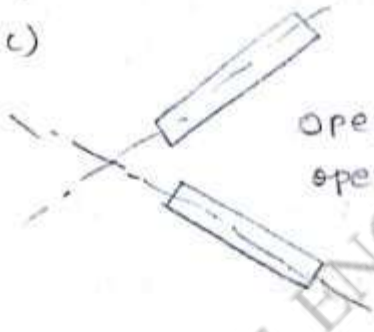
RUNWAY CONFIGURATION:

It refers to shape or arrangement of runways. They may be parallel or intersecting.

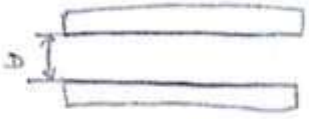
RUNWAY CONFIGURATION:

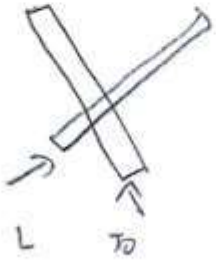
a)  single runway

b)  Independent IFR approach departure Parallel

c)  open v dependent operations away from intersection

RUNWAY BASIC PATTERN:





Airport classification	Taxiway width	Max. Long. Gradient	Max Transverse gradient	Max. rate of change of long. gradient (%)
E	23m	1.5%.	1.5%	1%. per 30m (Min. R.O.C 3000m)
D	18 to 23m	1.5%.	1.5%.	"
C	15 to 18m	1.5%.	1.5%.	1%. per 30m "
B	10.5m	3%.	2%.	1%. per 20m (min. R.O.C 2500m)
A	7.5m	3%.	2%.	1%. per 25m (min. R.O.C 2500m)

~~Taxiway~~ curves:

RUNWAY DRAINAGE:

* Drain pipes should be stronger enough to withstand heavy and dynamic wheel load of aircrafts

* crushing of pipes may be hazardous to aircrafts.

special characteristics of runway drains are

1) Heavy concentrated & dynamic wheel loads
2) wider runways when compared with highway pavements
3) Absence of side drains

TAXIWAY DESIGN:

1) Taxiway is the link b/w runways and aprons.

2) It provides access to aircrafts from railways to apron or service hangar & back

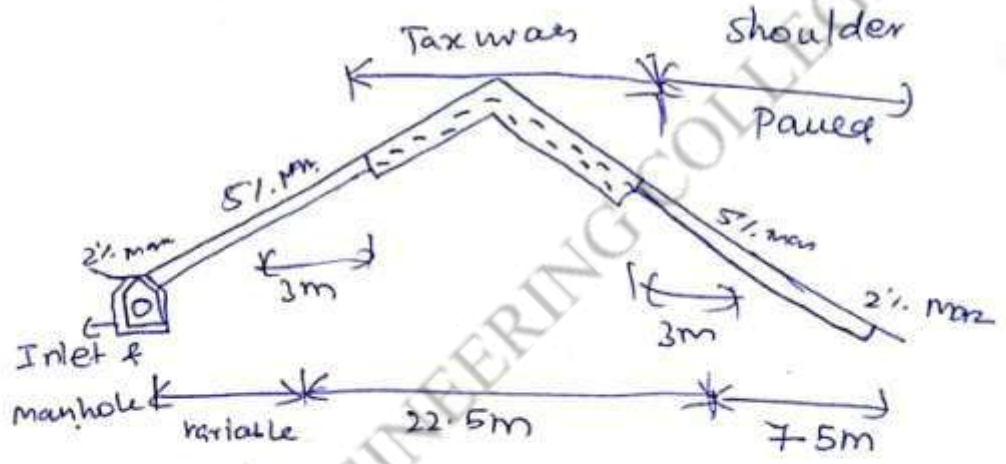
3) Route for a taxiway should be shortest and straight as far as possible

4) Taxiways provide safe and expeditious surface movement of aircrafts when road traffic is high rapid exit taxiways are provided.

Design Elements of taxiways are i) Length ii) width iii) width of safety area iv) Longitudinal gradient v) Transverse gradient vi) Rate of change of longitudinal gradient vii) sight distance viii) Turning radius.

1) CLEARANCE:

The clearance distance b/w outer main wheel of an aircraft & edge of the taxiway. It is measured when the cockpit of aircraft is over the centre markings of taxiway



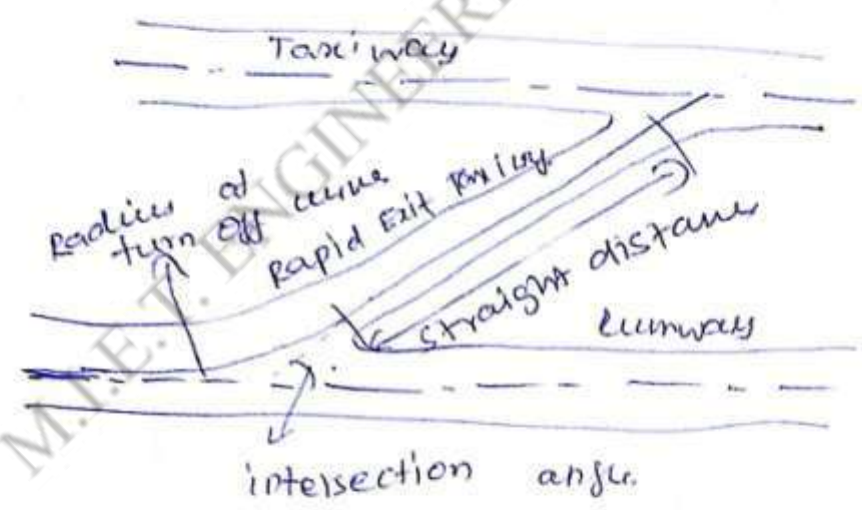
2) Taxi way shoulders:

code letter	Min. overall width of Taxiway & shoulders
C	25 m
D	38 m
E	44 m.

Strength & surface of Taxiways

* strength should be atleast equal to that of runways
* Should not have irregularities that cause damage to aircraft structures
* good frictional characteristics when the taxiway is wet

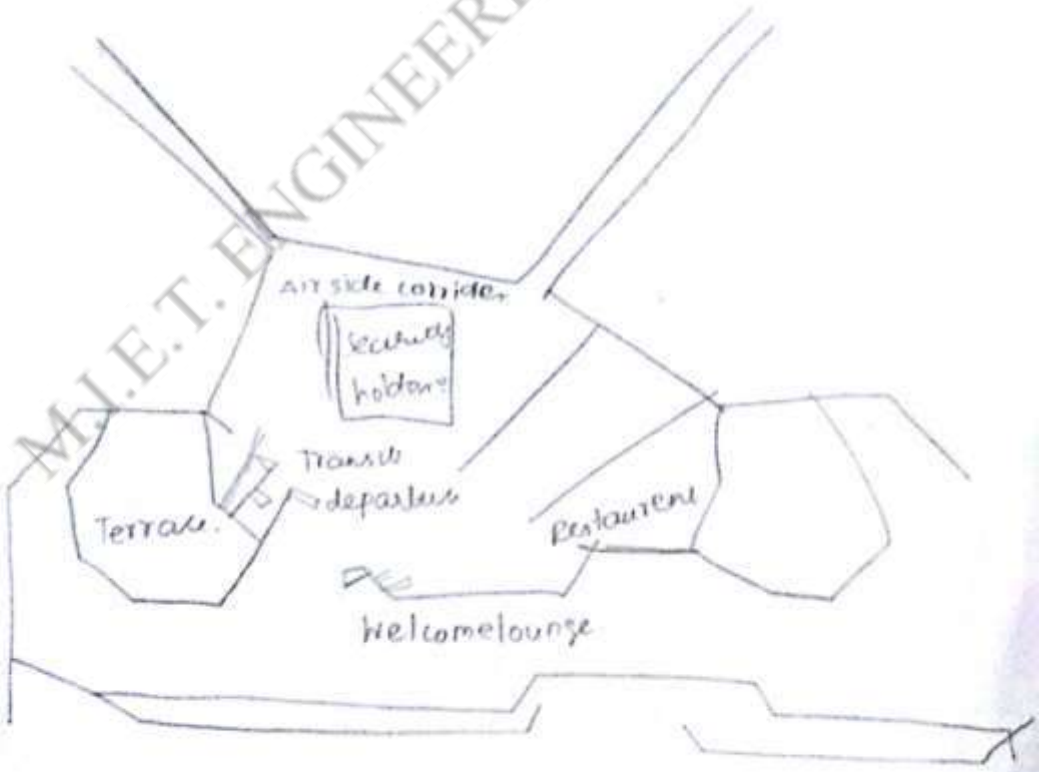
Rapid Exit Taxiways



PASSENGER FACILITIES & SERVICES

i) The general facilities Provided in airports

a) Economic lounges to comfortable ii)
b) Electronic lockers
c) Parent rooms
d) Inter-terminal Transport
e) Arrival hall
f) Departure hall.
g) Medical services
h) Flight information enquiries counter.



Visual aids:

They are apparatuses which support or helps pilots in helping pilots in sighting various features.

Pilots need aids during landing and take off operations

i) INDICATORS AND SIGNALLING DEVICES:

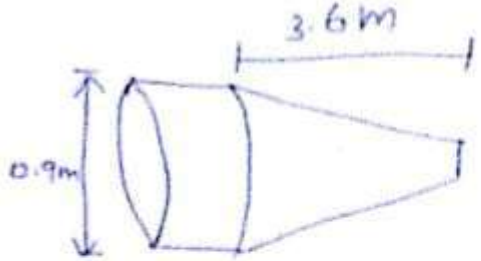
They are wind direction indicators and landing indicators

WIND DIRECTION INDICATOR:

It shows the direction from which wind blows. It may be a wind cone. The wind cone is placed within a segmented circle together with landing directions. This helps to locate airports & Wind direction indicator.

LANDING DIRECTION INDICATOR:

It is in the form of 'T' at the centre of segmented circle. It is to indicate the direction of active runway of airport to pilots



RUNWAY MARKINGS:

a) Runway designation Markings:

It shall be made at thresholds of pared runways. It consists of two digit number. It indicates magnetic azimuth measured clockwise for north direction

b) RUNWAY CENTER LINE MARKING:

It is done on the centre line of runway.

UNIT - V

HARBOUR ENGINEERING

Harbours:

It is a protected inlet or branch of a sea where ships can anchor.

Harbour Engineering:

It is concerned with planning, construction and maintenance of infrastructure for efficient performance of harbours

Definition of basic Terms:

Port:

It is a connecting link b/w sea and land traffic. It is a gateway to land from the sea and from sea to the land.

Docks:

They are enclosed area for berthing of vessels to facilitate loading and unloading of cargo and embarkation and disembarkation of passengers for repairs, oiling etc.

Tides:

The level of sea undergoes a constant oscillation, rising and falling generally twice within about 25 hours. This is due to difference in combined gravitational attraction of sun and moon upon various parts of the earth's surface.

Waves:

They are undulations caused on surface of sea water due to wind. It is the raised curvilinear caused on surface water. They are of 2 types.
i) waves of oscillation ii) waves of Translation

satellite port:

It depends on resources and facilities of another. It is a small port which is subordinate to a major port and depends upon the latter for higher order facilities.

Sheet No :

Date :

Requirements of harbours :

The principal requirements are

* Shelter
* accomodation

shelter:

* An essential requirement for ships during slack & rough seasons against violent waves of sea.
* Ships have to be sheltered for many days of a year when it is not possible to load or unload them.

Accomodation;

* Accomodation is related to facilities and opportunities required for carrying on Trade operations. Examples are
  - Quays to berth ships alongside
  - Sheds & Warehouses to deposit goods
  - cranes and appliances for handling goods.
  - Repairing Workshops.
  - passenger Facilities.

Classification of harbours:

Primary classification

Natural | protected | Artificial

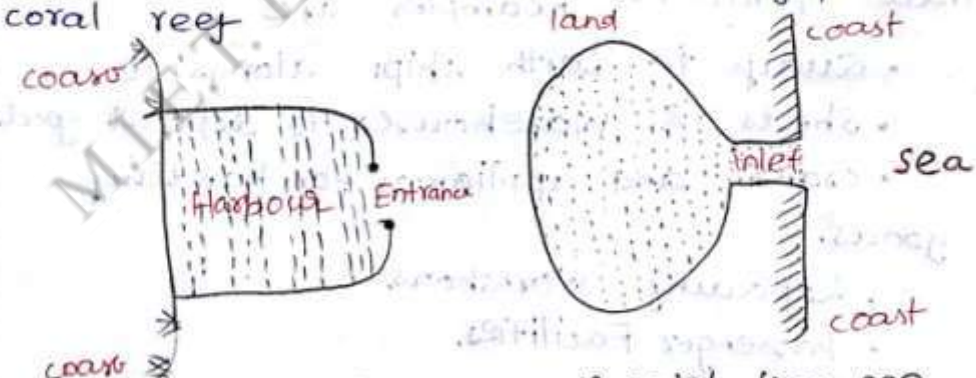
Natural or land locked harbours:

They are formed entirely by inlets from sea.

It may also be constituted by headlands or projecting parts of a coast converging towards each other.

They have narrow entrances leading to a sheltered area of water.

They may be coral reefs, series of islands forming lagoons with gaps in coral reef

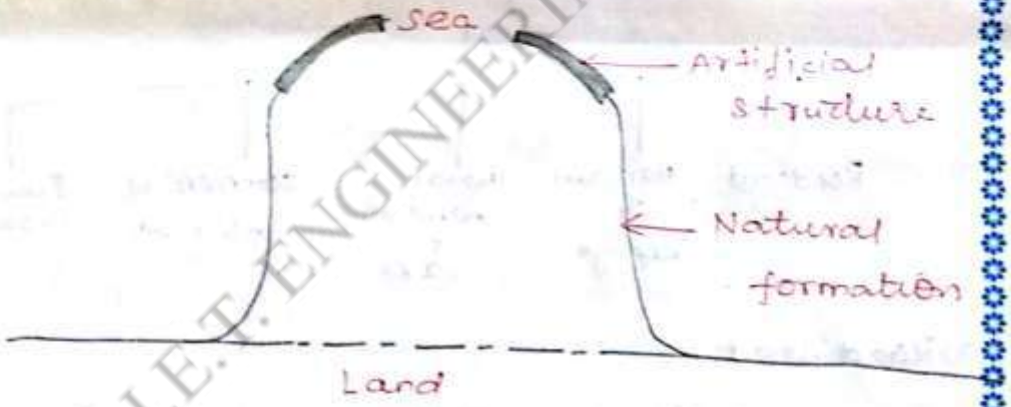


a) Head lands converging towards each other.

b) Inlet from sea

Protected Harbours.

* Partly natural and partly artificial.
* Formed in bays or positions in coastline.
* Artificial construction of break waters or entrance moles may supplement existing natural features
* They give protection from wave action to vessels using or entering harbours.

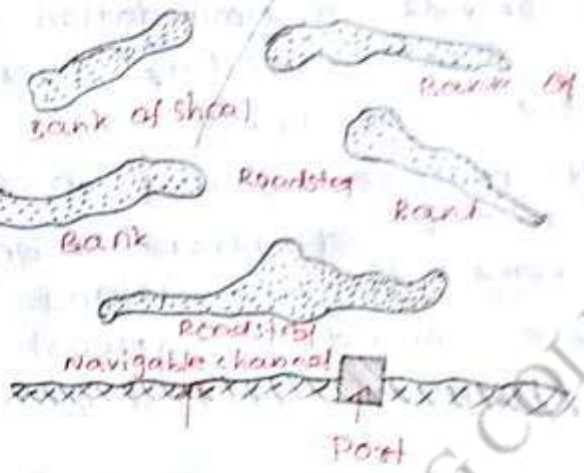


Artificial harbours:

They have to be created where there no natural features

Breakwater on an almost open coastline.

necessary characteristics.



b) Harbour of Refuge:

* Provide a refuge during cyclones or when vessels are under disrepair.

* The best location for their construction is at readily accessible stations upon dangerous coasts

c) Naval harbours and bases:

During emergency, every type of harbour ranging from roadstead with min. facilities to one possess facilities for refuelling repairs with dockyard workshops, may be used as naval base

d) Commercial harbour:

They provide accommodation for vessels for loading and unloading operations and transactions of Trade.

They may be located on coasts, estuaries, mouth of rivers or on banks of rivers some distance island.

There should be atleast possible delay in reception and despatch of vessels.

Simple Moles are built out into sea with level quay and covered sheds for reception of vessels inaddition to breakwaters for shelters.

e) Fishing harbours.

Fishermen require max. time for fishing with min. delay in despatching fishes in view of perishable nature of Fishes

* Entrance - not to be made narrow; Fishing craft beam - 6 to 8 m. Allowance should be made for atleast 3 to 4 vessels
* Size - 4 to 40 hectare.
* Depth - 3 to 5 m

Location of harbours:

Identification of a suitable location is the decisive factor in the process of planning a harbour.

Harbour Engineers can have accurate knowledge on wave characteristics, their action in terms of erosion and deposition to help decide pattern, location, size and shape of coastal structures.

SITE INVESTIGATION FACTORS FOR LOCATION:

1) Speed of water:

* speed of water that enters and leaves a harbour should neither be excessive nor slow.

* If the speed is too slow it silts an area.

* If it is too fast, it may erode the harbour & channel areas.

* : speed of water should be studied during different seasons over years

ii) Amount of dredging:

A site must be located that the amount of initial dredging & amount of maintenance dredging should be lesser.

It is important when position lies in an estuary of river or upon a coast, subject to coastal changes and littoral drift.

iii) Tidal range:

vessels can be loaded and unloaded at quayside, berths or wharves if tide doesn't exceed 5.5m.

It is important to select a site with a minimum tide range.

iv) Waves & their characteristics;

The incidence and magnitude of storms & direction and velocity of Maximum and prevailing winds have to be decided

Waves & their effects forms & design of breakwaters, pattern of sites, shoaling, shallowness, beach building

v) Wind characteristics:

* Wind causes waves.

* velocity and heights of waves depend on the direction, duration and velocity of prevailing wind.

* waves of greater heights and velocity have greater impact on efficient economy of ports.

* Wind data plays a vital role in site selection for harbours.

* It is collected for atleast 10 years analysed and harbour location is studied.

vi) Tidal currents:

* They are caused by earthquakes on sea beds.

* They may cause great damage to stability of coastal structures.

* Direction & velocity of the tidal currents at various states of tides are studied with greater accuracy.

Planning and Design of harbours:

surveying is the first factor in planning & design of harbour. to ascertain the soil profile, its geological characteristics and fitness for anchorage. special considerations are

* Direction & intensity of winds
* Frequency of storms.
* Height and force of waves.
* Field range and velocity of currents
* Littoral drift, erosion and silting.

Design Elements in Planning of Harbours.

i) Area for free movement and depth:

* Area depends on class of harbour, maximum number of vessels to be accomodated simultaneously and size of the greatest vessel.

* steady increase of vessel' size makes it important to allow ample area and depth for harbours. Modern vessels are around 300m long & about 30m wide

* Area must be adequate for free movement for large no of ships. It takes up their positions at berth.

* Area should not be adequate for reception but also for manoeuring them into and out of the berth.

* There should be sufficient space for manoevring.

Harbour Entrance:

* It should be wide enough for access to shipping.

* It should be so sited as to exclude waves and its impacts.

* It is a trade off blw the efficiency of port operations by precluding violent sea from entering into harbour & facilitates easy entry & exit of vessels into and out of harbour.

Entrance channel:

* The basic principle should be that the depth should be adequate to permit largest commercial vessels that frequently use harbours without undue delay or hazard.

* The entrance channel is long & tidal, a ships arrival and departure are usually timed so that it enters and leave on tide & not against it.

* In a channel, there must be sufficient draft - the depth of water below the bed to permit safe and efficient navigation of a ship underway by its own power.

* Where reduced speeds are imposed, minimum draft should be atleast one meter.

Light house:

It is a tall tower on a high pedestal, In an ideal planning of harbour, the light house should be in alignment with the centre line of entrance channel.

Parking, loading & unloading space:

Along with railway track and approach roads, sufficient parking and loading and unloading of inland transport carriers should be provided on port side.

Harbour layouts and Terminal Facilities:

Terminal facilities:

They are essential requirements of harbours. The elements of Terminal facilities are

i) Inter - Modal Transport services:

They are other modes of Transport such as roadways and railways. Therefore other modes of Transport are needed

Passengers and cargo to reach or to leave harbours.

Coastal structures for accomodation:

Quays & jetties are coastal structures alongside which ships are berthed.

Adequate no. of berthing facilities should be available in any harbour.

Hence adequate and efficient berthing facilities are crucial for successful port operations.

Transit sheds and warehouses:

They are attached to unloading platforms.

They are used as central collection & check area from where it is taken to loading platform when required. Requirement are a) adequate space b) Adjacent position to quay c) Cranes & other equipments.

Mooring accessories:

In addition to berths @ regular wharves or quays, the port should also provide facility of mooring for vessels on open waters. In any harbour, considerable amount of unloading often proceeds at moorings.

Navigational Aids:

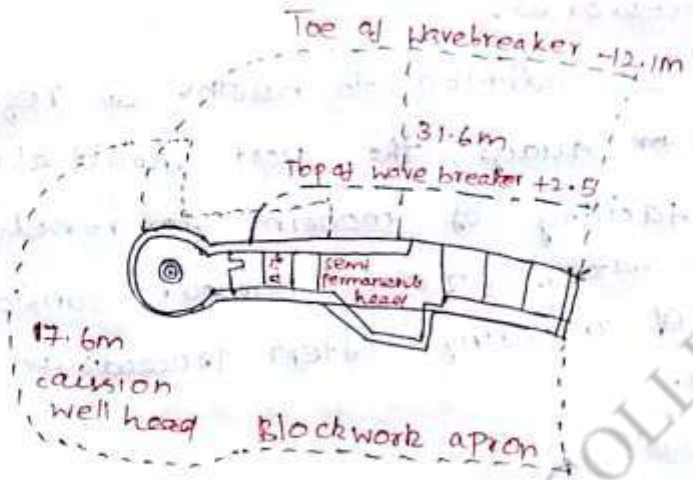
The primary purpose is to ensure safer and speed movements of vessels.

Coastal structures:

Piers:

It refers to iron cylindrical structures. They exit at seaside resorts for use of visitors and for landing and embarkation of passengers.

Pier head is termination of breakwater. It is subjected to most unfavourable conditions than any other maritime structures.



Breakwaters:

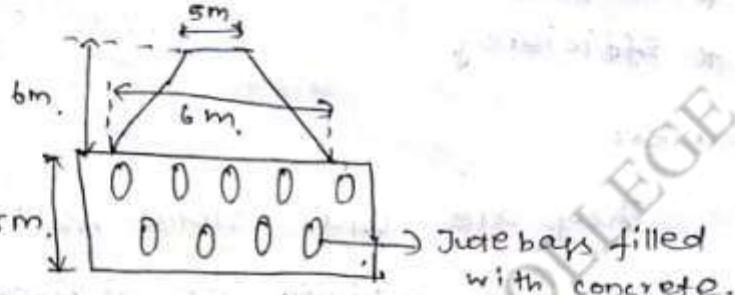
Its function is to breakup and disperse heavy seas.

It prevents waves from exerting their destructive influence within enclosed area of the harbour.

classification of breakwaters:

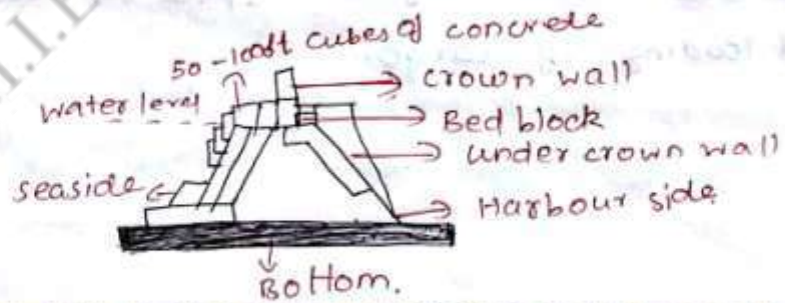
i) wall of masonry or concrete blocks or mass concrete.

a) Wall type / block breakwater.



b) Heap or mound breakwater.

c) Mound with Super Structure:



Advantages of Three types of breakwaters

* cost of construction
* comparative cost of maintenance
* Efficiency

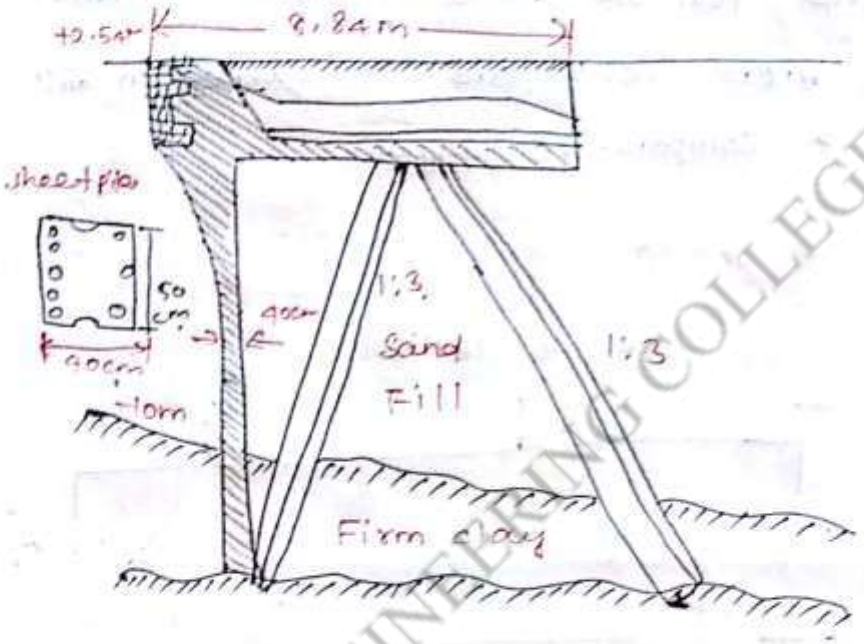
Wharves:

They are wide stone walls built along edge or out into sea or river, where ships can be tied upto unload goods.

It is a structure for berthing Purpose distinct from quays.

It is constructed of piles and framing instead of solid masonry or concrete

Both wharves and quays are provided with adjacent space for receiving and loading of cargo.



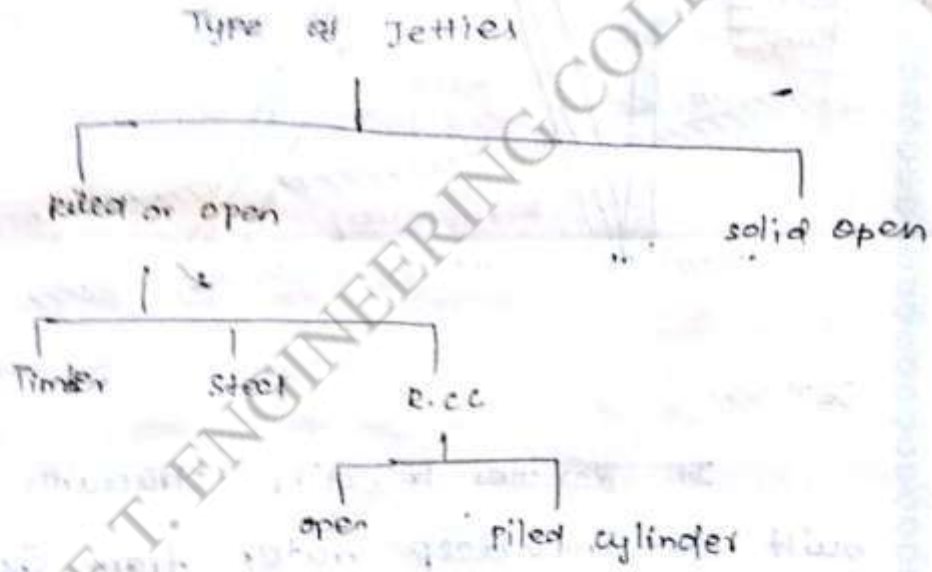
Jetties:

It denotes projecting structures built out into deep water from shore.

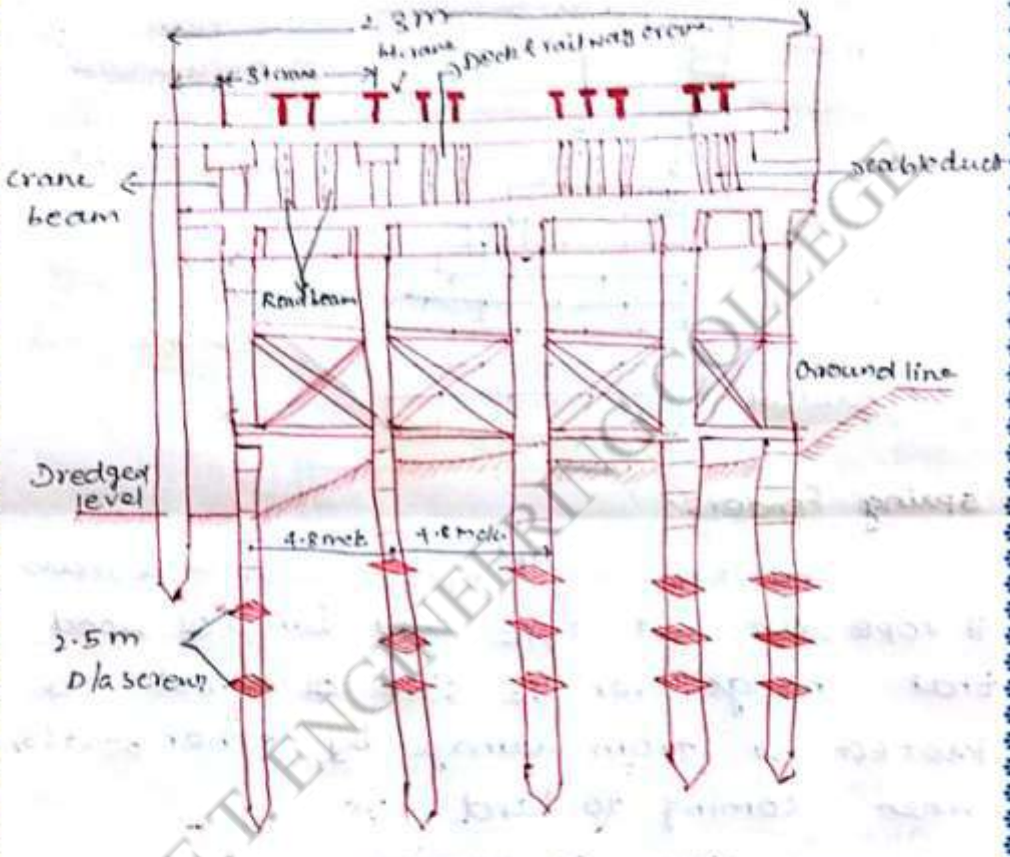
Structures in harbours which perform duties of loading and unloading platforms with break water are termed as jetties

They are situated more or less in sheltered position inside harbour or wet dock where vessels are manoeuvred in still water & comparative safety.

Types of jetties.



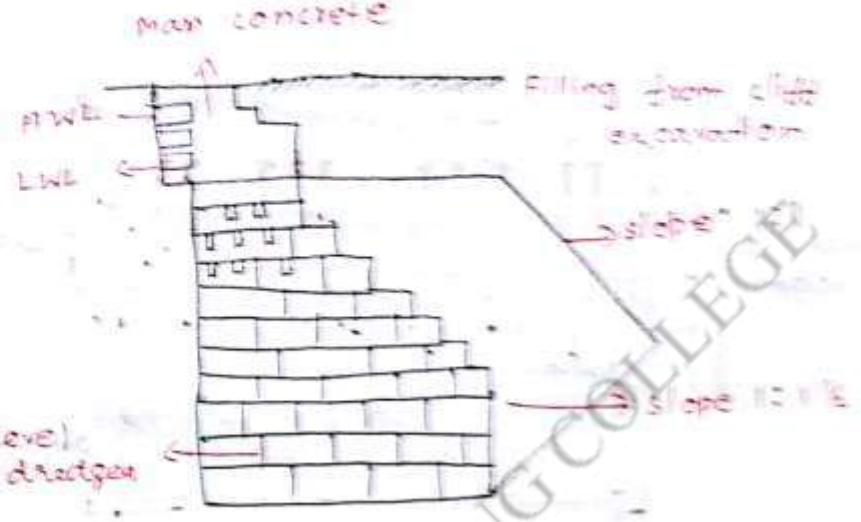
Date : ..... Sheet No : 22



Quays:

They are artificial structures where vessel can land. They are parallel to coast and they are made up of monolithic structures. It is constructed in water.

Quay Wall



Spring Fenders:

Fenders are objects such as a mass of rope, car old tyre and sump of wood that hangs over the side of a boat to protect it from damage by other boats when coming to land.

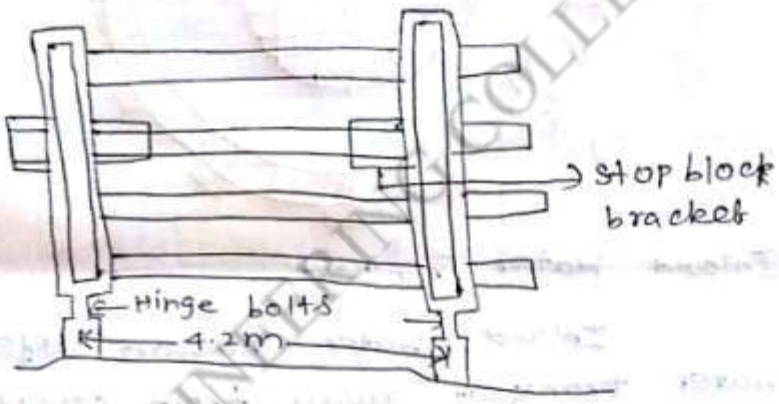
Different ways of Fending:

a) Simple Fending:

Simple Fenders of separate piles driven infront of structures with system of walling and verticals. It is efficient for berthing of vessels of moderate displacement

Spring Fenders:

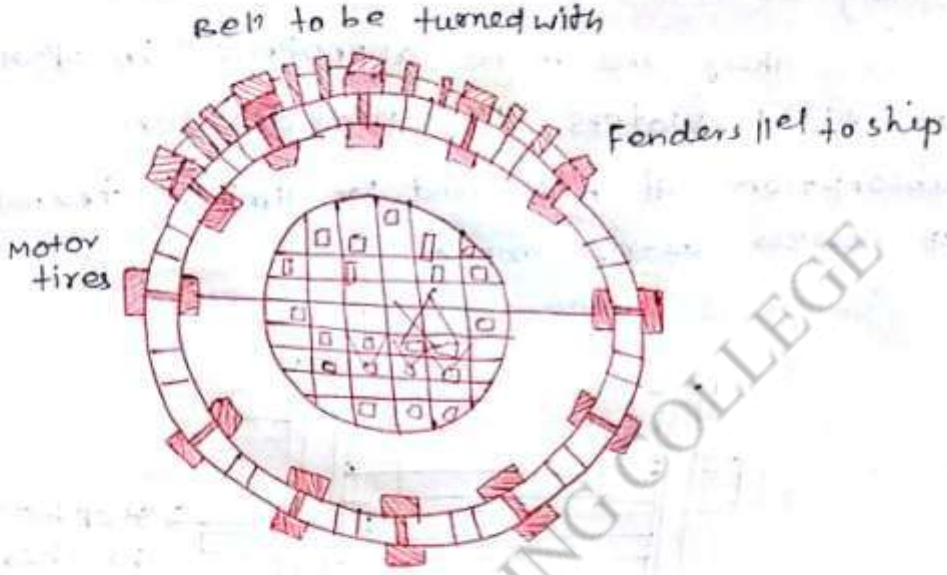
They are more appropriate in open or tidal waters. It provides for absorption of K.E and for limiting travel of vessels after impact.



Dolphins:

It refers to a buoy, pile or cluster of piles for mooring a vessel. It is shock absorbing.

It shows the Baker bell dolphin The weight of the bell when ballasted with concrete block is 170t. It is @ a speed of 38 cm/sec.



Inland water Transport:

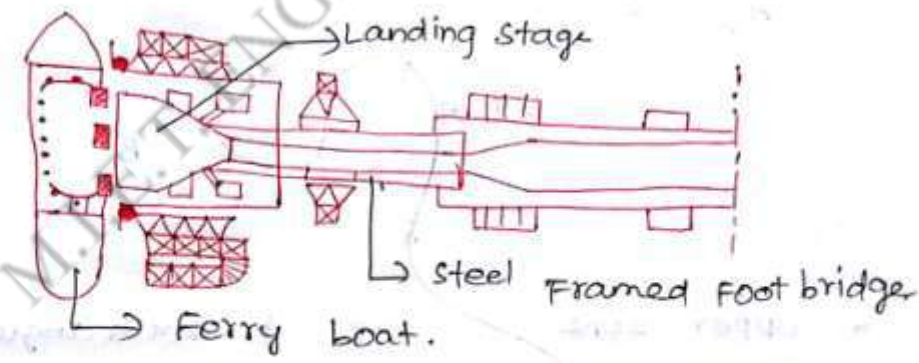
Inland water Transport refers to water transport away from coasts. Inland waterways are integral part of Transport System. Rivers were principal means of Transportation of goods.

Landing stage & Floating landing stage (FLS)

It is a raised platform along which vessels could be berthed for loading and unloading of cargo and embarkation & deembarkation of passengers

The FLS in its simplest form is a single pontoon or a large low boat with a flat bottom. The pontoon is fixed b/w timber dolphins or group of piles.

It is to overcome the problem due to tides. The FLS overcome this problem by maintaining the same level b/w landing stage and the vessel irrespective of sea water level because the pontoon rises and falls with tides.

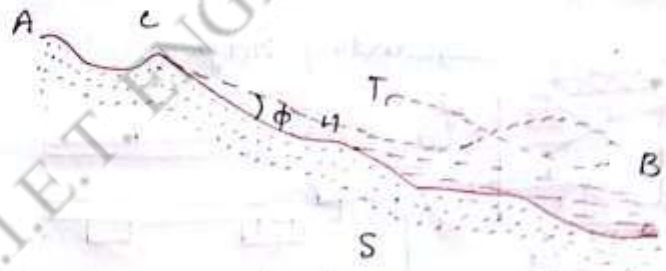


Waves and their action on coastal structure

Types of waves

- Types of waves
  - Waves of oscillation
    - Ordinary unbroken waves
  - Waves of Translation
    - When they enter shallow water
  - Tidal waves
    - Frequently occurs as a result of EQ in seabed.

Beach zones;



A - Upper zone

B - Lower beach

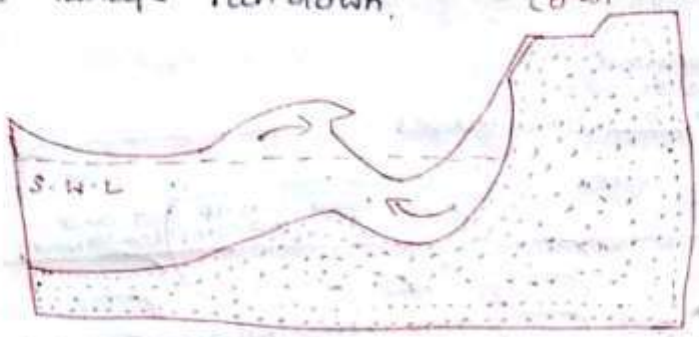
S - Separation of two beaches

C - crest, the highest pt.

ϕ - beach angle

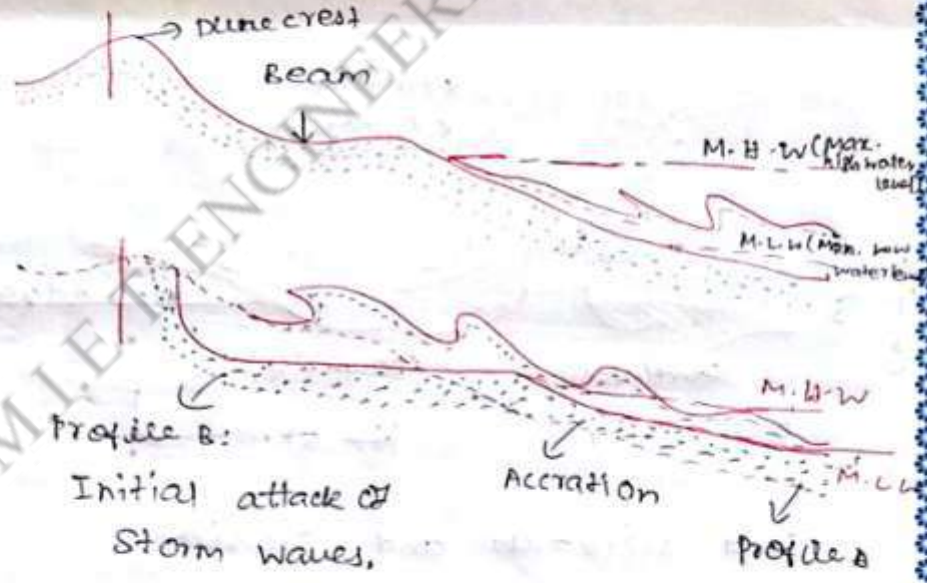
H - wave amplitude.

Wave runup- run down.

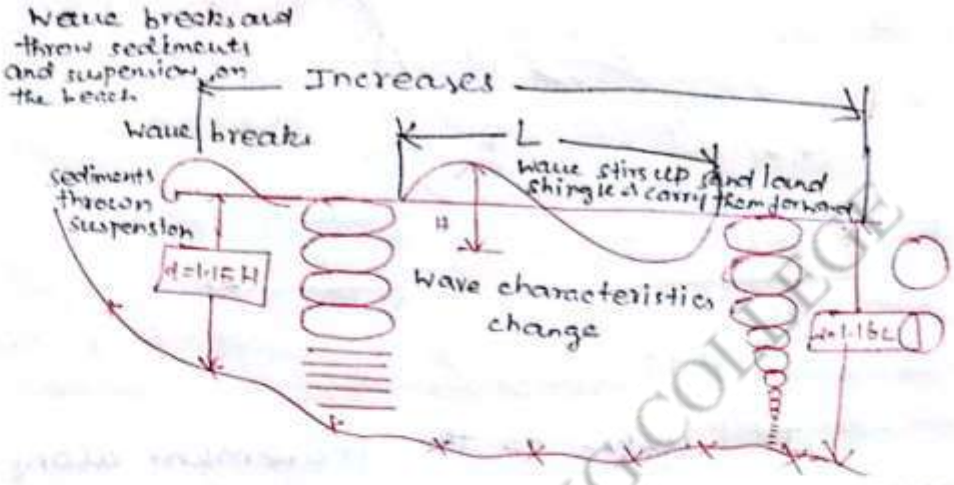


Littoral Drift;

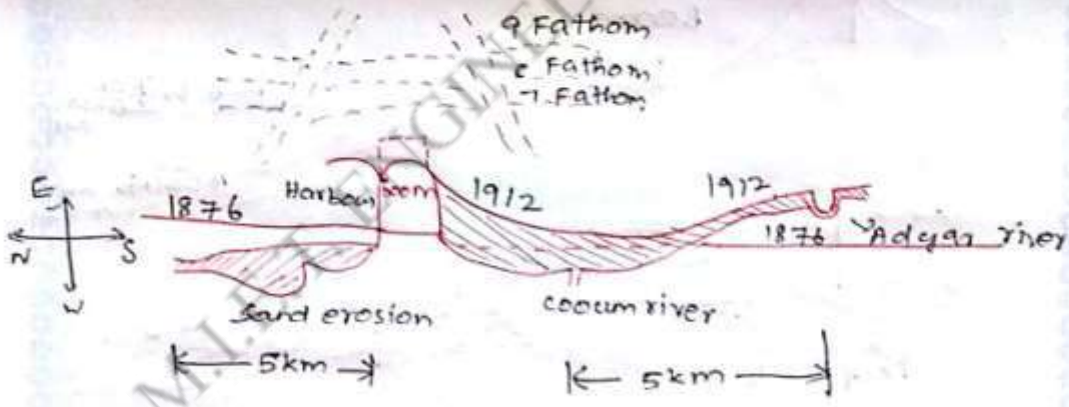
It refers to the movement along a coast.



Mechanics of littoral Drift:



Wave action on coastal structures



Sand accretion and Erosion.

Environmental concern in Port Operations

Environmental concern is vital for any project. It is more important incase of projects. The impacts are

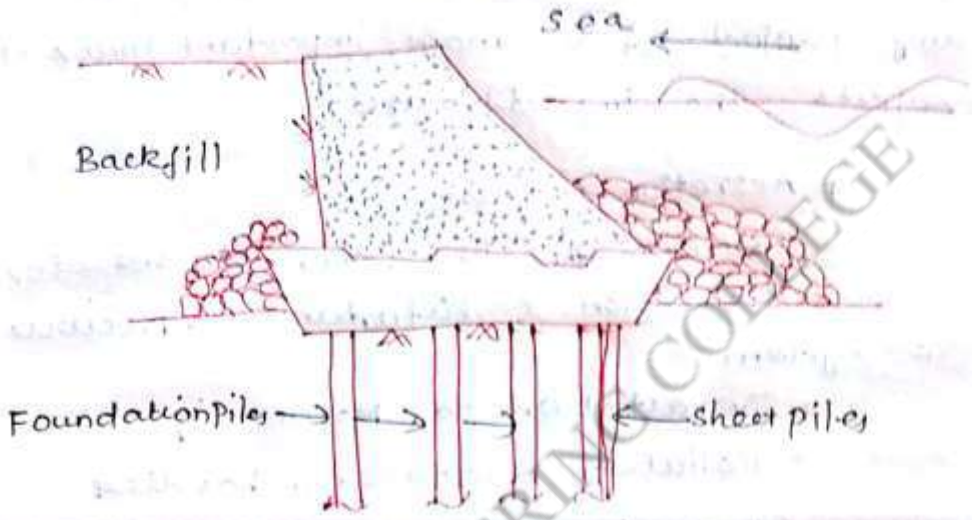
* Accretion & Erosion
* Intrusion of saline water into sea water
* Dislocation & disturbance to precious eco-system
* Devastation to Marine life
* Pollution due to cargo handled
* Impact on soil due to cutting
* Pollution due to spillover of oil & grease.

Coastal Protection Works:

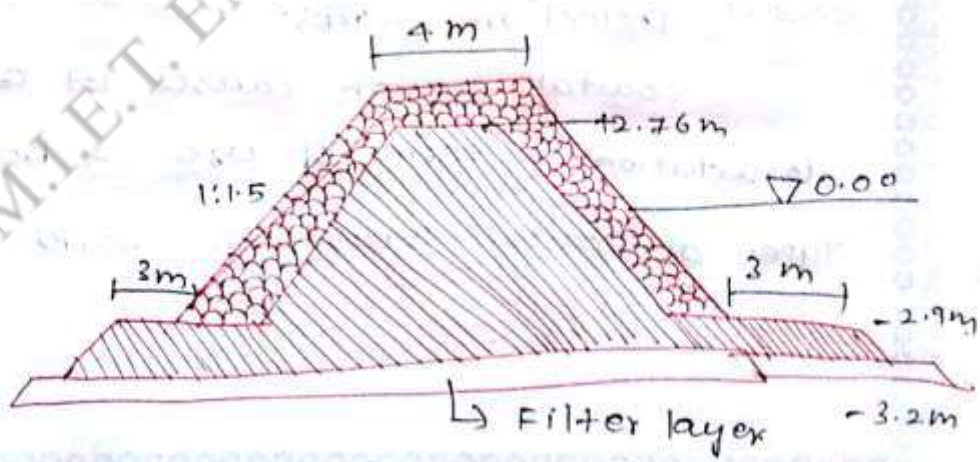
Coastal erosion causes lot of devastation in terms of life & Property.

Types of coastal protection works

a) sea wall c/s



b) Groin, c/s.



c) Offshore breakwater.

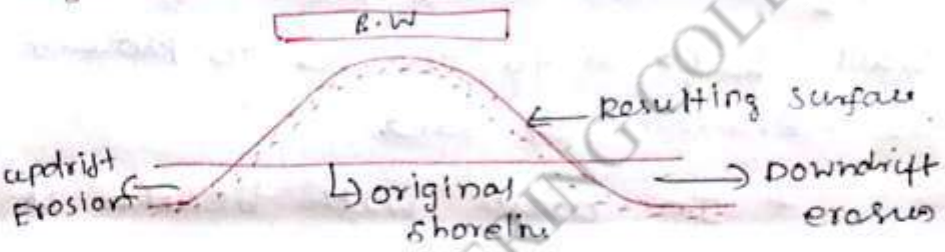
There are two types

a) Exposed type

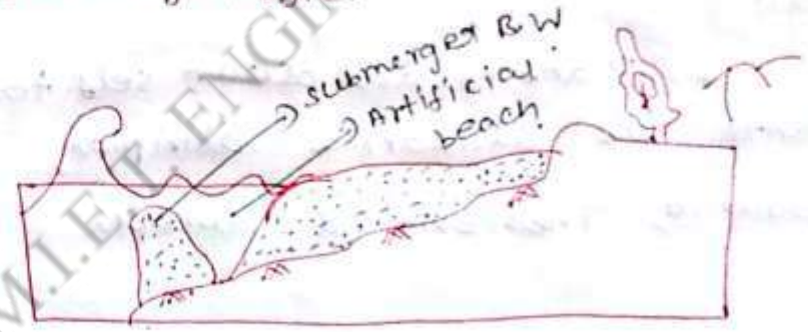
b) submerged type.

a) Exposed type.

Single detached B.W



b) submerged type.



Protection against naturcy calamities

* construction of coastal Retaining wall along coast.

* Afforestation along the coastal area.

* construction of groins of low walls built in to the sea to proceed the erosion of sand.

* In coasts with beaches it is not necessary to construct a wall.

* Planting and ocean self tolerant Plants like salicornia atiriplex, casuarina, Thespesia & bamboo

5.17 Coastal Regulation Zones (CRZ)

5.17.1 Definition of terms

(i) Zone: Zone may be defined as a demarcated area. It has to be contiguous (continuous) (continuous) area. It may be a homogeneous area with common characters.

(ii) CRZ: CRZ refers to stretches along coasts, where certain rules are enforced to any development on land or building construction activities in these areas are governed by CRZ regulations. CRZ refers to an area 500m from in landward side from high tide line (HTL) and the area between low tide line (LTL) and the HTL.

These regulations were notified in the year 1991 and 1994 under Environment (Protection) Act 1986 and rules made thereunder. From 1991 to 1994, CRZ was 500m from from 1994 onwards. It has been reduced to 200m from HTL.

(iii) High tide line: The line on land upto which the highest water line reaches during spring tide. The Surveyor General of India demarcates HTL uniformly in all parts of the country.

5.17.2 Activities prohibited within CRZ

Notifications issued by Ministry of Environment and Forests imposes certain restrictions on industrial, operations and processes in the CRZ.

The following activities are not normally permitted

(i) Setting up of new industries and extension of existing industries. However, such developments are permitted if they are directly related to water front or are directly needed for shore facilities.

(ii) Manufacture or handling or storage or disposal of hazardous substances.

(iii) Setting up and expansion of fish processing units including warehousing. However, hatchery and natural fish drying in permitted areas may not be prohibited.

(iv) Setting up and expansion of units/mechanism for disposal of waste and effluent expecting where it is permitted under water Act 1974

(v) Dumping of solid waste for purpose of land filling or otherwise or ash or any other waste from thermal power station

(vi) Land reclamation, bunding or any other action to cause distribution to natural course of sea water, there is no bar for these activites if they are required for control of coastal erosion, maintenace or cleaning of cleaning of water ways and for prevention of sand bars.

(vii) Harvesting or drawl of ground water and construction of mechanism there for such activites shall be permitted if done - manually, through ordinary well for purpose of drinking, horticulture, agriculture and fisheries.

(ix) Construction activites for residential buildings, office building, hospital complexes and work shops shall not be permitted.

(x) Any construction activity expect facilites to carry treated effluents and waste water discharge into sea, facilites for carrying sea water for cooling purpose oil, gas and similar pipe lines and facilities essential for permissible activites

(xi) Dressing or altering of sand dunes, hills, natural features including landscape, changes for beautification, reorientation and other such purpose

4.17.3 Regulation of Permissible activities

(i) any Activity which requires water form foreshore facilities

(ii) Activities permitted with clearance from the ministry of Environment and Forest

(a) Construction activities related to defence facilities requirements for which Foreshore facilities such as slipways and jetties are essential.

(b) Coastal structures such as jetties, quays, breakwaters and light house

(c) Thermal power plants

4.17.4 Coastal zone management Plans (CZMP)

As per notification for CRZ all coastal states and union Territory Administration in india shall prepare CZMP. The plan shall be submitted with in a period of one year from the date of notification. (19th Feb 1991) ministry of Environment and forest (MEOF) shall approve the CZMP for coastal states and union Territory and local Governments, with in the frame work of the CZMP.

4.17.5 Norms and guidelines for development of beach resorts/ Hotel in CRZ III

(i) NO Construction

(ii) (a) Plot size – not less than 0.4 hec

(c) FSI - Shall not exceed 0.33

(iii) (a) ~~over-hall~~ overall height - shall not exceed 9.0m

(b) No. of Floors - not to exceed two

(iv) Ground water shall not be tapped

(v) Extraction of sand, dwelling or digging of any structures for structural foundation of building and swimming pool shall not be discharged into the sea.

(vii) At least a gap of 6om width shall be provided between any two hotels/ beach resorts to allow public access to beach

(viii) Construction of beach resorts and hotels shall not be permitted in ecologically sensitive areas.

4.17.6 Classification of CRZ

For regulation of developmental activities coastal stretches within 500m as classified into four zones

(i) Coastal Regulation zone - (CRZ I)
(ii) Coastal Regulation zone - (CRZ II)
(iii) Coastal Regulation zone - (CRZ III)
(iv) Coastal Regulation zone - IV (CRZ IV)

Table depicts details of regulations enforceable in each zone.