Lecture No. 01

UNIT I – AIRPORT PLANNING

Topic(s) to becovered	Air Transport characteristics.

	Lecture Outcome (LO) At the end of this lecture ,students will be able to	Bloom's Level
L.No:1	✓ characteristics of Air transports ✓ History of Airport	understanding

TeachingLearningMaterial	Student Activity
PPT, Chalk & Talk	Listen / participate / discuss

Lecture Notes

Airport (History)

ICAO – International civil aviation organisation (1944)

↓

The Government of India

↓ 1972

1972: International Airports Authority of India (IAAI)

To manage the the Nation's International Airports

↓

1986: National Airport Authority of India (NAAI)

for domestic Airports

↓

1995 April: The organizations were merged by an Act of parliament

Act of parliament

⇓

1994: Airport Authority of India Act 1994

⇓ Statutory Body named as

(AAI) ⇒ Airport Authority of India in 1995 April.

This Organisation was to be Responsible for creating upgrading, maintaining and managing civil aviation infrastructure both on the ground and air space in the Country.

International Civil Aviation Organisation (ICAO)

The nations of the world have established the International Civil Aviation Organisation (ICAO) to serve as the medium through which the necessary international understanding & agreements b/w nations in all the technical and economic and legal fields so that the air can be the high road to carry man and his goods anywhere and everywhere

ICAO → Signing of a treaty in december 1944

ICAO → Create as a Inter Governmental Organisation in 1947.

Air transport characteristics:

General: A machine which finds its support in the atmosphere due to reactions of the air is defined as an Aircraft.

⇒ It can be heavier (or) lighter than air and may be power or non-power driven.

⇒ Aeroplanes and helicopters are also heavier than air but are power driven.

Relation Between Aircraft and Airports:

1. Aircraft and airports are dependent on each other providing a service for the passenger in conventional air transport system.

2. In past: The system involved largely with separate planning of the airport, the Route Structuring and aircraft technology. Using advancement in technology

3. advancement in engine and airframe technology reduced the real cost of air travel

4. 85% of operating costs of entire air transport system, Airport — 10%, 5% navigation charges, overheads of governmental control

AIRCRAFT CHARACTERISTICS:

characteristics are of prime importance to the airport planner and designer.

1. Type of propulsion
2. Size of aircraft
3. Minimum turning Radius
4. minimum Circling Radius
5. Speed of aircraft
6. Capacity of aircraft.
7. Aircraft weight and wheel Configuration.
8. Jet blast
9. Fuel Spillage
10. Noise

1. Types of propulsion:

Engines	use	Speed limit kph	Advantages	Limitations
(1) Piston	1. Long Range moderate speed transport & bomber	250 -	Low fuel, long service life	operates at Relatively low altitude
	2. Moderate Range	750 -	Versatile reliable	Relatively High fuel consumption, medium altitude
	3. Small private air	400 -	Low Initial cost, Reliable	Low altitudes, Short Range

②	Turbo prop	Intermediate long Range transports & bombers.	Sub-Sonic [being a speed less than that of Sound in air]	Low fuel consumption @ High power long Range	Speed limited by propeller efficience
③	Turbo-Jet	High Speed medium Range fighters	Sonic to the Speed of Soundwaves	High Speed at Relatively High altitude, Smooth performances.	Payloade & Range limited by fuel consumption
④	Ram Jet	Pilotless aircraft guided missiles	1280 to 2400	Simple design Cable of great speed	Very high Fuel consumption
⑤	Rocket	Missiles High	4600	Extremely high Speed, can operate outside oxygen bearing atmosphere	Extremely High Fuel consumption.

② Size of Aircraft:

The Sizes of aircraft involves following important dimension: (i) wing Span (ii) Fuselage length (iii) Height (iv) distance between main gears, (v) Wheel base (vi) Tail width.

[The wing Span decides the width of taxiway Separation clearance between two parallel trafficways, Size of aprons and hangars, width of hangar gate etc. The length of aircraft decides the widening of taxiways on Curves width of exit taxiway, sizes of aprons and hangars etc. The ht of aircraft, also called as empennage ht.

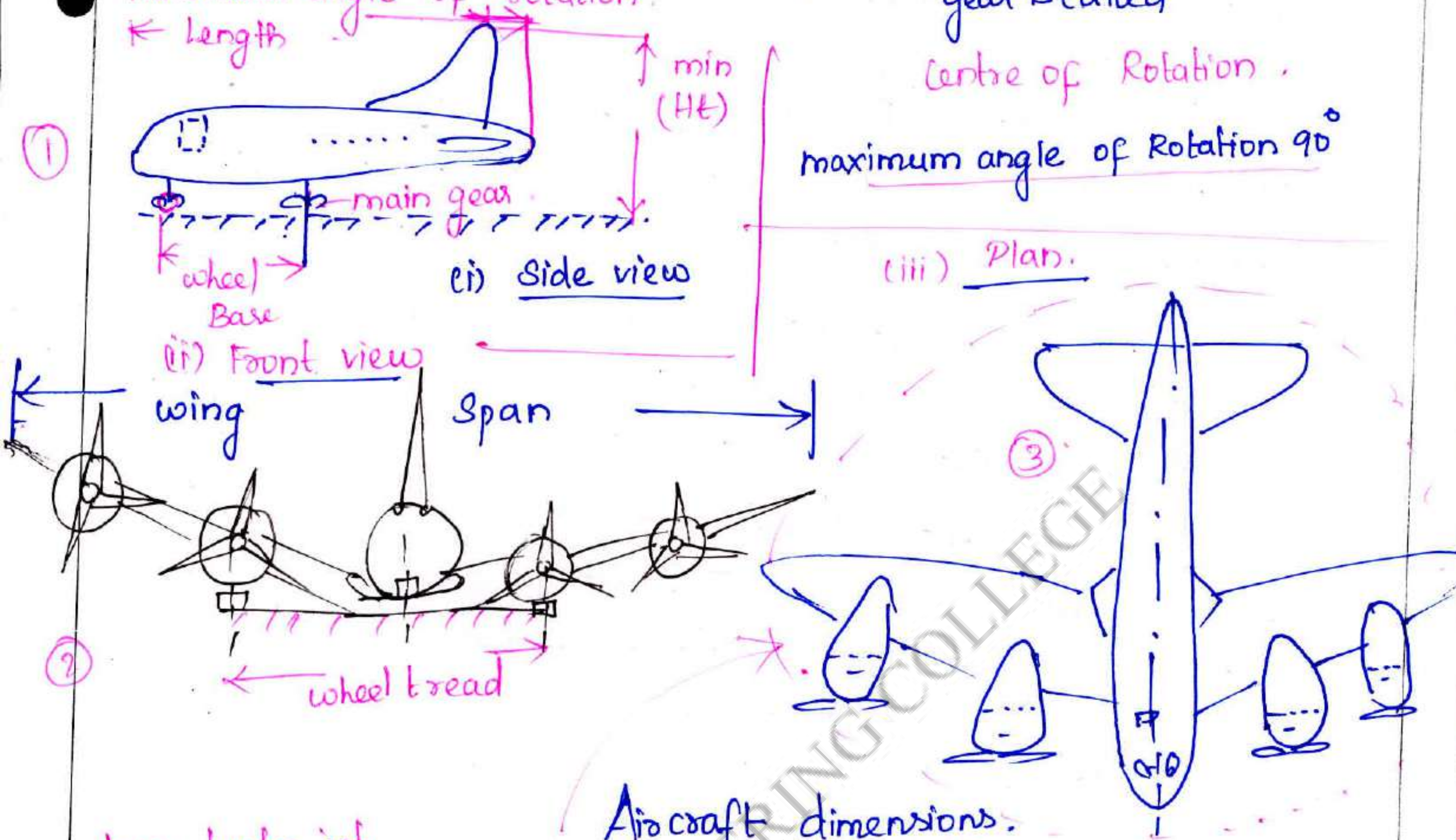
3. Minimum Turning Radius.

In order to decide the radius of taxiway, the position of aircraft in loading aprons and hangars and to establish the path of the movement of aircraft, it is Very essential to study the geometry of the turning movement of aircraft.

To determine the minimum turing Radius, aline is drawn

Through the axis of the nose gear when it is at its main maximum angle of rotation gear is called Centre of Rotation.

maximum angle of Rotation 90°



Aircraft dimensions.

large turbo jet this angle is b/w 50° to 60°.

4. Minimum Circling Radius: This depends (Radius) upon the type of aircraft air traffic volume and weather conditions.

1. Small general aviation aircraft under VFR condition (under Flight Rules) = 1.6 km (1 mile)
2. Bigger aircraft say two piston engine under VFR = 3.2 km (2 mile)
3. Piston engine aircraft under IFR Condition (Instrument Flight Rules) = 13 km (8 mile)
4. Jet engine aircraft and IFR Condition = 80 km (50 miles)

VFR : visual flight rules

5. Speed of Aircrafts.

→ depends upon the ground speed and air speed.

(ground speed (or) ~~Cruising speed~~), * aircraft relative to the wind.

→ Air speed related to

→ aircraft flying at a speed of 500 kph

→ head wind 50 kph

→ air Speed 450 kph

5. Aircraft Capacity: Number of passengers, baggage, Cargo & fuel depends upon the capacity.
6. Weight of Aircraft & wheel Configuration.
-> as well as the Structural Requirements (ie) thickness of the Runway, taxiway, apron & Hangars. It depends on wt of passenger baggage, Cargo and Fuel it is carrying & Structural weight.
7. Jet Blast:- Velocity of jet blast may be High as 300 kmph. The effect of the jet-blast should also be considered for determining the position, size and location of gates.
8. Fuel Spillage: At loading aprons and Hangars it is difficult to avoid Spillage completely, but effort should be made to bring it with in minimum limt.
9. Noise. It Generated by aircraft create problems in making desisions on layout and capacity.

Suggested Questions / Assignments /Home works / any other

	Text Books/ ReferenceBooks		
S.No	Title	Author	Publisher
1.			
2.			
3.			
Any other suggested Materials			

Lecture No. 02

UNIT I – AIRPORT PLANNING

Topic(s) to becovered	AIRPORT CLASSIFICATION

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture ,students will be able to	
LO2	Airports are classified into different Types.	understanding

TeachingLearningMaterial	Student Activity
chalk & Talk	Listen

Lecture Notes

AIRPORT:

* An airport is a location where aircraft such as airplanes take off and land.
* passengers connect from ground to air transportation
* Aircraft may also be stored (or) maintained at an airport.
* An airport should be have runway for takeoffs and landings, Buildings such as Hangars and terminal Buildings.

AIRPORTS ARE CLASSIFIED INTO DIFFERENT TYPES

1. Based on Take-off & Landings Speed
2. Based on Aircraft approach
3. Based on Function
4. Based on Geometric Design
5. Based on aircraft wheel characteristics.

BASED ON TAKE-OFF & LANDING:

Aircraft can have different ways to take-off and land. Conventional airplanes accelerate along the ground until sufficient lift is generated for take off and reverse the process to land. Some airplanes can take off at low speed, this being a short takeoff.

a. Conventional Take-off and landing Airport (CTOL)
   Runway Length > 1500m

b. Reduced Take-off & Landing Airport (RTLA)
   Runway Length 1000 to 1500m

c. Short Take-off and Landing Airport (STOL)
   Runway Length 500 to 1000m

d. Vertical Take-off and Landing Airport (VTOL)
   Operational area 25 to 50 Sq.m

BASED ON AIRCRAFT APPROACH SPEED:

Grouping differentiating aircraft based on the speed at which the aircraft approaches a runway for a landing.

Approach category A - <91

Approach category B - 91-120

Approach category C - 120-140

Approach category D - 141-165

Approach category E - >165

BASED ON FUNCTION:

a. Civil Aviation:

It is one of two major categories of Flying, Representing all non - military aviation, both private and Commercial.

(i) Domestic:

⇒ with in the Same Country

⇒ Do not have Customs and immigration Facilities.

(ii) International:

Airport with Customs and border control Facilities enabling passengers to travel b/w Countries.

b. Military Aviation:

Military Aviation → use of military aircraft and other Flying machines For the purpose of conducting (or) enabling aerial welfare, including national airlift capacity to provide logistical Supply to forces stationed in a theater or Front

ICAO AIRSAPACE 101:

→ Current ICAO - designations where adopted in 1990 (US) updated in 1993

⇒

ICAO AIR SPACE

↓ Controlled Airspace

↓ Uncontrolled Airspace

1. Class A: (Controlled Airspace)

IFR Fight only are permitted

all Fight have traffic Control Service and are Separated from each other

Class B:
IFR & VFR Fights are permitted, all Fights are provided with air traffic control Service

Class C: IFR & VFR Fights are permitted
VFR Fights are Separated from Fights and receive traffic information in respect of other VFR.

Class D:

Class E: All Fights receive traffic Information as for as is practical. class E shall not be used for Control zones.

Uncontrolled Air Space:

Class F: IFR & VFR Flights are permitted all participating Service. IFR flights receive an air traffic advisory Service

Class G:
IFR & VFR Flights are permitted and receive Flight Information Service if Requested.

Suggested Questions / Assignments /Home works / any other

	Text Books/ ReferenceBooks		
S.No	Title	Author	Publisher
1.			
2.			
3.			
Any other suggested Materials			

Lecture No. 03 **UNIT I – AIRPORT PLANNING**

Topic(s) to becovered	International Civil Aviation Organisation (ICAO)

	Lecture Outcome (LO) At the end of this lecture ,students will be able to	Bloom's Level
LO3	International Civil Aviation Organisation.	understanding

TeachingLearningMaterial	Student Activity
Chalk & Talk, ppt.	Listen / participate / discuss

Lecture Notes

International Civil Aviation Organisation (ICAO)

The Nations of the world have Established the International Civil Aviation Organisation (ICAO) to Serve as the medium through which the necessary International understanding and agreement b/w nations in all

* technical & economic & legal Fields

ICAO's membership comprises 151 Sovereign states. with the Signing of a treaty in december 1944.

ICAO → Inter Governmental Organisation and in 1947. became a Specialised agency in Relationship with the United Nations.

ICAO → provides the machinery for the achievement of international co-operation in the air.

3 decades → proof → Nations can work together effectively to achieve good results.

ICAO provides the international link b/w civil and military flying activities. Specific recommendations

(i) Co-ordination b/w military authorities and air traffic services.

(ii) Co-ordination of activities potentially dangerous to civil aircraft.

(iii) Strayed (or) unidentified aircraft, and

(iv) Interception of civil aircraft.

ICAO works in close - co-operation with other members of United Nations family such as the

(WMO) – World Meteorological Organisation

(ITU) – The International Telecommunications union

(UPU) – Universal Postal Union.

(WHO) – World Health Organisation

(IMCO) – Intergovernmental ~~Organisations~~ maritime Consultative Organisations

Non-Governmental Organisations:

The International Air Transport Association (IATA)

The International Federation Airline Pilot Association. (IFAPA)

The Internation Council of Aircraft Owner and Pilot Association (ICAOPA)

Structure of ICAO:

a) The Assembly:

Assemby in "every 3 years" at a place of meet and time convened by the Council.

All contracting states may be represented and decisions are taken by a majority of vote cast. The Financial arrangements of ICAO are determined and a triennial budget voted. The work of the council is reviewed and directions and recommendations given for future action.

b. The Council:

The Council is the permanent governing body and Composed of 33 members elected by the Assembly. The Council elect its own president.

One of its major duties is to adopt international standards and recommended practices and to incorporate ~~them as~~ Convention

The Council control and co-ordinates the work of Six additional representative Bodies.

These are: The Air Navigation Commission, The air Transport Committee, Committee for Joint Support of Air Navigation Services, Legal Committee Finance Committee and the ICAO Secretariat.

[(membership - 151) Sovereign States] → ICAO → 1944
⇓ Created as an Inter Governmental Organisation

Specialised agency in Relationship with United Nations. (1947)

Regional offices: Cairo, Dakar, Lima, Mexico City, Paris & Nairobi.

[WMO, ITU, UPU, WHO, IMCO] co-operation with other members of united Nation Family such as.

Non - Governmental Organisation: IATA, IFAPA, ICAOPA

Structure of ICAO

The Assembly
1. meeting - every 3 years
2. All contracting states - Represented & decisions are taken by majority of votes cast
3. Financial arrangements → triennial budget.

The Council
1. permanent governing body & composed of 33 members elected by Assembly.
2. Council elect its own President.

Suggested Questions / Assignments /Home works / any other

Text Books/ ReferenceBooks

S.No	Title	Author	Publisher
1.			
2.			
3.			

Any other suggested Materials

Size of Aircraft:

model	~~produced~~ Year	Length
L-1011	1972-1985	54.17-50.05 m. [illegible]
11-86	1980-1994	60.21m
11-96	1992-present	55.3-63.94 m.
777	1993-present.	63.7-73.9 m.

Fuselage diameter is 5 to 6m (16 to 20 ft).

diameter of 3 to 4m (10 to 13ft)

Aprons/ Ramp: is a designated area of an airport where aircraft are parked, unloaded, loaded, refueled. ~~Hangars:~~ The apron is typically located adjacent to the terminal Building.

Hangars: Hangars are buildings in which airplanes are repaired or serviced. Most airlines have their own Hangars. In which they can park many jets at the same time. most hangars are far away from terminals and Runways so that they do not interfere with airport traffic.

Lecture No. 04

UNIT I – AIRPORT PLANNING

Topic(s) to becovered	Airport planning – site Selection typical. Airport Layout.

	Lecture Outcome (LO) At the end of this lecture ,students will be able to	Bloom's Level
	FAA Recommendation, Airport planning Site Selection typical, Airport Layout.	understanding

TeachingLearningMaterial	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Airport planning : Site selection typical. Airport Layout

General:

Airport planning Requires more intensive Study and Force though as compared to planning of other modes of transport.

* Most dynamic industry and its Forecast is quite complex.

* FAA – Federation Aviation Agency (FAA)

⇓

Master plan depents upon (FAA) Federation Aviation Agency:

(i) To provide an effective graphical presentation of the ultimate development of the airport and of the Anticipated land uses adjacent to the Airport.

(ii) To establish a schedule of priorities and phasing for the various improvements proposed in the plan.

(iii) To present the pertinent back-up information and data which were essential to the development of the master plan.

(iv) To describe the various concepts and alternatives which were considered in the establishment of the proposed plan.

FAA Recommendation:

Phase I : Airport Requirements

The first phase essentially is an examination of the scale and demand and anticipated environmental implications.

Phase II : Site Selection:

(i) new airport (or) major expansions of existing facilities.

(ii) Evaluation → study of Airspace Requirements, environmental impact, development access, land cost & political implications.

Phase III Airport plans

1. Airport Layout Plan
2. Land use plan
3. Terminal Area Plans
   Size & location of various buildings.
4. Airport Access Plans.
   Show proposed routings for the various access modes to the transportation information of the Region.

IV : Financial plan:

1. Schedules of proposed development.
2. Estimates of development costs
3. Economic Feasibility Analysis
4. Financial Feasibility Analysis.

AIRPORT SITE SELECTION

* The development of airport by stage will be made easier and economical.
* Factors listed below are for the Selection of a Suitable Site For a major airport installation.

1. Regional Plan:

Site Selected —fit well→ the national network of airport

2. Airport Use:

* Site Selection depends —use→ Civilian (or) military operations

during emergency, civilian airport taken over by defence:

* provides Natural protection
* Sometimes the topography is Such that the planes can be hidden by the underground istallation.

3. Proximity to other Airport. (near by)

The Required Separation b/w airport mainly depends upon the volume of air traffic. (traffic control)

planning guide:

1. airport Serving Small general aviational aircraft under VFR condition = 3.2 km (2 miles)
2. For airport bigger aircraft, Say two two piston engine (VFR) = 6.4 km (4 miles)
3. For airport operating ~~po~~ piston egine and IFR = ~~85~~ 25.6 km (16 miles)
4. Jet engine / under IFR Condition: 160km (100 miles)

4. Ground Accessibity:

5. Topography.

6. obstruction: when aircraft is landing (or) taking off its loses (or) gains altitudes very slowly as compared to the forward speed.

8. Visibility

9. wind

10. Noise Nuisance

10 Grading Drainage and Soil characteristics

11. Future development

12 Availability of Utilities from Town.

13 Economic Consideration.

Suggested Questions / Assignments /Home works / any other

Text Books/ ReferenceBooks

S.No	Title	Author	Publisher
1.			
2.			
3.			

Any other suggested Materials

Lecture No. 06

UNIT I – AIRPORT PLANNING

Topic(s) to becovered	Parking:

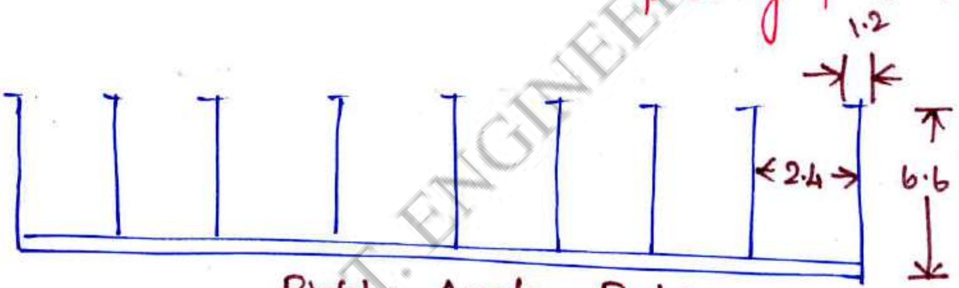
	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture ,students will be able to	
	Vehicular circulation and parking area Basic Vehicular parking patterns.	Understanding

TeachingLearningMaterial	Student Activity
PPT, chalk and talk.	Listen

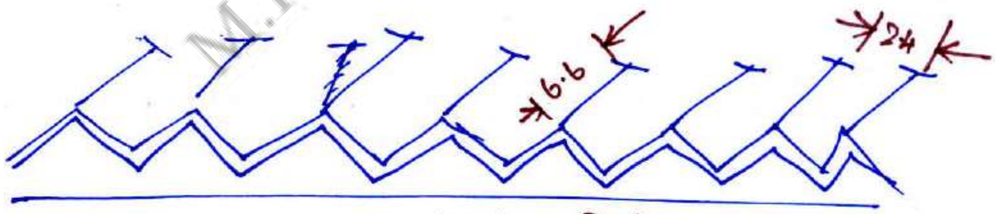
Lecture Notes

Vehicular Circulation and parking area:

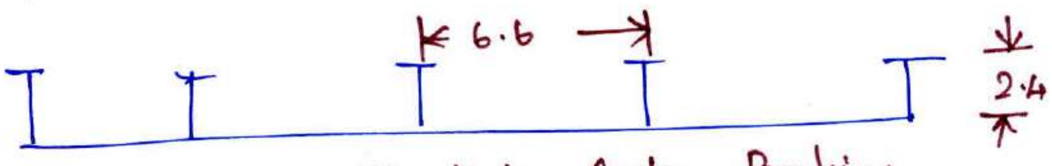
Basic Vehicular parking patterns:



Right Angle Parking



Angle Parking



Parallel Curb Parking

Dimensions are in metres.

Airport users normally arrive at the airport in automobiles, access Roads and parking Facilities are of vital importance in the airport design.

The Circulation of traffic and location of parking lots Should be Such that access to the terminal Building.

One of the present disadvantages of air travel is the that the time Saved through air travel is lost in ground transportation.

Circulation of vehicular traffic within the terminal area is also Carefully planned.

For most efficient airport Vehicular Circulation & parking System The following points are Considered.

1. Ease of passenger unloading and loading at the terminal building.
2. One way traffic wherever possible.
3. A minimum of driveway intersection
4. Adequate driveway width to permit overtaking
5. Sufficiently and clearly defined parking and Circulation routes.
6. Well lighted routes For pedestrians and Vehicles.

FAA Suggests → size of public parking Facility Should be based on 1.5 to 2 Cars For each pear hour passenger.

Apron:

It is a paved area for parking of aircraft, loading and unloading of passengers and cargo.

It is usually located close to the terminal building (or) hangars.

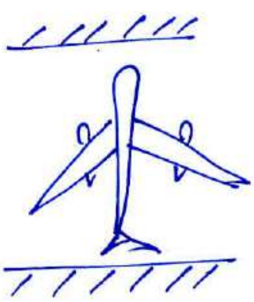
The size of apron depends upon:

(i) Size of loading are required for each type of aircraft. This area is known as gate position.

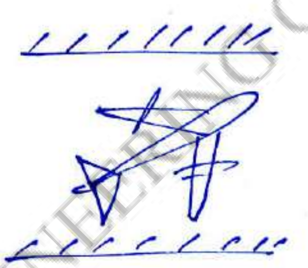
(ii) Number of gate position

(iii) Aircraft parking system.

Size of Gate position:

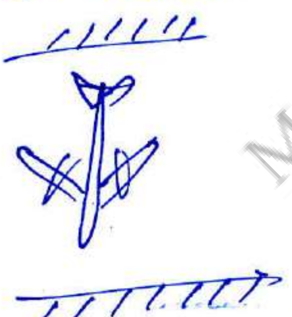


NOSE – IN



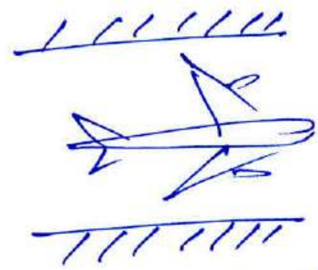
(b) Nose-in and angled nose-out.

(a) Nose-in and angled nose-in



(c) Nose out

Angle Nose out

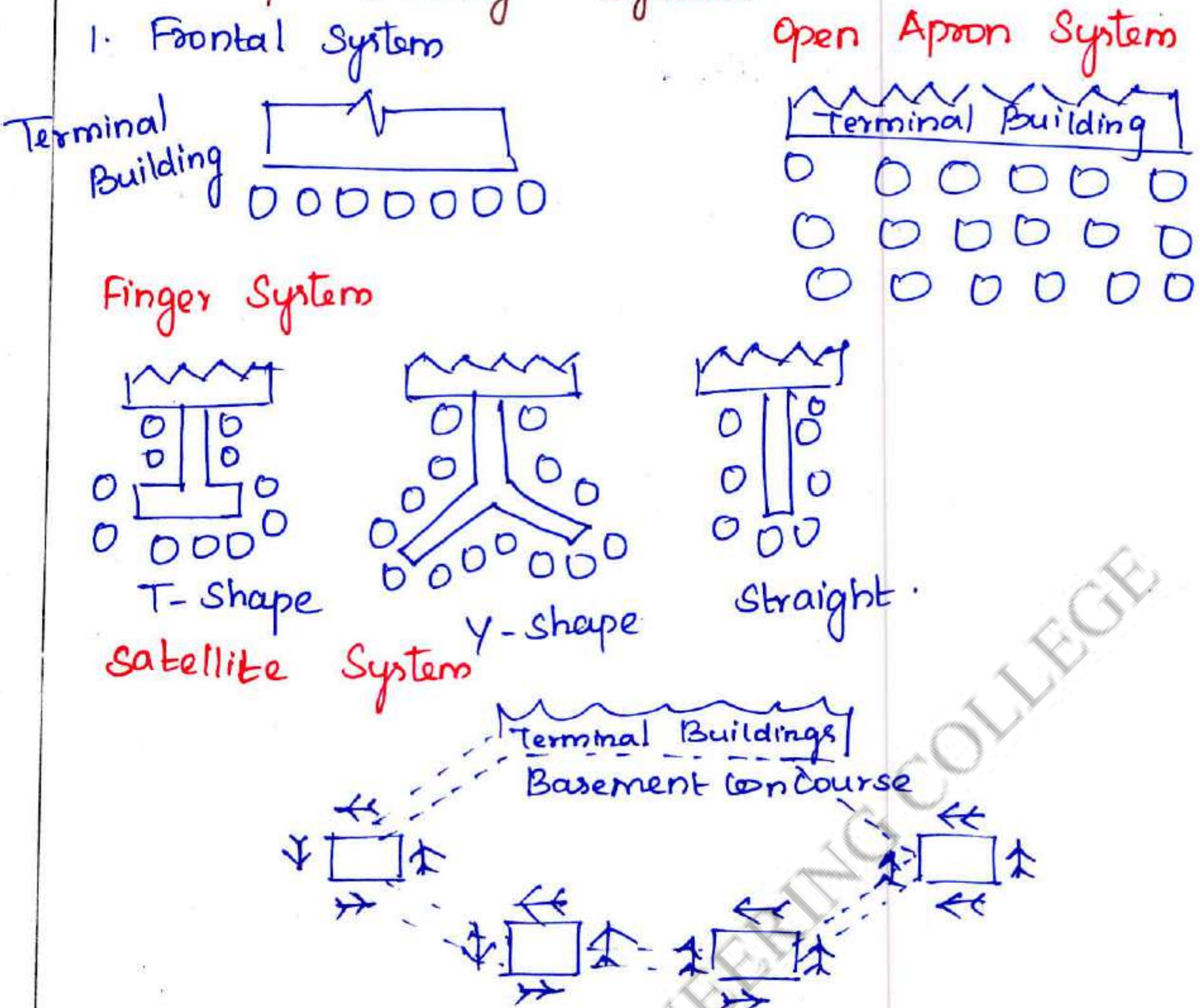


Parallel.

Number of Gate Positions:

$$\frac{\text{Capacity of Runway}}{60 \times 2} \times \text{average gate occupancy time.}$$

Aircraft Parking System:



Suggested Questions / Assignments /Home works / any other

Text Books/ ReferenceBooks

S.No	Title	Author	Publisher
1.			
2.			
3.			

Any other suggested Materials

Lecture No. 07 **UNIT I – AIRPORT PLANNING**

Topic(s) to becovered	Airport - Circulation Area

	Lecture Outcome (LO) At the end of this lecture ,students will be able to	Bloom's Level
	Hangers , Terminal Building	understanding

TeachingLearningMaterial	Student Activity
PPT, Chalk and Talk	Listen / participate / discuss

Lecture Notes

Airport
- Landing area
- Terminal area
  - Terminal and operational building
  - Vehicular parking
  - Apron & Hanger

Hangers:-

It's size depend upon the size of aircraft

It is usually constructed of steel frames & covered with galvanized iron sheets.

It is also provided with machine shops and stores for spare parts.

hanger can be located close to the terminal Building & loading aprons, such as an arrangements offers many advantages.

The Functional effeiciency of airport Should not be impaired.

(i) Convenient Road access

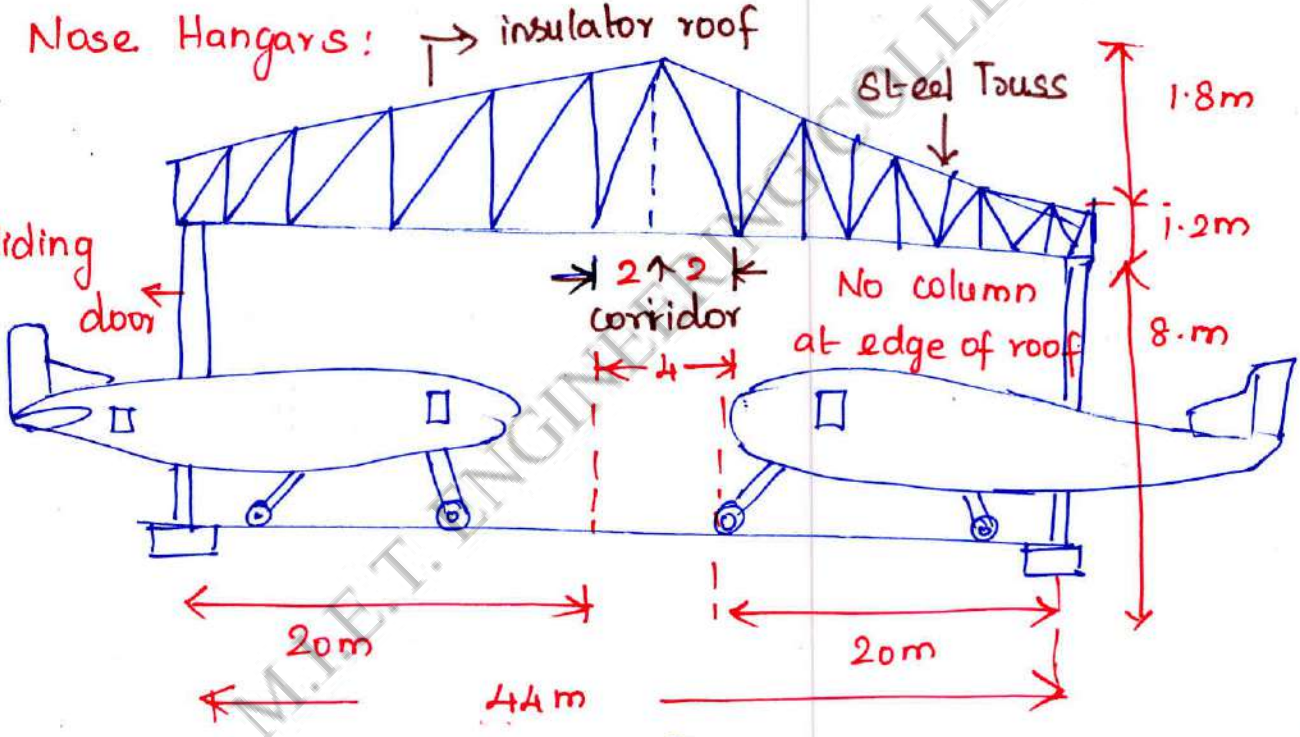
(ii) Utilities & Facilities like electricity, telephone, water Supply, Sewer etc

(iii) Reasonable proximity.

(iv) Topography for good natural drainage

(v) Future expansion & Car parking for working personal.

1. Nose Hangars:

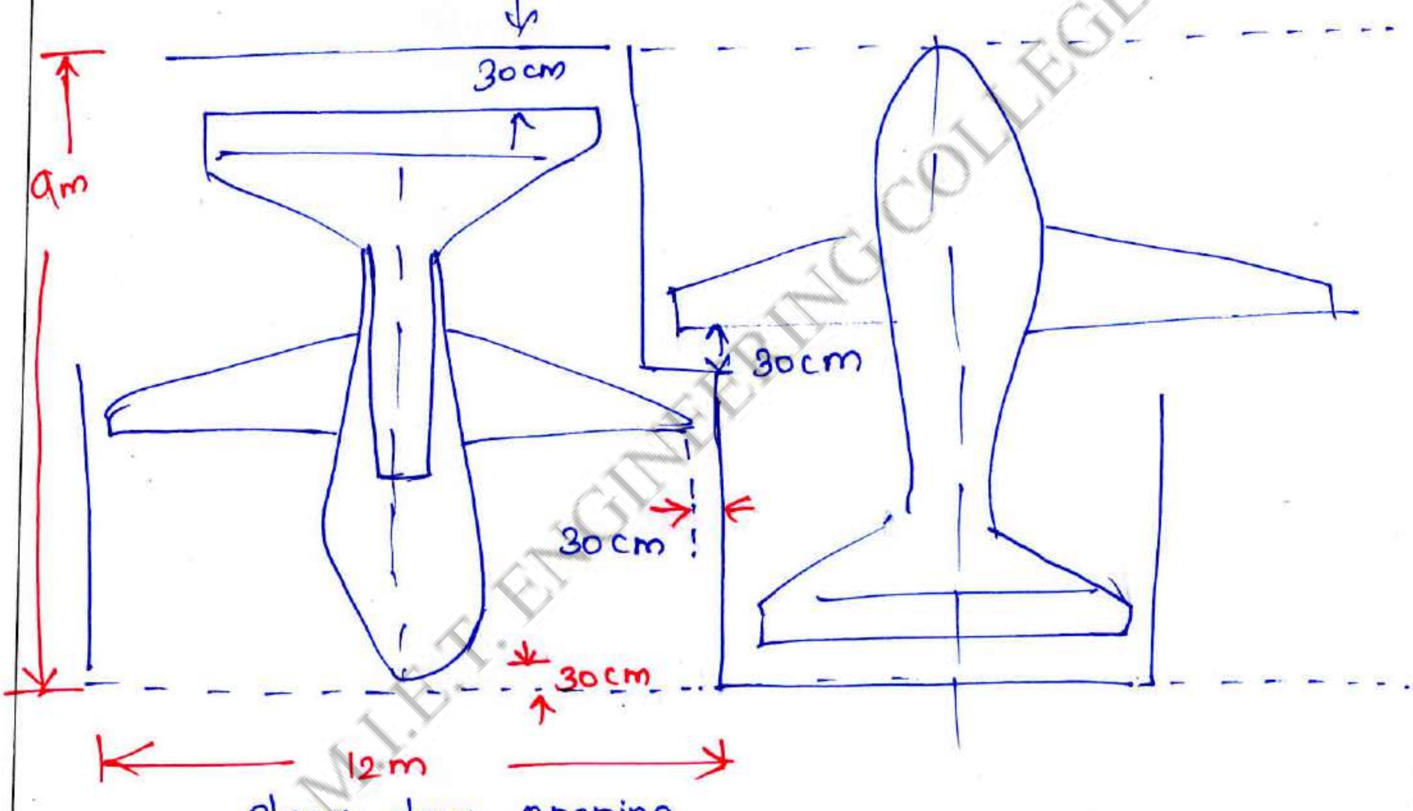


1. Provided for larger Size aircraft
2. They enclose only forward portion of aircraft
3. Tail and Some portion of Fuselage is outside
4. Helps in Servicing and provide better working Conditions.

2. T. Hangars:

These are provided with Small Size Aircraft Pilot can easily manoeuver the aircraft in and out of hangar without any assistance.

The area should be large enough to accommodate different types of aircraft a minimum clearance of 30cm



Clear door opening

Terminal Area

It is the portion of the airport other than the landing area

It serves as a focal point for the activities on the airport.

(iii) It includes terminal and operational building Vehicle parking area, aircraft service hangars etc.

Terminal Building:-

1. The purpose of airport buildings is to provide shelter and space for the various surface activities related to the air transportation.
2. Terminal building usually refers to a building mainly used for passenger airline and administration facilites
3. planned for the maximum efficiency, Convenience & economy.

Suggested Questions / Assignments /Home works / any other

	Text Books/ ReferenceBooks		
S.No	Title	Author	Publisher
1.			
2.			
3.			
Any other suggested Materials			

The Trend of allowing aircraft DOC (direct operating cost) was broken by Several Factors. because the design dominates to the air transport System.

Runway: According to the ICAO : Runway is a "defined Rectangular area for landing and takeoff of aircraft.

1. Short Range of aircraft needs lesser Runway length than the long Range of type, Since there is a Smaller Fuel Requirement
2. Runway length → Important factor for aircraft performance and cost for the airport layout.
3. Aircraft and airport also interact in the area of Runway & terminal Capacity.

Influence of Aircraft "Design of Runway Length"

All Commercial aircraft design depends on the development of propulsion Systems and application led to the Full use of propulsive improvement.

$$\text{lift} = \text{weight} \sim \rho v^2 S C_L$$

where ρ = air density, kg/m³, V = forward Speed of the aircraft kmph
S = area of wing m² C_L = non-dimensional co-eff. of lift which approximately proportional

$$\text{(or)} \ \frac{W}{S} = \text{wing loading} \sim \rho v^2 C_L$$

W = aircraft weight.

Disc loading → the thrust developed by a Fan per unit Swept area.

Static efficiency $1/\alpha$ to disc loading.

REQUIREMENTS OF AIRCRAFT TYPES:

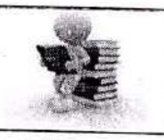
Field Length Requirements :

1. Checking the ability of an aircraft to take a Specified payload Form (or) land at a Specified airfield in Specified environmental condition.

(ii) Calculating the allowable maximum payload that may be moved under those Specific conditions when the payload is limited by available field length.

(iii) Planning and provision of Field length required at an airport to allow operation of a Specific type from that airport to allow ~~operation~~ of Specified type destinations on a Specified percentage of occasions annually. (determined by local environmental History) . with a specified percentage of its maximum payload.

Suggested Questions / Assignments /Home works / any other



Text Books/ ReferenceBooks

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1.			
2.			
3.			

Any other suggested Materials

Lecture No. 05 **UNIT I – AIRPORTS PLANNING**

Topic(s) to be covered	Case Studies on Airport planning

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
	checklist for case study.	understanding

Teaching Learning Material	Student Activity
PPT, chalk and Talk	Listen / partcipate / discuss

Lecture Notes

Case Study checklist:

A. Site Level:

1. Site details:

- Location
- History
- Nearest Landmark
- Major Access to site – Entry and Exit
- Road Geometrics in the site
- Topography
- Utilities
  ⇒ water supply, Electricity, telephone, Sanitary Fire, Storm water drainage, waste disposal etc.
- Surrounding Context.

⇒ Neighborhood structure, Views - Vistas, Noise from streets, etc.

- parking Facilities
- Landscape Features
- Any Sustainable aspects, eg: Rainwater harvesting.etc.

B. Building level

2. Planning Study
   - Horizontal & Vertical zoning of spaces
   - Typology of Spaces
   - Hierarchy of Spaces

3. Parking Level(s) planning
   - Entry and Exit ramps
   - Spaces and Numbers
   - Signagels
   - Safety and Security
   - Circulation routes
   - Any advanced System of parking

4. Floor plans Study:
   - Each level Study
   - Vertical cores - analysis
   - Any philosophy / theme in planning
   - Circulation routes of Public (Horiz, Vert, Visual)
   - Circulation Service routes (Horiz, Vert.)

5. Services:

- Lighting (Natural and Artifical)
- HVAC
- Water Supply and Sanitation
- Fire Safety
- Elevator / Escalators
- Waste disposal
- Communication

6. Structural and constructional Techniques

7. Material Study

- At Site level - pavement - steps, Entrance Flooring etc.
- Building level
  - Flooring details of common Spaces, passages
  - Atriums, shops interiors
  - Facade treatments
  - Roof details
  - wall claddings
  - Service Spaces
- Detailing of any Special Feature / technique.

8. Activity Study

- Use of different spaces
- Activities in common spaces, passages around
- elevators, entrance - exit.
- Recreation Areas (play zones)
- Food Courts
- Seating Spaces and Resting spaces
- Study and analysis based on Anthropometrics.

Suggested Questions / Assignments /Home works / any other

	Text Books/ ReferenceBooks		
S.No	Title	Author	Publisher
1.			
2.			
3.			

Any other suggested Materials

Lecture No. 01 **UNIT II – AIRPORT COMPONENTS**

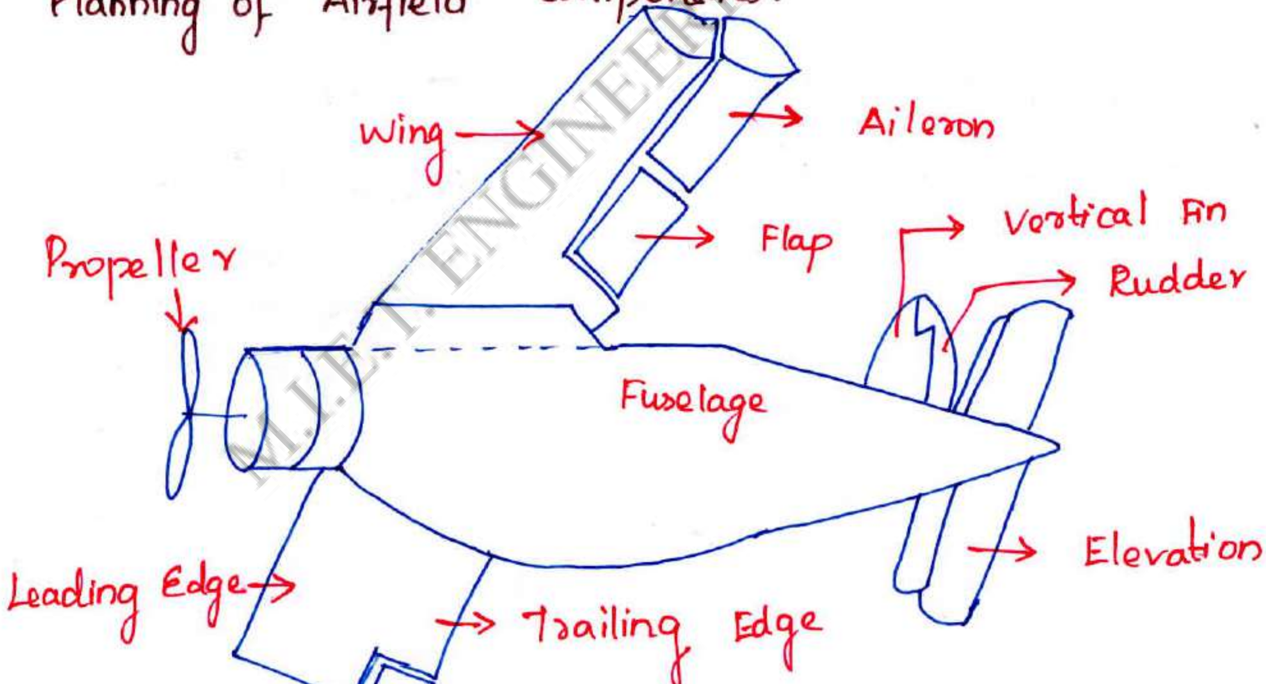
Topic(s) to be covered	Airport classification, Planning of Airfield components.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
	✓ Planning of Airfield Components	understanding

Teaching Learning Material	Student Activity
PPT, Chak and Talk	Listen / participate / discuss.

Lecture Notes

Planning of Airfield Components:-



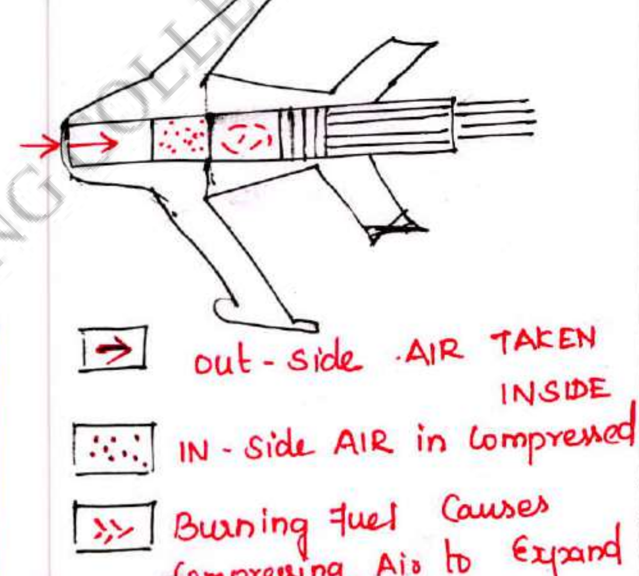
Component Parts of an Aeroplane:

1. Engine
2. Propeller
3. Fuselage
4. Wings
5. Three Controls
6 Flaps
7. Tricycle under - Carriage.

Engine: The main purpose of an aircraft engine is to provide a force for propelling the aircraft through the air.

Aircraft can be classified according to their propulsion as Follows:-

1. Piston engine
2. Turbo jet
3. Turbo Fan or Turbo prop
4 Rocket



Principle of Turbo Jet propulsion.

Advantages of Jet Engines over Conventional Engines:

1. Freedom from vibrations.
2. Simplicity of control:- The power produced is applied in the best possible way that is directly.
3. No radiators (or) other cooling surface are required which will add to weight and drag on the Jet units.
4. Negligible air is required for cooling of engines.
5. No Spark plugs are required for operations.
6. No Carburettors and hence no mixture Control is required.

Cross Sectional method:

⇒ Cross Sectional method, cross section area is plotted at suitable intervals say 30m.

⇒ The area of each c/s is then determined ⇒ by graph (or) planimeter.

⇒ The Volume of earthwork is calculated by Horizonal (or) trapezoidal formula.

⇒ Trapezoidal Formula Requires odd number of c/s (or) otherwise the last c/s is considered separately.

Trapezoidal formula:

$$V = D\left[\frac{A_0 + A_n}{2} + A_1 + A_2 + A_3 \ldots\ldots A_{n-1}\right]$$

Prismoidal Formula:-

$$V = \frac{D}{3}\left[A_0 + 4A_1 + 2A_2 + 4A_3 + 2A_4 + \ldots\ldots + 2A_{n-2} + 4A_{n-1} + A_n\right]$$

where
V = Volume of cut (or) embankment
D = distance b/w two consecutive c/s
A_0, A_1, A_2, A_n = Cross-sectional areas at zero
D, 2D, ...nD = distance from the beginning.

Mass-haul Curve:

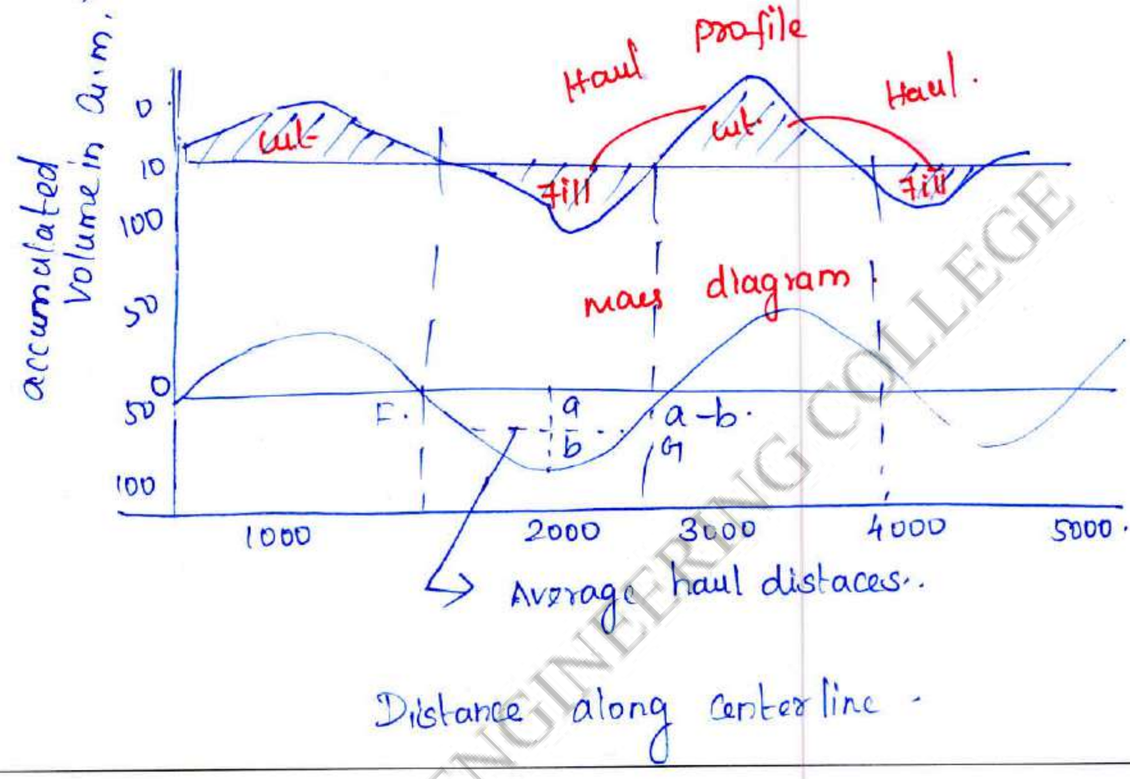
Embankments are built of material which is obtained from the excavation during grading operations (or) from the barrow pits. the limit of the distance upto which materials is hauled without any extra cost is called Free haul distance

$$L = \frac{B}{O} + F$$

where L = limit of economical haul in stations.
B = cost of barrow per cubic metre per station
O = cost of overhaul per station metre, carrying one cubic metre for one station beyond the limit of free haul.
F = free haul in stations.

The mass haul curve show a cumulative volume of earthwork at any point.

(i) The quantity of earthwork
(ii) The direction of movement of earth work.
(iii) Free haul earthwork
(iv) The amount of earth from borrow pits



Suggested Questions / Assignments /Home works / any other

	Text Books/ ReferenceBooks		
S.No	Title	Author	Publisher
1.			
2.			
3.			
Any other suggested Materials			

Lecture No. 02 **UNIT II – AIRPORT COMPONENTS**

Topic(s) to be covered	Runway, Taxiway, Apron, Hangar

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
	✓ Runway, Taxiway, Apron, Hangar.	understanding.

Teaching Learning Material	Student Activity
PPT	Listen

Lecture Notes

Runway Orientation:

Runway is usually oriented in the direction of Prevailing wind:

(Prevailing wind (or) Invariable winds:)

The head wind i.e. the direction of wind opposite to the direction of landing and take off, provides greater lift on the wings of the aircraft when it is takeoff.

CROSS WIND COMPOUND AND WIND COVERAGE:

It is not possible to obtain the direction of wind along the direction of the centre line of Runway throughout the year.

the wind may blow making certain ~~anto~~ angle with the Centre line of Runway.

In the direction of wind is at an angle to the Runway centre line,

↳ Its component along the direction of Runway will be Components

$V \cos\theta \rightarrow$ direction of Runway

$V \sin\theta \rightarrow$ direction of Runway (normal to the runway Centre line)

V = wind velocity.

The normal Component of the wind is called Cross wind Component.

may interrupt the Safe landing and take off of the air craft.

The maximum permissible cross wind Component depends upon the Size of of aircraft and the wing configuration.

FAA Recommends that for Small air crafts.

The cross wind Component Should not exceed 15 kmph (10mph)

~~Max~~ mixed traffic condition:

Should not exceed 25 kmph (15 mph)

Airports serving big aircraft ICAO Recommends. Cross wind component Should not exceed

Taxiway:

The taxiway provides access from the runways to the terminal area and Service Hangers.

This is the main function of taxiway In busy airports, the pavement adjacent to the end of Runway is termed as Holding apron also

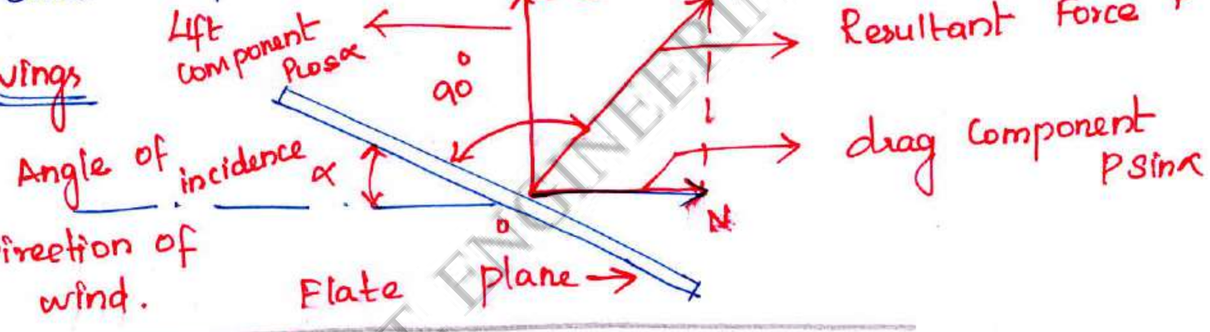
7. Noiseless operation :
8. Decreased fire Hazards
9. Lower Specific weight
10. Less Consumption of Lubricated oil.

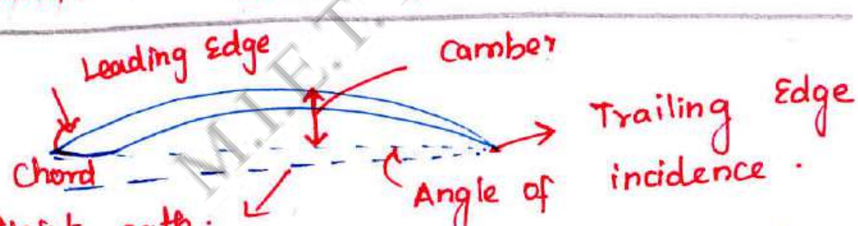
Propeller :

provided in the Conventional piston Engine aircrafts as well as in turbo prop engine. [Ref. in I unit]

Fuselage:

It forms The main body of the aircraft and provides for the power plant, fuel, cockpit, passengers, cargo etc. It must be large enough to given Sufficient tankage Space and yet be as Small as possible in order to reduce the wind Resistance.

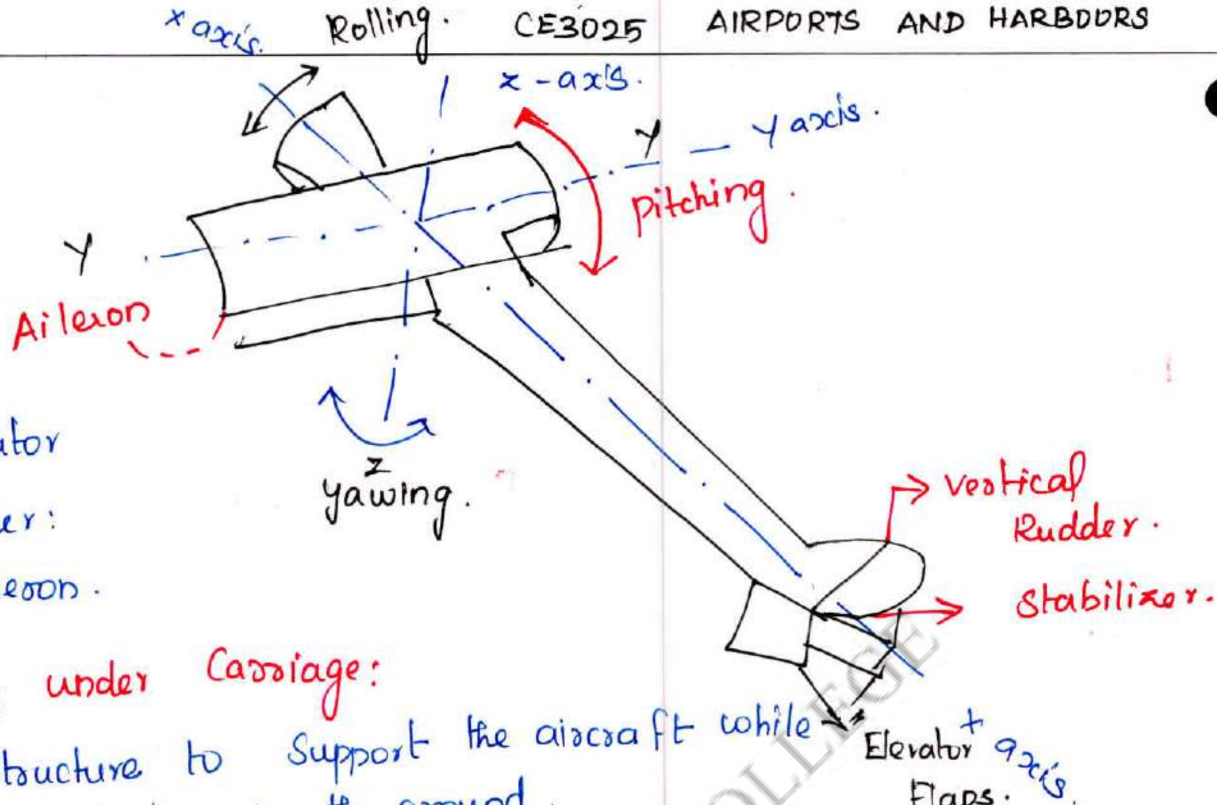




The wing Structure must be torsionally Stiff to resist forces which tend to twing the wing. It should also be strong enough to resist flexure or bending Forces

Three Controls :

x-axis : lateral (or) rolling movement
y-axis : pitching movement
z-axis : yawing movement



(i) Elevator
(ii) Rudder:
(iii) Aileron.

Tricycle under Carriage:

This structure to support the aircraft while it is in contact with the ground. Two principal functions to perform as listed below

1. To absorb landing shocks:
2. To enable the aircraft to manoeuvre on ground.

Suggested Questions / Assignments /Home works / any other

Text Books/ ReferenceBooks

S.No	Title	Author	Publisher
1.			
2.			
3.			

Any other suggested Materials

Lecture No. 03 **UNIT II – AIRPORTS PLANNING**

Topic(s) to be covered	Geometric design of Runway

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level

Teaching Learning Material	Student Activity

Lecture Notes

Runway Geometric Design:

ICAO gives various geometric standards for the airport design.

Most of its members nations provide international air service.

In order to have uniformity in the landing facilities at the airports located in different countries, it is desirable to follow the common design standards as recommended by ICAO.

Considered in the Geometric design of Runways:

(i) Runway length
(ii) Runway width
(iii) width and length of safety area
(iv) Transverse gradient

(v) Longitudinal and effective gradient

(vi) Rate of change of longitudinal gradient

(vii) Sight distance

Runway length:

The basic runway length as recommended by ICAO for different types of airports are given in Table.

actual length of Runway – obtain

* Correction of elevation
* temperature and gradient are applied to the basic Runway length.

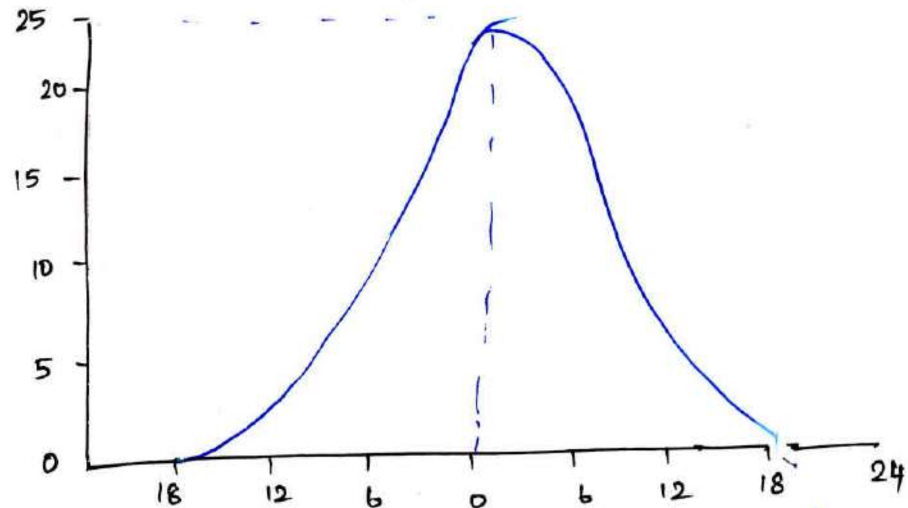
Summary of Runway Geometric (ICAO)

Airport types	Basic runway length maximum		Basic runway length minimum		Runway Pavement width		Maximum longitudinal grade %
	m	ft	m	ft	m	ft	
A			2100	7000	45	150	1.5
B	2099	6999	1500	5000	45	150	1.5
C	1490	4999	900	3000	30	100	1.5
D	899	2999	750	2500	22.5	75	2.0
E	749	2499	600	2000	18	60	2.0

Runway width:

ICAO Recommends the Pavement width Varying from 45m (150ft) to 18m (60ft) for different types of airports.

Figure indicates that the aircraft traffic is more concentrated in the Central 24m (80ft) width of the Runway pavement.

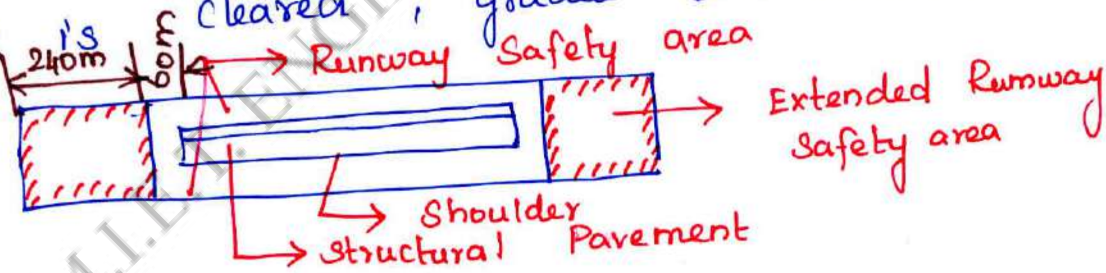


The outer engines of a large jet transport are about 13.5m (45 feet) from the longitudinal axis of the aircraft

As such a pavement width of 45m will provide adequate protection to the engine from the should material during normal operation.

Width and length of Safety Area:

Safety are consists of the Runway, which is a paved area plus the Shoulder on either side of Runway plus the area that is cleared, graded and drained.



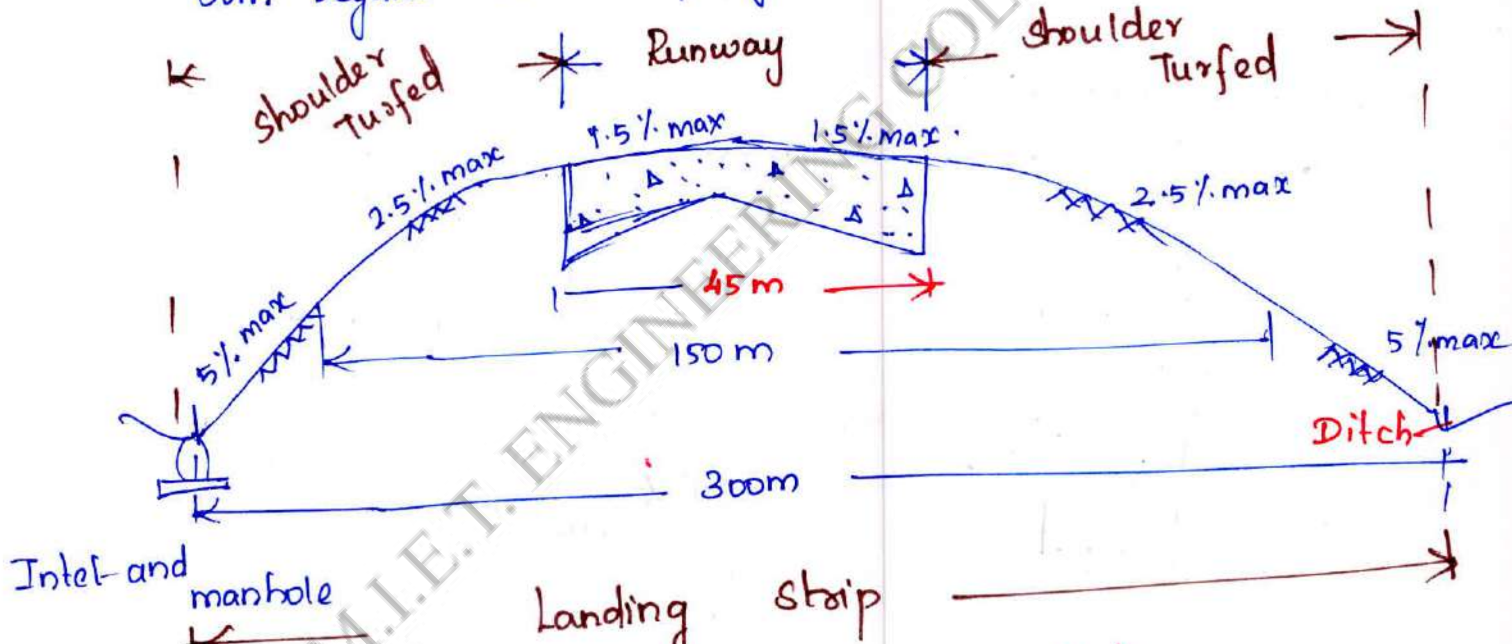
Runway Element.

Shoulders are usually unpaved as they are used during emergency. when there is some abnormality in the aircraft operations.

Most be prepared → Soil (or) be turfed.

Another advantage of providing shoulders on either side of Runway is that they impart a sense of openness to pilot and improve his psychology during landing & take off

* A, B, C are least 150m
  For D and E types = 78m.
* Instrumental runway, it should be minimum 300m.
* In length direction, the landing strip extends 600m beyond the Runway at both the ends
* Hence length of Safety area is equal to the length of Runway plus 120m.
* Spotway provided → Strip should extend a distance of 60m beyond the Stopway.



ILS Runway cross Section.

Transverse Gradient:

Transverse gradient is essential for quick drainage of Surface water. If Surface water is allowed to pond on the runway, the aircraft can meet Severe hazards.

Transverse gradient of Runway pavement should not exceed 1.50 per cent for A, B, C and 2 per cent for D and E types.

Busy airport typically construct high-speed (or) rapid exit taxiways to allow aircraft to leave the runway at High Speed. This allows the aircraft to vacate the Runway quicker, permitting another to land (or) take off in a shorter interval of time.

Factors Controlling Taxiway Layout:

1. Taxiways should be so arranged that the aircraft which have just landed and are taxiing toward apron, do not interfere with in aircrafts taxiing for take off.
2. At Busy airport, taxiways should be located at various points along the Runway so that the landing aircraft leaves the runway as early as possible and keeps it clear for use by other aircraft. Such taxiways ared called **exit taxiway:**
3. The Route for taxiway should be so selected that it provides the shortest practicable distance from the apron to the Runway end.
4. As far as possible the intersection of taxiway and Runway should be avoided
5. Exit taxiway should be designed for High turn off speeds. This will reduce the Runway occupancy time of aircraft and thus increase the airport capacity.

Classification of Flying Activity:

a) Personal

1. local
2. Cross Country
3. Aircraft Sales
4. Glider
5. Autogiro

b) Non - Scheduled Commerical

1. Aircraft testing
2. Executive personal travel and sales representation
3. Forest patrol
4. Crop dusting
5. Aerial photography and mapping

c. Scheduled Commerical

1. Loyal Schedule
   (i) on line
   (ii) Feeder
2. Intercontinental
3. Trans oceanic
4. Air Cargo
   (i) Intracontinental
   (ii) Intercontinental
   (iii) Trans oceanic

d. Military operations

1. Flight training
2. Tactical
   1. Fighter
   2. Light bombing
   3. Heavy bombing
   4. Patrol
   5. Medical
   6. Transport eg. personnel, cargo etc.

Suggested Questions / Assignments /Home works / any other

	Text Books/ ReferenceBooks		
S.No	Title	Author	Publisher
1.			
2.			
3.			
Any other suggested Materials			

Lecture No. 04 **UNIT II – AIRPORT COMPONENTS**

Topic(s) to be covered	Problems in Runway

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level

Teaching Learning Material	Student Activity

Lecture Notes

Basic Runway Length: It is the length of Runway under the following assumed conditions at the airport.

(i) Airport altitude is at sea level

(ii) Temperature at the airport is standard (15°c)

(iii) Runway is levelled in the longitudinal direction

(iv) No wind is blowing on Runway.

(v) Aircraft is loaded to its Full loading capacity

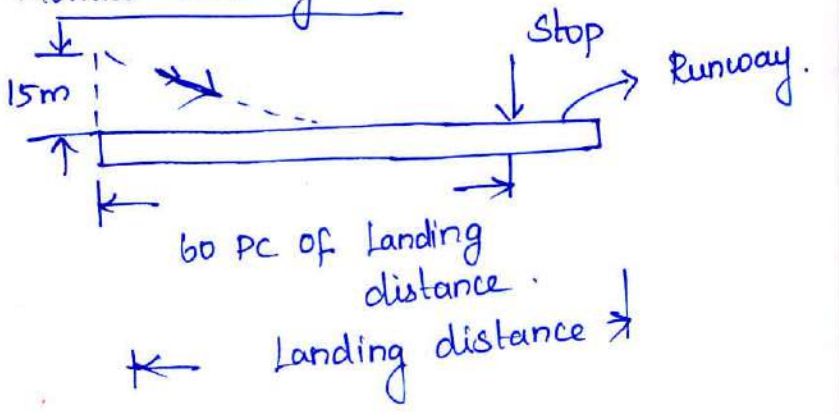
(vi) There is no wind blowing enroute to the destination

(vii) Enroute temperature is Standard.

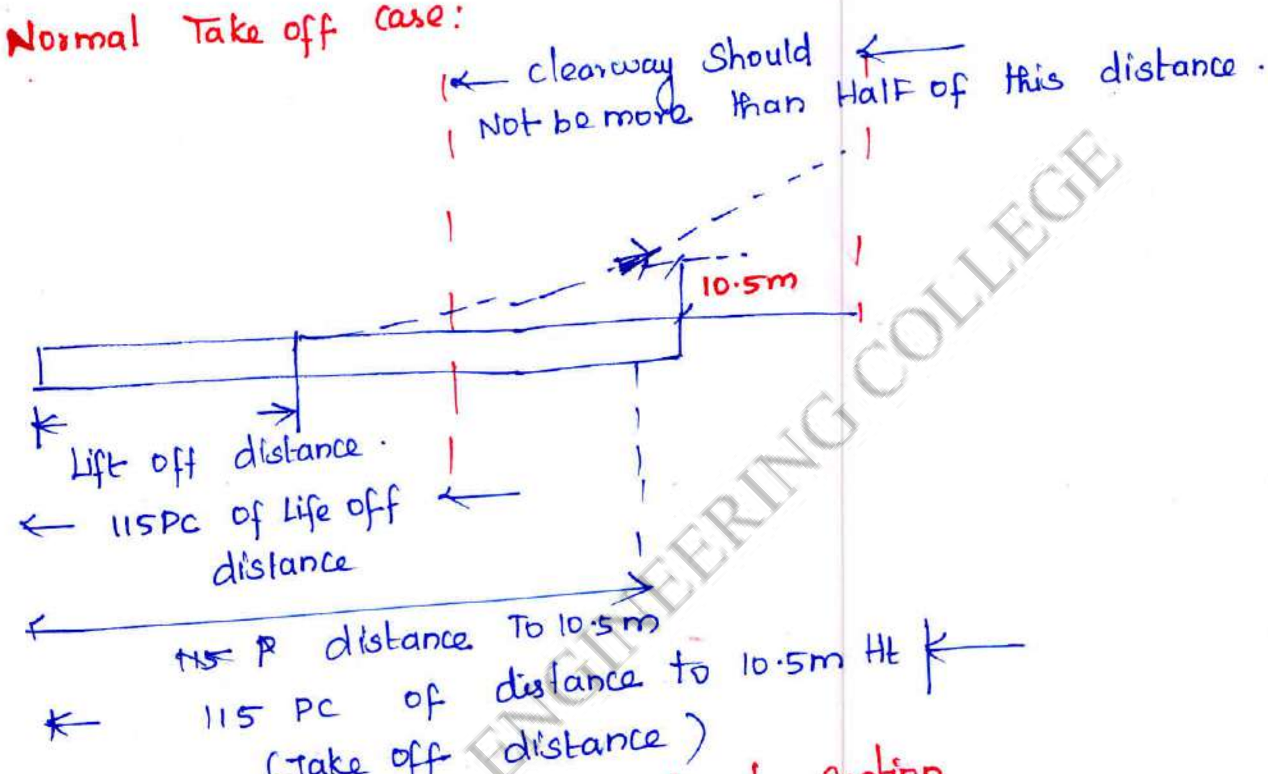
Basic Runway length is determined from the performance characteristic of the aircraft using in airport:

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

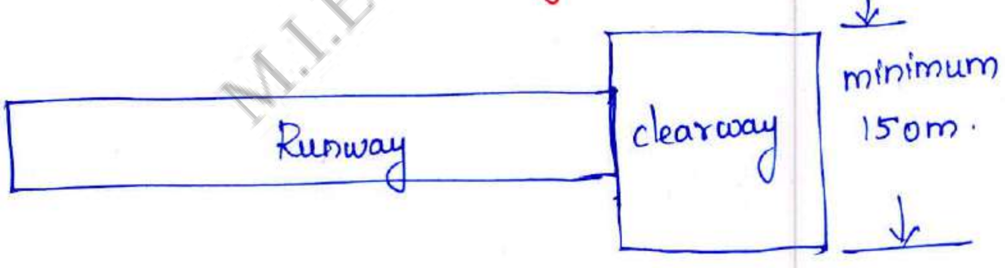
Normal Landing case:



Normal Take off case:



Longitudinal Section



Plan

Normal Take-off case.

Normal take off case requires a Clearway which is an area beyond the runway and is in alignment with the Centre line of Runway. The width of the clearway is not less than 150m (500ft)

Longitudinal and Effective Gradient:

The longitudinal Gradient of Runway increases the required runway length.

For longitudinal gradient:

A, B and C types of airports = 1.50 per cent

D and E types of airports = 2.00 per cent.

For effective gradient:

A, B and C types of airport = 1.00 per cent

D and E types of airport = 2.00 per cent.

Rate of change of Longitudinal Gradient:-

The changes in gradients should be Smoothened by Vertical Curves. ICAO recommends that the rate of change of gradient should be Vertical Curve limited to a maximum of 0.10 per cent per 30m length of Vertical Curves are generally not necessary if the change in slope is not more than 0.4 per cent.

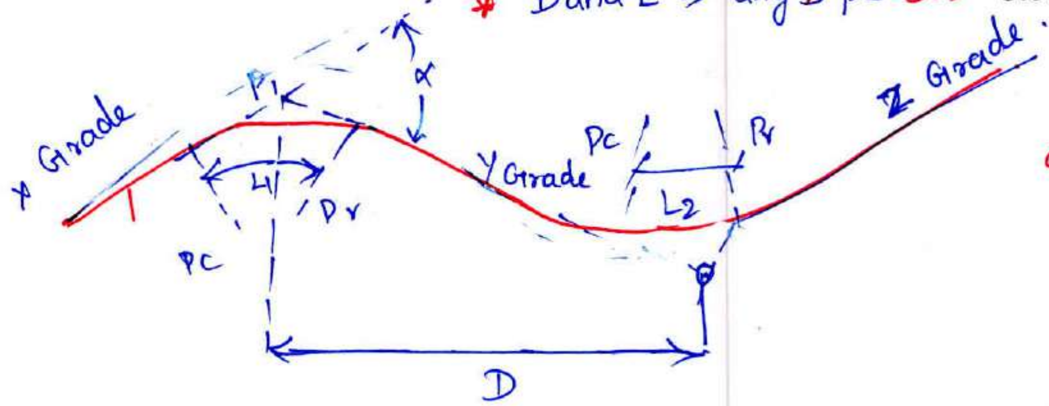
Numerical value of the change in slope multiplied by 300m for A and B and 49.5m for D.
150m for C type
and E type runway.

Recommendation by FAA.

Sight distance: The longitudal gradient Recommended For Runway are quite gentle. As such there is Hardly any sight Restriction due to the longitudinal profile of Runway.

ICAO Recommends: * A,B,C – type of aircrafts (any two points 3m) above the Surface

* D and E ⇒ any 3m above Runway. other pt 2.1m above Runway.



	Description	Small airport	Large airport.
1.	maximum grade change such as (a) (or) (b) should not exceed	2 per cent	1.5 per cent
2.	Length of Vertical Curve (L1 (or) L2) for each one percent grade change	90m	300m
3.	Distance b/w points of intersection of grade lines (D)	75 (a+b)m	300 (a+b)m.

Suggested Questions / Assignments /Home works / any other

	Text Books/ ReferenceBooks		
S.No	Title	Author	Publisher
1.			
2.			
3.			

Any other suggested Materials

Lecture No. 05 **UNIT II – AIRPORT COMPONENTS**

Topic(s) to be covered	Geometric design of Taxiway:

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level

Teaching Learning Material	Student Activity

Lecture Notes

Geometric design standards:

The Speed of an aircraft on taxiway is much lower than its Speed on a Runway during the landing (or) take off.

1. length of taxiway.
2. width of taxiway
3. width of safety area
4. longitudinal gradient
5. Transverse gradient
6. Rate of change of longitudinal gradient
7. Sight distance
8. Turning radius

Taxiway Geometrics: (ICAO)

classification by ICAO	Taxiway width m	ft	maximum Longitudinal gradient percent	minimum Transverse gradients.	Max. rate of change of long gradient per 30m (100ft) per cent	Safety area width
A	22.5	75	1.5	1.5	1.0	Turfed or paved
B	22.5	75	1.5	1.5	1.0	Shoulders are not
C	15.0	50	3.0	1.5	1.0	mandatory
D	9.9	33	3.0	2.0	1.2	but are
E	7.5	25	3.0	2.0	1.2	Suggested if need exists

Length of Taxiway:

* It Save the fuel consumption.
* No sepecifications are Recommended by any organisation For limiting the length of taxiway.

width of Taxiway:

* width of taxiway is much lower than the Runway width
* Speed of the Aircraft on taxiway is also lower than the Runway.

width of Safety Area:

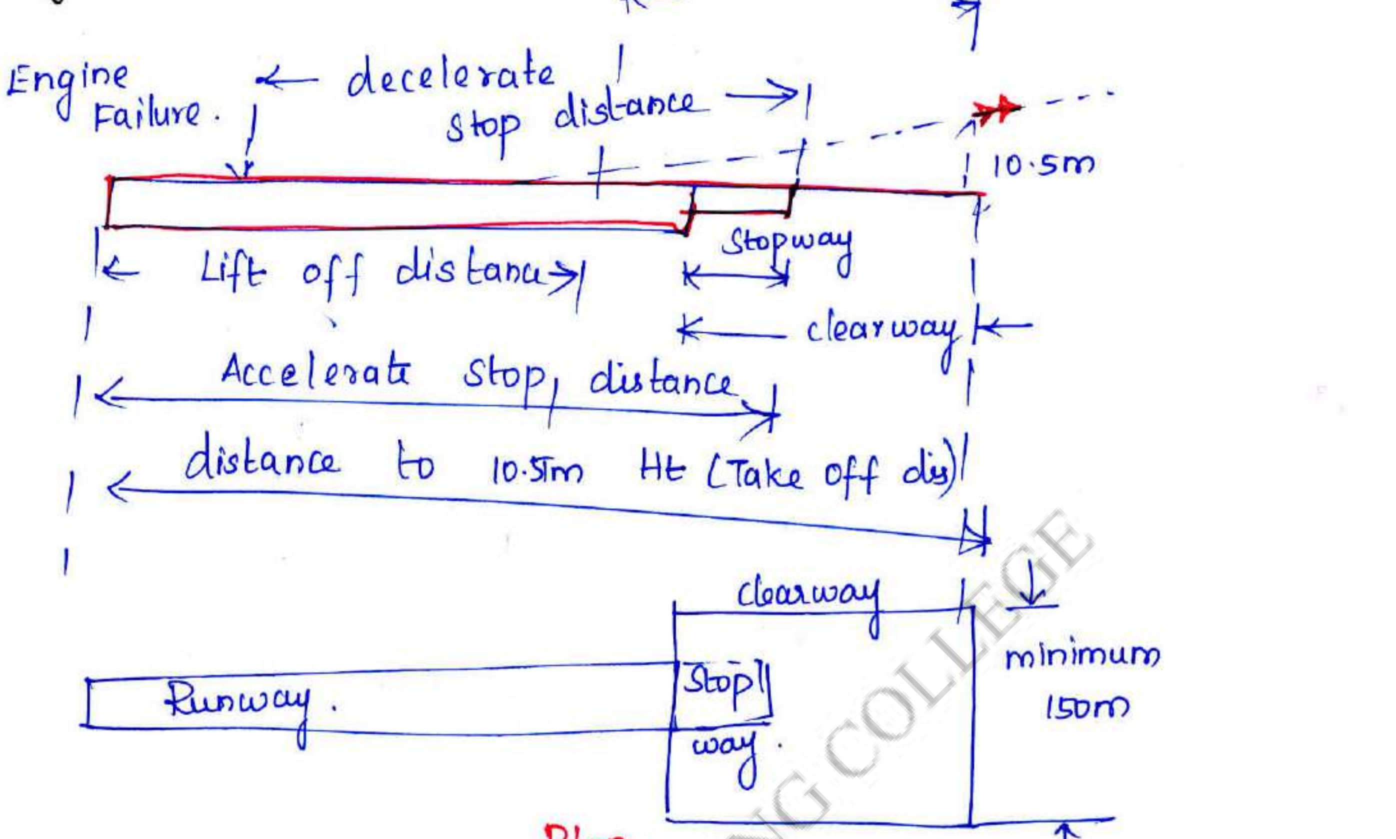
This area includes taxiway pavement shoulders on either side that may be partially paved plus the area that is graded and drained.

This may extend upto a point where it intersects a parallel runway, taxiway or an apron.

Bitumen treated shoulders are normally used.

The Shoulder must be thick enough to Support the airport petrol vehicles and Sweeping equipments.

Engine Failure Case:



Plan.

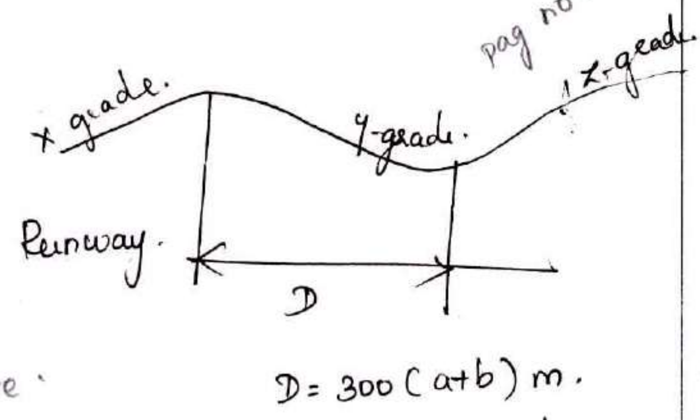
Pblm: 1

In the grading operation for Runway it is proposed to have a rising gradient of 0.5 percent meeting a falling gradient of 0.7 percent. There is again an up grade of 0.40 percent. Determine the length of Vertical Curves and the distance between the grade changes of runway. Assume that the runway is required to handle jet aircraft.

→ Solution:

$D = 300\,(a+b)\ m.$

pag no 192.



FAA Recommendations for longitudinal Grade change in Runway.

$a = x - y = 0.5 - (-0.7)$ (fall) – ve.

$= 1.2$ percent.

$D = 300\,(a+b)\ m.$

large airport.

$b = y - z = -(0.7 - 0.4) = 1.1$ percent

$\therefore L_1 = 300 \times 1.2 = 360m \quad L_2 = 300 \times 1.1 = 330m$.

$D = 300(1.2 + 1.1) = 690m$.

$\boxed{D = 690m}$

Pblm:2 The Runway gradation map indicates that there is a Rising gradient of 1.0 precent meeting a falling gradient of 0.70 percent. There is again an up grade of 0.70 percent. design the Runway Profile as per FAA Specifications.

$a = x - y = 1.0 - (0.7) = 1.70$ percent

$b = y - z = -(0.70 + 0.70) = 1.40$ percent

Since a is greater than 1.5 percent limit for large airports, the design is to be carried out for small airport.

$L_1 = 90 \times 1.70 = 153m$

$L_2 = 90 \times 1.40 = 126m$.

$D = 75(a+b) = 75(1.70 + 1.40) = 232m$

$\boxed{D = 232m}$

Suggested Questions / Assignments /Home works / any other

	Text Books/ ReferenceBooks		
S.No	Title	Author	Publisher
1.	Airport planning & design	Khanna S.K	Nemachand & Bros
2.	Highway Railway Airport & Harbour.	Subramanian K.P.	Scitech Publication.
3.			
Any other suggested Materials			

Lecture No. 06 **UNIT II – AIRPORT COMPONENTS**

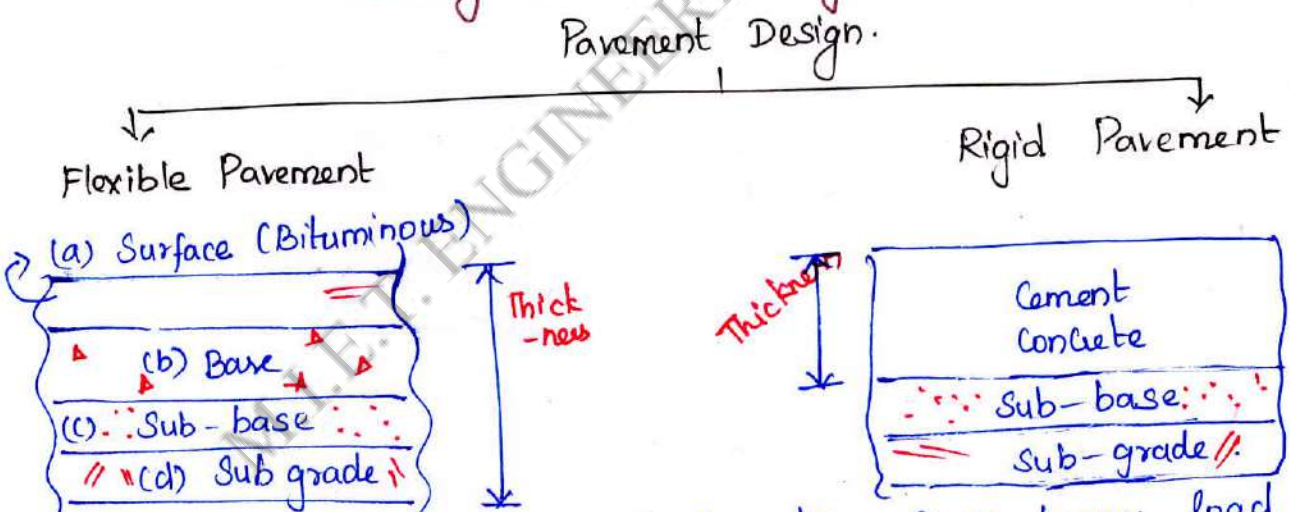
Topic(s) to be covered	Runway Pavement design:

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
	✓ Pavement ✓ Runway Pavement design.	understanding

Teaching Learning Material	Student Activity
PPT, Chalk & Talk	Listen / participate / discuss.

Lecture Notes

Runway Pavement design:



Main Function of a pavement is to carry heavy load of aircraft and transmit the stresses over larger area of the underlying subgrade soil, thereby causing deformation within elastic range.

Number of design methods are employed for both groups flexible and Rigid pavement. In flexible groups, methods based on test like California Bearing Ratio (CBR) and Plate bearing etc.

Flexible pavement test.
* California Bearing Ration (CBR)
* plate Bearing test. etc.
thies design methods are largely empirical. However method based on Burmister's approach is considered as Semi-empirical.

Rigid pavement:
* methods based on Westergaard analysis seems to be widely accepted.
* This method is considered as rational, ∵ it is based on the Analytical treatment.
* Plate bearing test - "k value" measuring subgrade reaction method " modulus of Subgrade reaction (k) considered in thickness determination.

Various Design Factors:

The Following design Factors are

1. Design wheel load
2. Strength characteristics of materials used in layers
3. Subgrade Supporting capacity.

DESIGN METHODS FOR FLEXIBLE PAVEMENTS:

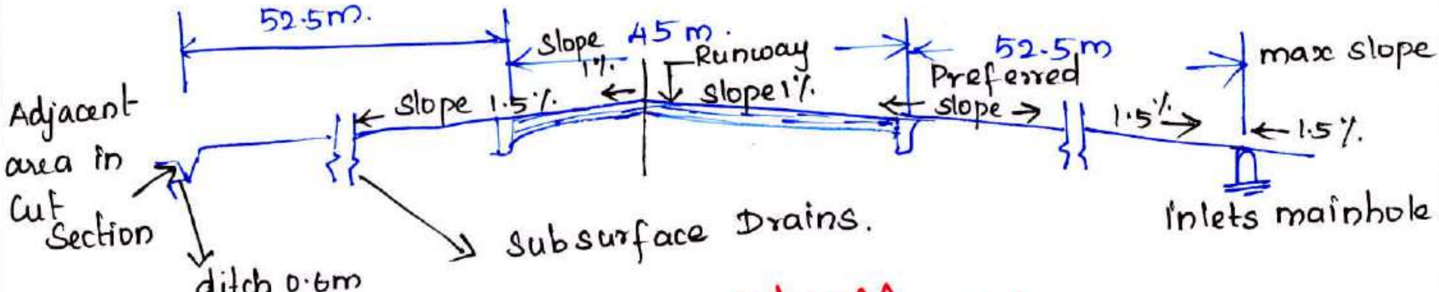
Following methods are considered for designing the Pavement thickness!

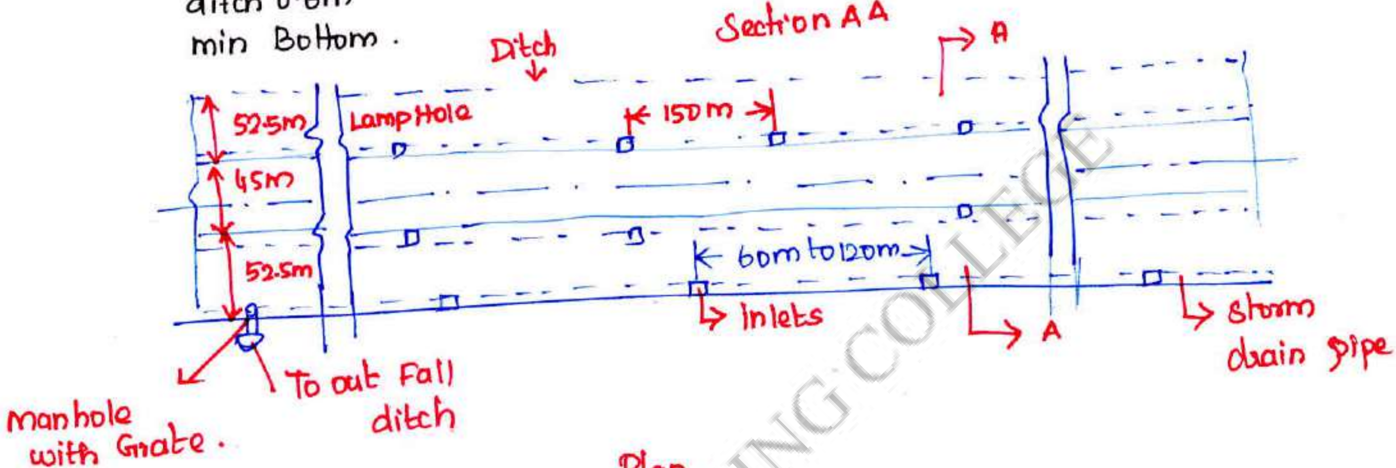
(i) CBR method
(ii) Mc leod Method
(iii) Burmister method
(iv) ~~Compu~~ Analytical method
(v) Computer Aided design (CAD) application.

CBR - method:

In, 1928 california division of Highway, developed CBR method. Subsequently, corps of Engineers, USA adopted this method during world war II for designing the military airport pavements.

Recommended Drainage layout for a Runway (FAA)





Plan

(ii) Contour interval should be 0.3m (1ft)

(iii) The rainfall date such as frequency, intensity and duration of storms ofor a period of 5 to 10 years. is taken from the meteorological studies. The rainfall intensity - duration curve is then developed for the site.

(iv) Centre line profiles of all the runway, taxiways and apron area with necessary cross section are prepared.

(v) Boring plans of soil strata along with ground water profile etc are prepared.

(vi) Temperature data, especially on maximum and minimum temperature including seasons of freezing and thawing, depths of frost penetration etc are collected.

(vii) Data on the infiltration properties of the soils encountered and actual Run off records for drainage areas having similar characteristic of soils are gathered.

(viii) Necessary hydraulic data graphs and table for the design including standard specifications and structural characteristics for pipes, gutters, manholes, inlets, gratings, fittings etc are also prepared.

Suggested Questions / Assignments /Home works / any other

Text Books/ ReferenceBooks

S.No	Title	Author	Publisher
1.	Airport Planning and design	Khanna. S.K.	Nemachand & Bros
2.	Highway, Railway, Airport & Harbour	Subramanian - an. t. p.	Scitech Publications
3.			

Any other suggested Materials

Lecture No. 07 **UNIT II – AIRPORT COMPONENTS**

Topic(s) to be covered	Different between Highway and airport Pavements. and Joints in Concrete pavements

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level

Teaching Learning Material	Student Activity

Lecture Notes

Joints in Cement Concrete Pavements:

The Cement concrete pavements expand and contract with Rise and fall of temperature and to reduced the compression, tension and flexural stresses, the slabs of concrete pavement ared divided in longitudinal panels by predetermined dimensions.

1. Expansion
2. Contraction
3. Warping
4. Construction.

Expansion Joints.

Expansion Joint

1. The basic function of Expansion Joint is provide the adequate space for the expansions of the pavement & to eliminate the compressive stresses. which can overcome the of demage the pavement edges.
2. Expansion Joint provided → Space of 2cm b/w two meeting slab.
3. This Space → compressible material called Filler and top (Sealed material) known as Sealer.

Contraction joint:

Cement concrete pavement to limit the tensile stresses developed due to contraction of pavement with in a Safe value. Two types of joints 'formed groove' and 'Sawed groove' are generally in use.

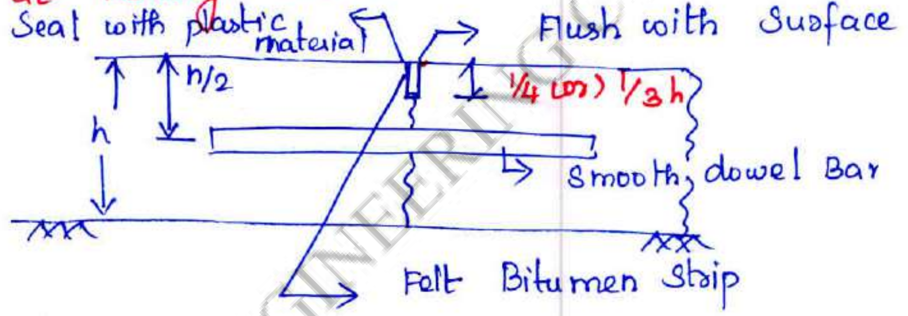
warping joint:

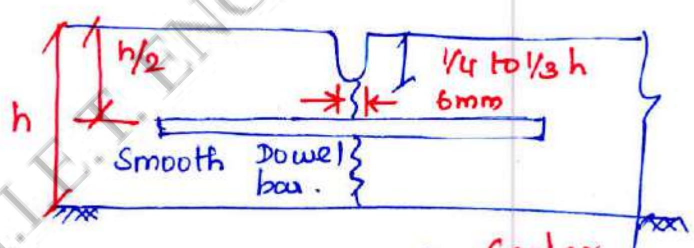
the possible vertical movement of edges due to Curling up and down of cement concrete pavement as and when it occurs due to temperature gradient developed in the pavement depth.

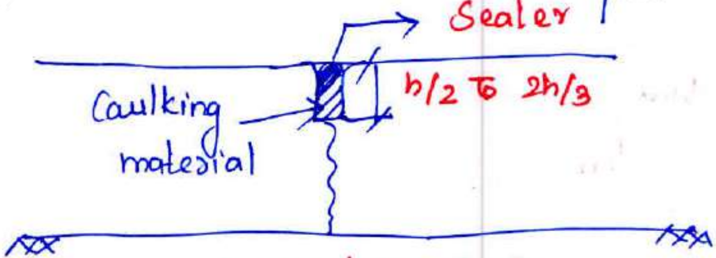
Construction joint:

Joint is also provided at the end of days job during the Construction of Cement Concrete pavement.

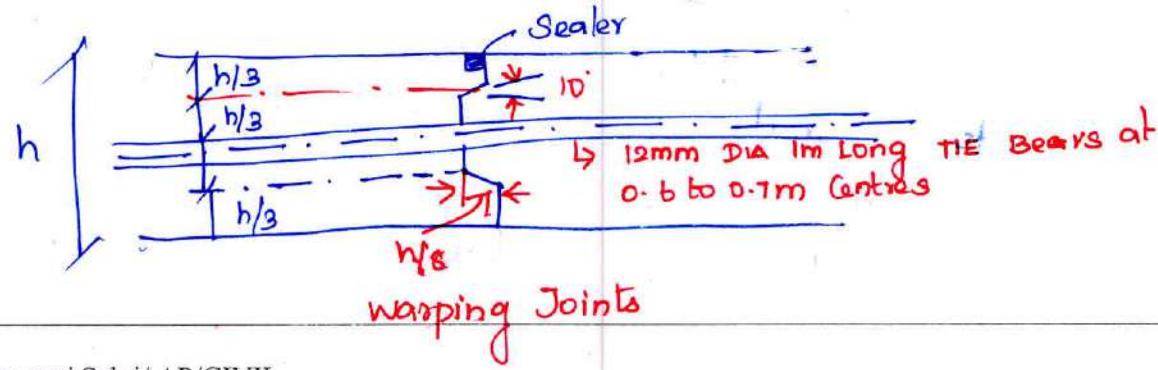
Joint Layout at Runway Pavement Intersection.







Contraction Joints



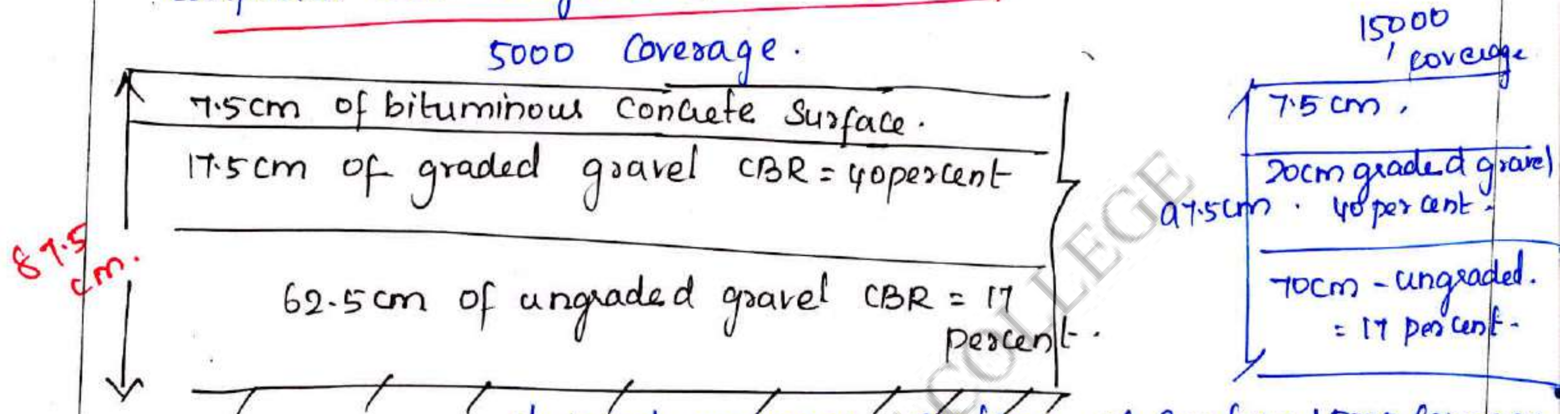
warping Joints

Recommended to increase the thickness as under:

Coverage	Percent increase in design thickness.
10000	7
15,000	11
20,000	14.

Compacted soil Subgrade CBR = 17 percent.

5000 Coverage.



designed pavement section of Surface 15000 Coverage

Mclead method: Norman W. Mc lead through - Canadian department of transport - extensive plate bearing test on airfield.

$$T = k \log \frac{P}{S}$$

where : T = thickness of gravel materials.

P = gross wheel load

S = Subgrade Support

k = base Course constant.

Burmister method:

$$\frac{\text{elastic modulus of pavement } (E_p)}{\text{elastic modulus of Subgrade } (E_s)} \text{ and } \frac{\text{radius of contact area } (a)}{\text{pavement thickness } (h)}$$

Comparison of Burmister two layered System and Boussinesq Single System

Vertical Stress of Subgrade pressure of 5 kg/cm² is reduced to 2 kg/cm² [from 70 to 30 percent]. by introducing a pavement layer ⇒ h = a with elastic modulus 10 times Higher than Subgrade Soil.

Recommended minimum thinkness of Bituminous Surfacing.

wheel load (kg)	Thickness (cm)
7000 (or) less	3.75
7000 – 11,250	6.25
11,250 – 22,500	7.40
22,500 – or more	10.00

assume, trial Section for 0.5cm deflection yields, Pavement thickness 40 percent higher than the design value.

$$h = 35 + 35 \times 0.40$$

$$h = 49cm \simeq 50cm$$

$$\boxed{h = 50cm}$$

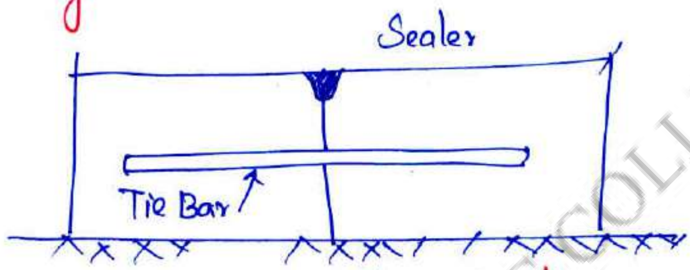
Analytical design method:

(i) Selection of Suitable design model
(ii) Solution to the equations for the stresses, strains and deformations.
(iii) Criteria for design and performance interms of strain stress and deformation
(iv) the presentation of the design System in a form that is convenient for use by the airfield pavement engineers.

Computer Aided design Application:

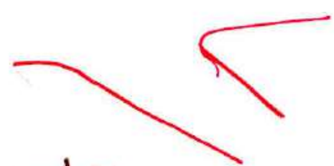
1. Theory and design
2. Design of airfield pavement
   1. Corps of Engineers methods
   2. Procedure
   3. Flow charts
   4. Deflection factor & data file
   5. Prensentation of Results

The typical layout of branch intersection between runway and taxiway. while planning the layout for such an intersection, it is essential to consider that the greatest expansion and contraction of the two pavements will occurs in different directions and at the same time it is required that on pavement should restrain movement occurring in the adjacent pavement. It also suggested by Civil Aviation Agency that forming corner with acute angle should be avoided.



Construction Joint.

Intersection b/w Runway & taxiway.



Difference between Highway and Airport pavements:

	Highway Pavements	Airport pavements
1.	Higher no: of load Repetitions.	Higher gross load. (or) Total load.
2.	Lower (or) moderate Generally not more than 800 kPa on tyre pressure.	High, Typically up to 1,500 kPa and sometimes up to 2,500 kPa for small military Jets
3.	Traffic is Highly channelized	wheel load is less channelized due to large variation in wheel assembly and layout of different aircrafts.
4.	wheel load: Low Generally only up to 3 t per wheel.	High, up to 25 t per wheel.

	Highway	Airport.
5.	Design of pavement based on moving loads with the load duration as input	Design based on moving loads in the interior of runway but stationary loads at end of runway. Thicker pavement at end rather than interior.
6.	Serious distress at edge for Flexible pavement.	No distress at edge for flexible pavements.
7.	Pumping action for rigid pavements without base course	No pumping action.
8.	Serious distress at edge for flexible pavements.	No distress at edge for flexible pavements
9.	Durability: Moderate Particularly at turns and intersections less so on straight runs.	High durability, Especially in the "touch down" zones where tyre "run up" occurs.
10.	water tightness, High, Especially for granular pavements	Water tightness, High Especially. For granular pavements.

Suggested Questions / Assignments /Home works / any other

	Text Books/ ReferenceBooks		
S.No	Title	Author	Publisher
1.	Airport planning and design	khanna.S.K Arora. M.G	Nemachand & Bros
2.	Airport & Harbour Engineering	Subramani	Scitech Publication
3.			

Any other suggested Materials

Lecture No. 08 **UNIT II – AIRPORT COMPONENTS**

Topic(s) to be covered	Introduction to various design methods - Airport drainage.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level

Teaching Learning Material	Student Activity

Lecture Notes

Airport Grading and Drainage:

* The Site selection for airport may have undulating ground profile.
* The entire area is properly graded to enable the quick drainage of storm water and also to facilitate the construction of various airport elements.
* The grading is done with minimum cost of earthwork.
* The grading for each stage construction is planned in such a way that the resulting grades conform well with the final grades.
* Complex problem → involves an additional dimension of width.

used : Typical Topographical map used. For Airport drainage

The Following Steps (or) general points involved in grading:

1. The amout of cut and Fill should be as far as possible balance each other. The amount of earkwork → minimum.

2. Sub grade soil: uniform character to ensure a uniform Subgrade Support.

3. proper Surface and subsurface drainage should be done to ensure the Stability of the pavement and embankments.

4. Grading plan: To carry water away from the Runway, taxiways, apron areas and building area.

5. If two (or) more landing strips cross each other, Intersecting Runway assigned common grades elevation at the intersections

6. The area at the end of the landing strips should also be graded as a precautionary measure.
due to undershooting, the strip while landing would have minimum.

7. The choice of the equipment for Clearing, grading and Compaction Should be determined Considering the nature of the material involved, job size, local practice and Construction time assigned etc.

Computation of Earth work:

The volume of earthwork can be Computed by Using any one of the two methods, Cross-Sectional method and mass haul Curve.

Fundamental Consideration for Rigid Pavement:

For airports, Westergaard developed equations for stresses and deflections for interior and edge of the Concrete slab.

$$S_c = 0.316 \frac{W}{h^2}\left[4\log_{10}\frac{l}{b} + 1.0693\right]$$

where

S_c = flexural stress at the Centre of the slab in lbs/sq.in.

W = applied load in lbs

h = thickness of the slab in inches

E : modulus of elasticity of the Concrete in lbs/sq.in

b = Radius of contact area

μ = possion's Ratio

l = the radius of Relative Stiffness in inches.

l is give by $l = \sqrt[4]{\frac{Eh^3}{12(1-\mu^2)k}}$

where k = the modulus of Subgrade reaction in lbs/sq.in/in

units In SI unit where h and l are in mm

E = MPa, k = MPa/m.

$$l = \sqrt[4]{\frac{1000\ Eh^3}{12(1-\mu^2)k}}$$

l = Radius of Relative Stiffness
W = load
k = modulus of Subgrade Reaction.

$$R = k.z$$

R = Vertical reation ∝ to the amout of deflection.

k = a Soil constant (ie) modulus of Subgrade Reaction.

z = deflection

Assumption involved in Westergaard's theory are:

- Concrete slab in Homogeneous
- Slab is Isotropic elastic Solid

Design procedure for Rigid pavements:

1. Similar to flexible pavement,
2. ∴ separate curves for single, dual and dual tandem landing gears
3. Separate design curves for wide-body jet aircraft.
4. These based on (curves) jointed edges.

Design inputs: For Rigid pavement design:

(a) Concrete flexural strength
(b) Subgrade modulus (k-value)
(c) Gross weight of the design aircraft
(d) Annual departure of the design aircraft.

Other procedures of pavement design.

1. Reinforcement Concrete Pavement → Type and Spacing of R/F; → Amount of R/F. Pg no: 191 SC Saxena
2. Continuously R/F concrete pavement
3. Prestressed Concrete Pavement.

$$A_s = \frac{0.64 L\sqrt{Lt}}{f_s}$$

where
As = area of steel, Square Centimeters per metre.
L = length of (or) width of slab in metre
t = thickness of slab in millimetres., fs = allowable tensile stress.

Suggested Questions / Assignments /Home works / any other

Text Books/ ReferenceBooks

S.No	Title	Author	Publisher
1.	Airport planning and design.	khanna S.K Arora MG & Jain SS	Nemachand & Bros
2.	Highway, Railways, Airport & Harbour. Subramanian. K.P	Subramanian. K.P.	Scitech publication.
3.			

Any other suggested Materials

Topic(s) to be covered	Airport drainages.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level

Teaching Learning Material	Student Activity

Lecture Notes

AIRPORT DRAINAGE:

An drainage system is essential for the safety of aircraft and long life of pavement.

Improper drainage results in heavy ponding on the pavement surface which can be Hazardous to safe landing (or) taking off of aircraft.

Poor drainage can also result is → early in failure of pavement.

(i) Removal of surface run off the airfield

(ii) Interception and diversion of surface and ground water flow originating from lands adjacent to the air field area.

(iii) Lowering of subsurface water level in the airfield area.

Special characteristics & Requirements of Airport Drainage.

The airport drainage has unusual requirements It is Considered to be a complex design problem. Its Special characteristics are.

(i) Extensive area under Consideration
(ii) Varying soil Conditions
(iii) Heavy Concentrated wheel loads of aircrafts
(iv) wide Runways, taxiways and aprons
(v) Flat longitudinal and transverse grades
(vi) Shallow water Courses.
(vii) Absence of Side ditches
(viii) Concentration of outfall flow.

The drainage pipe should have Sufficient capacity of ot Carry the ground water as well as Surface water.

Rapid drainage is essential for Safety of the aircraft operations as well as of the pavement.

Withstand the heavy concentrated wheel loads of the aircraft.

Possibility of Future runway extension additional runway and taxiway should be given due Consideration at the initial stages.

DESIGN DATA:

(i) Contour map of the airport site and land adjacent to the site showing all natural water Course, the area contributing runoff on the site and possible outfalls and ditches is prepared.

The Countour interval should not be more than 0.6m (2ft)

Longitudinal Gradient:

If the gradient is steep, there will be greater Fuel Consumption. ICAO Recommends that the longitudinal gradient should not exceed 1.5 per cent for A and B types and 3 per cent for other types of airports.

Transverse Gradient:

This is essential for quick drainage of Surface water. ICAO recommends that for taxiway pavement, like Runway the transverse gradient should not exceed a value of 1.5 per cent For A, B, and C types of airports. and 2 per cent for D and E types of airports.

minimum value of gradient is not Specified. FAA recommends, that it should be 5 per cent for the First 3m and 2 per cent thereafter for all types of airports.

Rate of change of Longitudinal Gradient.

Directly affects the available Sight distance on the pavement. ICAO recommends that rate of change of slope in longitudinal direction should not exceed 1 percent per 30m length of vertical Curve for A, B and C types 1.2 percent for D and E type of airports.

Sight distance:

∵ the Speed of aircraft on taxiway is lower than on runway, Smaller value of sight distance will be Sufficient on taxiway. ICAO recommends that the Surface of a taxiway must be Visible from 3m (10ft) ht for a distance of 300m (1000ft) for A, B, and C types and distance of 250m (830ft) be visible from 2.1m (7ft) ht for D and E type of airports

Turning Radius:

change in the direction of a taxiway a horizontal Curves is provided.

The Curve is so designed that the aircraft can negotiate it without significantly reducing the speed.

circular Curve of large radius is Suitable for this purpose.

Formula: $R = \frac{V^2}{125f}$

R = Radius in metre.
V = Speed in kmph.
f = Co-eff. of friction b/w tire & pavement surface.

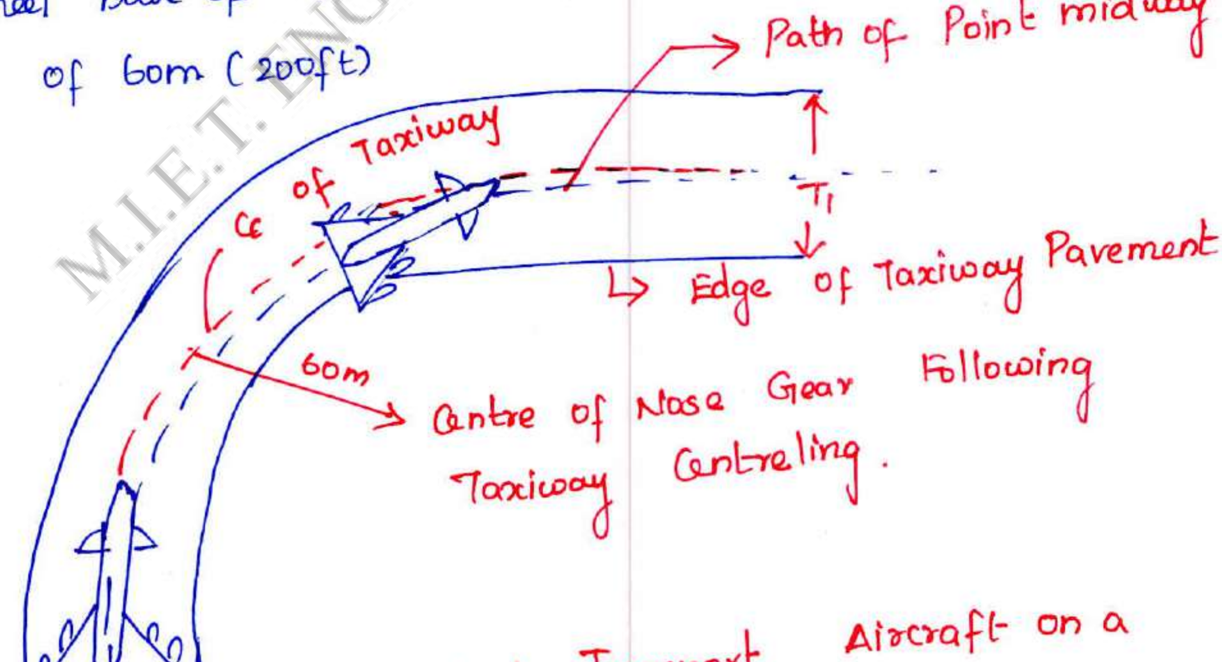
The value of f may assumed as 0.13

minimum value of radius of Curvature is 120m (400ft)

For Large Subsonic Jet minimum value of Radius of Curvature = 120m (400ft)

For Subsonic transport, a minimum radius = 180m (600ft)

wheel base of 31.2m (104ft) manoeuvres a curve of 60m (200ft)



Super Sonic Transport Aircraft on a Taxiway Curve

~~Longitu~~

equation as Suggested by Horonjeff.

where:

R = radius of taxiway in metre

$$R = \frac{0.388 W^2}{\frac{T}{2} - S}$$

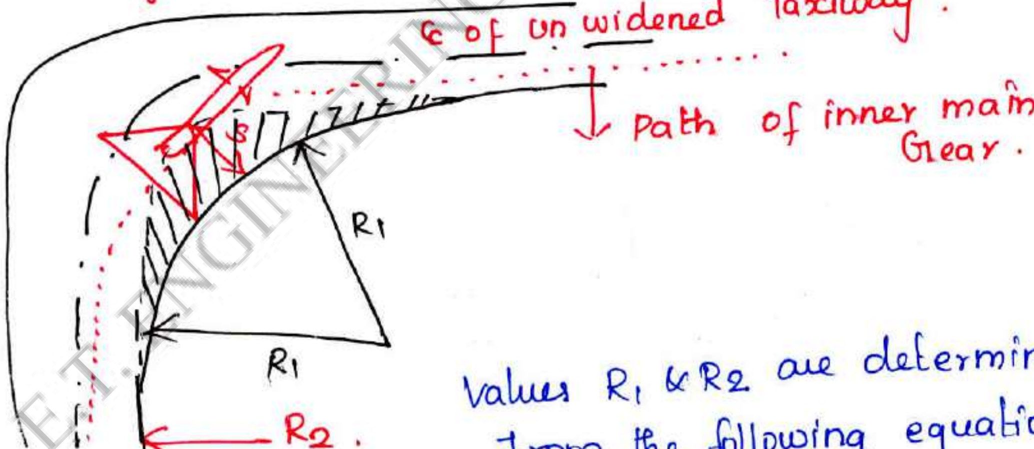
W = wheel base of aircraft in metre

T = width of taxiway pavement in metre

S = distance b/w midway point of the main gears and the edge of the taxiway pavement in metre.

* pilot maintains the nose gear on the Centre line of the taxiway having the radius as obtained from the above expression.

widening is done by providing a to widen the pavement.



Values R_1 & R_2 are determined from the following equation.

$$R_2 = R - \left(\frac{0.388 W^2}{R} + S\right)$$

If the expression $\left(\frac{0.388 W^2}{R} + S\right)$ is less than T/2, no widening Required:

If T/2 greater than radius R, ~~and~~ should be

$$R_1 = \frac{D_r^2 + (T/2)^2 + 0.30R - R_2^2 - RT}{2(R - R_2)}$$

where R = radius of centre line of taxiway in metre

W = wheel base of aircraft in metre

S = distance between a midway point of the main gears and edge of taxiway pavement in metre

T = width of taxiway pavement in metre

$D_r = 3W - 0.4R$ If D_r is less than W, then use W instead of D_r

$D_r < W$, $W = D_r$

Pblm: A taxiway is to be designed for operating Boeing (707 - 320) which has the following characteristics. Determine the turning radius of the taxiway.

wheel base = 17.70m (W)

Tread of main loading gear = 6.62m

Turning Speed (v) = 40 kmph

Co-efficient of friction between tire and pavement surface = 0.13 (f)

→ Solution:

(i) Turning Radius $R = \frac{V^2}{125f}$

$= \frac{40^2}{125 \times 0.13}$

$R = 98.5m$

(ii) From Horonjeff's equation

$$R = \frac{0.388 W^2}{(T/2 - S)}$$

W = 17.70m   T = 22.5m from the table Taxiway width T = 22.5 (maximum) ICAO

$S = 6 + \frac{6.62}{2} = 9.31m$

Turning radius

$$R = \frac{0.388 \times (17.70)^2}{\frac{22.5}{2} - 9.32}$$

$= 62.9m$

(iii) The absolute minimum turning Radius for Subsonic aircrafts regardless of any speed = 120m.

Selecting the maximum value amongst the three case discussed above the turning radius to be actually provided = 120m.

Suggested Questions / Assignments /Home works / any other

Text Books/ ReferenceBooks

S.No	Title	Author	Publisher
1.	Airport planning & Design. Khanna. S.K. Arora	Khanna. S.K Arora. M.G. & Jain. S.S.	Nemachand & Bros.
2.	Subramanian. K.P.	Highways, Railways. Airport & Harbours.	Scitech.
3.			

Any other suggested Materials

UNIT III AIRPORT PLANNING

2 MARK QUESTIONS AND ANSWERS

1.Define wind Coverage (AUC NOV/DEC 2010) ,(AUC NOV/DEC 2011)

The percentage of time in a Year During Which the cross-wind components remain within the limits is called the wind coverage. For busy Airport the wind coverage may be increased to as much as 98 to 1007.

2.**What are the Factors Affecting airport operating capacity?** (AUC NOV/DEC 2010)

The number of aircraft movement Which an airport Can process within a Specified period of time, with an average delay in to the departing aircraft within the acceptable range.

3.Distinguish Between Runway and taxiway? (AUC NOV/DEC 2012)

Runway is a long Rectangular Strip, which is Constructed with Adequate Strength for landing and takeoff of Aircraft at an Airport

A Strip of Pavement connecting the apron to the Hanger as well as Runway ends to the Apron is called Taxiway

4.Listout the four Standard Factor Conditions involved for the Design of Runways (AUC NOV/DEC 2009)

Runway Geometric design comprises of the following Elements as per ICAO recommendations. That are

1. length of the runway
2. Width of the Runway
3. Longitudinal Slope or Gradient
4. Transverse Slope of cross Gradient
5. Sight distance
6. Runway Surface
7. Runway Strips
8. Runway- end safety areas
9. clearway
10. Stop ways

5.Define Cross Wind component and Wind coverage (AUC NOV/DEC 2009)

If the direction of wind with a Velocity of V is making a certain angle θ with the centre line of the runway, Its components perpendicular to the enter line of the Runway will be V and θ.

This normal components of the wind is called the Cross-wind Components The percentage of time in a Year During Which the cross-wind components remains within the limits is called the wind coverage. For busy Airport the wind coverage may be increased to as much as 98 to 1007.

6. How much Correction Should be made in the Runway Length for Gradient (AUC MAY/JUNE 2011)

1. Correction for elevation

2. Correction for Temperature

3. Correction for elevation and temperature

4. Correction for Gradient

7.What is an Exit Taxi way (AUC NOV/DEC 2011)

Exit taxiway are the Taxiways Which are Provided ti minimize the Runway occupancy time by the landing Aircraft

8. Write any Three Components of an Airport (AUC MAY/JUNE 2011)

1. Types of Airport

(a) Based on Function

(b) Based on Usage

(c) Based on Utilities

(d) Based on type of Aircraft

2. Landside Part of an Airport

(a) Terminal Area

(b) Terminal Building

(c) Service for the Air passenger

(d) Government Agencies

(e) Security Arrangement

3. Airside part of an Airport

(a) Runway

(b) Taxiway

(c) Apron

(d) Holding pad or Bay

(e) Navigational Aid `

(f) Hanger

(g) Landing Indicators

9. What are the Objectives of the master plane According to FAA (AUC MAY/JUNE 2011)

- Determines the Development of physical facilities including land use
- Give short- and long-term policy guidance
- Assist in getting the financial aid
- Coordinates the monitoring procedure, data management
- Determining the funding Sources and constrains during the physical planning
- Determines the community attitude

10.What are the data Required before the site Selection for new airport (AUC MAY/JUNE 2012) ¬

- The class of the Airport , viz., national, the Size and the Shape , Runway and Taxiway Requirements ¬
- The peak-hourly volume of air traffic to be Handled now and in Future ¬
- The various types of operational Control to be Used
- To provide facility now based on the airport and Anticipated additional facility

11.Wing rose Diagram Using a Diagram is plotted called wind rose Diagram.

There are two Types that re Given Below

Type 1 : Showing direction and Duration of Wind

Type 2 : Showing Direction, Duration and Intensify of Wind.

12.List the Various imaginary Surfaces around the Airport

1. Approach Surface

2. Horizontal Surface

3. Conical Surface

4. Take-off climb Surface

5. Transitional Surface.

Unit 5 -SEAPORT REGULATIONS AND EIA

Wave action on Coastal Structures and Shore Protection and Reclamation – Coastal Regulation Zone, 2011-EIA – methods of impact analysis and its process

Coastal Structures:

Coastal Protection Structures

The main and prime reason to construct coastal protection structures is to protect harbor and other infrastructures from sea wave effects such as erosion. Not only are they useful for changing current and sand movements but also to redirect rivers and streams.

Types of Coastal Protection Structures

There are various structures that considered or used as coastal protection structures for example groins, seawalls, bulkheads, break waters, and jetties. Description and advantages of these structures will be discussed in this article.

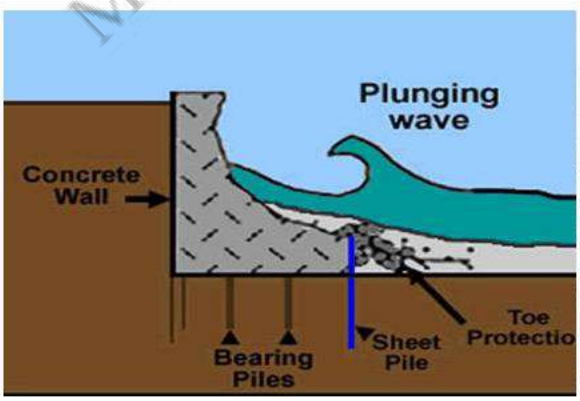
1. **Seawalls**

This large coastal protection structures can be built using different types of **construction materials such as rubble mound, granite masonry, or reinforced concrete**.

Seawalls are commonly built and run along shoreline to prevent coastal structures and areas from the detrimental influence of ocean wave actions and flooding which are driven by storms.

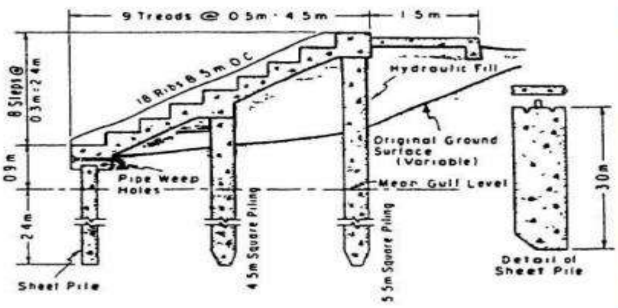
There are various arrangements or configurations that might be employed includes curved face seawall, stepped face seawall, rubble mound seawall. These forms will be explained in the following sections:

1.1 __**Curved face seawall**__: Curved face seawall is designed to withstand high wave action effects. Foundation materials loss, which might be caused by scouring waves and/or leaching from over topping water or storm drainage underneath the wall, is avoided by employing sheet pile cut off wall. Moreover, the toe of the curved face seawall is built from large stones to decrease scouring. The Figure below show curved face sea wall with its components.



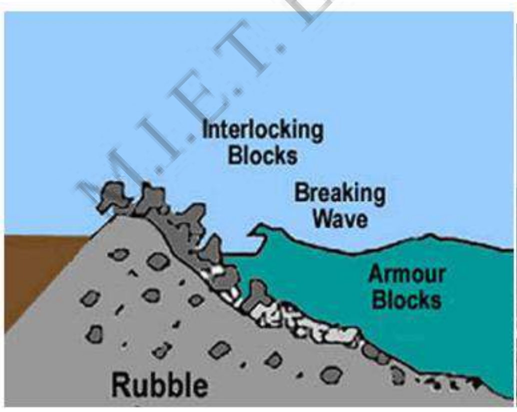
1.2 Stepped face seawall

- Stepped face seawall is used to oppose or resist moderate wave actions.
- Reinforced concrete sheet piles with tongue- and- groove joints are employed to construction this type of seawall.
- The spaces which is created between piles is either filled with grout in order make sand proof cut off wall or install geotextile fiber at the back of the sheet pile to form sand tight barrier.
- Applying geotextile is beneficial because it allows seeping water through and consequently prevents accumulating hydrostatic pressure. The Figure below shows stepped face seawall with the components and details.



1.3 Rubble Mound Seawalls

- Design and construction this type of seawall configuration might be easier and cheaper. It can resist substantially strong wave actions.
- Despite scouring of the front beach, quarry stone comprising the seawall could be readjusted and settled without causing structural failure.
- The Figure below provides components of rubble bound seawall. The rubble bound seawall dimensions are determined based on-site conditions.

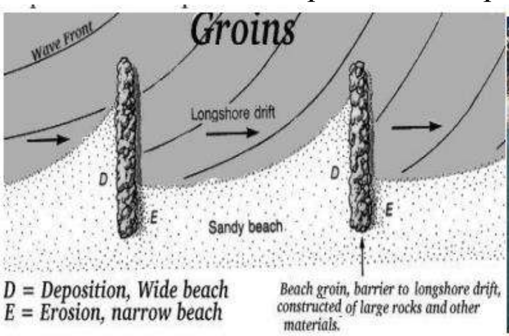


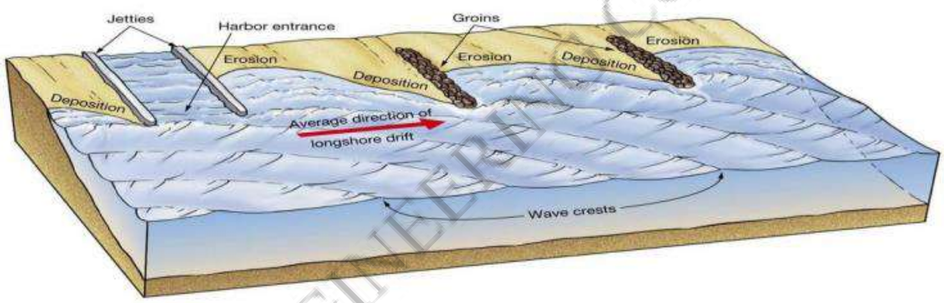
2. **Bulkheads** Bulkheads can be constructed by concrete, steel, or timber. There two major types which are gravity structures and anchored sheet pile walls. The bulkheads might not have exposed to substantially strong wave actions and its main purpose is to retain earth but scouring at the base of the structure should be considered by the designer. Cellular sheet pile bulkheads are employed for situations where rock is close to the surface and enough penetration cannot be achieved for the anchored

bulkhead type. Moreover, sheet pile should be sufficiently reinforced for bending moment, soil conditions, hydrostatic pressures, and support points

3. **Groins**

- Groins are shore protection structures that decrease erosion affects to the shoreline by changing offshore current and wave patterns.
- Groins can be built by materials such as concrete, stone, steel, or timber and are categorized depend on length, height, and permeability.
- Furthermore, groins are commonly constructed vertically to the shoreline and it can either impermeable or permeable.





4. **Jetties**

- **j**etties are usually built of materials such as concrete, steel, stone, timber, and occasionally asphalt used as binder.
- This structure is constructed at river estuary or harbor entrance and extended into deeper water to oppose forming of sandbars and limit currents

5. **Breakwaters**

There are three major types of breakwaters namely: offshore, shore-connected, and rubble mound. Not only are they used to protect shore area, anchorage, harbor from wave actions but also to create secure environment for mooring, operating, and handling ships.

Unit 4- SEAPORTS COMPONENTS AND CONSTRUCTION

Definition of Basic Terms: Harbor, Port, Satellite Port, Docks- Dry and Floating Dock, Waves and Tides – Planning and Design of Harbors: Harbor Layout and Terminal Facilities – Coastal Structures: Piers, Break waters, Wharves, Jetties, Quays, Spring Fenders, Dolphins Floating Landing Stage – Navigational Aids- Inland Water Transport.

INTRODUCTION

Movement on land is easy through roadways and railways but area available is nearly one-third of entire earth surface. On the contrary two third of entire earth surface is covered by water which proves importance of waterways or water transportation. A waterway is any navigable body of water. A shipping route consists of one or several waterways. Waterways can include rivers, lakes, seas, oceans, and canals.

Advantages of water transportation

❖ It assists and provides a powerful means of defence in the emergency of national security.

❖ It is the cheapest mode of communication because rail and road transport require a special track.

❖ It leads the overall development of commerce, industries and international trade.

❖ It possesses high load carrying capacity.

❖ It encourages consumption of foreign goods.

❖ It require cheap motive power for its working.

Disadvantages of water transportation:

❖ It is slow and consumes more time due to slow speed and circuitous routes.

❖ It is use when water is available as the mode of transport and that too, along particular routes only

❖ It may lead to accidents in case of frequent ocean storms and hurricanes causing great loss of cargos.

❖ There are more chances of attack by other countries

❖ The fluctuation of water level will cause the rubbing of sides of ship against the berth.

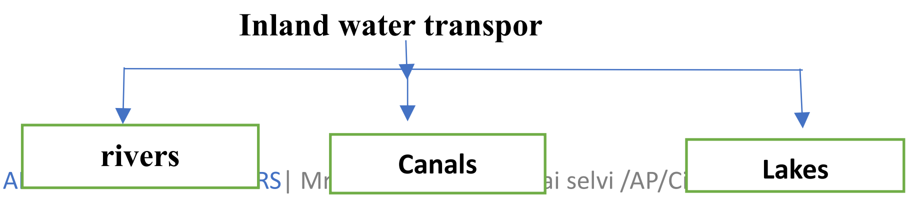
❖ The fleets of water ships are used exhibition of power and political domination.

<u>Classification of waterways</u>

Kinds of Water Transport Water transport consists of

A. Inland water transport

B. Ocean-transport



1) **Inland Water Transport:**

As shown in the chart, inland water transport consists of transport by rivers, canals and lakes.

Rivers:

- Rivers are natural waterways that can be used as a means of transport.
- They are suitable for small boats as well as big barrages.
- River transport played a very important role prior to the development of modern means of land transport.
- Their importance has gradually declined on account of more reliable and cheaper transport services offered by the railways

Canals: They are artificial waterways made for the purpose of irrigation or navigation or both. ¬

- Canal transport requires a huge amount of capital investment in the construction and maintenance of its track i.e., the artificial waterways.
- The cost of canal transport is, therefore, higher than that of river transport.
- To add to it, the cost of providing water for the canals is also a very big problem of canal transport.

Lakes: It is a large body of water (larger and deeper than a pond) within a body of land.

- Lakes do not flow like rivers, but many have rivers flowing into and out of them.
- Lakes can be either natural like rivers or artificial like canals.

Advantages:

- **Low Cost** - Rivers are a natural highway which does not require any cost of construction and maintenance.
  Even the cost of construction and maintenance of canals is much less or they are used, not only for transport purposes but also for irrigation, etc.
- **Larger Capacity** - It can carry much larger quantities of heavy and bulky goods such as coal, and, timber etc.
- **Flexible Service -** It provides much more flexible service than railways and can be adjusted to individual requirements.
- **Safety** - The risks of accidents and breakdowns, in this form of transport, are minimum as compared to any other form of transport

Disadvantages

Slow - Speed of Inland water transport is very slow and therefore this mode of transport is unsuitable where time is an important factor.

Limited Area of Operation - It can be used only in a limited area which is served by deep canals and rivers.

Seasonal Character - Rivers and canals cannot be operated for transportation throughout the year as water may freeze during winter or water level may go very much down during summer.

Unreliable - The inland water transport by rivers is unreliable. Sometimes the river changes its course which causes dislocation in the normal route of the trade.

Unsuitable for Small Business - Inland water transport by rivers and canals is not suitable for small traders, as it takes normally a longer time to carry goods from one place to another through this form of transport.

Definition for basic terms:

Harbour: harbours and sea works, any part of a body of water and the manmade structures surrounding it that sufficiently shelters a vessel from wind, waves, and currents, enabling safe anchorage or the discharge and loading of cargo and passengers.

PORTS

A port is a harbour where marine terminal facilities are provided. A port is a place which regularly provides accommodation for the transfer of cargo and passengers to and from the ships.

Port = Harbour + Storage Facility + Communication Facility + Other Terminal Facility From above, It can be stated that a port includes a harbour i.e. every port is a harbour.

satellite port:

- A satellite port can either be one that is already existing or is created near a port that is reaching capacity.
- Satellite ports help overcome issues such as limited land availability and draft adequacy, which is depth of water to which a ship sinks according to its load.

DOCKS

- Docks are enclosed areas for berthing the ships to keep them afloat at a uniform level to facilitate loading and unloading cargo.
- A dock is a marine structure for berthing of vessels for loading and unloading cargo and passengers.
- Docks are necessary for discharging of the cargo as ships require a number of days for discharging cargo, during which period they need a uniform water level.
- If ship is subjected to a vertical movement by the tides, great inconvenience will be felt in lifting the cargo from the ship and special arrangement will be needed for lifting the cargo.

Classification of docks

Docks can be classified into following two categories:

➢ Wet docks.

➢ Dry docks.

WET DOCKS –Docks required for berthing of ships or vessels to facilitate the loading and unloading of passengers and cargo are called wet docks. These are also known as harbor docks.

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

Classification of Dry docks

Dry docks are classified in the following five categories:

➢ Graving or dry docks.

➢ Floating dry dock.

➢ Marine railway dock.

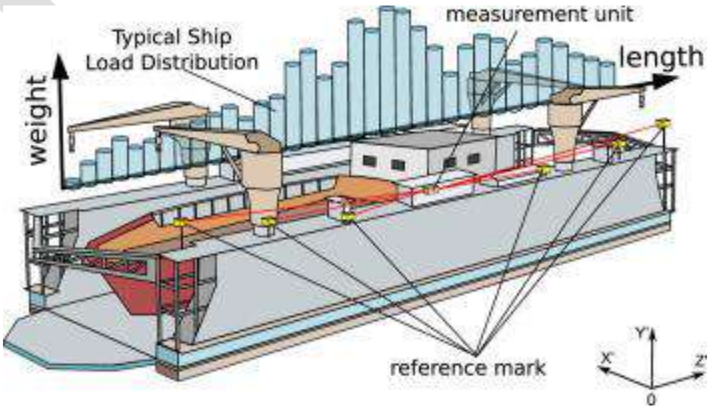
➢ Ship lifts dry docks.

➢ Slip ways.

Dry or graving dock - A dry dock is also known as graving dock. It is long excavated chamber, having side walls, a semicircular end wall and a floor. The open end of the chamber is provided with a gate and acts as the entrance to the dock.

Floating dry docks

- Floating dry docks are able to submerge underwater and to be placed under a ship in need of repair below the water line.
- Water is then pumped out of the floating dry dock, raising the ship out of the water. The ship becomes blocked on the deck of the floating dry dock for repair.



ballasting the chambers by pumping out the water. The earliest floating dry docks resembled the shape of ships

Marine railway dock - The marine railway or slip dock or slip way is an inclined railway extending from the shore well into the water as the off there. This railway track is used to draw out a ship needing repair out of the water.

Lift dry dock - This is a constructed platform capable of being lowered into and raised from water. Lowering and rising is achieved by means of hydraulic power applied through cylinders supporting the ends of cross girders carrying the platform.

Ship lifts - As the name suggests, in the ship lift, the ships are lifted bodily out of water. The ship lifts may be electric, hydraulic or pneumatic. These lifts are used for launching as well as 19 for dry docking the ships. Their main advantage is the ease in adaptability to transfer system enabling multiple garaging of ships.

Slipways - This technique is used for repairs as well as for building of vessels. In its simplest form a slip way consists of an inclined path of timber or stone lay on a firm ground. On this inclined path a series of rails are fixed. The rails run up from a sufficient depth of water to the required height above the high-water level to a point at which the longest vessel to accommodate is completely out of range of tide. The lower end of slip is tidal and open to water.

Requirements

➢ Approaches must be of sufficient depth and sheltered. In many cases approach channels both on the open coast and island docks have to be dredged frequently.

➢ Availability of fresh water to replace fouled and leaked water from docks.

➢ In inland to replace the fouled water from docks, separate canals from the rivers have to be provided, if alternate sources of water supply are not available. In case of sea coast docks, the sea water could be used for cleaning and replenishing the dock.

Waves	Tides
1. Waves are caused by the movement of particles of surface water because of the force of wind.	1. Tides are created due to the gravitational pull of the Sun and the Moon.
2. Waves occur almost all the time due to the action of the wind.	2. Tides only occur twice a day with a time gap of 12 hours and 35 minutes.

Planning and Design of Harbors:

Before designing a harbor, there are two major activities which have to be done. These activities are 'Collecting the necessary information' and 'Identifying the area required'

The planning and design of harbor is an important engineering phenomenon with both major commercial and social implications.

The various approaches for harbors design of harbors such as

- Fishing
- commercial
- refugee harbors.

Collection of the Necessary Information

To carry out the planning of a harbor, the first step is that the collection of necessary information of the existing properties of the suggested site.

The following important facts should be investigated first:

• To perform a complete investigation of the neighborhood including the foreshore and depths of water in the vicinity

• To study the nature of the harbor (if it is refuge or not)

• To study the existence of sea insects which could give damage the foundation

• To study the problem of silting or erosion of coastline

• To ascertain the character of the ground borings and to take the soundings

• To identify the probable surface conditions on land and borings on land

• To study the natural metrological phenomenon at site with respect to frequency of storms, rainfall, range of tides, maximum and minimum temperatures, direction and intensity of winds, humidity and also direction and velocity of currents

Identify the Area Required

The area of the harbor depends upon the following factors:

• Size and number of ships to be accommodated in the harbor at a time

• Length and width needed for movement of ships to and from berths

• Type of cargo carried General Requirements of a Harbor

Following are the requirements of a good harbor:

• The ship channels should have sufficient depth for the draft of the visiting vessels to the harbor

• The bottom of the harbor should provide secured anchorage to hold the ships against the force of strong winds

• The land masses or breakwater must be provided to protect against the destructive wave action

• The entrance of the harbor should be wide enough to provide the ready passage for shipping and at the same time it should be narrow enough to restrict the transmission of excessive amount of wave energy in time of storms.

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Requirements of a Harbor of Refugee Including Naval Base

Following are the requirements of a harbor of refugee:

- Facilities which obtain repairs and supplies
- Safe and convenient anchorage against the sea
- Ready accessibility from the high seas
- Spacious accommodation as damaged ships will need immediate shelter and quick repairs
- Accommodation for naval vessels

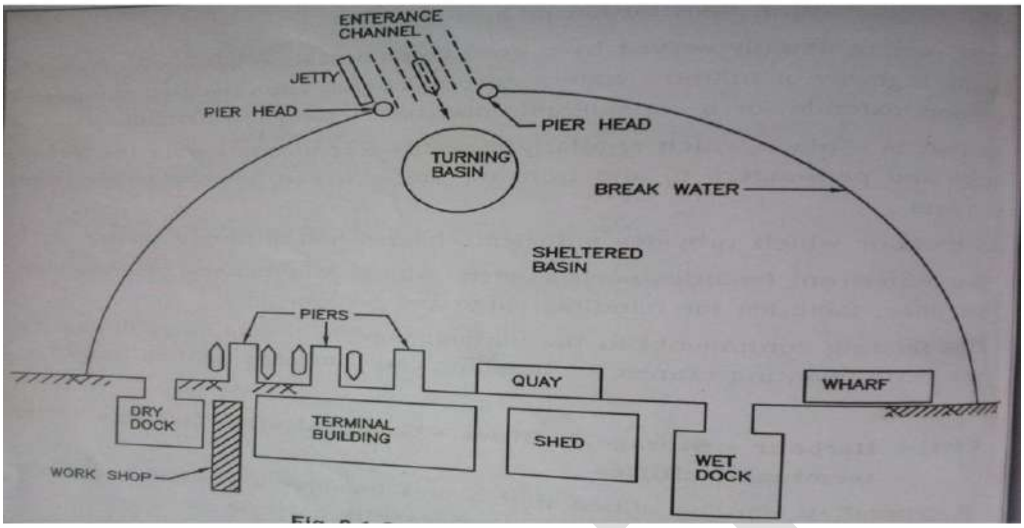
Following are the requirements of a commercial harbor :

- Storage sheds for cargo,
- Good and quick repair facilities to avoid any delay,
- Long and large quays to make loading and unloading of cargo and facilities for transporting easier and quicker,
- Sufficient accommodation for the commercial marine,
- Large accommodation for the commercial marine,
- Well and enough sheltered conditions for loading and unloading.

Following are the requirements of a fishing harbor:

- The harbor should be continuously available for arrival and departure of fishing ships
- Loading and unloading facilities along with quick dispatch facilities for the perishable fish catch such as railway sidings and roads should be there,
- Freezing compartment stores with sufficient storing space for keeping the fish safe.

HARBOUR COMPONENTS:-

- 

Components of Harbour

1. Entrance Channel
2. Break Water
3. Turning Basin
4. Shelter Basin
5. Pier
6. Wharf
7. Quay
8. Dry Dock
9. Wet Dock
10. Jetty

Entrance Channel - Water area from which ships enter in the harbour and it should have sufficient width, 100 for small harbour, 100 to 160m for medium and 160 to 260m for large harbour.

Break Water - A protective barrier made up of Concrete or Course Rubble Masonry constructed from shore towards the sea to enclose harbour

Turning Basin - It is water area which is required for maneuvering the ship after entering to the harbour and it is large enough to permit free turning.

Shelter Basin - It is area protected by shore and breakwater. Pier - It is a solid platform at which berthing of ships on both the sides are possible.

Wet Dock - Due to variation in tidal level, an enclosed basin is provided where in number of ships can be berthed. It has an entrance which is controlled by a lock gate.

Dry Dock - It is a chamber provided for maintenance, repairs and construction of ships. It includes walls, floor and gate. Jetty - It is a solid platform constructed perpendicular to the shoreline for berthing of ships.

Quay - It is also dock parallel to the shore which is solid structure providing berthing on one side and retaining the earth on the other.

Wharf - It is a docking platform constructed parallel to shoreline providing berthing facility on one side only.

<u>Site selection for a harbour</u>

The guiding factors which playa great role in choice of site for a harbour is as follows,

➢ Availability of cheap land and construction materials

➢ Transport and communication facilities

➢ Natural protection from winds and waves

➢ Industrial development of the locality

➢ Sea-bed, subsoil and foundation condition

s ➢ Availability of electrical energy and fresh water

➢ Favourable marine conditions

➢ Defence and strategic aspect

Classification of harbour

1. Classification depending upon the protection needed
2. Classification depending upon the utility
3. Classification depending upon the location

Classification based on the protection needed

i. **Natural Harbour**

Harbour protected by storms and waves by natural land contours, rocky out crops, or island that is called Natural Contour.

Example - Kandla port, Cochin port & Mumbai Harbour

ii. **Semi - Natural Harbour** A semi – natural harbour is protected on the sides by the contours of land and requires manmade protection only to the entrance.

Example - Mandvi, Veraval & Visakhapatnam port

iii. **Artificial Harbour** An artificial harbour is one which is manmade and protected from storms and waves by engineering works.

Example - Chennai Harbour

Classification based on utility

i. **Commercial Harbour** It is a harbour in which docks are provided with necessary facilities for loading and unloading of cargo. Example - Chennai Harbour

ii. **Refuge Harbour** These are used as a heaven for ships in a storm or it may be part of a commercial harbour. Example - Chennai Harbour and Visakhapatnam Harbour

iii. **Military Harbour** It is a naval base for the purpose of accommodating naval ships or vessels and it serves as a supply depot. Example -Mumbai Harbour & Cochin Harbour

iv. **Fishing Harbour** These HARBOURs have facilities for departure and arrival of fishing ships. They have also necessary arrangement to catch fish.

Classification based on location

i. Ocean Harbour

ii. River Harbour

iii. Canal Harbour

iv. Lake Harbour

Coastal Structures:

Piers, Break waters, Wharves, Jetties, Quays, Spring Fenders, Dolphins Floating Landing Stage

piers:

piers are rather long structures with a horizontal deck on series of piles extending perpendicular to the coast into the sea. Piers and trestles are constructed to serve as a landing place for vessels, as a recreation facility, as a measuring facility for coastal processes or as a part of sand by-pass facility.

Break waters

There are three major types of breakwaters namely: offshore, shore-connected, and rubble mound. Not only are they used to protect shore area, anchorage, harbor from wave actions but also to create secure environment for mooring, operating, and handling ships.

BREAKWATER

- A breakwater is a structure constructed for the purpose of forming an artificial harbour with a basin so protected from the effect of waves as to provide safe berthing for fishing vessels.
- There are many different types of breakwaters; natural rock and concrete, or a combination of the two, are the materials which form 95 percent or more of all the breakwaters constructed.
- When a breakwater is to be built at a certain location, and the environmental impact of such a structure has already been evaluated and deemed environmentally feasible,

the following parameters are required before construction can commence:

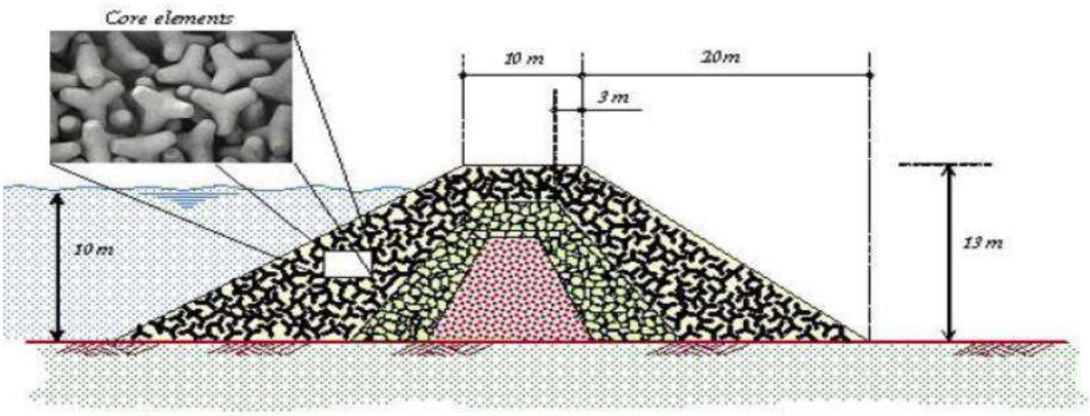
❖ A detailed hydrographic survey of the site;

❖ A geotechnical investigation of the sea bed;

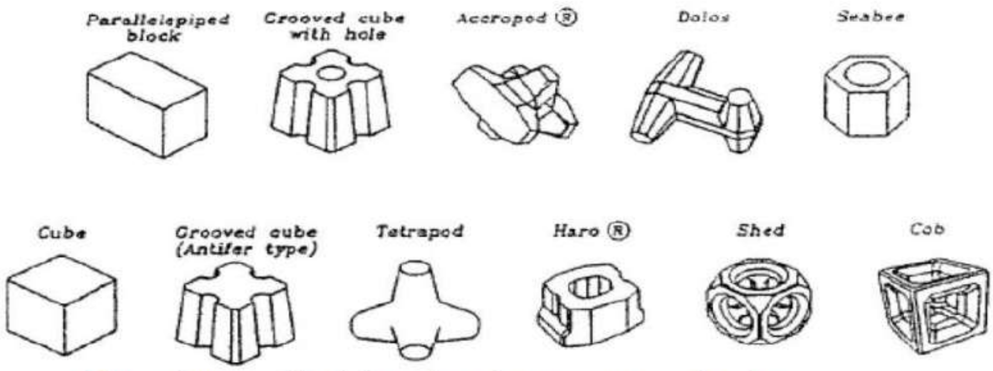
❖ A wave height investigation;

❖ A material needs assessment; and

❖ The cross-sectional design of the structure



Cross section of a breakwater



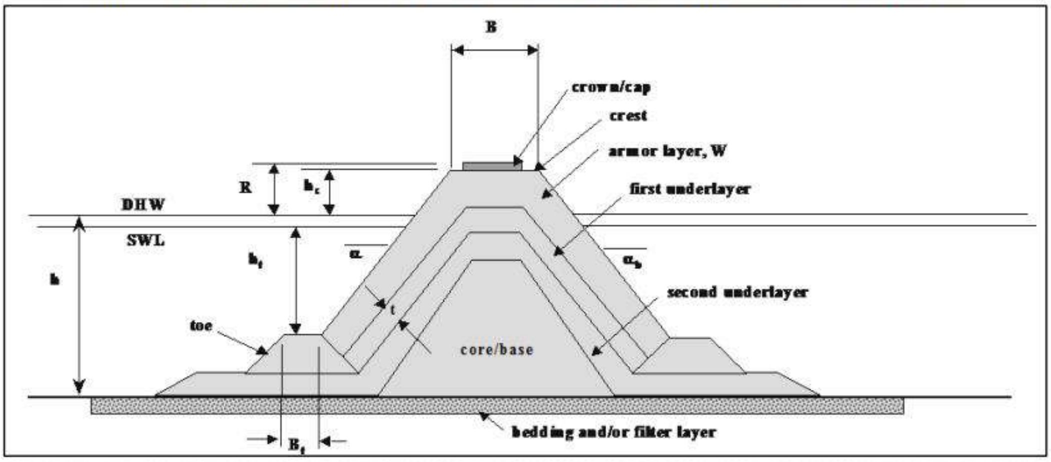
Types of concrete blocks in various shapes to construct breakwater

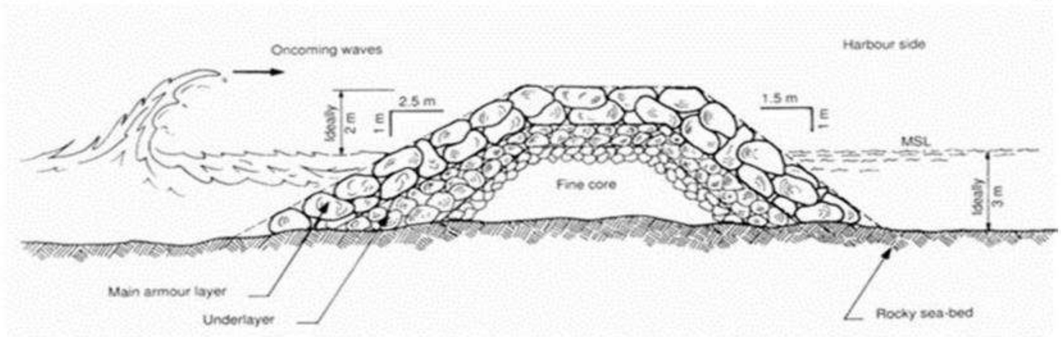
CLASSIFICATION OF BREAKWATERS

Rubble mound breakwater - A rubble mound breakwater normally consists of a core of small size rock covered with large [heavy] rocks or concrete elements. This outer layer is called the armour layer. An under-layer of rock is provided between the core and the armour layer.

➢ Outside layer large enough to resist wave action.

➢ Inside layer small enough to prevent removal of native fine material in between.





Advantages rubble mound breakwater

- Use of natural material
- Reduces material cost
- Use of small construction equipment
- Less environmental impact 29
- Easy to construct
- Failure is mainly due to poor interlocking capacity between individual blocks
- Unavailability of large size natural rocks leads to artificial armour blocks.

Disadvantages rubble mound breakwater

- Needs a considerable amount of construction materials.
- Continuous maintenance is required.
- Sometimes there are difficulties in erection, as the rock weight increases with the increase of wave heights.
- Can't be used for ship berthing

Vertical breakwater - A breakwater formed by the construction in a regular and systematic manner of a vertical wall of masonry concrete blocks or mass concrete, with vertical and seaward face.

➢ Reflect the incident waves without dissipating much wave energy.

➢ Wave protection in port/channel

➢ Protection from siltation, currents

➢ Tsunami protection

➢ Berthing facilities

➢ Access/transport facility

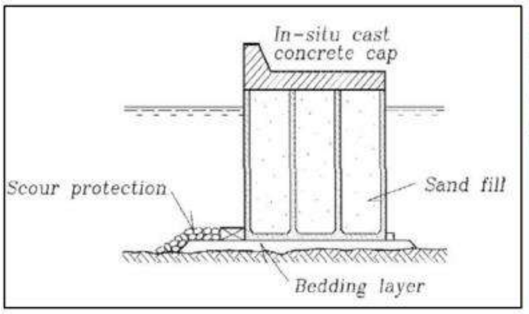
➢ Normally it is constructed in locations where the depth of the sea is greater than twice the design wave height.

Types of vertical breakwater

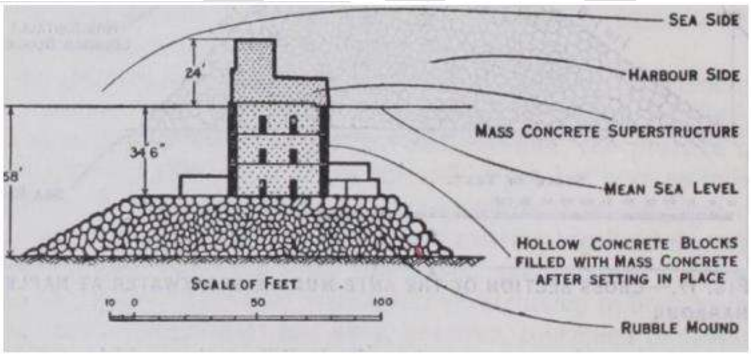
1. Conventional type
2. Composite type

Conventional type

The caisson is placed on relatively thin stone bedding. The main advantage of this type is the minimum use of natural rock (in case scarce). Wave walls are generally placed on shore connected caissons



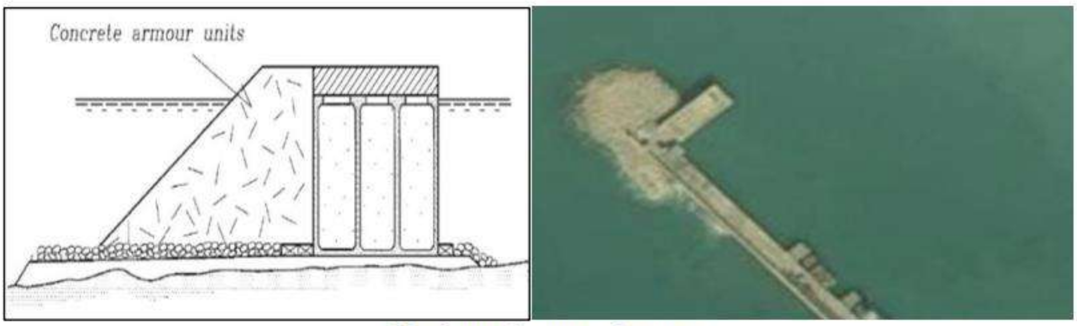
<u>Composite type</u> the caisson is placed on a high rubble foundation. This type is economic in deep waters, but requires substantial volumes of (small size) rock fill for foundation



Composite type

<u>Horizontal composite type</u>

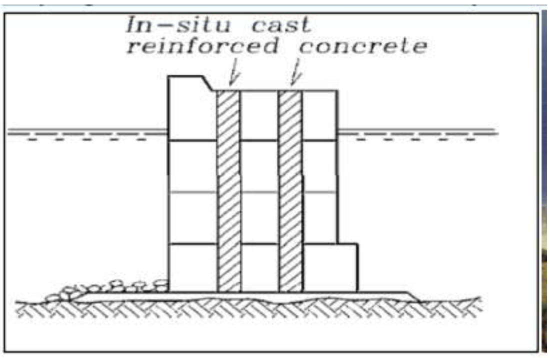
The front slope of the caisson is covered by armour units. This type is used in shallow water. The mound reduces wave reflection, wave impact and wave overtopping. Used when a (deep) quay is required at the inside of rubble mound breakwater



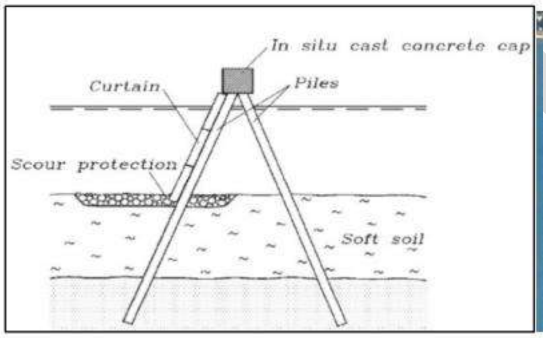
Horizontal composite type

Block type

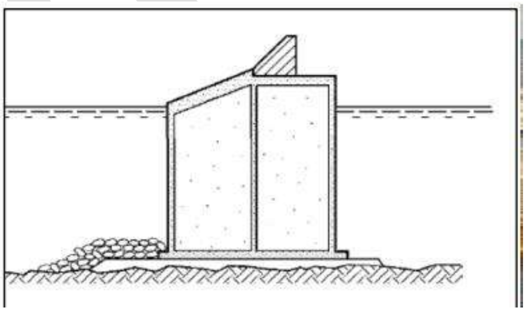
This type of breakwater needs to be placed on rock sea beds or on very strong soils due to very high foundation loads and sensitivity to differential settlements.



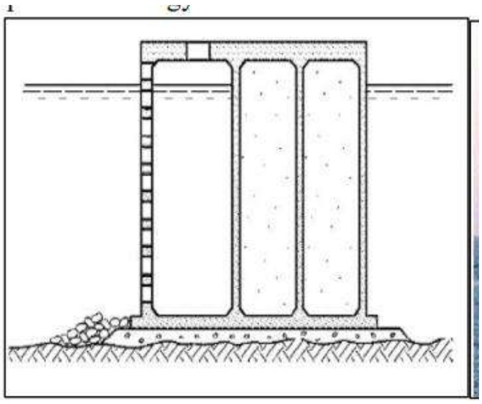
Piled breakwater with concrete wall Piled breakwaters consist of an inclined or vertical curtain wall mounted on pile work. The type is applicable in less severe wave climates on site with weak and soft sub-soils with very thick layers.



Sloping top breakwater, the upper part of the front slope above still water level is given a slope to reduce wave forces and improve the direction of the wave forces on the sloping front. Overtopping is larger than for a vertical wall with equal level.



Perforated front wall breakwater The front wall is perforated by holes or slots with a wave chamber behind. Due to the dissipation of energy both the wave forces on the caisson and the wave reflection are reduced



Disadvantages of vertical wall breakwaters

- Sea bottom has to be levelled and prepared for placements of large blocks or caissons.
- Foundations made of fine sand may cause erosion and settlement.
- Erosion may cause tilting or displacement of large monoliths.
- Difficult and expensive to repair.
- Building of caissons and launching or towing them into position require special land and water areas beside involvement of heavy construction equipment's.
- Require form work, quality concrete, and skilled labour, batching plants and floating crafts.

Wharves

- A wharf is a structure extending parallel with the shoreline, connecting to the shore at more than one point (usually with a continuous connection), and providing, in most cases, berthing at the out-shore face of the structure only.
- It is a landing place or platform built into the water or along the shore for the berthing of vessels.
- It is probably the oldest of these terms, and it applies to any structure projecting from the shore that permits boats or ships to lie alongside for loading or unloading.
- It is typically a structure of timber, masonry, concrete, earth, or other material built along or at an angle from the shore of navigable waters (as a HARBOUR or river).

Jetties

- A jetty is any of a variety of structures used in river, dock, and maritime works that are generally carried out in pairs from river banks, or in continuation of river channels at their outlets into deep water; or out into docks, and outside their entrances; or for forming basins along the coast for ports in tide less sea.
- The forms and construction of these jetties are as varied as their uses (directing currents or accommodating vessels), for they are formed sometimes of high open timber-work, sometimes of low solid projections, and occasionally only differ from breakwaters in their object.
- A jetty is a structure that projects from the land out into water. It refers to a walkway accessing the centre of an enclosed water body.

Quays

- A quay is an artificial wall or bank, usually of stone, made toward the sea or at the side of a HARBOUR or river for convenience in loading and unloading vessels.

- It is a structure of solid construction along a shore or bank that provides berthing and generally provides cargo-handling facilities.
- A quay usually refers to an artificial embankment lying along or projecting from a shore and mainly used for loading and unloading.
- A similar facility of open construction is called a wharf

Fenders

- In boating, a fender is a bumper used to absorb the kinetic energy of a boat or vessel berthing against a jetty, quay wall or other vessel.
- Fenders are used to prevent damage to boats, vessels and berthing structures.
- Fenders are typically manufactured out of rubber, foam elastomer or plastic.
- Rubber fenders are either extruded or made in a mould.
- The type of fender that is most suitable for an application depends on many variables, including dimensions and displacement of the vessel, maximum allowable stand-off, berthing structure, tidal variations and other berth-specific conditions.
- The size of the fender unit is based on the berthing energy of the vessel which is related to the square of the berthing velocity

TYPES OF FENDERS

1. **SHIP TO QUAY (STQ)**

- Marine fenders are used at ports and docks on quay walls and other berthing structures. They absorb the kinetic energy of a berthing vessel and thus prevent damage to the vessel or the berthing structure.
- The many types of marine fenders include:
- 1. Cylindrical fenders
- 2. Arch fenders
- 3. Cell fenders
- 4. Cone fenders
- 5. Pneumatic fenders
- 6. Foam elastomer fenders

2. **SHIP-TO-SHIP (STS)**

For bunkering operations between two vessels, floating fenders such as pneumatic or foam elastomer fenders are typically used.

3. **BOAT**

Boat fenders are used on recreational boats, tugboats, ferries, naval vessels, passenger vessels, luxury yachts etc. Boat fenders are also available in different types, such as:

1. D fenders

2. Square fenders

3. Wing fenders

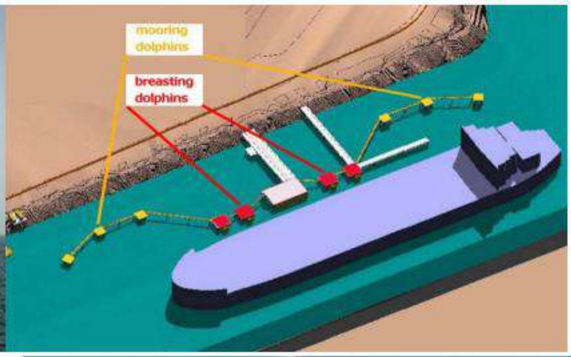
4. Keyhole fenders

5. Tug boat fenders

6. Lightweight foam elastomer fenders

DOLPHINS

- A dolphin is a structure consisting of a number of piles driven into the seabed or river bed in a circular pattern and drawn together with wire rope.
- It may be used as part of a dock structure or a minor aid to navigation. A dolphin is commonly used when a single pile would not provide the desired strength.
- These may be either breasting dolphins or mooring dolphins.
- The breasting dolphins are used to carry the lateral load during vessel impact, transferred through an energy-absorbing fendering system. A breast line is a mooring or dock line extended laterally from a vessel to a pier or float, as distinguished from a spring line.

Navigational Aids \ Signals

For safe, efficient **economic and comfortable travel** of vessels in rivers, channels, harbors and along lake and ocean shores navigation aids are necessary.

<u>**Purposes**</u>

- To avoid dangerous zones
- To follow proper harbour approaches
- To locate ports during night and bad weather conditions Requirements of signals
- Compels attention
- Permits time for easy response

- Commands respect
- Visibility distance

Types of signals

1. **Fixed type**
   - ❖ Light house
   - ❖ Beacon lights
   - ❖ Lights on piers
2. **Floating type**
   - ❖ Buoys
   - ❖ Lightship

FIXED NAVIGATIONAL AIDS

Light house

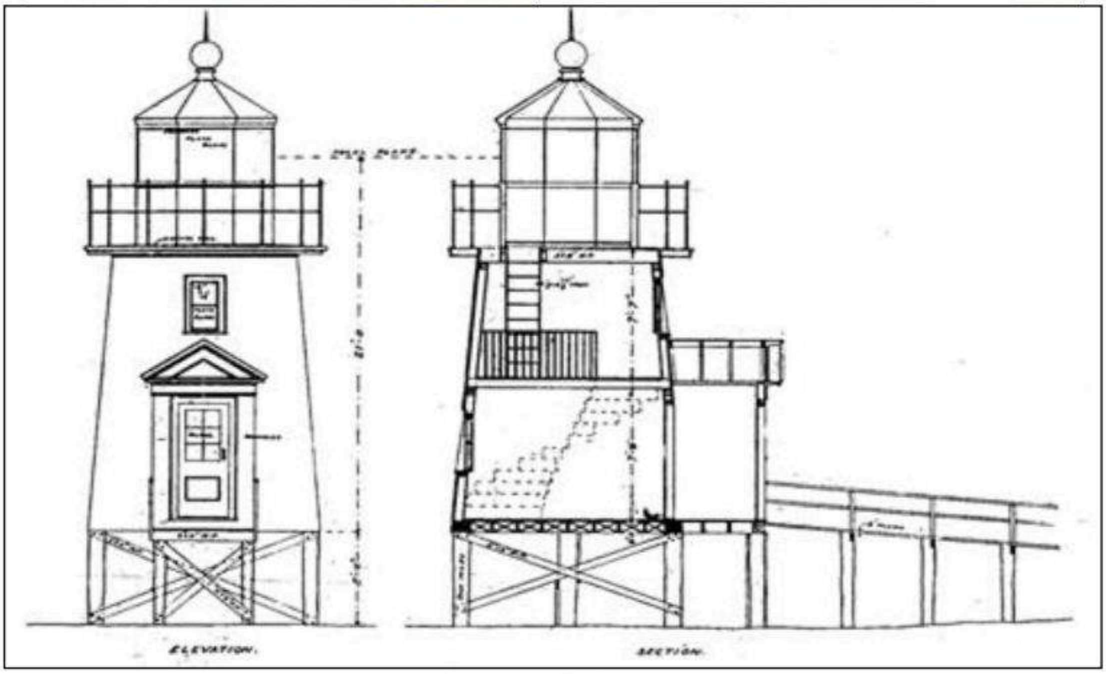
➢ They are all tower structure built of masonry or reinforced concrete.

➢ Beacon light is provided.

➢ Tower is divided into number of floors.

➢ The tower should be strong enough to with stand heavy wave action.

➢ Usually, they must have a visibility up to 30 km.



Rough layout of a lighthouse

Beacon lights

➢ Beacon light are fixed or flashing for easy identification by the navigator.

➢ They are used for means of alignment or indicating changes of direction.

Beacon structure *A Beacon light*

FLOATING NAVIGATIONAL AIDS

These are two types,

1. Buoys

2. Lightships Buoys

They are small sized floating structures, generally in the form of large cylindrical cans and drums.

Buoys are of different types:

- Channel and entrance demarcation buoys
- Luminous buoys
- Audible buoys or bell buoys
- Mooring buoys