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LECTURE NOTES

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MODULE 5

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Module – 5
Airport Planning

Structure

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4.0 Introduction

The planning of an airport is such a complex process that the analysis of one activity without regard to the effect on other activities will not provide acceptable solutions. An airport encompasses a wide range of activities which have different and often conflicting requirements. Yet they are interdependent so that a single activity may limit the capacity of the entire complex. In the past airport master plans were developed on the basis of local aviation needs. In more recent times these plans have been integrated into an airport system plan which assessed not only the needs at a specific airport site but also the overall needs of the system of airports which service an area, region, state, or country. If future airport planning efforts are to be successful, they must be founded on guidelines established on the basis of comprehensive airport system and master plans.

The elements of a large airport, It is divided into two major components, the airside and the landside. The aircraft gates at the terminal buildings form the division between the two components. Within the system, the characteristics of the vehicles, both ground and air, have a large influence on planning. The passenger and shipper of goods are interested primarily in the overall door to-door travel time and not just the duration of the air journey. For this reason access to airports is an essential consideration in planning.

4.1 Objectives

1. Design and plan airport layout, design facilities required for runway, taxiway and impart knowledge about visual aids

Air transport has the following characteristics:

1. Unbroken Journey: Air transport provides unbroken journey over land and sea. It is the fastest and quickest means of transport.

2. Rapidity: Air transport had the highest speed among all the modes of transport.

3. Expensive: Air transport is the most expensive means of transport. There is huge investment in purchasing aero planes and constructing of aerodromes.
4. Special Preparations: Air transport requires special preparations like wheelers links, meteorological stations, flood lights, searchlights etc.

Fastest Mode of Transport:

Advantages:

1. High Speed: The supreme advantage of air transport is its high speed. It is the fastest mode of transport and thus it is the most suitable mean where time is an important factor.
2. Comfortable and Quick Services: It provides a regular, comfortable, efficient and quick service.
3. No Investment in Construction of Track: It does not require huge capital investment in the construction and maintenance of surface track.
4. No Physical Barriers: It follows the shortest and direct route as seas, mountains or forests do not come in the way of air transport.
5. Easy Access: Air transport can be used to carry goods and people to the areas which are not accessible by other means of transport.
6. Emergency Services: It can operate even when all other means of transport cannot be operated due to the floods or other natural calamities. Thus, at that time, it is the only mode of transport which can be employed to do the relief work and provide the essential commodities of life.
7. Quick Clearance: In air transport, custom formalities can be very quickly complied with and thus it avoids delay in obtaining clearance.
8. Most Suitable for Carrying Light Goods of High Value: It is most suitable for carrying goods of perishable nature which require quick delivery and light goods of high value such as diamonds, bullion etc. over long distances.
9. National Defence: Air transport plays a very important role in the defence of a country. Modern wars have been fought mainly by aeroplanes. It has upper hand in destroying the enemy in a very short period of time. It also supports over wings of defence of a country.
10. Space Exploration: Air transport has helped the world in the exploration of space.

Disadvantages:

In spite of many advantages, air transport has the following limitations:

1. Very Costly: It is the costliest means of transport. The fares of air transport are so high that it is beyond the reach of the common man.

2. Small Carrying Capacity: Its carrying capacity is very small and hence it is not suitable to carry cheap and bulky goods.

3. Uncertain and Unreliable: Air transport is uncertain and unreliable as it is controlled to a great extent by weather conditions. Unfavourable weather such as fog, snow or heavy rain etc. may cause cancellation of scheduled flights and suspension of air service.

4. Breakdowns and Accidents: The chances of breakdowns and accidents are high as compared to other modes of transport. Hence, it involves comparatively greater risk.

5. Large Investment: It requires a large amount of capital investment in the construction and maintenance of aeroplanes. Further, very trained and skilled persons are required for operating air service.

6. Specialised Skill: Air transport requires a specialised skill and high degree of training for its operation.

7. Unsuitable for Cheap and Bulky Goods: Air transport is unsuitable for carrying cheap, bulky and heavy goods because of its limited capacity and high cost.

8. Legal Restrictions: There are many legal restrictions imposed by various countries in the interest of their own national unity and peace.

4.2 Airport classification:

Based on take-off and landing:

- Conventional Take-Off and Landing Airport (CTOL)
  Runway Length > 1500 m
- Reduced Take-Off and Landing Airport (RTOL)
  Runway Length 1000 to 1500 m
- Short Take-Off and Landing Airport (STOL)
  Runway Length 500 to 1000 m
- Vertical Take-Off and Landing Airport (VTOL)
  Operational area 25 to 50 sq m.

FAA Classification:

Based on Air Craft Approach speed:

Approach Category	Approach Speed (knots)
A	< 91
B	91 – 120
C	120 – 140
D	141 – 165
E	>165

1 knot = 1.852 kmph

3.3 Based on Function:

1. Civil Aviation
   Domestic
   International

2. Military Aviation

ICAO Classification:

Based on Geometric Design:

Airport Type	Basic Runway Length (m)		Width of Runway Pavement (m)	Maximum Longitudinal Grade (%)
	Maximum	Minimum		
A	Over 2100	2100	45	1.5
B	2099	1500	45	1.5
C	1499	900	30	1.5
D	899	750	22.5	2.0
E	749	600	18	2.0

Based on Aircraft Wheel Characteristics:

Code No.	Single Isolated Wheel Load (kg)	Tyre Pressure (kg/cm^2)
1	45000	8.5
2	34000	7.0
3	27000	7.0
4	20000	7.0
5	13000	6.0
6	7000	5.0
7	2000	2.5

Aerodromes in India:

International Hubs: This category includes airports currently classified as International Airports and having facilities of world standards.
Delhi, Mumbai, Bangalore, Chennai, Kolkata, Hyderabad, Thiruvananthapuram

Regional Hubs: Regional Airports will have to act as operational bases for regional airlines and also have all the facilities currently postulated for model airports, including the capability to handle limited international traffic. (Cochin, Ahmedabad etc)

Domestic Airports:

- Model Airports (Indore, Nagpur, Vadodara, Bhubaneshwar)
- Operational (Udaipur, Kota, Kanpur)
- Non Operational (Patna, Mysore)

Custom Airports:
Having National and International tourist potential (Jaipur, Calicut, Agra, Gaya etc.)

Civil Enclaves (At defense airfields) :

- Operational (Bagdodara, Leh etc.)

- Non Operational

Air force aerodromes

- Not for civil use

Airport planning:

Objectives

- Update aircraft activity forecasts for the airport.
- Refine the size and layout of commercial service and general aviation areas.
- Determine the preferred development alternatives for meeting airfield facility requirements and FAA safety and design standards.
- Provide a plan for improvement of the facility to accommodate increased usage and to meet current FAA airport design standards.
- Identify optimum landside uses, which will enhance the economic benefits of the airport and that are compatible with airside development.
- Prepare a schedule of development projects and reasonable cost estimates by which to implement the improvements proposed herein (i.e. Capital Improvement Plan).
- Develop realistic, phased development and maintenance plans for the airport.
- Provide an Airport Layout Plan drawing set in accordance with current FAA standards. Prepare an Environmental Overview for proposed development.
- Prepare a proposed, comprehensive Airport Standards Manual for the Airport, which incorporates the necessary information and regulations for users of the Airport.
- Prepare a compatible land-use and height restriction plan for the airport vicinity including recommended zoning protection within the airport influence zone.
- Rehabilitating/reconstructing airfield pavements to provide a safe airport.
- Providing a high quality and aesthetic facility that can be marketed for aerial tours and economic development.
- Identifying planning areas for future hangars and aviation related businesses.

4.3 Components of Airport

Therefore, the main components of airport are

1. Runway
2. Terminal Building
3. Apron
4. Taxiway
5. Aircraft Stand

6. Hanger
7. Control Tower
8. Parking

Runways: It is the most important part of an airport in the form of paved, long and narrow rectangular strip which actually used for landing and takeoff operations. It has turfed (grassy) shoulders on both sides. The width of runway and area of shoulders is called the landing strip. The runway is located in the centre of landing strip. The length of landing strip is somewhat larger than the runway strip in order to accommodate the stop way to stop the aircraft in case of abandoned takeoff.
The length and width of runway should be sufficient to accommodate the aircraft which is likely to be served by it. The length of runway should be sufficient to accelerate the aircraft to the point of takeoff and should be enough such that the aircraft clearing the threshold of runway by 15m should be brought to stop with in the 60% of available runway length. The length of runway depends on various meteorological and topographical conditions. Transverse gradients should not be less than 0.5% but should always be greater than 0.5%.

Terminal Buildings: Also known as airport terminal, these buildings are the spaces where passengers board or alight from flights. These buildings house all the necessary facilities for passengers to check-in their luggage, clear the customs and have lounges to wait before disembarking.

The terminals can house cafes, lounges and bars to serve as waiting areas for passengers. Ticket counters, luggage check-in or transfer, security checks and customs are the basics of all airport terminals.

Hangers: A hangar is a closed building structure to hold aircraft, spacecraft or tanks in protective storage. Most hangars are built of metal, but other materials such as wood and concrete are also used

Hangars are used for protection from the weather, direct sunlight, maintenance, repair, manufacture, assembly and storage of aircraft on airfields, aircraft carrier.

Aprons: Aircraft aprons are the areas where the aircraft park. Aprons are also sometimes called ramps. They vary in size, from areas that may hold five or ten small planes, to the very large areas that the major airports have.

Taxiway: Taxiway is the paved way rigid or flexible which connects runway with loading apron or service and maintenance hangers or with another runway. They are used for the movement of aircraft on the airfields for various purposes such as exit or landing, exit for takeoff etc. The speed of aircraft on taxiway is less than that during taking off or landing speed.

The taxiway should be laid on such a manner to provide the shortest possible path and to prevent the interference of landed aircraft taxying towards loading apron and the taxiing aircraft running towards the runway. The intersection of runway and taxiway should be given proper attention because during turning operation, this part comes under intense loading. If it is weaker then the aero plane may fell down from taxiway. Its longitudinal grade should not be greater than 3% while it s transverse gradient should not be less than 0.5%. It is also provided with a shoulder of 7.5m width paved with bituminous surfacing. The taxiway should be visible from a distance of 300m to a pilot at 3m height from the ground.

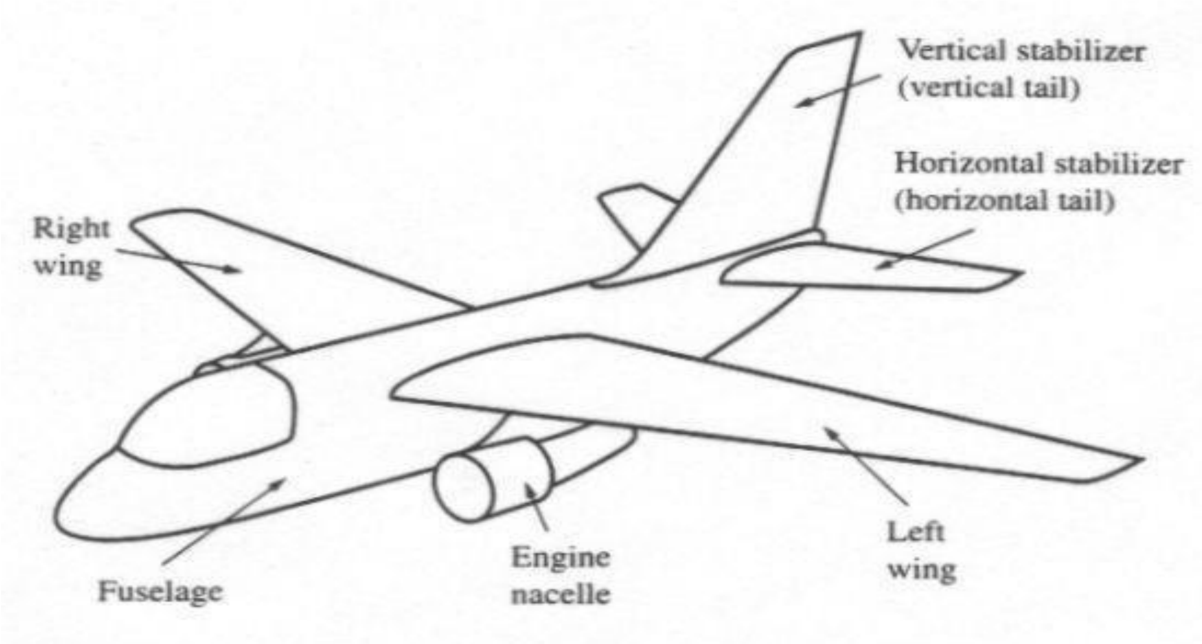
Aircraft Stand: A portion of an apron designated as a taxiway and intended to provide access to aircraft stands only.

Control Tower: A tower at an airfield from which air traffic is controlled by radio and observed physically and by radar.

Parking: Parking is a specific area of airport at which vehicles park

Aircraft Characteristics:
Component parts of an Aircraft
Following are the seven essential parts of an aero plane:-

1. Engine
2. Flaps
3. Fuselage
4. Propeller
5. Three Controls
6. Tricycle Undercarriage
7. Wings and tail



Engine:
- The propulsion of the aircraft is mainly due to the engine.
- Engine can be divided into a) Piston Engine b) Jet engine c) Rocket Engine.

Piston Engine:
- Conventional type of aircraft engines
- Operates at low altitudes and with moderate speeds (500-800 km/hr)
- The aircraft is provided with gasoline fed engine which is driven by a propeller
- The engine rotates a shaft with a huge torque and the torque so developed is absorbed by the propeller mounted on a shaft.
- When the rated speed is attained by the propeller, large quantity of air is hurled rearwards (backwards) which pulls the aircraft forward and creates lift on the wings.

Jet engine:

There are three types:
- Turbo Jet
- Turbo Propulsion
- Ram Jet

Turbo Jet:
- To start the machine, a compressor is rotated with a motor. As the compressor gains its speed it sucks in air through the air intake and compresses it in the compression chamber.
- The air- fuel mix is ignited in the chamber.
- When the air-fuel mix burns the expanding gases pass through fan like blades of the turbine
- The hot exhaust gases escape with high velocity through the tail pipe which is tapered at the end, giving a forward thrust to the engine.
- The exhaust gases comes out of the tail pipe at a speed of 1600 kmph and such speed of exhaust gases push the plane with speeds up to 800kmph
- Turbo jet has a lower performance ratio at moderate altitude than at high altitudes

Turbo Propulsion:
- The performance of a turbo propulsion aircraft is similar to that of turbo jet, except that a propeller is provided in it.
- The turbine in the turbo propeller extracts enough power
- Its performance is equally satisfactory in low and high altitudes as compared to turbo jet engines.
- Turbo engines may acquire speeds 1280 – 2400 km/hr

Propeller:
- Propeller is provided in the piston engine as well as the turbo prop engine
- It has two or more blades which are driven round in a circular path.
- The blades deflect the air backwards with acceleration and thus, forward thrust is imparted to the airplane.

Fuselage:
- Main body structure - All other components are attached to it
- It Contains a) Cockpit or flight deck b) Passenger compartment
  c) Cargo compartment
- Produces a little lift, but can also produce a lot of drag.

The fuselage must possess the following characteristics:
1. It is shaped to a fine point at the rear end and yet it should not be too fine so as to make it unable to resist twisting stresses due to the wind.
2. It should have enough depth for strength. But it should not be very deep because in that case, the side area may become very large which is undesirable for safety and efficiency.

Wings:

- The wings provide necessary force to lift the aircraft and to support and stabilize the aircraft while in air.
- Wings contain very important parts such as Ailerons, Slats, Flap and spoilers.
- Also carries the fuel
- Designed so that the outer tips of the wings are higher than where the wings are attached to the fuselage
    - Called the dihedral angle.
    - Helps keep the airplane from rolling unexpectedly

The wings have a number of movable parts, hinged to which facilitate their function. They are:

a) **Flaps b) Ailerons c) Slats**
b) **Flaps:** These are found at the trailing edge of the wing. The flaps work together with the slats to increase lift. The flaps, when stretched out increase the surface area of the wings, consequently increasing the area for air flow which in turn increases lift.
c) **Ailerons:** These are found at the trailing edge of the wing. They facilitate the turning of the aircraft from left to right or from right to left.
d) **Slats:** Found at the leading edge of the wings, the slats open to facilitate the movement of air from the bottom to the top of the wing to increase the speed of air flow at the top of the wing. This action helps the wings to increase lift.

Tail Planes:

This element is found at the back of the aircraft. It consists of two parts; the vertical part which is also referred to as the **fin** and the horizontal part which is also referred to as the **stabilizer**. The stabilizer and the fin both have movable parts which enable movement of the aircraft nose.

Elevator: The elevator is a movable part attached to the stabilizer which when moved up enables the aircraft nose to move up and vice versa. This movement is referred to as pitching.

Rudder: The rudder is another movable part, attached to the fin that, when side moved to the left will cause the aircraft nose to move right and vice versa. This movement is referred to as yawing.

The wheel structures/ under carriage

- An aircraft touches down on the runway on its under carriage
- The main function of the wheels/under carriage is to cushion and absorb the shock waves resulting from the impact when the aircraft touches the ground.
- It enables the aircraft to manoeuvre on ground – The suitable assembly of wheels allows the aircraft to move on the runway carrying its entire weight.
- The wheels are retracted at take-off to minimize drag.

Three Controls:

When a plane is in flight, there are three imaginary axes of rotation. These lines run through the weight center (or center of gravity) of the plane. The airplane's rotation around the y axis is called yaw; rotation around the x axis is called pitch, and rotation around the z axis is called roll.

Controls:

- **Roll** is controlled by the ailerons
  - Used to raise and lower the wings.
  - Turning the control wheel left causes the left aileron to raise and lowers the right aileron. The plane rolls left.
  - Turning the control wheel right causes the right aileron to raise and lowers the left aileron. The plane rolls right.
- **Pitch** is controlled by the elevators on the tail of the plane.
- **Yaw** is controlled by the rudders.

4.4 Aircraft Characteristics Affecting Airport Design:

1. Engine and Propulsion
2. Size
3. Aircraft capacity
4. Aircraft speed
5. Minimum turning radius
6. Minimum circling radius
7. Aircraft weight and wheel arrangements
8. Range
9. Noise
10. Take off and landing distances
11. Tire pressure and contact area.

Size of Aircraft: Size depends upon

1. Wing Span
2. Length (Fuselage length)
3. The maximum height
4. Distance between main gears
5. Wheel base
6. Tail Width

Size decides load carrying capacity

Wing Span decides: The apron size, taxiway clearance, hangar size turning radius – ICAO classification

The length of Aircraft decides: The width of exit taxiway, apron size, length of hanger etc.

The height decides: The height of hangers and its gate.

The gear treads and wheel base affect the minimum turning radius of the aircraft.

Air Craft capacity:

Aircraft capacity determines;

- Number of Passengers

- Baggage
- Cargo and
- Fuel.

Aircraft Speed:

- Speed now a days is measured in mach i.e. the speed of sound
- Piston engines – 500 to 800 km/hr (0.6 to 0.8 mach)
- Jet Engines - 1200 – 2400 km/hr (1 to 2 mach)
- Rocket engines - > 4800 km/hr (4 mach and above)
- Speed determines the travel time.

Speed has nothing to do with planning of airport, it gives an idea of the time of arrival of aircraft. However approach speed decides runway length.

Minimum Turning Radius: It is necessary to know the minimum turning radius of an aircraft to decide the radius of taxiways and to ascertain its position in the landing aprons and hangars.

Minimum Circling radius: A certain minimum circling radius in space is required for the aircraft to take a smooth turn. It is known as the minimum circling radius. It depends upon,

- Type of aircraft
- Air traffic volume
- Weather conditions
- The knowledge of minimum circling radius helps in separating two nearby airports by adequate distance.
- For jet planes its around 80 km
- For other planes its around 8 – 15 km.
- If minimum circling radius is not provided it will reduce the airport capacity and adjustment of timings for landing and take-off of aircrafts between the airports needs to be adjusted.

Aircraft Weight and Wheel Configuration:

- Governs the length and thickness of the runways, taxiways.
- Number of wheels to be provided depends on aircraft weight.
- Structural design of the airport is based on the total load of the aircraft.

The weight of the aircraft may be classified into:

- **Operating empty Weight** – Weight of empty aircraft, including its crew and all equipment needed for flight, but excluding passengers, fuel load and cargo.
- **Pay load** – revenue producing load which consists of passengers, mail and cargo.
- **Fuel Load-** Weight of the fuel carried by the aircraft required for the trip and certain reserve. It may vary from 9% to 40% of the total gross weight .

Wheel Configurations:-

More number of wheels lesser is the load on the runway pavement.
- Depends upon the size and type of aircraft.
- Wheel configuration also decides minimum turning radius.

Fuel Spillage:-
- The spilling of fuels and lubricants occur in loading aprons and hangers.
- It is difficult to avoid spilling completely.
- The bituminous pavements are seriously affected by fuel spillage. Hence the areas of bituminous pavements below the fuel inlets, the engines, and main landing gears are kept under constant watch by the airport authorities.
- Causes skidding of aircrafts.

Range:
- The distance that an aircraft can fly without refueling is called range.
- As range increases pay load decreases and vice versa.

Noise: This is a big problem in the areas where airports are quiet near to the developed areas. Efforts are being made to bring it to minimum possible level.
The major source of noise is:
- Engine
- Machinery prominent during landing
- Primary jet, prominent during take off
- It causes Sleep disturbance, deafness, irritability, Loss of Concentration.

Factors determining airport catchment area

The need and potential for the development of existing airports or for the construction of new ones is determined by a number of internal and external factors. Internal factors involve, among other things, the airport management policy, as the economic success of an airport is not only an effect of general air transport development trends, but also of the success or failure of the business strategy pursued by airport management. Another key factor is the importance of cooperation between airport managers and local government. The latter should be interested in airport development given the stimuli to economic growth it generates. Such cooperation is usually based on the fact that the city or the region is often a key shareholder in airport management companies. The cooperation may take the form of involvement (including financial participation) of the local government authority in the opening and promotion of air connections offered by the airport. Also the role of local government in managing areas surrounding the airport is important as it has a direct impact on the potential for its undisturbed operation and further development. From the perspective of the catchment area of an airport, i.e. the impact of the airport on the market for air transport, local and regional government have the fundamental task of organising the public transport serving the airport.

The group of external factors is more varied as it comprises the spatial, social and economic determinants of airport development. The former (spatial) are mainly local in nature, i.e. they concern the immediate surroundings. The latter (socioeconomic) address development in a wider sense, i.e. the transport sector itself as well as the region and the country. The two groups of conditions are interrelated. A good spatial system within which the airport functions may remain unexploited if the region does not develop fast enough for the airport surroundings to represent attractive investment areas. And conversely, stimuli for economic development, such as increased mobility of the region's population, may be arrested by limited airport throughput and lack of development prospects. In the context of all the above conditions, transport solutions have a role to play as they stimulate both the airport itself and its surroundings.

4.5 Criteria for airport site selection and ICAO stipulations

The selection of a suitable site for an airport depends upon the class of airport under consideration. However if such factors as required for the selection of the largest facility are considered the development of the airport by stages will be made easier and economical. The factors listed below are for the selection of a suitable site for a major airport installation:

1. Regional plan
2. Airport use
3. Proximity to other airport
4. Ground accessibility
5. Topography
6. Obstructions
7. Visibility
8. Wind
9. Noise nuisance
10. grading, drainage and soil characteristics
11. Future development
12. Availability of utilities from town
13. Economic consideration

Regional plan: The site selected should fit well into the regional plan there by forming it an integral part of the national network of airport.

Airport use: the selection of site depends upon the use of an airport. Whether for civilian or for military operations. However during the emergency civilian airports are taken over by the defence. Therefore the airport site selected should be such that it provides natural protection to the area from air roads. This consideration is of prime importance for the airfields to be located in combat zones. If the site provides thick bushes.

Proximity to other airport: the site should be selected at a considerable distance from the existing airports so that the aircraft landing in one airport does not interfere with the movement of aircraft at other airport. The required separation between the airports mainly depends upon the volume of air traffic.

Ground accessibility: the site should be so selected that it is readily accessible to the users. The airline passenger is more concerned with his door to door time rather than the actual time in air travel. The time to reach the airport is therefore an important consideration especially for short haul operations.

Topography: this includes natural features like ground contours trees streams etc. A raised ground a hill top is usually considered to be an ideal site for an airport.

Obstructions: when aircraft is landing or taking off it loses or gains altitude very slowly as compared to the forward speed. For this reason long clearance areas are provided on either side of runway known as approach areas over which the aircraft can safely gain or lose altitude.

Visibility: poor visibility lowers the traffic capacity of the airport. The site selected should therefore be free from visibility reducing conditions such as fog smoke and haze. Fog generally settles in the area where wind blows minimum in a valley.

Wind: runway is so oriented that landing and takeoff is done by heading into the wind should be collected over a minimum period of about five years.

Noise nuisance: the extent of noise nuisance depends upon the climb out path of aircraft type of engine propulsion and the gross weight of aircraft. The problem becomes more acute with jet engine aircrafts. Therefore the site should be so selected that the landing and takeoff paths of the aircrafts pass over the land which is free from residential or industrial developments.

Grading, drainage and soil characteristics: grading and drainage play an important role in the construction and maintenance of airport which in turn influences the site selection. The original ground profile of a site together with any grading operations determines the shape of an airport area and the general pattern of the drainage system. The possibility of floods at the valley sites should be investigated. Sites with high water tables which may require costly subsoil drainage should be avoided.

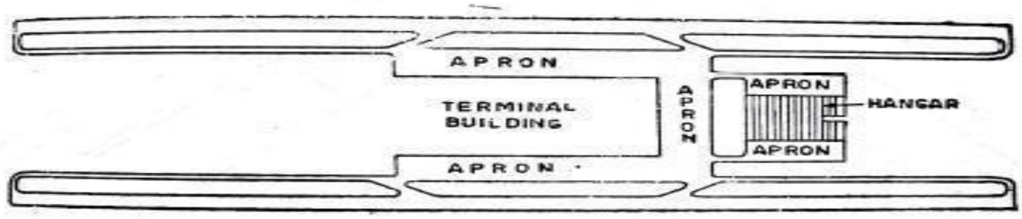
Future development: considering that the air traffic volume will continue to increase in future more member of runways may have to be provided for an increased traffic.

4.6 Typical airport layouts:

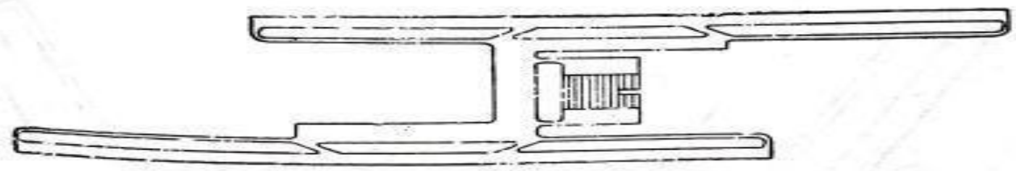
The layout of an airport mainly depends on the basic configurations of the runways. The other airport elements are then correlated in such a way that an integrated layout is developed giving smooth flow of traffic, keeping in mind the taxi distances to a minimum, providing shortest route for the passengers. A proper airport layout provides full functional efficiency with the minimum space utilization. An engineer should attempt to provide the simplest design which yields the optimum service to air passengers. A good airfield layout should posses the following characteristic:

- Landing, taxing and taking off as independent operations without interference.
- Shortest taxiway distance from loading runway end.
- Safe runway length
- Safe approaches
- Excellent control tower visibility
- Adequate loading apron space
- Sufficient terminal building facilities
- Sufficient land area to permit subsequent expansion
- Lowest possible cost of construction.

Single Runway Concept

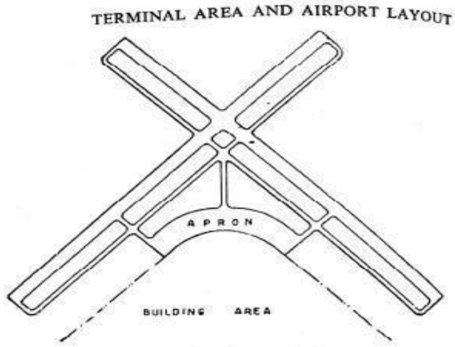


Open Parallel Concept

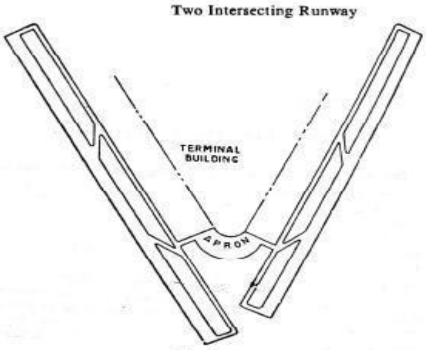


Offset Parallel Concept

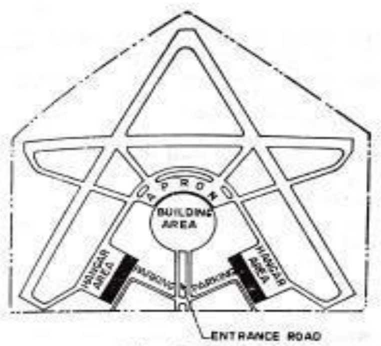
TERMINAL AREA AND AIRPORT LAYOUT



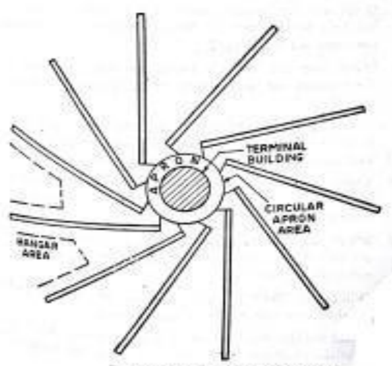
Two Intersecting Runway



Non-intersecting Runways



Three Intersecting Runways



Tangential Runway Layout

Parking and circulation area

Since the 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 is as convenient as possible.

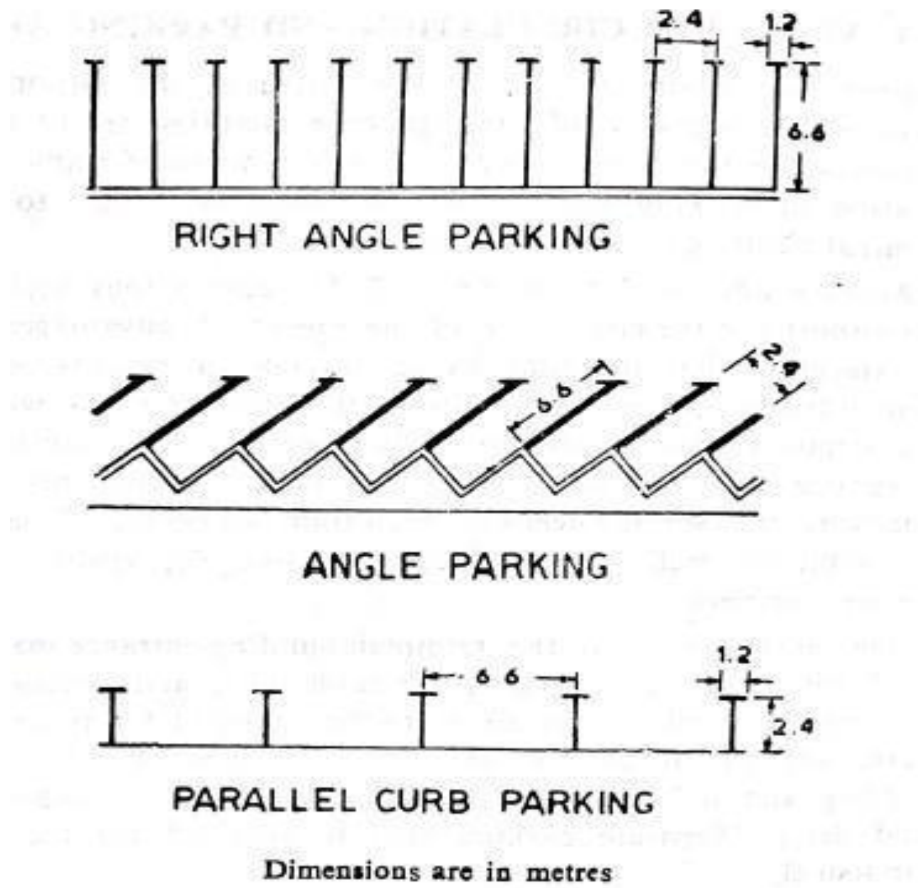
Access roads are planned to provide fact connections between the airport and the city. One of the present disadvantages of air travel is that the time saved through air travel is lost in ground transportation. Circulation of vehicular traffic within the terminal area is also carefully planned. It is essential to categorize the vehicular traffic to provide the road network satisfying the specific needs of each traffic category. Broadly the vehicular traffic is classified as passengers, visitors and service personnel.

The area closest to the terminal building entrance may be used for short time parking for enplaning and deplaning passengers. Sufficient space is to be provided for passengers cars, adjacent to the entrance of the terminal building boarding and alighting of passengers without any congestion and delay. Separate parking area is provided for the staff personnel.

For the most efficient airport vehicular circulation and parking system, the following points are considered:

- Ease of passenger unloading and loading at the terminal building
- One way traffic wherever possible
- A minimum of driveway intersection
- Adequate driveway width to permit overtaking
- Sufficiently and clearly defined parking and circulation routes
- Well lighted routes for pedestrians and vehicles

For determining the size and type of parking facility necessary, a traffic survey should be conducted. FAA suggests that the size of the public parking facility should be based on 1.5 to 2 cars for each peak hour passenger. The pattern of parking is dedicated by the shape and size of the parking area available. The basic parking patterns usually adopted are shown in fig



Basic Vehicular Parking Patterns

4.7 Recommended Questions

1. Enumerate the various factors which you would keep in view while selecting a suitable site for an airport.
2. Write the classification of airports based on ICAO and FAA?
3. Explain the component parts of airports.
4. Explain the typical airports layouts with neat sketch.
5. Explain the aircraft characteristics which affect the airport design.
6. What are the characteristics of air transport?

4.8 Outcomes

1. Acquires capability of choosing alignment and also design geometric aspects of runway, and taxiway.

4.9 Further Reading

1. http://science.howstuffworks.com/transport/flight/modern/airport1.htm
2. http://www.aai.aero/public_notices/aaisite_test/main_new.jsp
3. http://nptel.ac.in/reviewed_pdfs/105107123/lec31.pdf
4. http://www.ucalgary.ca/EN/civil/NLAircraft/Atrgpap.pdf

Airport Design

Structure

5.0 Introduction
5.1 Objectives
5.2 Wind Rose Diagram
5.3 Runway Length
5.4 Basic Elements of a Runway:
5.5 Runway Geometric Design
5.6 Taxiway Planning
5.7 Airport Zones
5.8 Passenger Facilities and Services
5.9 Airport Making and Lighting
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5.0 Introduction

Orientation

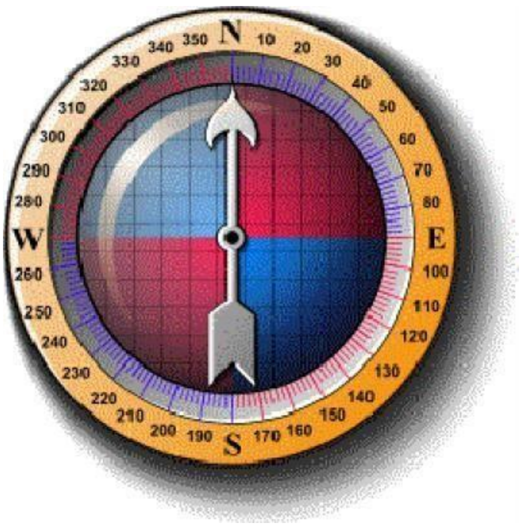
According to the International Civil Aviation Organization (ICAO) a runway is a "defined rectangular area on a land aerodrome prepared for the landing and takeoff of aircraft".

The orientation of the runway is an important consideration in airport planning and design. The correct runway orientation maximizes the possible use of the runway throughout the year accounting for a wide variety of wind conditions. FAA and ICAO regulations establish rules about runway orientation and their expected coverage Runway Location Considerations. FAA mandates identification standards for airport layout that is meant to assist pilots in easily recognizing runways.

Runway is usually oriented in the direction of prevailing winds. The head wind i.e. the wind direction of wind opposite to the direction of landing and taking-off provides greater lift on the wings of the aircraft when it is taking-off. As such the aircraft rises above the ground much earlier and in a shorter length of runway. During landing, the head wind provides a breaking effect and the aircraft comes to a stop in a smaller length of runway. Landing and take-off operations, if done along the wind direction, would require longer runway.

The challenge for the designer is to accommodate all of the aircraft using the facility in a reliable and reasonable manner.

In navigation, all measurement of direction is performed by using the numbers of a compass. A compass is a 360° circle where 0/360° is North, 90° is East, 180° is South, and 270° is West, as shown in figure.



5.1 Objectives

1. Design and plan airport layout, design facilities required for runway, taxiway and impart knowledge about visual aids

5.2 Wind Rose Diagram

Runway orientation using wind rose:

The wind data, i.e., direction, duration and intensity are graphically represented by a diagram called wind rose. The plotting of the wind rose diagrams can be done in the following two ways

Type I: Showing direction and duration of wind
Type II: Showing direction, duration and intensity of wind

Cross wind component:

It is not possible to get the direction of opposite wind parallel to the centre line of the runway length everyday or throughout the year.

If the direction of wind is at an angle to the runway centre line, its component along the direction of runway will be V Cos θ and that normal to the runway centre line will be V Sin θ where V is the wind velocity. The normal component of the wind is called cross wind component. Cross wind component should not exceed 25 kmph for mixed traffic.

Wind coverage:

The percentage of time in a year during which the cross wind component remains within the limit of 25 kmph is called wind coverage of the runway.

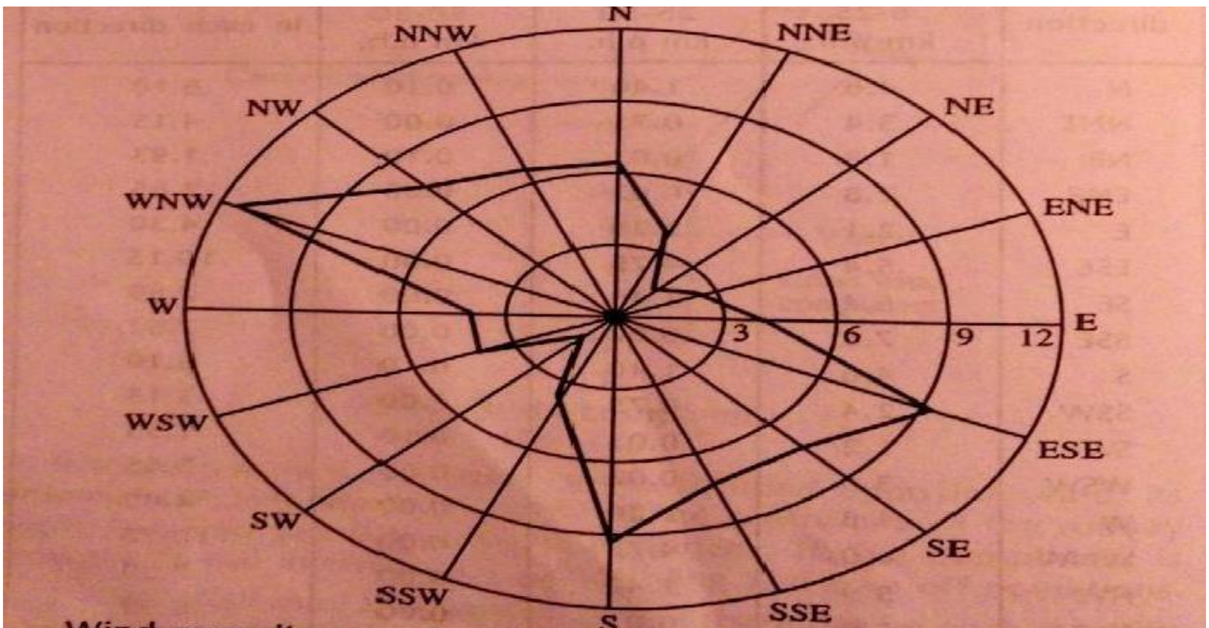
According to FAA, the runway handling mixed air traffic should be so planned that for 95 % of time in a year. For busy airports, the wind coverage may be increased to 98 % to 100%.

TYPICAL WIND DATA

Wind direction	Percentage of time			Total percentage in each direction
	6-25 km p.h.	25-50 km p.h.	50-80 km p.h.	
N	4.6	1.40	0.10	6.10
NNE	3.4	0.75	0.00	4.15
NE	1.8	0.03	0.10	1.93
ENE	2.8	0.02	0.03	2.85
E	2.1	2.20	0.00	4.30
ESE	5.4	4.75	0.00	10.15
SE	6.4	1.40	0.00	7.80
SSE	7.5	0.02	0.00	7.52
S	4.6	1.40	0.10	6.10
SSW	2.4	0.75	0.00	3.15
SW	1.2	0.03	0.10	1.33
WSW	3.6	0.02	0.03	3.65
W	1.8	2.20	0.00	4.00
WNW	6.0	4.75	0.00	10.75
NW	5.9	1.40	0.00	7.30
NNW	6.9	0.02	0.00	6.92
Total	66.4	21.14	0.46	88.00

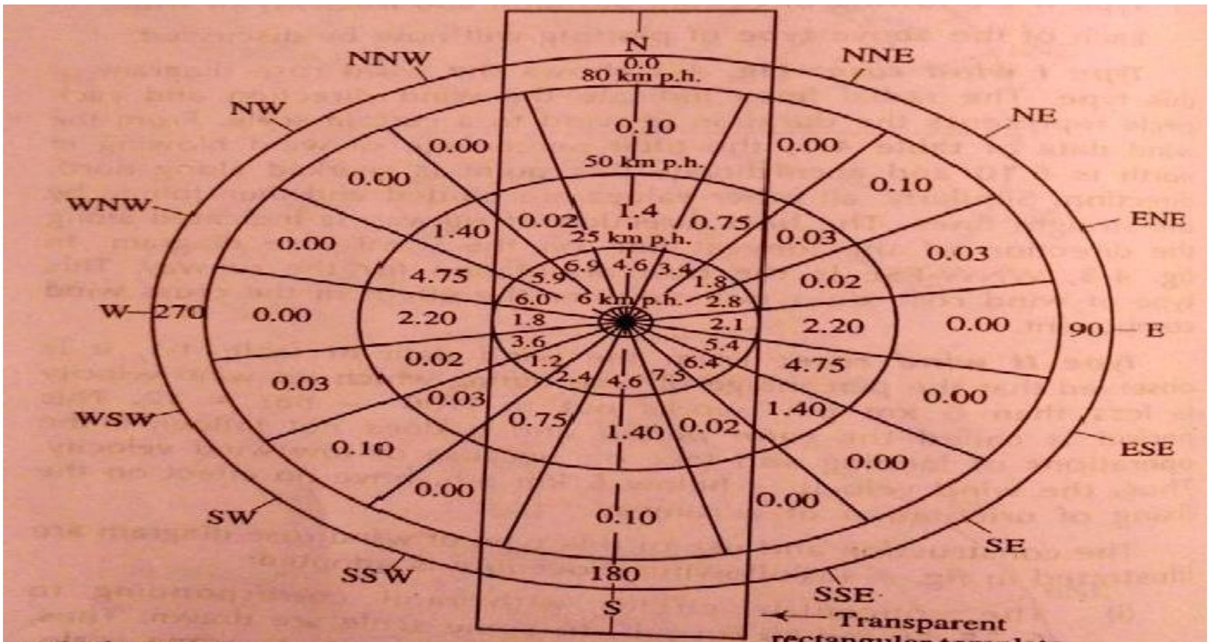
Type I wind rose:

The radial lines indicate the wind direction and each circle represents the duration of wind to a certain scale. The total percentage of wind blowing in each direction are plotted and then joined by the straight lines. The best direction of runway is indicated along the direction of the longest line on the wind rose diagram.



Wind rose diagram showing direction and duration of wind

Type II wind rose:



Wind rose diagram showing direction, duration and intensity of wind

- From the wind data table, it is observed that the percentage of time during which the wind velocity is less than 6 kmph works out to (100-88) = 12. this period is called the calm period and does not influence the operations of landing and take-off because of low wind velocity.
- Thus the wind velocities below 6 kmph have no effect on the fixing of orientation of a runway.
- Thus, the wind velocities below 6 Kmph have no effect on the fixing of orientation of a runway.
- The concentric circles with radii corresponding to 6, 25, 50, and 80 kmph to some scale are drawn. Thus, each circle represents the wind velocity to some scale
- Starting with centre of the concentric circles, the 16 radial directions are shown on the outer circle. The mid points of 16 arcs on the outermost concentric circle are marked and they are given the cardinal directions of compass like N, NNE, NE, ENE, E, etc.
- The recorded duration of winds and expressed as percentage are shown for each cardinal direction. It may be noted that the cardinal direction is central to sector.
- A transparent rectangular template or paper strip is taken. Its length should be slightly greater than the diameter of the wind rose diagram and its width should be greater than twice the allowable cross wind component i.e. 25 kmph.
- The scale for cross wind component should be the same as that of the concentric circles of the wind rose diagram.
- Along the centre of the length of this template, a line is marked corresponding to the direction of runway.
- The two parallel lines, one on either side of the centre-line, is drawn at a distance equal to the allowable cross wind component i.e. 25 Kmph from the centre line. In other words, the two parallel lines are 50 Kmph away from each other.
- The wind rose diagram is fixed in position on a drawing board.

- A hole is drilled in the centre of the template and it is placed on the wind rose diagram such that its centre lies over the centre of the wind rose diagram.
- In this position, the template is fixed by a pin passing through its centre so that the template can rotate about this pin as axis.
- The template is rotated and is placed along a particular direction.
- In this position of the template, the duration of 6-25, 25-50 and 50-80 Kmph winds are read for the cardinal directions (N, NNE, NE etc.) lying between the two extreme parallel line marked on the template.
- The sum of all these durations is expressed as the percentage and it gives the total wind coverage for that direction.

5.3 Runway Length

- It is the length of runway under the following assumed conditions:
  - 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 carrying capacity.
  - vi. En-route temperature in standard.

5.3.1 Corrections for elevation, temperature and gradient

The basic runway length as discussed earlier is for mean sea level elevation having standard atmospheric conditions. Necessary corrections are therefore applied for any change in elevation, temperature and gradient for the actual site of construction.

5.3.2 Correction for elevation

- As the elevation increases, the air density reduces. This is in turn reduces the lift on the wings of the aircraft and the aircraft requires greater ground speed before it can rise into the air.
- To achieve greater speed, longer length of runway is required.
- ICAO recommends that the basic runway length should be increased at the rate of 7 per cent per 300m rise in elevation above the mean sea level.

5.3.3 Correction for temperature

- The rise in airport reference temperature has the same effect as that of the increase in elevation. Airport reference temperature is defined as the monthly mean of average daily temperature(T_a) for the hottest month of the year plus one third the difference of this temperature (T_a) and the monthly mean of the maximum daily temperature (T_m) for the same month of the year.
- Thus airport reference temperature=
- ICAO recommends that the basic runway length after having been corrected for elevation, should be further increased at the rate of 1 percent for every 1°C rise of airport reference temperature above the standard atmospheric temperature at that elevation.

5.3.4 Check for total correction for elevation plus temperature

- ICAO further recommends that, if the total correction for elevation plus temperature exceeds 35percent of the basic runway length, these corrections should then the further checked up by conducting specific studies at the site by model tests.

5.3.5 Correction for gradient

- Steeper gradient results in greater consumption of energy and as such longer length of runway is required to attain the desired ground speed.
- ICAO does not recommend any specific correction for the gradient.
- FAA recommends that the runway length after having been corrected for elevation and temperature should be further increased at the rate of 20 % for every 1 percent of effective gradient.
- Effective gradient is defined as the maximum difference in elevation between the highest and lowest points of runway divided by the total length of runway.

5.4 Basic Elements of a Runway:

1. Structural Pavement
2. Shoulders
3. Runway Strip
4. Blast pad
5. Runway End safety area
6. Stop way and Clear way.

Structural pavement: It is the paved area whose length and width is designed to ensure a safe operating surface. It supports the airplane load

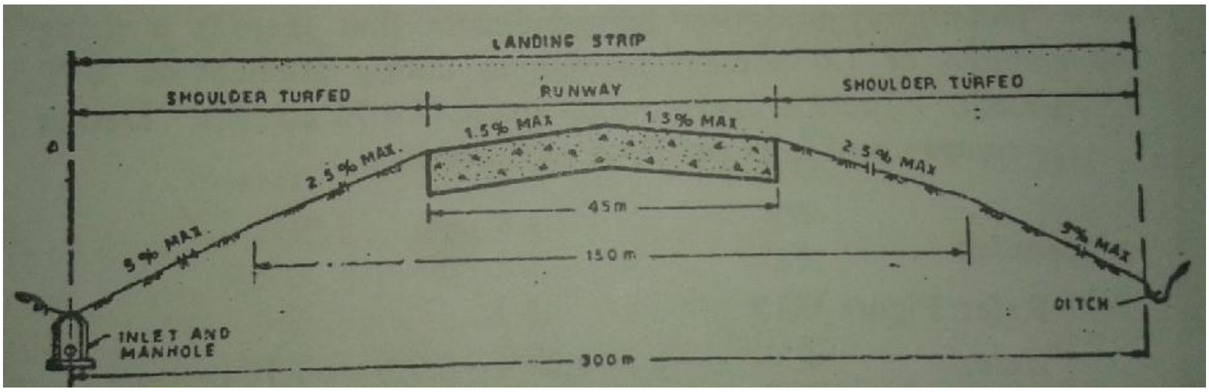
Shoulders: The shoulders are adjacent to the structural pavement, which are designed to resist erosion due to jet blast and to accommodate maintenance equipment and patrol.

Runway Strip: It includes the structural pavement, shoulders and an area that is cleared and graded. This area should be capable of supporting fire, crash rescue and snow removal equipment.

Blast Pad: The blast pad is an area designed to prevent erosion of surfaces adjacent to the ends of the runways which are subjected to repeated jet blasts and to minimize excessive ground maintenance. The area is either paved or planted with turf.

5.5 Runway Geometric Design

- Factors considered in 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



Runway length: The basic runway length as recommended by ICAO for different types of airport are given in the table below. To obtain the actual length of runway, corrections for elevation, temperature and gradient are applied to the basic runway length.

Runway width

- ICAO recommends the pavement width varying from 45 m to 18m for different types of airport.
- The aircraft traffic is more concentrated in the central 24m width of the runway pavement.
- Another consideration in determining the runway width is that the outermost machine of large jet aircraft using the airport should not extend off the pavement on to the shoulders. This is because the shoulder is usually of loose soil or established soil etc which is likely to get into the engine and damage it.
- The outer engines of a large jet transport are about 13.5m from the longitudinal axis of the aircraft.
- As such a pavement width of 45m will provide adequate protection to the engine from the shoulder material during normal operations.

Width and length of safety area

- Safety area 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.
- The shoulders are usually unpaved as they are used during emergency. They may at the most be prepared of stabilized soil or turf.
- Another advantage of providing shoulders on either side of runway is that they impart a sense of openness to the pilot and improve psychology during landing and take-off.
- ICAO recommends that for non-instrumental runway, the width of safety area should be at least 150m for A, B, C, and 78 m for D and E types and for instrumental runway, it should be minimum 300m.

Transverse gradient

- This is essential for quick drainage of surface water. If surface water is allowed to pond on the runway, the aircraft can meet severe hazards.

- ICAO recommends that the transverse gradient of runway pavement should not exceed 1.50percent for A, B, C and 2 percent for D and E types. It does not specify the minimum limit of the transverse gradient.
- ICAO recommends that the transverse gradient of portion of the shoulder should not exceed 2.50percent.
- Transverse gradient of the remaining portion of the shoulder should not exceed 5 percent.

Longitudinal and effective gradient

- The longitudinal gradient of runway increases the required runway length. ICAO gives the following recommendations for the maximum longitudinal gradient and the maximum effective gradient.
- For longitudinal gradient:
  - A, B and C types: 1.50 percent
  - D and E types: 2.00 percent
  - For effective gradient
  - A, B and C types: 1.00 percent
  - D and E types: 2.00 percent

Rate of change of longitudinal gradient

- The abrupt change of longitudinal gradient restricts the height distance and may also cause premature lift-off of the aircraft during the taking-off operation.
- The premature lift-off of aircraft will affect its performance of aircraft during its take-off and can also develop structural defects in the aircraft.
- Too many changes in the gradients over a small length of runway can also restrict the sight distance and increase the runway length.
- The changes in gradients should be smoothened by vertical curves.
- ICAO recommends that the rate of change of gradient should be limited to a maximum of 0.10 percent per 30m length of vertical curve for A and B types, 0.2 percent for C type and 0.4 percent for D and E types of airports.

5.6 Taxiway Planning

Geometric design standards:

- Length of taxiway
- Width of taxiway
- Width of safety area
- Longitudinal gradient
- Traverse gradient
- Rate of change of longitudinal gradient
- Sight distance
- Turning radius

Length of taxiway:

- It should be as short as practicable. This will save the fuel consumption.
- No specifications are recommended by any organisation for limiting the length of taxiway.

Width of taxiway:

- The width of taxiway is much lower than the runway width.
- The speed of the aircraft on a taxiway is also lower than the speed on runway.
- The pilot can comfortably manoeuvre the aircraft over a smaller width of taxiway than on a 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 up to a point where it intersects a parallel runway, taxiway and apron.
- Bitumen treated shoulders are normally used.
- The shoulders must be thick enough to support the airport petrol vehicles and the sweeping equipment.

Longitudinal gradient:

- If the gradient is steep, there will be greater fuel consumption.
- ICAO recommends that the longitudinal gradient should not exceed 1.5 percent for A and B types and 3 percent 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 percent for A, B and C types and 2 percent for D and E types of airports.
- ICAO does not specify any value for the transverse slope of taxiway shoulders.
- FAA recommends that it should be 5 percent for the first 3 m and 2 percent thereafter for all types of airports.

Rate of change of longitudinal gradient:

- ICAO recommends that rate of change of slope in longitudinal direction should not exceed 1 percent per 30 m length of vertical curve for A, B and C types and 1.2 percent for D and E types of airports.

Sight distance:

- ICAO recommends that the surface of a taxiway must be visible from 3 m height for a distance of 300 m for A, B and C types and distance of 250 m must be visible from 2.1 m height for D and E types of airports.

Turning radius:

Whenever there is a change in the direction of a taxiway, a horizontal curves is provided.

$$R = V^2 / 125 f$$

Where, R – Radius, m

V – Speed, kmph

f – Coefficient of friction, 0.13

- For airport serving subsonic jet transports, minimum value of radius of curvature is 120 m is suggested.
- For airport serving supersonic jet transports, minimum value of radius of curvature is 180 m is suggested.

ICAO classification	Taxiway width	Maximum longitudinal gradient, %	Minimum transverse gradient, %	Maximum rate of change of longitudinal gradient per 30 m, %
A	22.5	1.5	1.5	1.0
B	22.5	1.5	1.5	1.0
C	15	3.0	1.5	1.0
D	9.9	3.0	2.0	1.2
E	7.5	3.0	2.0	1.2

Table: Taxiway geometrics

5.7 Airport Zones

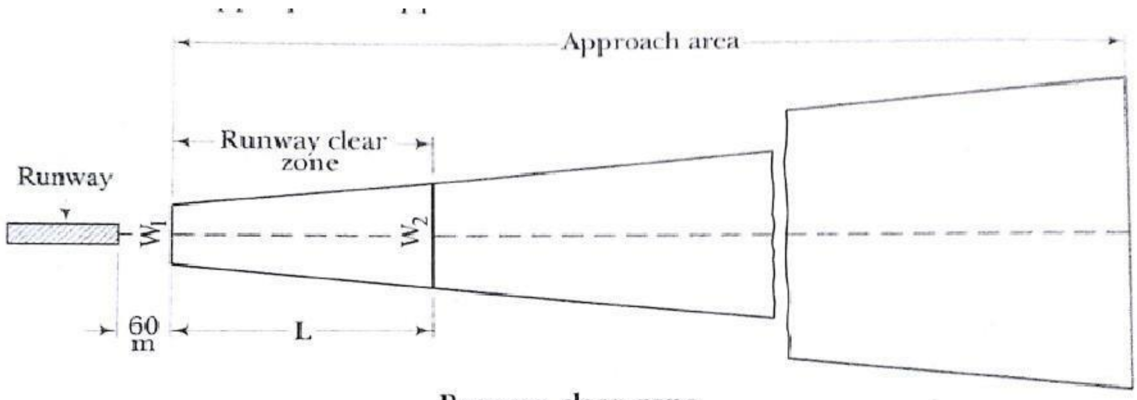
Approach Zone

During landing, the glide path of an aircraft varies from a steep to flat slope. But during take-off, the rate of climb of aircraft is limited by its wing loading and engine power. As such wide clearance areas, known as approach zones are required on either side of runway along the direction of landing and take-off of aircraft. Over this area, the aircraft can safely gain or loose altitude. The whole of this area has to be kept free of obstructions and as such zoning laws are implemented in this area. The plan of approach zone is the same as that of the approach surface. The only difference between the two is that while approach surface is an imaginary surface, the approach area indicates the actual ground area.

Clear Zone

The inner most portion of approach zone which is the most critical portion from obstruction view-point is known as clear zone.

The purchase of this land in this zone is recommended for the effective implementation of zoning laws. It is not necessary to grade this area, but all obstructions are removed. Naturally a level area is preferred but it is not essential. Fences, ditches and other minor obstacles are permitted.

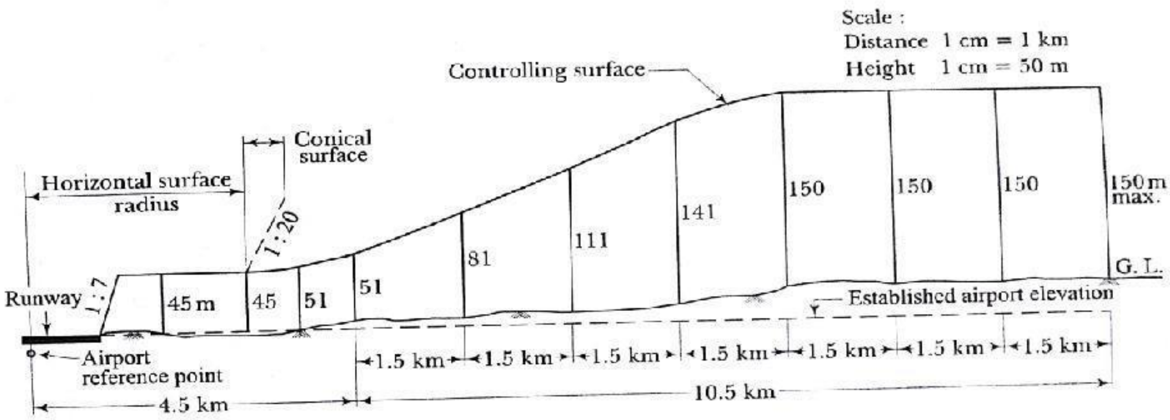


Runway clear zone
FIG. 3-4

TABLE 3-4
DIMENSIONS OF RUNWAY CLEAR ZONE

No.	Type of runway	W_1 (m)	W_2 (m)	L (m)
1	Instrumental runway	300	525	750
2	Non-instrumental runway			
	(i) Large aiprort	150	270	600
	(ii) Small airport	75	135	300

Turning Zone



Turning zone profile for runway with instrument landing system

The turning zone is the area of airport other than the approach area and it is intended for turning operations of the aircraft in case of emergencies like failure of engine or trouble in smooth working of aircrafts experienced at the start of the take off. In such cases, pilot takes the turn and comes in line with the runway before landing. Thus the aircraft operates at a considerably low height in the turning zone and it therefore becomes absolutely necessary to ascertain the fact that the area of turning is free from any obstructions.

The following discussion pertains to the turning zone of instrumental runway

Any object located within a distance of 4.5 km from airport reference point (ARP) is considered as an obstruction, if its height exceeds 51 m above the ground or the established airport elevation whichever is more.

Any object which is located beyond a distance of 4.5 km from the ARP is considered as an obstruction, if its height exceeds 51 m plus 30 m for each additional 1.5 km distance from the ARP or if it exceeds 150 m within a distance of 15 km from the ARP.

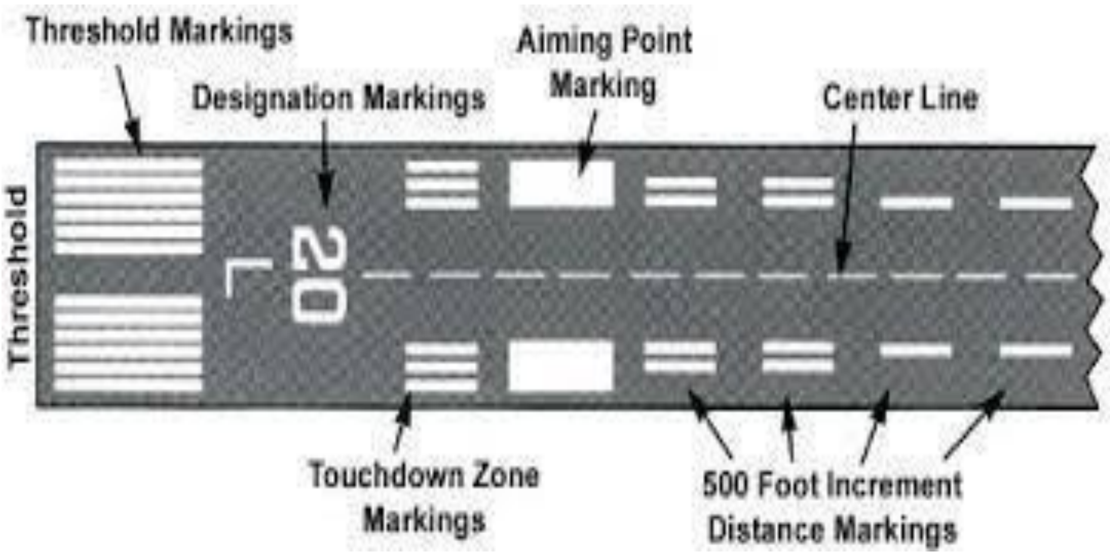
5.8 Passenger Facilities and Services

1. Baggage Enquiries: Baggage allowances are determined by airlines and will depend on a variety of factors such as fare paid and aircraft type, so be sure to check baggage allowance information well in advance of setting off to Airport.
2. Internet Access: If you have a mobile internet device such as a laptop or Smartphone, you can also print vital documents at the kiosks, ensuring you can brush up on last minute paperwork during the flight.
3. Escape Lounge: Escape Lounge now for complimentary food and drink, free Wi-Fi and to simply unwind before fly.
4. Prayer Room: If someone need somewhere for prayer or quiet reflection, can visit prayer rooms in the main Terminal Building.
5. VAT Refunds: Visitors from various countries can reclaim the sales tax (VAT) on purchases. This can be claimed by purchase goods from any merchant displaying the Tax Free Shopping sign and filling in a tax refund form by the retailer, which is to be kept alongside receipts which can be used to claim back tax.
6. Bag Wrapping and Weighing: Luggage-Point offer a Bag Wrapping facility within the Landside concourse at Airports.
7. Cash Machines: Cash machines will be available in Airports, before and after security check.
8. Family Facilities: Travelling with children doesn't need to be a stressful process. At Airports all the services and facilities will be available to keep kids happy and entertained at the airport, whether that's from baby changing rooms to pre-flight entertainment and dedicated family rooms at specified gates.
9. Information Desk: The 24-hour airport information desk is located in the international arrivals area, providing help with general airport enquiries, flight information and paging calls.
10. Meeting Rooms: Meeting and conference facilities are available at Airports and through a variety of nearby hotel spots.
11. Postal Services: Availability of postal services for passengers to send a letter or postcard from airports.
12. Rest and Relaxation: When seeking peace and quiet before departing the Airport, passengers can avail Escape Lounge. Further facilities geared towards a relaxing airport experience include an array of comfortable seating in one of our many cafés, restaurants and bars.
13. Smoking Areas: Airports are smoke-free, with smoking only permitted in designated areas outside the terminal building.

14. Trolleys: Baggage trolleys are provided in the reclaim hall and other key areas in the terminal building, car parks, rail station and coach station.

5.9 Airport Making and Lighting
5.9.1 Airport Lighting

Visual aids assist the pilot on approach to an airport, as well as navigating around an airfield and are essential elements of airport infrastructure. As such, these facilities require proper planning and precise design.



These facilities may be divided into three categories: lighting, marking, and signage. Lighting is further categorized as either approach lighting or surface lighting. Specific lighting are

1. Approach lighting
2. Runway threshold lighting
3. Runway edge lighting
4. Runway centreline and touchdown zone lights
5. Runway approach slope indicators
6. Taxiway edge and centreline lighting

Airfield marking and signage includes

1. Runway and taxiway pavement markings
2. Runway and taxiway guidance sign systems

Airfield lighting, marking, and signage facilities provide the following functions:

1. Ground to air visual information required during landing
2. The visual requirements for takeoff and landing
3. The visual guidance for taxiing

The Airport Beacon

Beacons are lighted to mark an airport. They are designed to produce a narrow horizontal and vertical beam of high-intensity light which is rotated about a vertical axis so as to produce approximately 12 flashes per minute for civil airports and 18 flashes per minute for military airports.

Obstruction Lighting Obstructions are identified by fixed, flashing, or rotating red lights or beacons. All structures that constitute a hazard to aircraft in flight or during landing or takeoff are marked by obstruction lights.

Alignment Guidance Pilots must know where their aircraft is with respect to lateral displacement from the centreline of the runway.

Height Information The estimation of the height above ground from visual cues is one of the most difficult judgments for pilots. It is simply not possible to provide good height information from an approach lighting system.

Approach Lighting Approach lighting systems (ALS) are designed specifically to provide guidance for aircraft approaching a particular runway under night time or other low-visibility conditions.

Visual Approach Slope Aids Visual approach slope aids are lighting systems designed to provide a measure of vertical guidance to aircraft approaching a particular runway.

Visual Approach Slope Indicator

The visual approach slope indicator (VASI) is a system of lights which acts as an aid in defining the desired glide path in relatively good weather conditions.

Precision Approach Path Indicator The FAA presently prefers the use of another type of visual approach indicator called the precision approach path indicator (PAPI)

Threshold Lighting During the final approach for landing, pilots must make a decision to complete the landing or ―execute a missed approach.

Runway Lighting After crossing the threshold, pilots must complete a touchdown and roll out on the runway. The runway visual aids for this phase of landing are be designed to give pilots information on alignment, lateral displacement, roll, and distance. The lights are arranged to form a visual pattern that pilots can easily interpret.

Runway Edge Lights Runway edge lighting systems outline the edge of runways during night time and reduced visibility conditions.

Runway Center line and Touchdown Zone Lights

As an aircraft traverses over the approach lights, pilots are looking at relatively bright light sources on the extended runway center line.

Taxiway Lighting Either after a landing or on the way to takeoff, pilots must maneuver the aircraft on the ground on a system of taxiways to and from the terminal and hangar areas. Taxiway lighting systems are provided for taxiing at night and also during the day when visibility is very poor, particularly at commercial service airports.

Taxiway Edge Lights Taxiway edge lights are elevated blue colored bidirectional lights usually located at intervals of not more than 200 ft on either side of the taxiway.

Runway Stop Bar Similar to runway guard lights, runway stop bar lights are in-pavement lights on taxiways at intersections with runways.

5.9.1 Airport Marking

Runway and Taxiway Marking In order to aid pilots in guiding the aircraft on runways and taxiways, pavements are marked with lines and numbers. These markings are of benefit primarily during the day and dusk.
Runway Designators The end of each runway is marked with a number, known as a runway designator, which indicates the approximate magnetic of the runway in the direction of operations.
Runway Threshold Markings Runway threshold markings identify to the pilot the beginning of the runway that is safe and available for landing.
Centerline Markings Runway centerline markings are white, located on the centerline of the runway, and consist of a line of uniformly spaced stripes and gaps.
Aiming Points Aiming points are placed on runways of at least 4000 ft in length to provide enhanced visual guidance for landing aircraft.
Touchdown Zone Markings Runway touchdown zone markings are white and consist of groups of one, two, and three rectangular bars symmetrically arranged in pairs about the runway centerline.
Side Stripes Runway side stripes consist of continuous white lines along each side of the runway to provide contrast with the surrounding terrain or to delineate the edges of the full strength pavement.
Blast Pad Markings In order to prevent erosion of the soil, many airports provide a paved blast pad adjacent to the runway end.
Centreline and Edge Markings The centreline of the taxiway is marked with a single continuous 6-in yellow line.
Taxiway Hold Markings For taxiway intersections where there is an operational need to hold aircraft, a dashed yellow holding line is placed perpendicular to and across the centreline of both taxiways.
Closed Runway and Taxiway Markings When runways or taxiways are permanently or temporarily closed to aircraft, yellow crosses are placed on these traffic ways.

5.10 Recommended Questions

1. Explain runway markings and runway lightings
2. Explain the geometric design of taxiway.
3. Write the assumptions of basic runway
4. Write a note on airport zone.