Transportation Engineering -II

Unit -4 (Contd.)

Topics Covered – Runway Modes of Operation, Runway Pavement Design, Runway lighting, Heliport marking

Runway Modes of Operation

In ATC terms, the various modes of operation available for the use of parallel or near-parallel instrument runways are distinguished as:

Simultaneous parallel approaches

- **Mode 1, independent parallel approaches:** simultaneous approaches to parallel instrument runways where radar separation minima are not prescribed between aircraft using adjacent ILS(Instrument Landing System); and
- **Mode 2, dependent parallel approaches:** simultaneous approaches to parallel instrument runways where radar separation minima between aircraft using adjacent ILS are prescribed.

- **Mode 3, independent parallel departures:** simultaneous departures for aircraft departing in the same direction from parallel runways.

It should be noted that when the spacing between two parallel runways is lower than the specified value determined by wake turbulence considerations, the runways are considered as a single runway with regard to vortex wake separation.

(**Wake Vortex Turbulence** is defined as turbulence which is generated by the passage of an aircraft in flight. It will be generated from the point when the nose landing gear of an aircraft leaves the ground on take off and will cease to be generated when the nose landing gear touches the ground during landing. Where another aircraft encounters such turbulence, a **Wake Vortex Encounter** (WVE) is said to have occurred.)

Segregated parallel approaches/departures

- **Mode 4, segregated parallel operations:** simultaneous operations on parallel runways where one runway is used for approaches and landings, and one runway is used for departures.

In the case of segregated parallel approaches and departures there may be semi-mixed modes of operations.

Semi-mixed parallel operations

1. One runway is used exclusively for approaches while approaches are being made to the other runway, or departures are in progress on the other runway.
2. One runway is used exclusively for departures while other is used for both departures and arrivals.

Mixed mode parallel operations

At least one runway is used for both take offs and landings.

Factors to Consider When Determining the Mode of Operations

Theoretical studies and practical examples indicate that maximum aerodrome capacities can be achieved by using parallel runways in a mixed mode of operation. In many cases, however, other factors such as the land-side/air-side infrastructure, the mix of aircraft types, and environmental considerations result in a lower achievable capacity.

Other factors such as non-availability of landing aids on one of the parallel runways or restricted runway lengths may preclude the conducting of mixed operations at a particular aerodrome.

Because of these constraints, maximum runway capacity may, in some cases, only be achieved by adopting a fully segregated mode of operation, i.e. one runway is used exclusively for landings while the other is used exclusively for departures.

The advantages to be gained from segregated parallel operations as compared to mixed parallel operations are as follows:

a) separate monitoring controllers are not required;

b) no interaction between arriving and departing aircraft on the same runway and a possible reduction in the number of missed approaches;

c) a less complex ATC environment overall for both radar approach controllers and aerodrome controllers; and

d) a reduced possibility of pilot error following undetected selection of the wrong ILS.

Runways :

The runway width should be not less than 60m.

Runway shoulders are recommended and, if provided, should be at least 7.5m in width each side, giving an overall minimum width of 75m.

The Obstacle Free Zone (OFZ) shall extend to at least 77.5m either side of the runway.

Taxiway Width :25m

Runway Orientation:

Because of obvious advantages of landing and taking off into the wind, runways are oriented in the direction of prevailing wind. Aircraft may not maneuver safely on a runway when wind contains large component at right angle to the direction of travel. The point at which this component (cross wind component) becomes excessive will depend upon the size and operating characteristics of the aircraft.

Airport Reference Codes[a]	Allowable Crosswind Component
A-I and B-I	10.5 kt
A-II and B-II	13.0 kt
A-III, B-III, and C-I through D-III	16.0 kt
A-IV through D-VI	20.0 kt

Factors affecting the determination of the siting, orientation and number of runways:

- weather, in particular the runway/aerodrome usability factor, as determined by wind distribution, and the occurrence of localized fogs;
- topography of the aerodrome site and its surroundings;
- type and amount of air traffic to be served, including air traffic control aspects;
- aeroplane performance considerations; and
- environmental considerations, particularly noise.

The primary runway, to the extent other factors permit, should be oriented in the direction of the prevailing wind. All runways should be oriented so that approach and departure areas are free of obstacles and, preferably, so that aircraft are not directed over populated areas.

Reference Field Length	Maximum Crosswind Component
1500 m or over[a]	37 km/h (20 kt)
1200 m to 1499 m	24 km/h (13 kt)
<1200 m	19 km/h (10 kt)

Head wind: direction of wind opposite to the direction of landing and takeoff

- Takeoff: head wind provides greater lift on the wings, thus shorter length of runway is enough
- Landing: Headway provides a braking effect and aircraft comes to stop in a smaller length of runway.

If landing and takeoff are done along the wind direction, it may require longer runway length.

Cross wind Component: it is not always possible to obtain the direction of wind along the direction of the center line of runway, this Normal wind component is called **cross wind component**. And it may interrupt the safe landing and takeoff of the aircraft. VSinθ is the Cross wind Component.

V

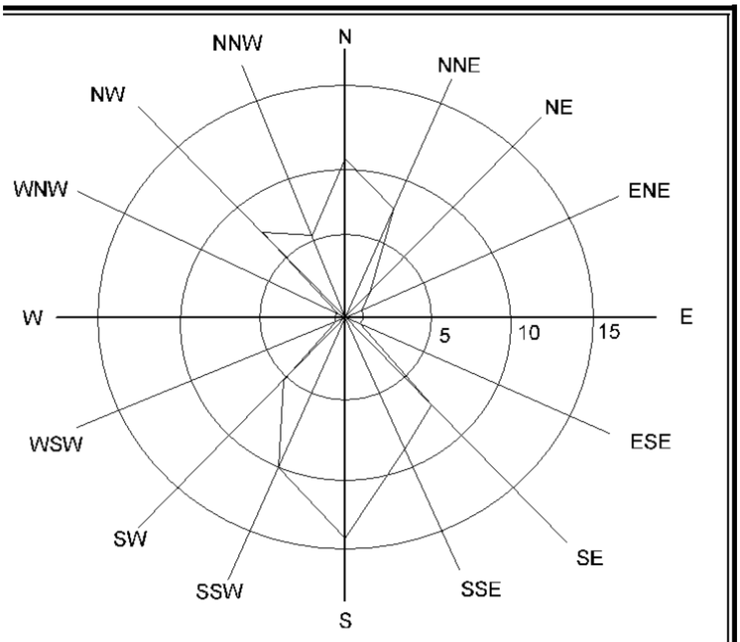
Wind Coverage: The percentage of time in a year during which the CWC remains within the limit is called Wind Coverage.

- FAA standards for mixed air traffic wind coverage should be 95 % with the limit of 25 kmph. CWC.
- For busy airport, WC may be 98 -100 %

Wind Rose method:

Typically wind rose is applied for the orientation of runway.

Wind Rose type: It is the graphical representation of wind data: direction and intensity. Data should be collected for the period of 5 to 10 years. Wind data average of 8 years period



Wind Rose

Elements of an Airport:

Runway:- Area for landing and takeoff operations.

Taxiway:- Connection between apron and runway.

Apron:- Planes parking are next to the building s line in which loading takes place.

Hanger: Building for storage of airplanes also maintenance ; hangers for repair and servicing of longer planes will usually be built for a specific air line according to its specification and most major repairs will be done at a planes home base.

Terminal Building : Consists of an administration facility and passenger services building. (Ticket offices, Rest rooms, waiting rooming).

Airport Pavement Design

Airfield pavements must be:

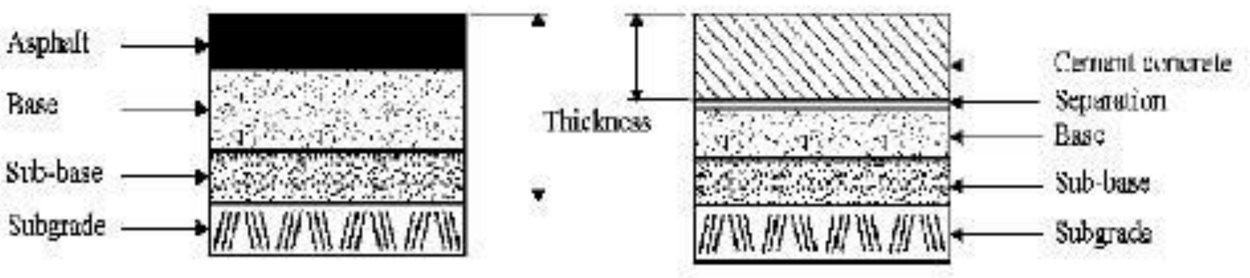
1- **Able to support loads imposed by aircraft without excessive distortion or failure.**

2- **Smooth, firm, and stable.**

3- **Free from dust or other particles that might be blown or pushed up by propeller wash or jet blast.**

4- **Usable in all seasons and in all weather conditions.**

A pavement is a structure consisting of one or more layers of processed or unprocessed materials placed on a prepared subgrade. There are two general classes of pavements: flexible and rigid.



Flexible pavements typically consist of bituminous "surface course," a "base course," and a subbase course." These courses or layers are carefully placed and compacted on a prepared subgrade in an embankment or excavation.

Rigid pavements consist of slab of portland cement concrete that rests on a prepared subgrade or subbase. Distributed steel or tiebars and dowels are used in portland concrete pavements to control and minimize the harmful effects of cracking and to provide for load transfer between adjacent slabs. Relatively thin subbases (4–6 in.) may be placed under rigid pavements to prevent pumping. Subbases may also be used to improve a low-strength subgrade.

1- <u>Rigid airport pavement design:</u>

The FAA method:

This method of design depends on determining the gross aircraft weight of the design aircraft, the flexural strength of the concrete, the modulus of subgrade reaction, and the annual equivalent departure.

Concrete Flexural strength. The 28-day flexural strength of concrete is deter-mined by ASTM Test method C78. A 90-day flexural strength may be used. It can be taken to be 10% higher than the 28-day strength, except when high ear-ly strength cement or pozzolanic admixtures are used.

2-Flexible airport pavement design:-

Flexible pavements consist of a hot mix asphalt wearing surface placed on a base course and, a subbase resting on subgrade conditions. The entire flexible pavement structure is ultimately supported by the subgrade. Definitions of the function of the various components are given in the following paragraphs.

1- **HOT MIX ASPHALT SURFACING.** The hot mix asphalt surface or wearing course must prevent the penetration of surface water to the base course; provide a smooth, well-bonded surface free from loose particles which might endanger air-craft or persons; resist the shearing stresses induced by aircraft loads. To success-fully fulfill these requirements, the surface must be composed of mixtures of ag-gregates and bituminous binders which will produce a uniform surface of suitable texture possessing maximum stability and durability.

2- **BASE COURSE.** The base course is the principal structural component of the flexible pavement. It has the major function of distributing the imposed wheel loadings to the pavement foundation, the subbase and/or subgrade. The base course must be of such quality and thickness to prevent failure in the subgrade, withstand the stresses produced in the base itself, and resist volume changes caused by fluctuations in its moisture content.

3- **SUBBASE,** A subbase is included as an integral part of the flexible pavement structure in all pavements except those on subgrades with a CBR value of 20 or greater . The function of the subbase is similar to that of the base course.

4- **SUBGRADE.** The subgrade soils are subjected to lower stresses than the surface, base, and subbase courses. Subgrade stresses attenuate with depth, and the con-trolling subgrade stress is usually at the top of the subgrade, unless unusual con-ditions exist. Unusual conditions such as a layered subgrade or sharply varying water contents or densities can change the location of the controlling stress.

Methods of the flexible pavement design:

1- California Bearing Ratio Method (CBR Method)

2- The FAA Method of Flexible Pavement.

3- The Canadian Department of Transportation.

4- The Asphalt Institute Method

Runway Lighting

- **Runway Edge Lights** are omni-directional and are located along or just beyond the edges of the area declared for use as the runway as defined by edge markings and are white subject to certain specific exceptions. The area defined may not necessarily be the maximum width of the paved runway surface. The lights may be either elevated or embedded in the surface. If a landing threshold is displaced, but the pre-landing threshold area is available for take off, then the edge lights between the beginning of the runway surface and the displaced threshold will be split so as to show red up to the landing threshold whilst still showing white after that point. If a runway 'starter extension' is provided which is narrower than its associated runway, then blue edge lighting may be used to mark its edges.
- **Runway Threshold Lights** are provided in a line along the landing threshold at the touchdown end of a runway and define the beginning of the declared Landing Distances. They are green and can only be seen from the approach.
- **Runway End Lights** are provided in a line along the end of the runway available for use. They are red and can only be seen in the direction of runway use.

Supplementary Runway Lighting

Various other forms of runway lighting may also be provided, especially if the runway is used for aircraft movements in less than ILS Cat 1 conditions, which require both Low Visibility Procedures (LVP) and, in most cases, specific forms of additional lighting.

- Runway Exit taxiways may be indicated by substitution of one or two of the white runway edge lights with blue ones.
- Stopway Lighting may be used to show the extent of a stopway beyond the designated end of a runway. Red unidirectional edge lights visible only in the direction of runway use are provided at intervals until a further transverse line which marks` the end of the stopway.
- Runway Centreline Lighting may be provided in which case it will extend for the full length of the runway, It will be white except in the event that colour coding is provided in order to indicate the approaching end of the runway. Such colour coded centreline lighting consists of alternating red and white lights beginning at 900 metres from the runway end and these change to continuous red lights for the last 300 metres of the runway.
- Touchdown Zone (TDZ) Lighting must be provided on runways available for use in low visibility conditions so as to provide enhanced identification of the touchdown area. The method of provision is specified in ICAO Annex14 Volume 1 'Aerodrome Design and Operations' and the lighting must extend from the landing threshold for either 900 metres or to the midpoint of the runway, whichever is the least.
- Rapid Exit Taxiway Indicator Lights (RETILs) may be provided to indicate the distance to go to the nearest rapid exit taxiway. In low visibility conditions, RETILs provide useful situational awareness cues to assist in appropriate rates of deceleration and to allow flight crew to concentrate on keeping the aircraft on the runway centre line during the landing roll. They usually consist of six yellow lights adjacent to the runway centreline, configured as a three - two - one sequence spaced 100 metres apart with the single light positioned at 100 metres from the start of the turn for the rapid exit taxiway.
- Caution Zone Lighting may be provided on ILS-equipped runways which do not have centreline lighting. It is provided by replacing the usual white edge lights with yellow` ones for the lesser of the last 600 metres or last one third of the lighted runway length available to provide a visual warning the approaching runway end.
- Landing Threshold Wing Bars, which are green but may take various detail forms, are sometimes provided if it is considered that the threshold needs accentuating.

Heliport Marking

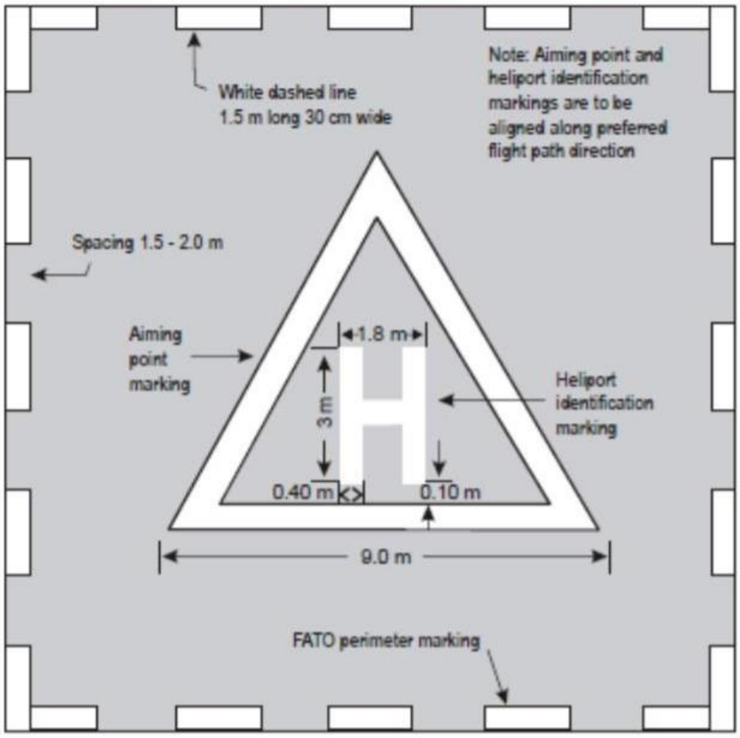
There are basically two terminologies to know in Heliport marking , i.e:

FATO :The **FATO** is a defied heliport area over which the final approach to a hover or a departure is made.

TLOF :The touchdown and lift-of area (TLOF) where the helicopter is permitted to land is normally centered in the FATO.

Whether the TLOF is circular or polygonal, it is defined by a continuous line of at least 30 cm width in reflective white paint. The contours of the FATO are marked by a broken line of 1 metre width using the same type of paint.

MARKING:



The heliport must be identified by the letter H in white, placed in the interior of the FATO, at the centre or near the centre of this and placed in such a way that the "horizontal" bar of this letter is perpendicular to the preferred direction of approach. This H is 1.80 metres wide and 3.00 metres in height and is constructed with the aid of 0.40 metre width bars.

The parking bays are each marked with a circular line at least 50 cm wide with reflective yellow paint. It is recommended that the internal diameter of this mark is equal to half of the overall length of the most disadvantageous helicopter without, however, being less than 6 metres. Intended to define the zone at the interior of which the landing-gear should be positioned, this circumference is naturally concentric to that of the diameter double having to be contained in the treated area of the parking bay. Also yellow in colour, the axis and stop-point markings placed on the traffic lanes intended for running at ground level of the helicopters have the same characteristics as those defined for airfields with normal characteristics. Finally, since there is no reason to treat them as lanes, the traffic lanes intended to be followed in a straight line in ground effect must be visible through vegetation. They must therefore, be lined with markings of 35 cm maximum height, comprising three reflective horizontal alternating bands in yellow, green and yellow. These markings will be at 30 metre spacings at most in a rectilinear section and 15 metres at most in the curves.