Problems :

corrections to basic runway length.

1.B.1. The length of a runway under standard conditions is 2010 m. The airport is located at an elevation of 410 m above mean sea level. The airport reference temperature is 30°C. If the effective gradient is 0.22%, determine the length of runway.

Soln Given data

The length of the runway = 2010 m.

elevation = 410 m

Reference temperature = 30°C

Effective gradient = 0.22%

(i) correction for Elevation : (7% per 300 m)

$$= \frac{7}{100} \times \frac{410}{300} \times 2010 + 2010$$

correction for elevation $= \frac{7}{100} \times \frac{410}{300} \times 2010$

$= 192.29$ m.

Length of runway after correction for elevation = 2202.29 m.

(ii) correction for temperature :: (1% for 1°C)

Standard Airport temperature $= 15 - \left(6.5 \times \frac{410}{1000}\right)$

$= 12.33°$

$= 30° - 12.33° = 17.67°C$

$\Rightarrow \frac{1\%}{1°C} = \frac{1}{100} \times 17.67 \times 2202.29 + 2202.09$

$= 2591.43$ m (389.145)

=

(iii) correction for gradient :. (20% for 1%)

$$= \frac{20}{100} \times \frac{100}{1} \times \frac{0.22}{100} \times 2591.43 + 2591.43$$

$$= 2705.45 \text{ m.} \quad (114.022)$$

Check: Total correction for elevation and temperature $= 192.294 + 389.145$

$= 192.293 + 389.145$

$= 581.44.$

Percentage Increase $= \frac{581.44}{200} \times 100$

$= 28.92\%.$

According to ICAO, this should not be more than 35%.

1.B.2 An airport is proposed at an elevation of 400 m above mean sea-level where the mean of maximum and mean of average daily temperatures of the hottest month are 44.8°C and 26.2°C respectively. The maximum elevation difference along the proposed profile of runway is 6.3 m. If the basic length of runway is 1260 m, determine the actual length of runway to be provided.

Soln

Given data

Elevation = ~~4~~ 400 m

T_2 = 44.8°C

T_1 = 26.2°C

Basic runway length = 1260 m.

(i) correction for elevation :- (7% per 300 m)

$$= \frac{7}{100} \times \frac{400}{300} \times 1260$$

$= 117.6$ say 118 m.

Length of runway after correction for elevation } = 118 + 1260 = 137

ii) correction for temperature : (1% per 1°C)

$$\text{Reference temperature} = T_1 + \frac{T_2 - T_1}{3}$$

$$= 26.2 + \frac{44.8 - 26.2}{3}$$

$= 32.4°C$

Standard } = 15°C

Rise in temperature = 32.4 − 15 = 17.4°C

$$\text{Correction for temperature} = \frac{1}{100} \times 17.4 \times 1378$$

= 239.77 say 240 m.

length of runway after Correction for elevation } = 1378 + 240

= 1618 m.

Correction for gradient :- $= \frac{6.3}{1260} \times 100 = 0.5$

$$= \frac{20}{100} \times \frac{0.5}{100} \times \frac{100}{1} \times 1618$$

$$= 161.8\,m \text{ say } 162\,m.$$

Actual length of runway $= 1618 + 162$

$$= 1780\,m.$$

1.B.3 Runway Patterns :-

* Single runway
* Parallel Runway
* Intersecting Runway
* Divergent or open V runway

Single Runway :-

This is the simplest of the runway pattern and it is usually adopted when the prevailing wind blows in one direction for most time of the year and the air-traffic is not much.

Under the condition of visual flight rules (VFR), the single runway can handle about 45 to 60 operations or movements per hour. For Instrument flight rules (IFR), The capacity of single runway is reduced to about 20 to 40 operations per hour. In this type of runway pattern, only one operation (ie) landing or take off can be done.

The single runway system, with high permissible cross wind component, will serve the purpose for most classes of the airports.

single Runway

Parallel Runway :

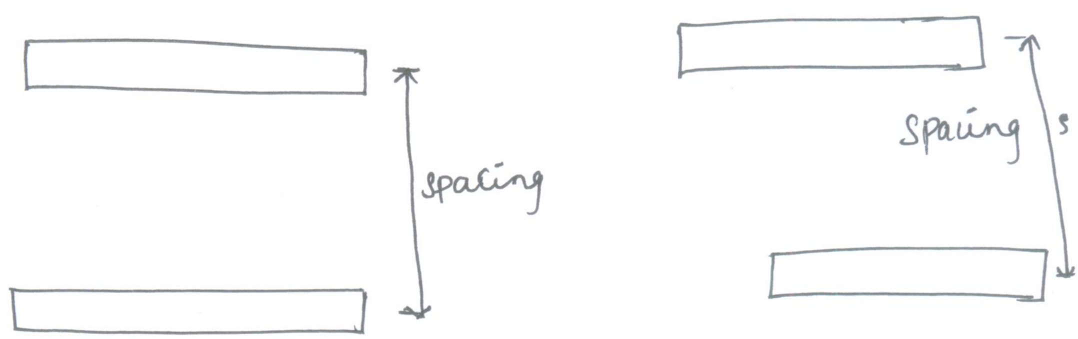
The Capacity of this pattern of runway will primarily depend on the number of runways an on the spacing between the runways.

The spacing dose not affect the capacity in VFR conditions and it may vary from 100 to 200 operatio
IFR conditions,

Closing spacing .... 50 to 60 operations

Intermediate spacing ..... 60 to 75 operations

Foe spacing .... 100 to 125 operations



parallel runways

Intersecting Runways :

When two Runways cross each other, This type of runway pattern is formed and it is adopted when wind in a particular direction

~~doses~~ okond does not provide the required wind

Coverage of 95%..

	Fig ①	Fig ②	Fig ③
IFR operation	60 to 70	45 to 60	40 to 60
VFR operation	70 to 175	60 to 100	50 to 100

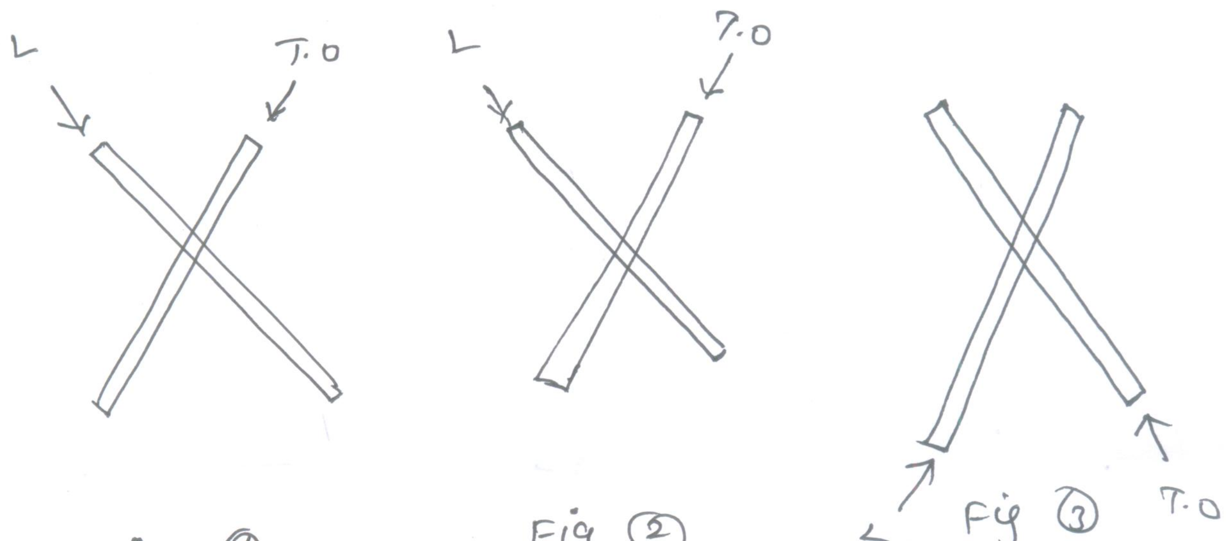


Fig ① Fig ② Fig ③

Divergent (or) open V runways :-

In this type of pattern, the runways diverge in direction with out Intersecting each other.

The divergent runways revert to a single runway when the winds are strong from one direction. when the winds are light, it is possible to use both the runways.

	Fig ①	Fig ②
IFR operations	50 to 80	60 to 180
VFR operations	50 to 60	50 to 100

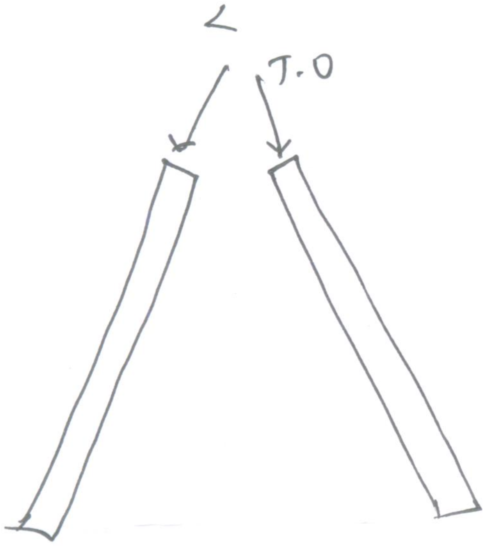


Fig ①

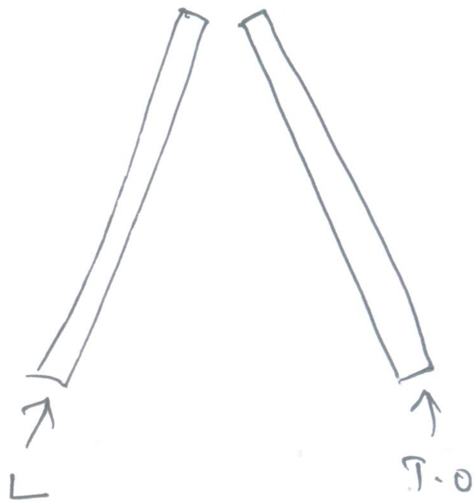


Fig ②

when the flight path is divergent the capacity is the highest. when the flight paths are towards the V. There is reduction in capacity. The hourly capacities shown are above the table

Problems :-

1.8.4 Determine the ~~taxiing~~ Turning radius of a taxiway for a supersonic transport aircraft with the wheel base 30m & tread of main loading gear is 6m. Design turning speed of 50 kmph. Assume co-efficient of friction b/w tyre and pavement is 0.13, tread of main loading gear is 6m & width of the taxiway pavement as 22.5m

Soln

Given data

W = 30m

tread of main loding gear = 6m

f = 0.13

b = 22.5m

Speed = 50 kmph (V)

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

$= \frac{(50)^2}{125 \times 0.13} = 153.85\,m$

(ii) Horonjeff's equation :-

$R = \frac{0.388 W^2}{0.5T - S} = \frac{0.388 \times 30^2}{0.5 \times 22.5 - 9} = 155.25\,m$

where,

$S = 6 + \frac{6}{2} = 9.$

(iii) For the conditions of super sonic aircraft, the minimum radius of curvature 180m.

Take the highest value in above value (R)

Turning radius R = 180m.

1.B.5 Runway orientation :-

(i) Preliminary Information required :-

(i) Maps of the area in the vicinity of the airport showing contours at suitable intervals.

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

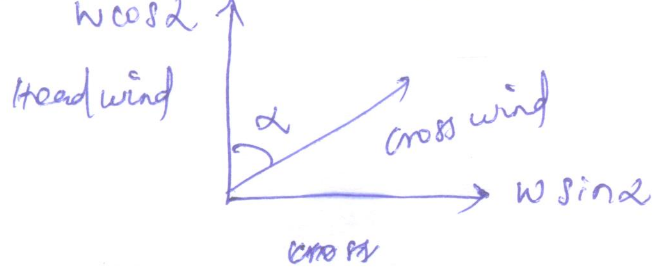
(ii) Cross wind component :-

It is not possible to get the direction of opposite wind. It is a component of wind perpendicular to the flight of the runway is called wind rose diagrame. It is computed,

$$w \sin \alpha$$

where, w - wind velocity

α - Inclination of the wind vector with respect to the flight of runway



(iii) Head wind :-

The runway is usually oriented in the direction of the prevailling winds. The head wind indicates the wind from the opposite direction of the head or nose of the aircraft

... or take off

Advantages :-

(i) During landing, it provides a breaking effort and the aircraft comes to a stop in a short length of the runway.

(ii) During take off, it provides greater lift on the wings of the aircraft.

(4) Wind coverage :-

The percentage of time in a year during which the cross wind component remains with in the limit of 25 k.m.ph. is called the wind coverage of the runway. The orientatio of the runway should be such that the minimum wind coverage of about 95% is obtained. For busy airports, it is possible to obtain wind coverage upto 98% or even 100%.

(5) Wind rose diagram :-

The airport, the average wind data of 5 to 10 years. It is assumed that the duration of wind for any one direction covers.

The average wind data of 5 to 10 years period are collected and represented graphically in the form of a chart known as wind rose.

1.B.6 Geometric design of runways:-

1. Length :-

Basic length depends on Airport Category as per ICAO. Actual length is determined by corrections for elevation, Temperature and gradient.

2. Longitudinal & Effective gradient :-

Recommendations of ICAO

Type of Airport	Max. Longitudinal gradient	Max. Effective gradient.
A, B, & C	1.5 %	1.0 %
D & E	2.0 %	2.0 %

The maximum difference in elevation between the highest and the lowest points of runway divided by the total length of the runway is known as the effective gradient.

3. Rate of change of longitudinal gradient :-

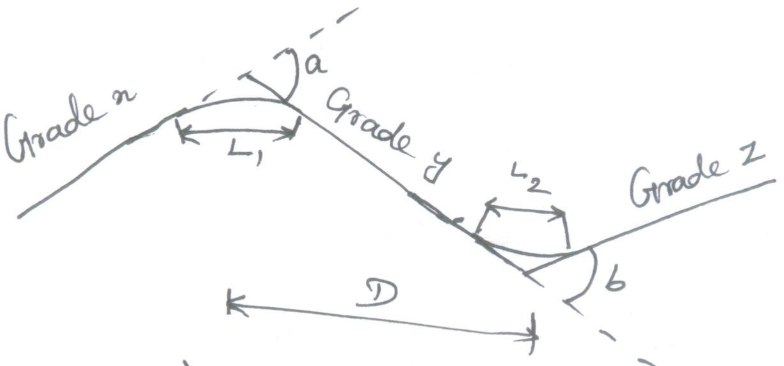
1. Sudden or abrup change is undesirable due to likelihood of premature lift off.

2. Change of gradients should be smooth.

3. As per ICAO, Maximum values for 30m.

Type	Rate of Change
A, B	0.1%
C	0.2%

4. If the change in slope is ≤ 0.4% ; vertical curves are not required.



Longitudinal Gradient.

D < (Change in slope × grade length)

Type	Grade length
A, B	300 m
C	150 m
D, E	50 m

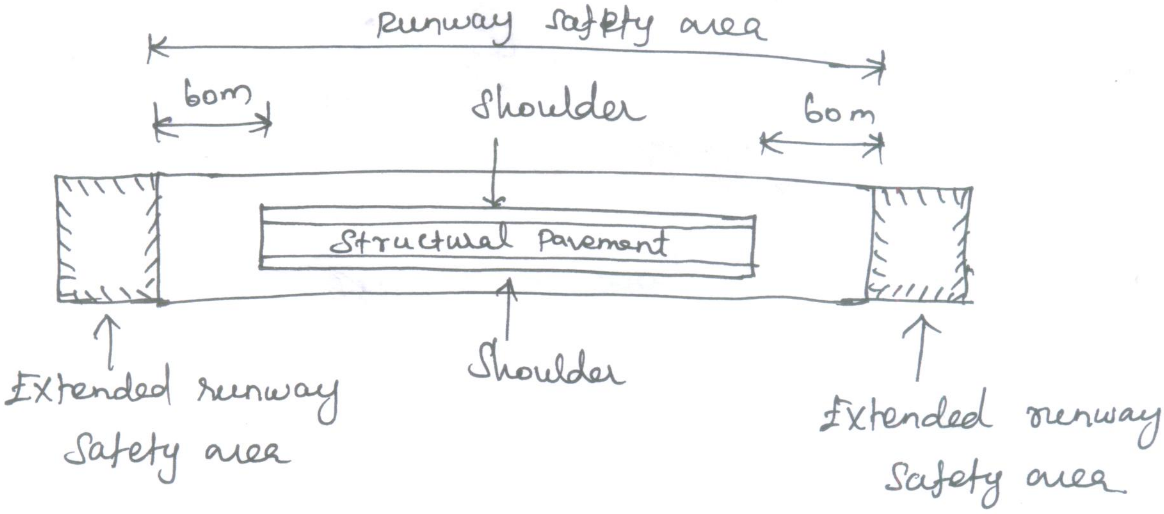
FAA recommendations for longitudinal grade change

No	Item	Small Airport	Large airport
1.	Maximum Grade change (a (or) b)	2%	1.5%
2.	Length of VI curve L_1 (or) L_2 for each 1% grade change	90m	300m
3.	Distance (D) b/w two successive points of grade intersections	75 (a+b) m	300 (a+b) m

4. Safety Area :-

Area which is cleared drained and graded. It includes the structural pavement, shoulders on either side of runway and an addition width.

The shoulders are generally unpaved as they are to be used only in case of an emergency.



Safety area.

Minimum width of safety area as per ICAO.

For instrument runway : 300 m

For non-Instrument runway : 150 m for A, B, C
78 m for D, E.

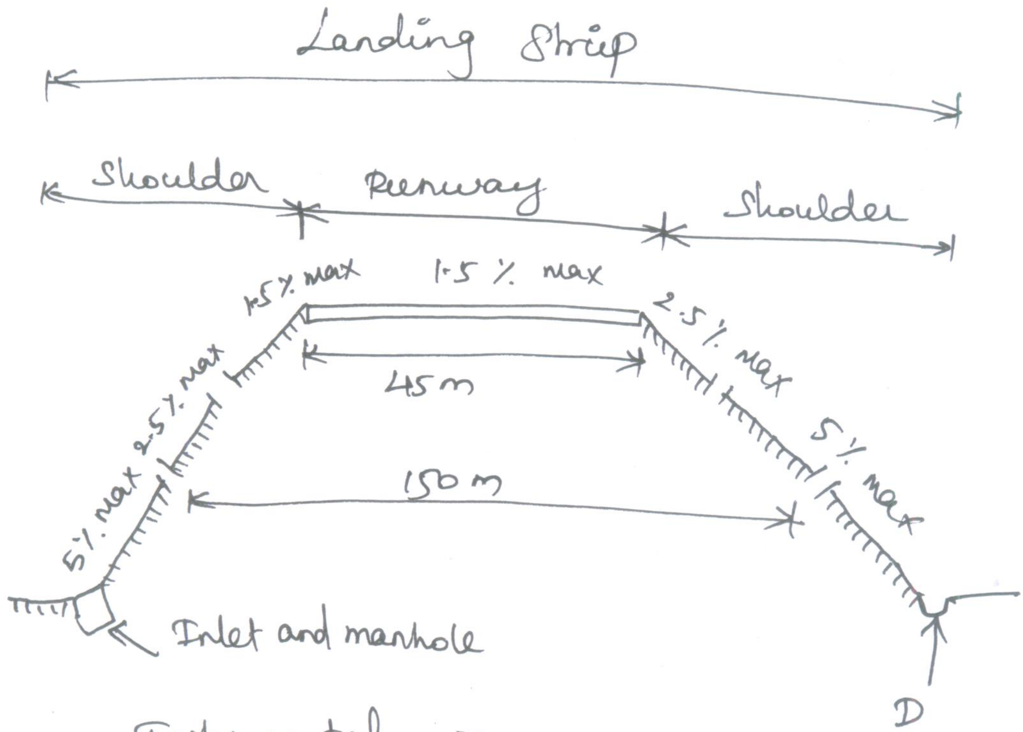
5. sight distance :-

(i) A, B, C : Any two points 3m above the surface should be mutually visible from a distance equal to half the runway length.

(ii) D, E : Clear line of sight from any point 3m above runway to all other points 2m above runway with in a distance of at least one-half the runway

6. Transverse Gradient :-

The transverse gradient is provided for quick disposal of the surface water.



Instrumental runway cross-section.

As per ICAO :

Maximum Runway gradient : 1.5% for A, B, C
2% for D, E

Minimum : 0.5 %

7. width :-

varies from 45 m to 18 m - Depends on Air traffic & outermost edge of aircraft. The central 24 m width of runway pavements takes more concentrated aircraft load. The outermost part of the machine of the largest aircraft should not extend beyond the pavement.

Drainage

1.B.7 Aims of Airport Drainage :-

* It grants longevity to the pavements
* It increases the efficiency of the airport.
* It is essential for proper and safe functioning of the aircraft.
* It reduces the maintenance cost of an airport.
* If the sub-surface drainage system is improper, it may moisten and weaken the subgrade and thus, reduce its load bearing capacity, resulting in the failure of pavements of runways, taxiways, etc.
* If the surface drainage system is improper, it may result in the ponding on the pavements of runways, taxiways and aprons which might prove hazardous to the take off and landing operations of the aircraft
* It shortens the periods during which the airport might have to be kept out of use due to Inundation, etc. The closing down of the airport results in great loss in addition to the inconvenience of the passengers.

Functions of Airport drainage (or) purpose of airport drainage

* To intercept and divert the surface and groundwater flow originating from lands adjacent to the airport.

* To lower the sub-surface water level in the airport so as to be with in permissible limit.

* To remove the surface runoff from the airport.

Special characteristics of Airport Drainage :-

* Absence of side surface ditches or drains.

* Combined drainage pipe for surface and sub-surface drainage.

* Concentration of the outfall flow.

* Heavy concentrated wheel loads of the modern aircraft.

* Extensive area under consideration.

* Shallow water courses

* Varying soil conditions.

* Proper provision of future runway extension.

* large percentage of paved areas in the form of the aprons, taxiways and runways.

* Requirement of rapid drainage for the safety of the aircraft operations.

Basic Requirements of Airport Drainage system :-

Capacity :-
The capacity of the drain pipe should be sufficient to carry the surface water as well as the ground water

Future expansion :-
The system should be designed in such a way that future extensions or additional works of runways, taxiways, etc. are easily accomodated when the need arises.

Rapid drainage :-
The system should grant the speedy collection and removal of the drained water.

Strength :-
The drain pipe material should be of sufficient strength to withstand the heavy concentrated wheel loads of the aircraft.

Surface drainage :-

* Objectives of surface drainage
* Time of concentration
* Estimating runoff
* Design procedure
* Layout of surface drainage

1.B.8 Geometric design of taxiways

1. Length of taxiway :-

The length of taxiway depends upon the distance between the apron and entry end or exit end of the runway. It should be as short as possible.

(ii) Longitudinal gradients :-

The maximum longutinal gradients recommended by the ICAO are as follows.

For A and B types of airport 1.5%

For C, D and E types of airport 3%

(iii) Rate of change of longitudinal gradient :-

The maximum rates of change of slope for 30m length of vertical curve are recommended by the ICAO as follows.

For A, B and C types of airport 1.5%

For D and E types of airport 1.2%

(iv) sight distance :-

with respect to the sight distance, the recommendations of the ICAO are as follows.

(a) For A and B types of airports, the surface of the taxiway should be seen for a distance of 195 m from a point 2.10 m above the taxiway.

b. for C, D and E types of airports, the comparable dimensions are 300 m and 3 m.

(v) Transverse gradient :-

The ICAO recommends the following maximum transverse gradients.

For A, B and C types of airport 1.5%

For D and E types of airport 2%

The minimum transverse gradient is 0.50 percent of the transverse gradient of taxiway shoulders. Should be 5% for 1st 3m width and 2% thereafter for all types of airport.

(vi) Turning radius :-

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

where
R = Radius of curve in m
V = speed of aircraft in km.p.h
f = co-efficient of friction between the tyre and pavement surface

The Horonjeff's equation

$$R = \frac{0.388\, W^2}{0.5T - S}$$

R = Radius of centre line of taxiway in m
W = wheel base of aircraft in m
T = width of taxiway pavements in m
... mid and end points.

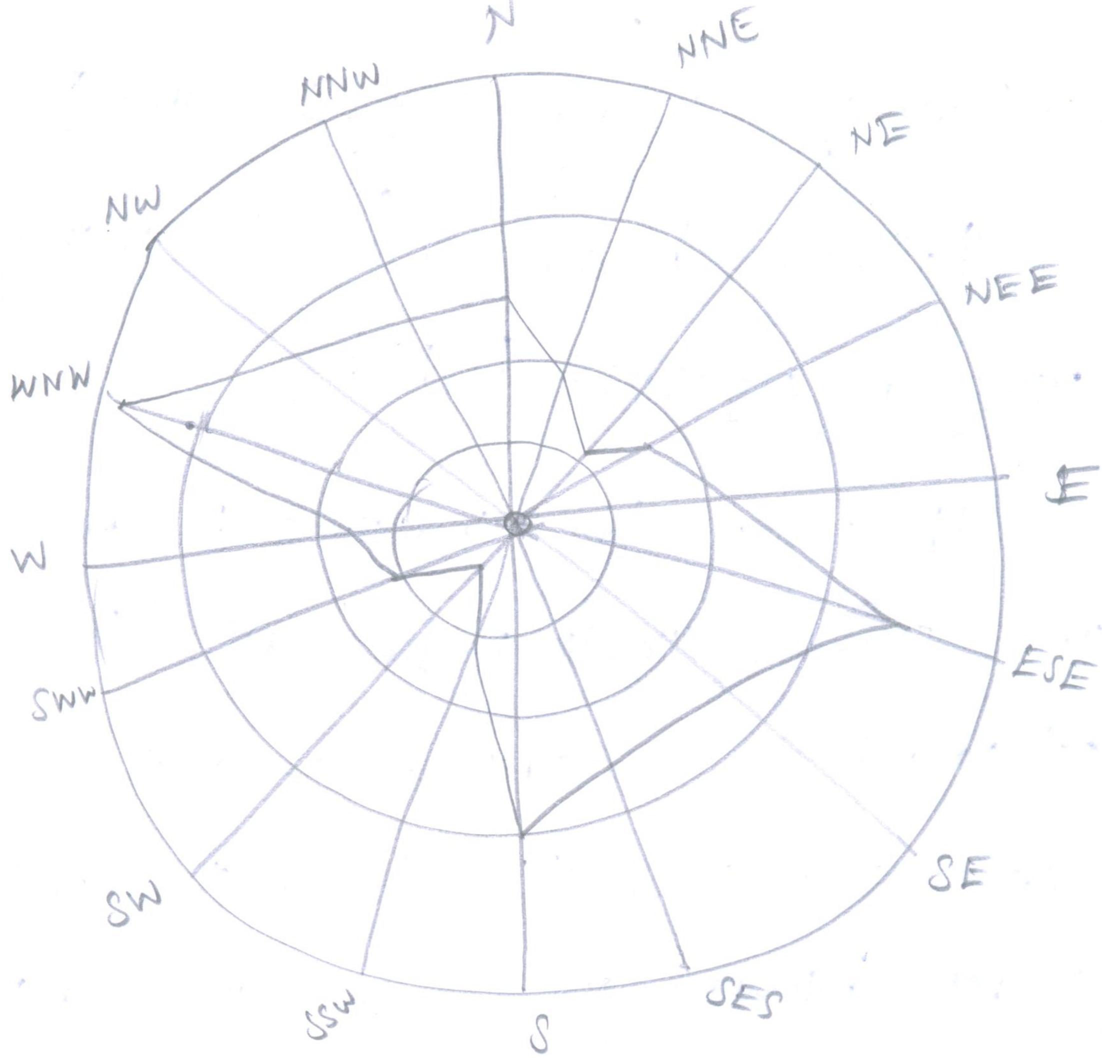
1.B.9. Plotting & using Type I wind Rose :-

R. Figure below shows the wind rose diagram of this type:-

The redial lines indicate the wind direction and each circle represents the duration of wind to a certain scale. From the wind data collected the total percentage of wind blowing in each direction is marked along the respective direction. All these points are then joined by starlight lines The best direction of runway is indicated along the direction of the longest line on the wind rose diagram. This type of wind rose does not consider the effect of the cross componet.

2. Plotting & using Type II wind Rose:-

A typical diagram of this type is shown



The wind rose concentric circles and redial lines. Each concentric circle res Presents the wind velocity to some scale

(1) Starting with centre of concentric circles, the 16 redial directions are shown on the outer circle. The mind Points of 16 arcs on the outermost concentric circles are marked and they are given the cardinal directions of compass like N, NE, NNE, NE, ENE, E, etc.

II The recorded duration of winds and expressed as percentage are shown for each cardinal direction in the sector pertaining to that direction. It may be noted that cardinal direction is central to its sector. The duration of wind velocities are shown in all thee sectors to complete the wind rose diagram.

III

A transparent rectangular temple or paper strip is taken. Its length should be slightly greater than the diameter of the wind rose diagram and and its width should be greater than twice the diameter cross wind component say (2X25) = 50 km p.h. Along the centre of the length of this template, a line is marked correction to the direction of runway. The two parallel lines, one on either side of center of the line is drawn to the allowble cross wind component ie 25 km ph from center line

IV A holes is drilled in the centre of the tem-plate and its placed on the wind rose diagram such that its centre lies over the wind rose diagram.

V The template is rotated and is placed along a particular direction. In the position of the between the two extreme parallel lines 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.

(Vi)

The template is then rotated and is placed in the next direction. The total wind coverage is calculated and the process is repeated for all the directions

(vii) The direction which gives the MAXIMUM wind coverage is the suitable direction for the orientation of the runway.

(VIII)

The MAXIMUM wind coverage of a runway should be 95% on the assumption that the calms are 5%. If a single runway is not sufficient to provide the necessary coverage. two or more number of runway should be planned to get the desired coverage.