TRANSPORTATION ENGG - 2

UNIT- 4

Airport Engineering: Runway length design, Taxiway, Airport layout

(Aircraft Characteristic & Airport planning & layout is covered in a ppt.) Part - 2

Runway modes of operations, Runway Pavement design, Runway lighting & marking heliport will be shared by PDF file. → Part - 3

→ So 3 (E-Content) would be shared of this Unit - 4 (Airport Engg.) including this one. (Part -1, 2 & 3)

Part -1:

Airport Designing:

* Airports are classified by 2 organization :

ICAO → International civil aviation organization

FAA → Federal Aviation agency

ICAO classifies airport into 2 categories :

1) Based on Basic runway length

A → longest runway

F → Shortest runway

2) Based on equivalent single wheel load of the aircraft.

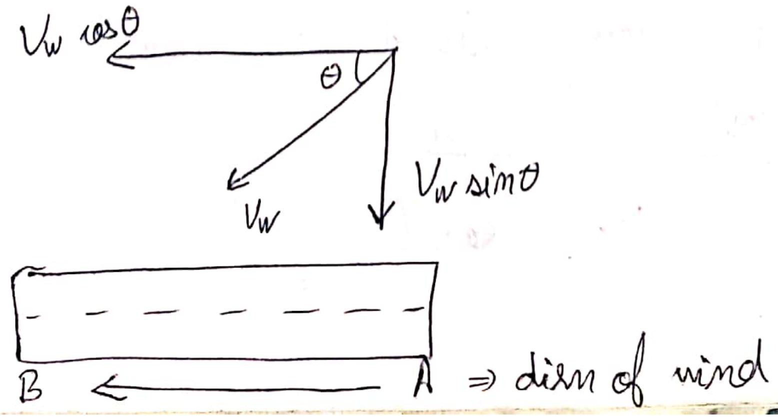
Runway length is min. if landing & takeoff is opp. to wind dirn. (for economical concept)

* Runway length requirement will be more if landing and takeoff operations are performed along the wind dirn.

* Wind Parameters (dirn, duration, intensity) are graphically represented by a diagram called windrose diagram.
Wind parameters should be collected for a period of atleast 5 years.

* The normal component of wind is called crosswind component and it may interrupt safe landing and takeoff of the aircraft.

→ The % of time during which in a year the cross wind component remains within the permissible limit is called as wind coverage.



* Basic Runway length requirement ⇒

1) ~~At~~ Airport altitude is at sea level.
2) Temp. at airport is standard 15°C
3) Runway is levelled in the longitudinal dirn.
4) Aircraft is loaded through its full loading capacity.
5) Speed of wind should be zero on a runway.

Correction for altitude above mean sea level

1620 m length, 270 m altitude

$$= \frac{7}{100} \times 1620 \times \left(\frac{270}{300}\right) = 106.06\ m$$

Corrected run way length = 1722.06

* Correction for elevation : (oxygen density)

ICAO recommends that basic runway length should be increased by 7% per 300m rise in elevation above mean sea level.

* Correction for temperature: (air density)

Standard atmospheric temperature at required altitude is calculated as :

$$\boxed{15°C - (0.0065 \times \text{change in elevation above MSL})}$$

Local body temperature of a particular site is called as Airport Reference temp. (ART)

Airport Reference temp. should be calculated for the hottest month of the year.

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

Scanned with CamScanner

$T_m \rightarrow$ Monthly mean of max. daily temp.
$T_a \rightarrow$ Monthly mean of avg. daily temp.

If Temp $\uparrow$ $\Rightarrow$ air density $\downarrow$ $\Rightarrow$ runway length $\uparrow$

$\Rightarrow$ ICAO recommends that basic runway length after corrected four elevation, should be increased by 1% for every 1°C rise of airport reference temp. above the standard atmospheric temp. at that elevation.

$\rightarrow$ If the total correction for elevation and temp. is less than equal to 35% $\rightarrow$ economical, no changes should be applied for wind parameters and temp. parameters.

Eg. 270, elevation, previous corrected length = 1722.06 m

$$\therefore \quad 15°C - (0.0065 \times 270)$$
$$= 13.24°C$$

$$A.R.T = T_a + \left(\frac{T_m - T_a}{3}\right)$$
$$= 32.94°C$$

$$\Delta T = 32.94°C - 13.24°C = 19.7°C$$

$$\therefore \quad = \frac{1}{100} \times 1722.06 \times \frac{19.07°C}{1°C}$$
$$= 339.24 m$$

Corrected length = 2061.3 m

$$\text{Check} = \frac{2061.3 - 1620}{1620} \times 100$$
$$= 27.2\% \leq 35\%$$

Here recommendation of correction of ICAO ends.

* Correction for gradient : ($mg \sin\theta$)

After corrected runway length, for elevation & temp., runway length should be increased by 20% for every 1% of effective gradient.

$$= \frac{20}{100} \times 2061.3 \times \frac{0.2\%}{1\%} \text{ gradient}$$

$$= 82.45$$

Corrected length = 2143.75 m

Provided length = 2150 m

Q. The length of runway under standard cond. is 1620 m. Airport sight has an eff. elevation of 270 m. Airport reference temp = 32.94°C. If the runway is to be constructed with an eff. gradient of 0.2%. Determine the corrected runway length.

Soln : 1) Correction for elevation

$$= \frac{7}{100} \times 1620 \times \left(\frac{270}{300}\right)$$

$$= 102.06 \text{ m}$$

Corrected Runway length = 1722.06 m

2) Change in standard atmospheric Temp.

$$= 15°C - (0.0065 \times \text{Change in elevation above MSL})$$

$$= 15°C - (0.0065 \times 270)$$

$$= 13.24°C$$

$$ART = T_a + \left(\frac{T_m - T_a}{3}\right) = 32.94°C \text{ (given)}$$

$$\Delta T° = 32.94°C - 13.24°C = 19.70°C$$

$$\text{Correction for } T° = \frac{1}{100} \times 1722.06 \times \frac{19.7°C}{1°C}$$

$= 339.24\ m$

Corrected Runway length $= 2061.3\ m$

Check: $\dfrac{2061.3 - 1620}{1620} \times 100$

$= 27.2\% \leq 35\%$

3) Correction for gradient:

$= \dfrac{20}{100} \times 2061.3 \times \dfrac{0.2\%}{1\%}$

$= 82.45\ m$

Corrected runway length $= 2143.75\ m$

Provide $= \underline{2150\ m}$

Q. Determine the actual runway length for given parameters
(i) Basic runway length $= 1800\ m$
(ii) elevation of airport sight $= 600\ m$
$T_a = 15°C$, $T_m = 21.6°C$
eff. gradient is $= 0.6\%$

Soln: 1) Elevation Correction:

$= \dfrac{7}{100} \times 1800 \left(\dfrac{600}{300}\right)$

$= 252$

corrected $= 2052$

2) $15°C - (0.0065 \times 600)$

$= 11.1°C$

$ART = T_a + \left(\dfrac{T_m - T_a}{3}\right) = 15 + \left(\dfrac{21.6 - 15}{3}\right) = 17.2°C$

$\Delta T = 6.1°C$

Correction for $T = \dfrac{1}{100} \times 2052 \times 6.1$

$= 125.172\ m$

Corrected = 2177.17

Check = $\frac{2177.17 - 1800}{1800} \times 100 = 20.95\% \leq 35\%$

3) Gradient:

$= \frac{20}{100} \times 2177.12 \times 0.6$

$= 261.25$

Corrected = 2438.42 m

Provide = 2440 m

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* In case of landing, only elevation correction is necessary.
* In case of takeoff; elevation, temp. & gradient corrections are necessary.

Q. Runway length reqd. for landing at sea level in std. atm. condition is 2100 m. Runway length reqd for takeoff at sea level in std. atm. condition is ~~2050~~ 2500 m. Airport sight elevation = 200 m

Airport Ref. temp = 24° C

Temp. in Std atmosphere for 200 m is 15° C. Runway slope is 0.5%. determine the length of runway after applying necessary correction.

Soln: 1) For landing:

Correction for elevation $= \frac{7}{100} \times 2100 \times \frac{200}{300}$

$= 98$ m

Corrected length = 2198 m

2) For Takeoff :

Elevation $= 2500 \times \frac{7}{100} \times \frac{200}{300}$

$= 116.67 m$

Corrected $= 2616.67 m$

Temp ⇒ ~~$15°C - (0.0065 \times 200)$~~

~~$= 13.7°C$~~

Change in std. temp

Temp: $15°C - 0$

$= 15°C$

ART $= 24°C$

$\Delta T = 9$

Correction $= \frac{1}{100} \times 2616.67 \times 10.3$

$= 235.5 m$

Corrected $= 2852.187 m$

Check, $\frac{2852.187 - 2500}{2500} \times 100$

$= 14.447\% \leq 35\%$

Gradient : $= \frac{20}{100} \times 2852.187 \times 0.5$

$= 285.21$

Corrected $= 3137.38 m$

Provide $= 3140 m$ (max.)

Apron → Loading / Unloading

Hangar → Servicing

* Taxiways:

The main function of taxiways is to connect runway to service hanger and apron.

→ Intersection of two taxiways should be avoided.

→ Intersection of taxiway & runway should be avoided.

→ Exit taxiways can be provided more than one.

neglected

$$\cancel{e}+f = \frac{V^2}{127R}$$

modified

* Turning Radius of Taxiways:

1) $R = \dfrac{V^2}{125f}$

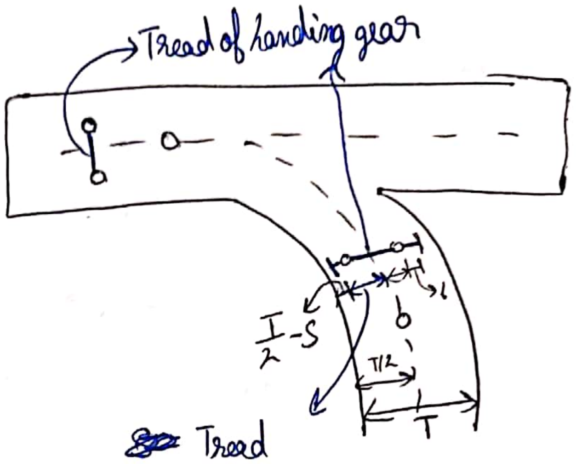
   where $f = 0.13$

2) $R = \dfrac{0.388\,w^2}{\frac{T}{2} - S}$

3) $R \geq 120\,m$ → for subsonic aircraft

   $R \geq 180\,m$ → fore supersonic aircraft

max^m



$$S = \frac{\text{Tread of landing gear}}{2} + 6$$

where R → Radius in 'm'

w → wheel base in 'm'

T → Width of Taxiway (22.5m)

Q. Determine the turning radius of supersonic aircraft with a speed of 50 KMPH and wheel base = 30m, Tread of landing gear = 6m.

Soln

1) $R = \dfrac{V^2}{125f} = \dfrac{(50)^2}{125 \times 0.13} = 153.84\,m$

2) $R = \dfrac{0.388w^2}{\frac{T}{2} - S} = \dfrac{0.388 \times (30)^2}{\frac{22.5}{2} - 9}$

   $= 155.2\,m$

$S = \frac{\text{Tread}}{2} + 6$

$= \frac{6}{2} + 6$

$= 9$

3) $R \geq 180\,m$ ✓

Max = 180m

Q. Determin the turning radius of supersonic aircraft, wheel base = 35 m, tread of landing gear = 7.5 m. Turning speed of aircraft is 50 km/hr

Soln : 1) $R = \frac{V^2}{125 f} = \frac{(50)^2}{125 \times 0.13} = \underline{153.84\ m}$

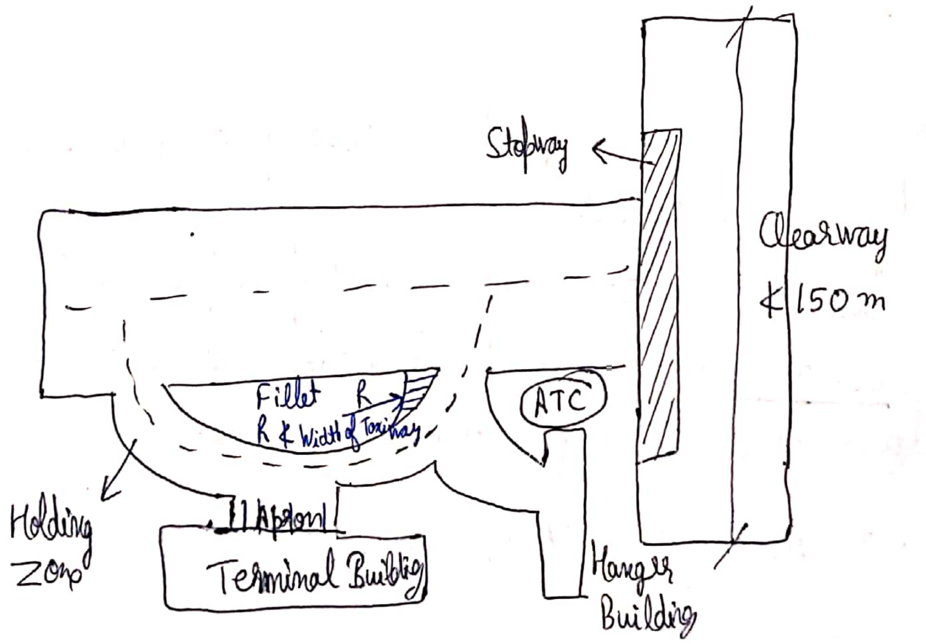
2) $S = \frac{\text{Tread}}{2} + 6 = \frac{7.5}{2} + 6 = 9.75$

$$R = \frac{0.388 (35)^2}{\frac{22.5}{2} - 9.75} = \underline{316.86\ m}$$

3) $R \geq 180\ m$

Max $= \underline{316.86\ m}$ Provide 317 m

* **Airport Layout :**



ATC → Air traffic control Unit

This unit is provided only in aircraft due to gliding effect of aircraft.

Holding zone is the zone where the aircrafts are holded before takeoff.

⇒ IFR → Instrument flight Rule (applicable in bad weathering cond., permissible to be taken from ATC)

VFR → Visual flight Rule

Aircraft movement is more in VFR.