2.3 ATMOSPHERIC STABILITY AND TURBULENCE

Stability:

- The ability of the atmosphere to enhance or to resist atmospheric motions.
- Influences the vertical movement of air.
    - If the air parcels tend to sink back to their initial level after the lifting exerted on them stops, the atmosphere is stable.
    - If the air parcels tend to rise vertically on their own, even when the lifting exerted on them stops, the atmosphere is unstable.
    - If the air parcels tend to remain where they are after lifting stops, the atmosphere is neutral.
- The stability depends on the ratio of suppression to the generation of turbulence.
- The stability at any given time will depend upon:
    - Static stability (related to changes in temperature with height)
    - Thermal turbulence (caused by solar heating)
    - Mechanical turbulence (A function of wind speed and surface roughness)
- Stability classified into 6 classes (A-F)

A	Strongly	Unstable
B	Moderately	Unstable
C	Slightly	Unstable
D	Slightly	Neutral
E	Slightly	Stable
F	Moderately	Stable

Table 2.3.1 Classification of stability

- Atmospheric stability can be determined using adiabatic lapse rate..

$\Gamma > \Gamma_d$	Unstable
$\Gamma = \Gamma_d$	Neutral
$\Gamma < \Gamma_d$	Stable

Table 2.3.2 Condition of lapse rate

Where,

Γ is environmental lapse rate

Γ_d is the dry adiabatic lapse rate (1°C/100 m)

dT/dZ = -1°C/100 m

Turbulence:

- Fluctuations in wind flow, which have a frequency of more than 2 cycles/hr.
- In fluid dynamics, turbulence or turbulent flow is fluid motion characterized by chaotic changes in pressure and flow velocity.
- It is in contrast to a laminar flow, which occurs when a fluid flows in parallel layers, with no disruption between those layers.
- Turbulence is commonly observed in everyday phenomena such as surf, fast flowing rivers, billowing storm clouds, or smoke from a chimney, and most fluid flows occurring in nature or created in engineering applications are turbulent.
- Turbulence is caused by excessive kinetic energy in parts of a fluid flow.
    - Which overcomes the damping effect of the fluid's viscosity.
    - For this reason turbulence is commonly realized in low viscosity fluids.
- In general terms, in turbulent flow, unsteady vortices appear of many sizes which interact with each other, consequently drag due to friction effects increases.
- Turbulence can be exploited.

Example:

By devices such as aerodynamic on aircraft that "spoil" the laminar flow to increase drag and reduce lift.

Types of Turbulence:

1. Mechanical turbulence:

It occurs because friction slows the wind in the lowest layers causing the air to turn over in turbulent eddies which can cause fluctuations in winds and vertical velocities.

2. Convective Turbulence:

Turbulence occurring in convective storms, particularly thunderstorms, that is felt by aircraft. The turbulence is caused by strong updrafts and downdrafts.

3. Clear- Air Turbulence (CAT):

Clear-air turbulence is the turbulent movement of air masses in the absence of any visual clues, such as clouds, and is caused when bodies of air moving at widely different speeds meet.

4. Wake Turbulence:

Wake turbulence is a disturbance in the atmosphere that forms behind an aircraft as it passes through the air. Wake turbulence can impose rolling moments exceeding the roll-control authority of encountering aircraft, causing possible injury to occupants and damage to aircraft.

5. Thermal Turbulence:

Thermal turbulence is caused by solar heating of the surface, which in turn heats the lower atmosphere resulting in uneven convective currents, which lead to turbulence.

These thermals act as obstructions to the normal air flow similar to mountainous terrain.

6. Temperature inversion turbulence:

An inversion occurs when the normal temperature (warm air below, cold air above) profile is reversed, creating a stable configuration of dense, cold air sitting below lighter, warm air.

7. Frontal Turbulence:

Frontal turbulence is caused by lifting of warm air, a frontal surface leading to instability, or the abrupt wind shift between the warm and cold air masses. The most severe cases of frontal turbulence are generally associated with fast-moving cold fronts.

8. Mountain Wave Turbulence:

It is as air flows over the tops of mountains, traveling down the leeward side, a standing mountain wave is formed and air currents oscillate between altitudes. Mountain waves and turbulence can extend for hundreds of miles downwind of the mountain range.