Module – 3

Engineering Seismology
What is Earthquake?

• An **earthquake** is the result of a sudden release of energy in the Earth's crust that creates seismic waves. Earthquake is also known as a **quake**, **tremor** or **temblor**.
What causes an Earthquake?

Movement of Tectonic Plates

Earth is divided into sections called Tectonic plates that float on the fluid-like interior of the Earth. Earthquakes are usually caused by sudden movement of earth plates.

Rupture of rocks along a fault

Faults are localized areas of weakness in the surface of the Earth, sometimes the plate boundary itself.
Why an earthquake occurs?

- The earth's crust (the outer layer of the planet) is made up of several pieces, called plates.
- The plates under the oceans are called oceanic plates and the rest are continental plates.

Earthquakes usually occur where two plates are running into each other or sliding past each other.

An image of the world's plates and their boundaries.
Where do Earthquakes occur?

Plate boundaries

Faults
Release of Accumulated energy

Epicenter

Surface trace of fault

Focus

Plane of earthquake fault
Rocks bend under stress while storing elastic energy. When the strain in the rocks exceeds their strength, breaking will occur along the fault. Stored elastic energy is released as the earthquake. Rocks “snap back” or rebound to their original condition.

Elastic Rebound Theory
Foreshocks and aftershocks

- Adjustments that follow a major earthquake often generate smaller earthquakes called aftershocks.

- Small earthquakes, called foreshocks, often precede a major earthquake by days or, in some cases, by as much as several years.
Study of Earthquakes

- The study of earthquake waves, Seismology, dates back almost 2000 years to the Chinese Seismographs, instruments that record seismic waves. The first seismograph called Di-Dong-Di was invented by Cheng Heng (132 A.D.).
How Are Earthquakes Measured?

- Device used to measure an earthquake is called ‘seismograph’
- The seismograph has three main devices, the Richter Magnitude Scale, the Modified Mercalli Intensity Scale, and the Moment-Magnitude Scale.
- First invented in 132 AD, the Dragon Jar was the first instrument for determining the direction of an earthquake.
- Chang Heng, a Chinese scientist, developed the Dragon Jar.
The ancient Chinese seismograph consist of a special vase that had eight sculpted dragons mounted around the vase in eight primary directions. Each dragon held in its mouth a metal ball. When the ground shook, some of the balls would fall from the mouths of the dragons into the waiting mouths of the sculpted frogs to show how the ground had moved.
Earthquake Waves

- The energy released during the earthquake travels as waves.
- Modern Seismograph can measure the intensity and duration of these waves in different directions.
- Seismogram is visual record of arrival time and magnitude of shaking associated with seismic wave, generated by a seismograph.
Modern Seismograph (Horizontal)
Seismogram
How Are Earthquakes Measured?

Modern Seismograph

A Typical seismograph

A typical seismogram
Location and Intensity of Earthquake

Seismographic stations around the World work together to

- record earthquake location
- determine earthquake strength
How Are Earthquakes Measured?

• The magnitude of most earthquakes is measured on the **Richter scale**, invented by Charles F. Richter in 1934.

• The Richter magnitudes are based on a logarithmic scale (base 10).
How Are Earthquakes Measured?

• Another way to measure the strength of an earthquake is to use the Mercalli scale. Invented by Giuseppe Mercalli in 1902.

• This scale uses the observations of the people who experienced the earthquake to estimate its intensity.
Earthquake Depth

Earthquakes usually occur at some depth below the ground Surface. The depth can also be calculated from seismograph records.

Earthquake foci are described as:

- **Shallow**: less than 70 km depth
- **Intermediate**: 70 - 300 km depth
- **Deep**: 300 - 700 km depth

90% of earthquake foci are less than 100 km deep.

Large earthquakes are mostly at < 60 km depth.

No earthquakes occur deeper than 700 km.
Predicting Earthquakes

Strange Animal Behavior
stress in the rocks causes tiny hairline fractures to form, the cracking of the rocks evidently emits high pitched sounds and minute vibrations imperceptible to humans but noticeable by many animals.

Foreshocks
unusual increase in the frequency of small earthquakes before the main shock

Changes in water level
porosity increases or decreases with changes in strain

Seismic Gaps
based of the chronological distribution of major earthquakes