5.1 SEISMOLOGY

Seismology is the scientific study of earthquakes and seismic waves that move through and around the earth, by both naturally and artificially generated seismic waves.

Seismograph

Seismograph or seismometer is an instrument used to detect and record earthquakes. Generally, it consists of a mass attached to a fixed base. During an earthquake, the base moves and the mass do not. The motion of the base with respect to the mass is commonly transformed into an electrical voltage. The electrical voltage is recorded on paper, magnetic tape, or another recording medium.

This record is proportional to the motion of the seismometer mass relative to the earth, which can be mathematically converted to a record of the absolute motion of the ground. Seismograph generally refers to the seismometer and its recording device as a single unit.

Seismic gap

A seismic gap is a section of a fault that has produced earthquakes in the past but is now they are quiet. However the fault segment is capable of producing earthquakes on some other basis, such as plate-motion information or strain measurements.

Seismic moment

The seismic moment is a measure of the size of an earthquake based on the area of fault rupture, the average amount of slip, and the force that was required to overcome the friction sticking the rocks together that were offset by faulting. Seismic moment can also be calculated from the amplitude spectra of seismic waves.

The seismic moment can be measured using the following relation. Seismic moment $M_o = \mu AD$

Where, μ – Rigidity modulus,

A **–** Fault rupture area,

D **–** Average dislocation

Uses of Seismology

1. Seismology is useful to measure the speeds at which seismic waves travel through the earth
2. Seismology is used in prospecting for oil deposits. The first oil field to be discovered by this method was found in Texas in 1924.

3. Seismic methods are used to locate subsurface water and do detect the underlying structure of the oceanic and continental crust.
4. With the development of underground testing of nuclear devices, seismographic stations are used to collect seismic wave data during nuclear tests conducted under (or) below the earth.

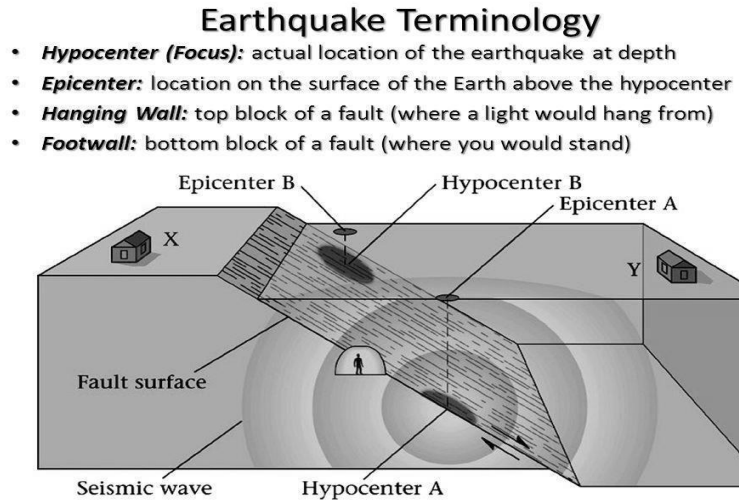

Fig:5.1.1-Earthquake Terminology

Seismic waves

Seismic waves are low frequency waves that travel through the earth's interior generally caused by the following, viz. (i) tectonic earthquake (ii) volcanic eruptions (iii) Magma movement (iv) Large landslides (v) Large man-made explosions.

Types of seismic waves

Seismic waves can be classified into two basic types, viz. (i) Body waves (ii) Surface waves.Waves that are most destructive are surface waves which generally have the strongest vibration.

(i) Body waves

Waves which travel through the earth are called body waves.

(a) Compressional or primary (P) waves

1. Sound waves are usually called P – waves and are heard but not often felt.
2. Expect in the most powerful earthquakes they generally do not cause much damage.

3. P – Waves shake the ground in the direction they are propagating as shown.
4. The P wave, or compressional wave, ultimately compresses and expands material in the same direction it is travelling.
5. P – Waves travel very fast, at speeds between 4-8 km/ secin the earth's crust.
6. The P – Wave is the first to arrive at a location, as it is the fastest.

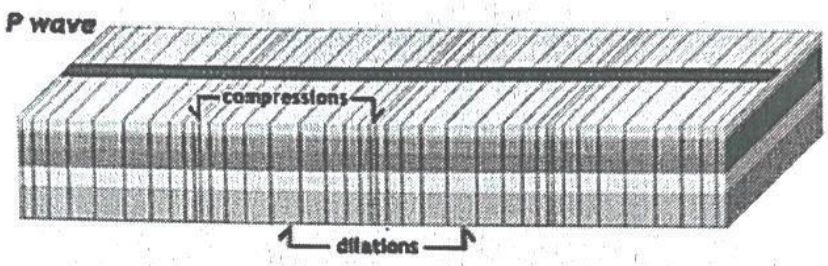

Fig 5.1.2-P Waves

(b) Shear or Secondary (S) waves

1. S wave is shear wave which causes particles to oscillate.
2. S waves can travel through solid material but not through liquid or gas.
3. S – Waves shake perpendicularly or transverse to the direction of propagation.
4. They displace material at right angles to their path.
5. S – Waves travel more slowly, usually at 2.5-4 km/ sec.
6. S – Waves arrive slower than P – Waves

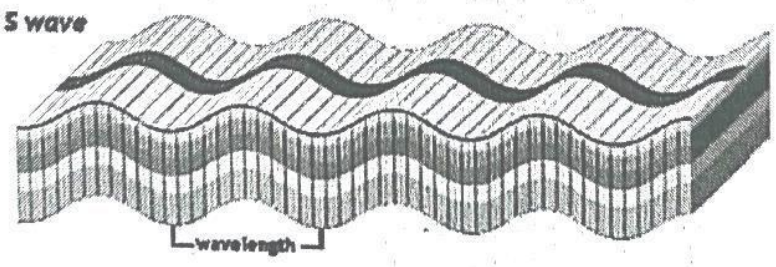

Fig 5.1.3-S Waves

(ii)Surface waves

Waves which travel along the earth's surface are called as surface waves. They arrive after the main P and S waves and are confined to the outer layers of the earth. They cause the most surface destruction.

Earthquake surface waves are divided into two categories,

(a) Love waves

1. Love waves are the fastest surface waves that move on the ground from side to side, which are confined to the surface of the crust.
2. Love waves have purely transverse motion in the horizontal plane. Hence love waves results most damage to structures.

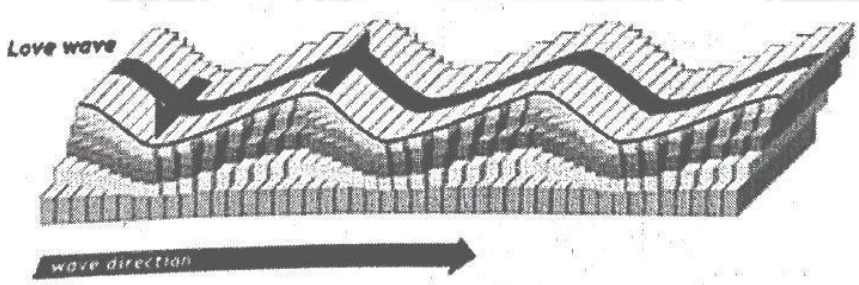

Fig 5.1.4-Love Waves

(b) Rayleigh waves

1. A Rayleigh wave rolls along the ground just like a wave rolls across a lake or an ocean.
2. Because it rolls, it moves the ground up and down, and side to side in the same direction similar to a wave motion.
3. Most of the shaking felt from an earthquake is due to the Rayleigh waves, which can be much larger than the other waves.
4. Rayleigh waves have retrograde particle motion confined to the vertical plane of motion.

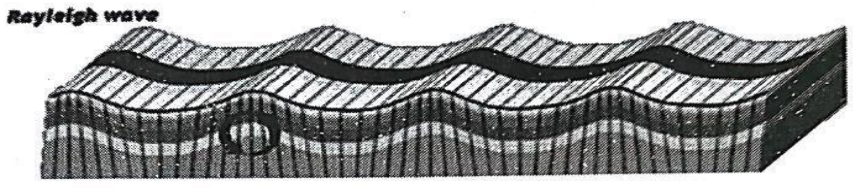

Fig 5.1.4-Rayleigh Waves