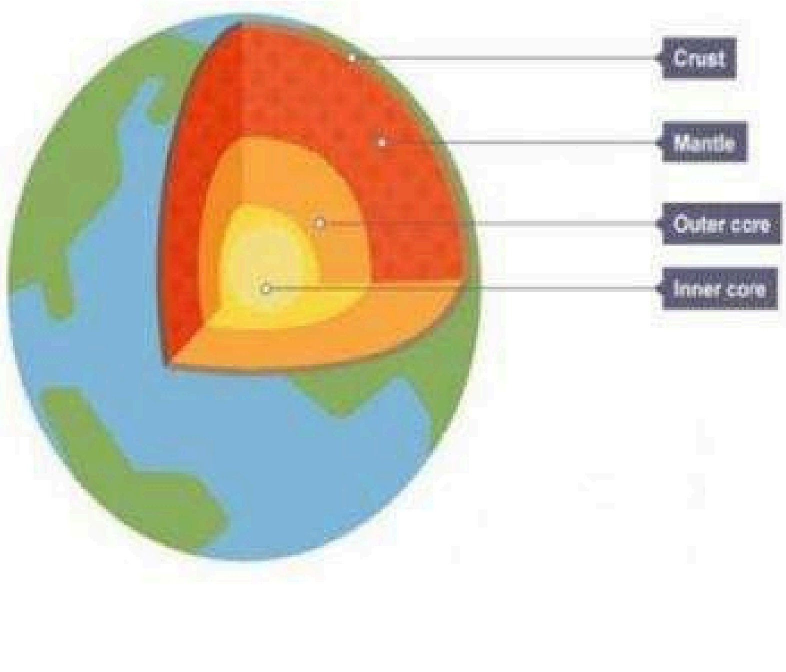
earthquake-database

1.2 EARTH AND ITS INTERIORS

Geological investigations with seismological data revealed that the earth primarily consists of four distinct layers: the inner core, the outer core, the mantle, and the crust, as shown in figure 1.1.



The uppermost layer called the crust is the outermost solid shell of the planet, its thickness varies from 5 to 70 km. The discontinuity between the crust and the mantle was first discovered by Mohorovicic through observing a sharp change in the velocity of seismic waves passing the mantle to the crust. This discontinuity is thus known as Mohorovicic discontinuity ("M Discontinuity"). The average seismic wave velocity (P-Wave) within the crust ranges from 4-8 Km s^{-1}. The oceanic crust is relatively thin (5-15km) while the crust beneath the mountains is relatively thick. Based on this principle mantle is considered to consist of an upper layer that is fairly rigid. The upper layer along with the crust of thickness ~ 120 km is known as the lithosphere. Straightaway below this zone is called the asthenosphere, which extends for another 200 km. This zone is considered to be composed of molten rock and highly plastic ~ 2900 km. Because of this plastic character, the variation of seismic wave velocity is less, indicating that the mass is nearly homogeneous. The movement in the plates is different in both magnitude and direction. This provides the basis of the foundation of the theory of tectonic earthquakes. Below the mantle is the outer core then the inner core in which it was observed that only P waves pass through the core region, while both P and S waves can pass through the mantle. The inner core is very dense and is assumed to consist of metals such as nickel and iron (thickness ~ 1290 km). Surrounding that is a layer of similar density (Outer core thickness ~ 2200 km) which is considered to be a liquid where S waves cannot pass through it.

1.3 PLATE TECTONICS

Plate tectonics could also be a theory describing the large-scale motion of the plates within the earth's lithosphere. The drift apart of plates is due to the flow of hot mantle upwards to the surface of the earth. The continental motions are related to a spread of circulation patterns. There are seven such major tectonics plates.

They move in several directions and at varying speeds. In general, there are three sorts of inter-plate interactions giving rise to 3 sorts of boundaries: convergent, divergent, and transform boundaries.

Earthquakes that are formed due to the faults at the plate boundaries are known as inter-plate earthquakes. Many earthquakes also occur within the plate away from the faults; these types of earthquakes are known as intraplate earthquakes, in which a sudden release of energy takes place due to the mutual slip of the rock beds, resulting in the formation of earthquake faults. In these faults, two types of slippages are observed: dip-slip, and strike-slip. Dip-slip takes place in the vertical direction whereas, strike-slip takes place in the horizontal direction,

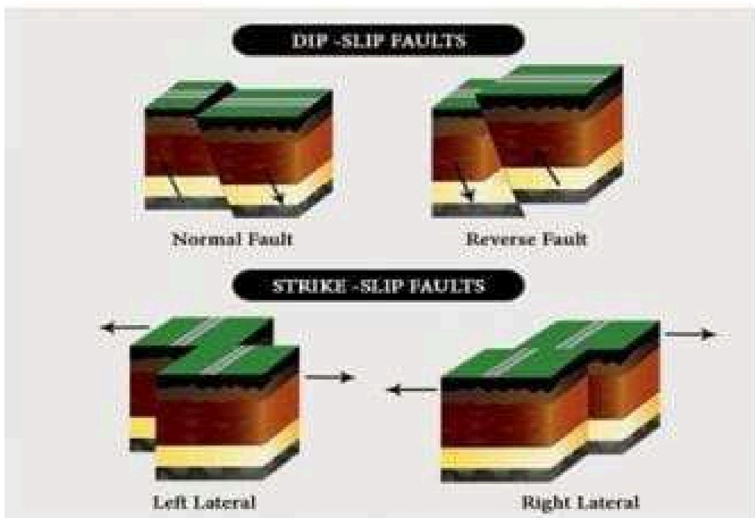


Figure 1.2: Type of Earthquake faults

1.4 CAUSES OF EARTHQUAKES

The movement of tectonic plates associated with one another , both in direction and magnitude results in the buildup of strain at the plate boundaries. When the strain energy reaches its limiting value along a weak region or at plate boundaries, a sudden movement (slip) occurs releasing the accumulated strain energy. These elastic potential energy waves are called seismic waves, which transmit energy from one point of the world to a different through different layers and eventually carry the energy to the surface causing destruction. Within the earth, the elastic waves propagate through an isotropic and homogeneous medium, which are known as body waves. On the surface, this energy waves propagate as surface waves.

The body waves are of two types: P- waves and S- waves.

- P Wave – Primary wave or Longitudinal waves, they can pass through the central core and mantle, they are waves in which the direction of particle motion is in the same or opposite direction to that wave propagation.

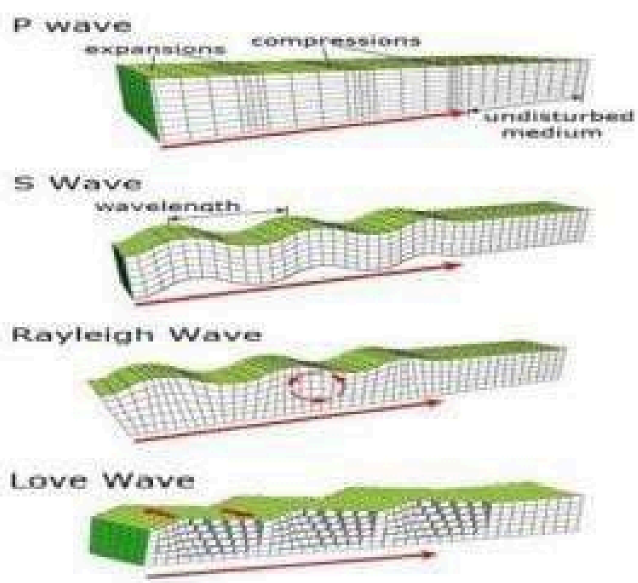
- S wave – Secondary wave or Transverse wave , can pass only through the mantle, waves in which the direction of particle motion is at right angles to the direction of wave propagation.

Surface waves - Waves that propagate on the earth's surface. Classifications are:

- L wave– Also known as love waves, particle motion takes place in the horizontal plane only and it is transverse/perpendicular to the direction of propagation.
- R wave- also known as Rayleigh waves, the particle motion is always in a vertical plane and traces an elliptical path, which is retrograde to the direction of wave propagation.

L waves travel faster than R waves.

Apart from tectonic earthquakes, volcanic activities, a sudden collapse of the reservoir are the additional causes of earthquakes.



1.5 EARTHQUAKE PARAMETERS

Seismic Intensity parameters refer to the quantities by which the size and energy of an earthquake is described. There are many earthquake measurement parameters, some are indirectly derived from the measured one. The most important parameters are the Magnitude and Intensity of an earthquake. Various types of waves propagating scales have been proposed after the use of Richter's magnitude scale. They are:

- Local Magnitude(M_L)

The local magnitude is defined as the logarithm of the maximum amplitude that is obtained from the record of a seismic event using a Wood -Anderson torsional seismograph located 100Km from the epicenter of the earthquake. Seismograph must have a natural period of 0.8s.

- Body Wave Magnitude(Mb)

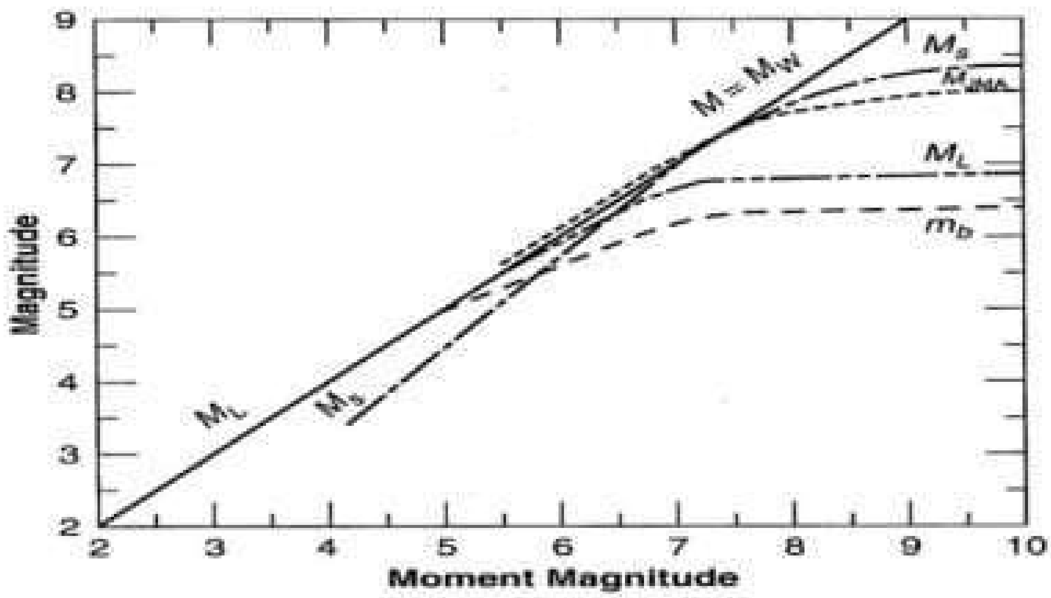
A Long period-instrument is used to determine the body wave magnitude for periods from 5-15s, mainly used for the largest body waves LP, PP.

- Surface wave magnitude (M_S)

Surface wave magnitude is based on Rayleigh waves that travel primarily along the uppermost layer of the earth with a period of 20 seconds.

- Seismic Moment magnitude (Mw)

Seismographs are used to measure Seismic Moment, using long-period waves. Up to a value of six, the Magnitude of $M= M_L = M_S= M_b= M_W$ will be the same. However, beyond the value of 6, it is better to specify the type of magnitude.



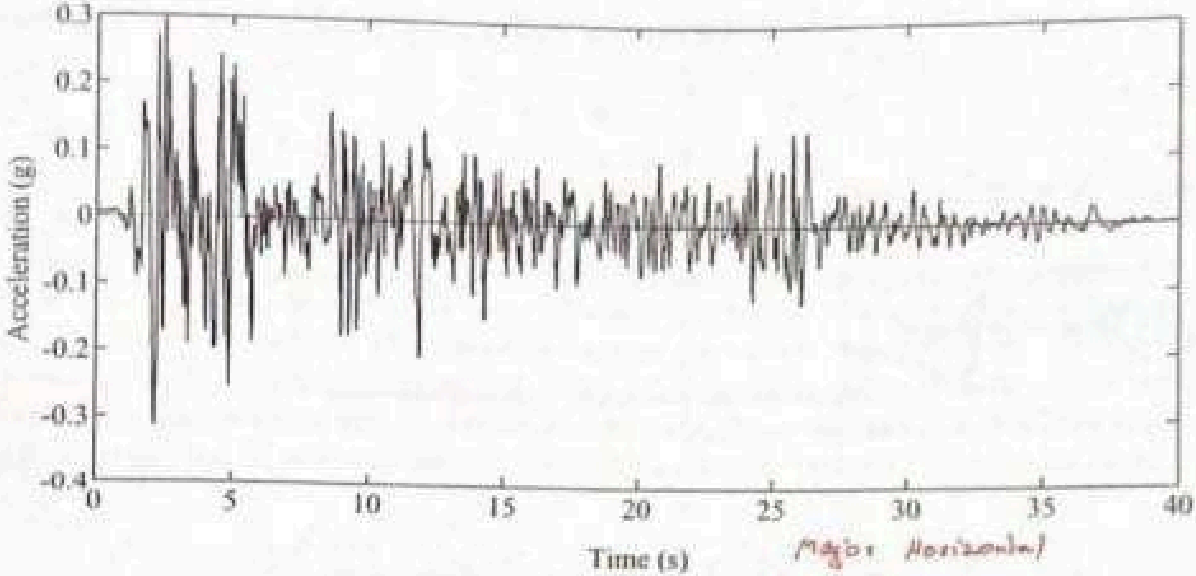
Magnitude
Moment Magnitude
$M = M_W$
M_S
M_{JMA}
M_L
m_b
M_L
M_S
2
3
4
5
6
7
8
9
10

1.6 SEISMIC INPUT FOR STRUCTURES

Seismic inputs are the earthquake data required to perform seismic analysis. These data are presented in two different ways, deterministic and probabilistic forms. Seismic inputs in the deterministic form are used for deterministic analysis and design of structures whereas, the probabilistic form is used for various vibration analysis of structures for earthquake forces, seismic risk analysis of buildings or structures, and estimated damage of structures due to future earthquakes. Seismic inputs for structural analysis are provided in terms of time domain or in the frequency domain. They include magnitude, intensity, peak ground acceleration/velocity/displacement, duration, and predominant ground frequency.

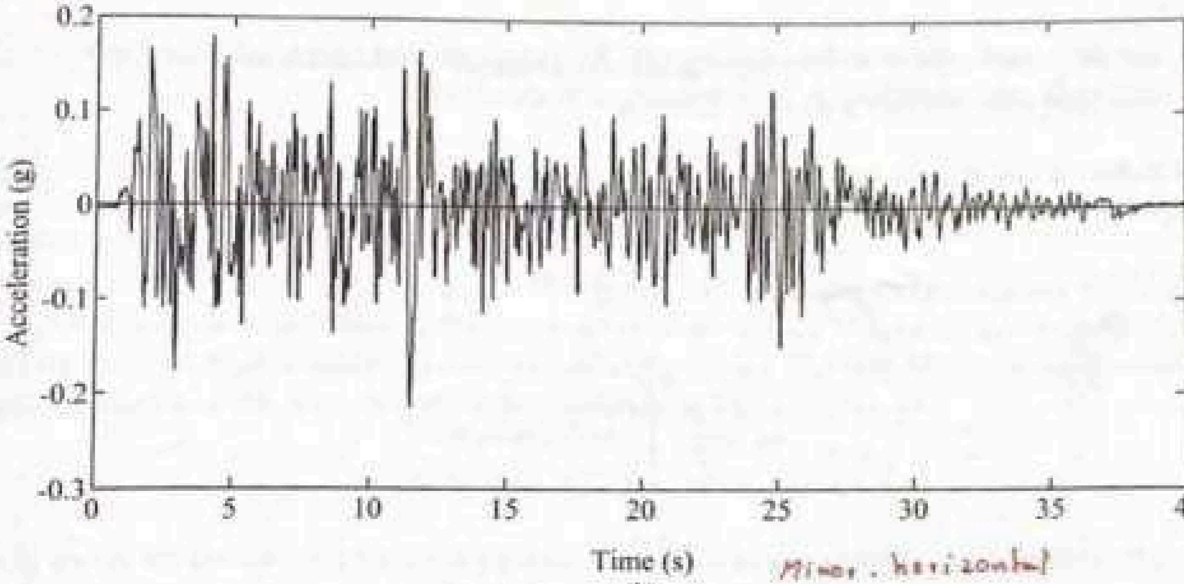
1.7 TIME HISTORY RECORDS

Time history record is the most common way to describe a ground motion. The motion parameters adopted in this methodology are acceleration, velocity, displacement, or all three combined. The measured time histories of records include errors resulting from many sources, such as noises at high and low frequencies, baseline error, and instrumental error. These errors are withdrawn from data before they are used. The measured data are in an analog form which is digitalized before they are used as seismic inputs. At any measuring station, the ground motions are recorded in three orthogonal directions; two of them are in a horizontal direction and the third in a vertical direction. For structural analysis, these three components of ground motions are transformed into principal directions. The components of ground motion in the principal directions are uncorrelated. Based on this concept, three principle components of ground motions are artificially generated in places where representative time histories of the ground motions are not available. Three components of ground motion for the



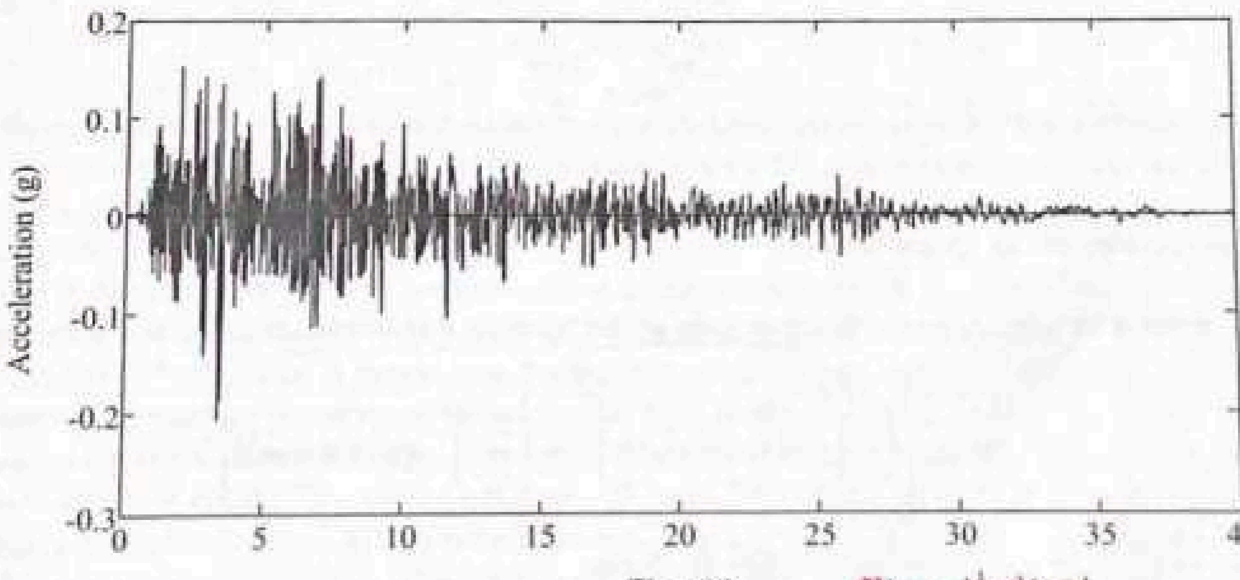
Major Horizontal

(a)



Minor. horizontal

(b)



Minor Vertical

(c)