Topic Covered: Earthquake, its causes, classification, Intensity & magnitude, siesmic zones of India. Geological consideration for construction of building & projects in Siesmic areas.

EARTHQUAKE

An earthquake is a sudden and rapid shaking of the ground due to passage of vibrations beneath caused by transient disturbance of elastic or gravitational equilibrium of rocks.

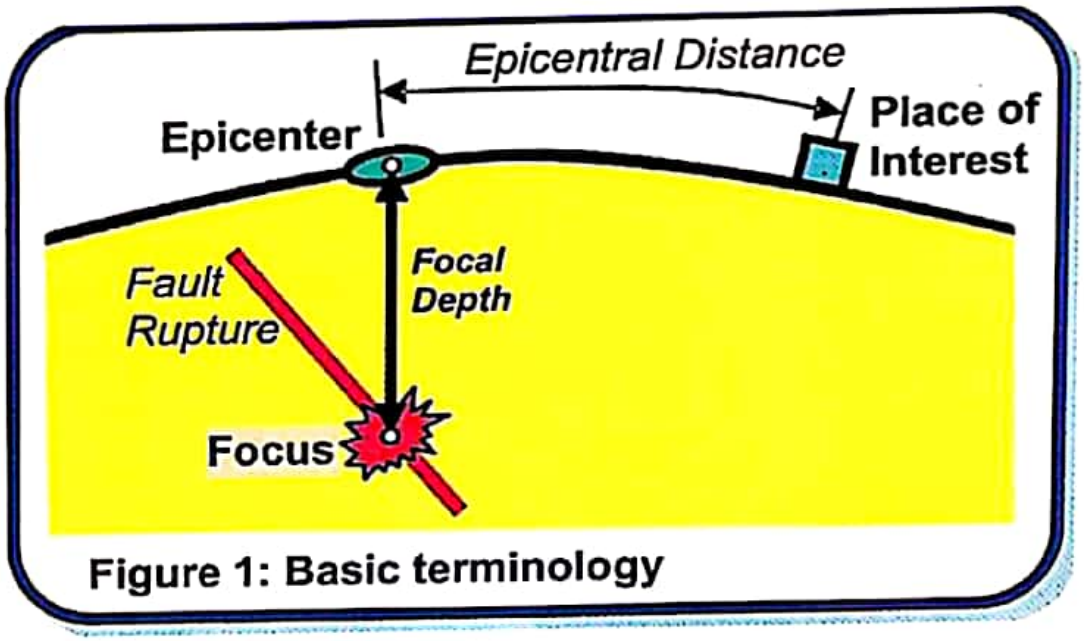


Figure 1: Basic terminology

An earthquake is the vibration of the earth produced by the rapid release of energy. Although earthquake occurs occasionally, but destruction they cause through loss of life and property. The exact spot underneath the earth surface at which an earthquake originates is known as its **FOCUS**, while the point on the earth surface lying above the focus is defined as the **EPICENTRE**.

Depth of Focus: - Earthquake focus is described

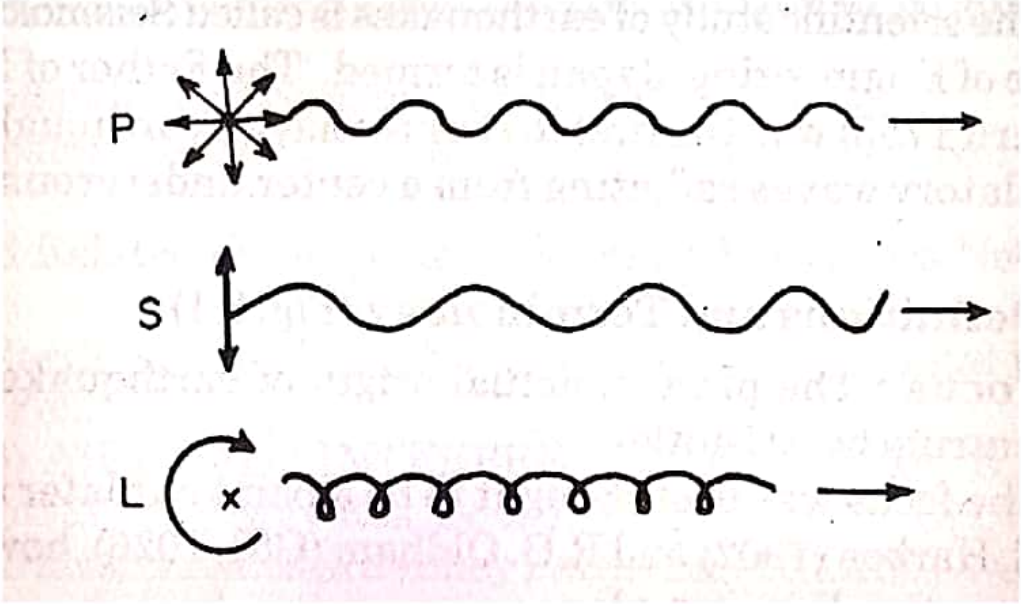
Shallow: - When it is less than 70km below ground surface

Intermediate: - Between 70 and 300 km and

Deep: - below 300 to 700km most earthquakes originate within the upper 250km and none below 700km below the ground surface.

EARTHQUAKE WAVES: - The strain energy released by an earthquake sets up several types of pulses (wave motion) at the focus. These called seismic or earthquake waves travel in all directions in different paths, modes and speeds proportional to the densities of the materials through which they travel. The speed increases with density. When the waves

reach the ground surface they spread out in ever widening circles around the epicenter like water waves from a point of impact in a pond and cause that span of the ground to shake.



P-waves (primary or push and pull waves): - These are high frequency short wavelength longitudinal compressive type, like sound waves. These take the quickest path and are transmitted by oscillations in the direction of propagation. P-waves travel through solids, semi-solids and liquids, i.e the crust the mantle and the core of the earth at speeds 5 to 15km/s

S-waves (Secondary or shake waves): -These are high frequency short wave-length transverse eaves like polarized light transmitted by oscillations perpendicular to the direction of propagation. These also take the quickest path but travel through solids and semisolids, only, i.e the crust and the mantle and are deflected at the core, S-waves travel at speeds 3 to 8km/s.

L-waves (Long or surface waves): - These are low frequency long wavelength waves produced by reflections and refractions of P and S waves in the immediate neighborhood of the epicenter. These travel with a rotary movement in the vertical plane, like sea waves and are transmitted along the periphery of the earth at speeds 3 to 5km/s.

EARTHQUAKE MOTION

Earthquake motion consists of two components- a vertical and a horizontal. The seismic vibrations. Earthquake waves arise vertically from the focus below and cause oscillations of the ground, at the epicenter. As the vibrations advance the horizontal component increases in proportion to the vertical.

EARTHQUAKE MAGNITUDE AND INTENSITY

Magnitude: - Magnitude of an earthquake is an instrumental rating of the energy (the size or strength of the quake) released by it. Magnitude varies with the wave amplitude of an earthquake recorded by a seismograph. By knowing the distance from a seismograph station to the epicenter and the maximum amplitude recorded, an empirical quantitative rating is estimated.

The intensity of an earthquake is a numerical index describing the degree of ground shaking and effects on life and property at any given locality. Intensity is essentially a function of an earthquake and local geological conditions. Intensity is severe at and around the epicenter area and decreases away from it.

Intensity number	*Designation of shock*	*Effects*	*Magnitude (Approx.)*
I	Instrumental	detected by instruments only	—
II	Feeble	felt by observers and by a few people at rest	2
III	Slight	generally felt by many	—
IV	Moderate	felt by all Utensils, glassware clink and clash window shutters rattle	3.5
V	Fairly strong	buildings tremble,, parked vehicles rock, wall clocks stop	3.5 – 4.3
VI,	Strong	sleeping people awakened,, disturbance of furniture	4.3 – 4.9
VII	Very strong	violent disturbance of furniture, walls crack, hanging objects swing,, church bells ring	4.9 – 5.5
VIII	Destructive	moving objects, vehicles, trains over thrown, rails twisted,, monuments,, chimneys,, towers sway crack and fall down,	5.5 – 6.5
IX	Ruinous	heavy damage to buildings, begin to collapse reservoirs sway	6.2 – 7.0
X	Disastrous	Buildings razed to ground, life lines destroyed	7 – 7.3
XI	Very Disastrous	only a few structures left,, dams affected breeched or overthrown,, ground cracked,	7.4 – 8.1
XII	Catastrophic	complete destruction, ground badly twisted	8.1

DISTRIBUTION OF EARTHQUAKE: - It is estimated that over 150000 quakes occur round the world every year. Several of them are terribly destructive involving heavy tolls and property damages.

World distribution

1). The Circum Pacific Seismic Belt,

2). The Mid Atlantic Seismic Belt,

3). The alpine-Himalayan trans Asiatic Seismic Belt

Indian distribution

1). Kutch Gujarat 1819

2). Assam, 1897

3). Bihar1934

4). Anjar-Gujarath,

5). Peninsular India (South India)

Indian continent is divided into (based on earthquakes)

Zone of Maximum Intensity: - Which comprises the Northeastern regions, especially the folded chains of Himalayas, geographically this area covers Assam, Himachal Pradesh, Kashmir, U.P, Nagaland.

Zone of Intermediate Intensity:- Which covers the regions of indo-Gangetic basin. This zone of moderate Intensity comprises the remaining areas of Punjab, West Bengal and Bihar.

Zone of Minimum Intensity: - No land mass is free from earthquake, all the regions are highly affected by this activity.

EARTHQUAKE HAZARDS

The energy released by an earthquake travel along the earth's surface, it causes the ground to vibrate in a complex manner by moving up and down as well as from side to side. The amount of structural damage attributable to the vibrations depends on several factors including

The intensity and duration of the vibration

The nature of the material upon which the structure arrest

The design of the structure

Earthquake effects are remarkable and directly proportional to the intensity of then tremblers and geologic setting of the affected area. Earthquake effects comprise of changes super induced upon land and sea levels, topography and surface and groundwater regimes as a result of readjustments of certain, components of the crust in order to restore equilibrium. The hazards are due to two important seismic events are Ground shaking and Tsunami generation.

Violent ground shaking induces topographic changes and ground failure by landslides, fissuring surface faulting and soil liquefaction. Ground shaking is maximum in epicenter regions. Generally topography of the affected areas is transformed partly or totally. Hill ranges rise or fall or rented. The ground is thrown into terraces or wave like a choppy sea and extensional cracks.

FIRE HAZARDS

The loss of life and property that accompany great quakes often is mainly due to secondary cause especially fire. If a quake strikes a modern town or city today it may cause uncontrollable fire due to electric short circuit severance of gas and water mains and flooding with attendant serious damages.

There are reports of fanciful behavior of animals sometimes before and during an earthquake. Tigers and chimpanzees scream. Domestic animals horses and cows become restless and run abut madly stampeding or seek highlands. Dogs and cats howl and huge closer to people. Rats disappear, pigs rush out in swarms. Rabbits try to climb walls and fences. Zoo animals refuse to get into their cages and shelters.

EARTHQUAKE SOUNDS

Earthquake records frequently refer to strange sounds that accompany ground shaking. It is reported that earthquake sounds are due to the shaking ground beating upon the air above like the membrane of a drum. The near vertical incident of P-waves is supposed to be responsible for the sounds with the ground behaving like an enormous loud speaker driven by them. It is observed that earthquakes occurring in areas of crystalline rocks like granite or gneiss produce strong high frequency sounds and those in thick sedimentary terrines produce softer low frequency sounds.

TYPES OF EARTHQUAKE PROOF STRUCTURES

Quake proof models: - TO bear the strain due to earthquake shocks and prevent or minimize damages and death two opposite methods of anti-earthquake construction in earthquake regions are recommended, they are Light and elastic constructions and Heavy and rigid constructions

Light and elastic constructions: - In India and elsewhere in earthquake countries most people in countryside live in non-engineered mud huts or timber structures. The mud habitats usually are constructed with mud walls and sloping thatched roof, in some cases bamboo walls with plaster or crude brick or rubble masonry. These fail in earthquakes with disastrous effects. Mud structures are very popular in India, especially in Kashmir, Kutch, Maharashtra, Bihar and Assam regions. Timber frame structures and Brick Masonry

Heavy and rigid constructions: - These are well built structures of brick and stone masonry, RCC frames with filler brick walls, and single or multistoried buildings. The main object of these is to construct stronger than ordinary building in order to prevent their collapse and loss of life and property, especially those of large selling's, schools, office building, hospitals, business complexes community halls etc. Where commonly good number of people assembles at a time and also certain vital or critical installations like powerhouses nuclear facilities.

Safety measures to be adopted for buildings to be construction in seismic areas. As stated earlier, an earthquake resultant building must be strong and sturdy. Hence, besides incorporating these additional safety factors in the design of such buildings the following other points must be given due attention to

1. Good quality materials, strictly according to the specifications, should be used.

2. The foundation should not be on soft ground and rather it should preferably be on the solid rocks. The depth of foundation should also be uniform.

3. The walls should be continuous in nature. The long walls and cross wall be erected simultaneously without any joints.

4. Doors and windows should be minimized.

5. Height of the building should be kept uniform.

6. All parts of the buildings, particularly its edges and corners should be well tied, so that it moves as a single unit during an earthquake vibration.

7. Construction of cantilevers, Chimneys, Arches and other extra projections should be avoided.

EARTHQUAKE AND CIVIL ENGINEERING

An earthquake is a vibratory motion having components in all directions. The vertical components are more dominant near the epicentral tracts and the horizontal components away from these tracts. Hence strong structures have to withstand bigger forces near the epicenter and soft and flexible structures are safer, away from the epicenter flexi bile structure suffer severe damage while hard structures as safer. Extensive research has been carried out in the last 50 years to develop new methods to minimize losses.

Buildings: - Steel – framed tall buildings in which the frame supports all wall and floor loads usually behave well during earthquake. Reinforced concrete buildings may develop cracks in walls and piers houses with roofs; wall and foundations tied into one strong unit behave safely during earthquake. Houses built with wood and flexible materials of construction absorb earthquake shocks. In our country modern methods are increasingly being adopted and reinforced brick buildings are built against earthquake forces. This method increases the construction cost 2-5%, but simultaneously saves buildings and lives. Even more recently by a new direction in research and developed insulators for absorbing energy transmitted by ground motion to reduce damage to structure. Some of these methods are useful for rigid structures.

Foundations: - The amount of damage caused by ground shaking depends on the type of foundation below the building or structure. These are built in low-strength roc materials such as sand and silt tend to absorb much of the shaking motion, hence buildings have not been designed to cope with strong shaking but rather to accommodate large foundation movements. Such buildings have to provide competent footings, adequate drainage and flexible power, water and sewage connections. Unconsolidated sandstone may saturate as a result of earthquake vibrations, sometimes the entire structure is destroyed.

Slopes and embankments: -Settlement of embankments can be minimized by careful compaction control during construction but even then settlement can occur. Landslides due to earthquakes have resulted in loss of lives and property. So embankment has to be designed with extra care. Highways and railway cuttings and avoidance of steep slopes for residential development re necessary in high seismic areas.

Dams: -Rock fill dams usually stand up well to earthquake shocks. A river valley project may consist of a dam or barrage, tunnel, powerhouses, buildings and bridges of various types, which may fail during strong earthquake.

Tunnels: - Tunnels, which intersect at geological fault, are often seriously affected by earthquake movement. Special tunnel deigns are necessary in seismically active zones. Generally rupture of the lining may cause flooding of partial dislocations. Earth tunnels are less affected by earthquake movements but the chances of liquefaction of the surrounding materials are real.

Earthquake zones in India : India is divided into 4 earthquake zones.

1) Siesmic Zone - II : Area with minor damage, earthquake corresponding to intensities V to VI on MM scale (Modified Mercalli Intensity scale) It is low risk zone.

2) Siesmic Zone - III : Moderate damage corresponding to intensity VIII on MM scale. (Kerela, Goa, Lakshadeep, U.P, Gujrat, W.B, parts of Punjab, Rajasthan, M.P, Bihar, Jharkhand, Chattisgard, Maharastra, Orissa, Andra Pradesh, T.N & Karnataka)

3) Seismic Zone - IV : Major damage corresponding to intensity VII & higher on MM scale. (J & K, H.P, NCT of Delhi, Sikkim, Northern part of U.P, Bihar & W.B ; parts of Gujrat)

4) Seismic Zone V : Area determines by pro seismically of certain major fault systems. Most active region & comprises of entire northeastern India, parts of J & K, H.P, Uttranchal, Rann of Kutch in Gujrat, Anadaman & Nicobar Islands.