Earthquake Resistant Building Construction

Unit-1-Elements of Engineering seismology

Earthquake- An Earthquake is the shaking of the surface of the earth, resulting from the sudden release of energy in the Earth's lithosphere that create seismic wave. It is also known as tremor or temblor.

Focus- The point place inside the surface of the earth at which an Earthquake originates is termed as focus or seismic center.It is also termed as Hypocenter.

Epicenter- The epicenter is the point on surface of the earth directly above the focus.

Seismology- The word seismology comes from Greek words, "Seismos" meaning earthquake and 'logos' meaning science.

The seismology is the study of earthquake and seismic waves that move through and around the earth.

Seismograph- An instrument which is used to record ground vibration or surface displacement.It is used only to record weak motions and are unsuitable to record vibration very higher intensity.

Accelerograph- An instrument which is used to record very higher intensities vibrations.

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Seismic waves- During an earthquake, elastic waves. Are generated at the hypocenter. These waves are called seismic wave.

Seismic waves are of the three types:

A) Body waves

1. P-waves/ Primary waves
2. S-waves/ secondary waves

B) Surface waves(L-waves)

1.Rayleigh waves

2.Love waves

Magnitude- Magnitude of an earthquake is a measure of the amount of energy released during an earthquake. It is a quantitative measure of actual size of earthquake.

Intensity- It is an earthquake may be defined as a qualitative measures of actual vibration set upon earth surface due to seismic shock. It is an measure of destruction caused by an earthquake.

Causes of Earthquakes

1.Surface causes:- Earthquake of mild intensity which occur over the ground surface caused by dynamic agencies operating upon the

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surface of the earth are termed as superficial or surface causes. For example-

a) A huge landslide or a rock fall along hill slopes.

b) Mining blasts in mining areas.

2.Volcanic causes- Volcanic activities taking place in different part of the world, oftenly produce volcanic outbursts or explosions during which the surface of the earth resemble.

3.Tectonic causes- The seismic shocks which occur due to sudden release of enormous strain energy owing to crustal movement are termed as tectonic earthquake. The tectonic earthquake occur due to:-

a) Displacement of rocks masses along pr-existing cracks.

b) Development of new fault planes.

Classification of earthquake

Earthquake are usually classified on the following bases:

A) Cause of origin

B) Depth of focus

C) Intensity And Magnitude of earthquake.

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On the basis of Cause of origin:

1) Tectonic - Earthquake occur when the plate move against one another. This movement can create stress that causes the Earth's exterior shell the lithosphere, to shift or break.

2) Non tectonic earthquake- The earthquakes mainly of three types due to surface cause,volcanic causes and collapse of cavity roofs.

On the basis of Depth of focus

1) **surface earthquake**- In which the depth of the focus is less than 10,000 meters.

2) **Shallow earthquake**- The earthquake with the hypocenter at a depth of 10 to 50 kms.

3) **Intermediate earthquake**- When the earthquake is originated at a depth of 50 to 300 kms

4) **Deep earthquake** - The plutonic earthquake are those with hypocentres located at depth more than 300 kms.

On the basis of Intensity/ Magnitude of Earthquake

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On the basis of intensity earthquake are classified:

a)**Instrumental** - Detected only by seismograph

b)feeble -noticed only by sensitive people.

c)**Slight-**Resembling vibrations caused by heavy traffic.

d)Moderate- felt by people walking: rocking of free standing object.

e)**Fairly strong**- sleepers awakened and belt ring

f)**Strong**-tree sway, some damage from overturning and falling objects.

g)**Very strong** -General alarm, cracking of walls

h)**Destructive**- Chimney fall and there is some damage to buildings.

i)**Ruinous**-ground begins to crack, houses begin to collapse and pipes leak.

j)**Disastrous**- ground badly cracked and many building are destroyed. There are some landslides.

k)**Very disastrous**- few building remain standing; bridges and railways destroyed water, gas, electricity and telephones out of action.

l)**Catastrophic**-Total destruction ; objects are thrown into the air,much heaving, shaking and distortion of the ground.

On the basis of magnitude earthquake are classified:

a)Micro earthquake (M<3)

b)Macro earthquake(M 3-4)

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c)Moderate earthquake (M 5-5.9)

d)Strong earthquake (M 6-6.9)

e)Major earthquake (M7-7.9)

f)Great earthquake (M>8.0)

Seismic zoning map of India

India can be divided into three seismic zones.

1. **Highly seismic zone**- The Himalaya is one of the most tectonically active belt of the world which is still passing through a state of instability. The Himalayan ranges and the Indo- Gangetic plains are the areas, which may be termed as Highly seismic zone.

2. **Moderately seismic zone**- The other parts of Himalayan ranges and Indo gangetic plains, which do not fall along the zones of great boundary fault and the syntaxial bends may be termed as Moderately seismic zone.

3. **Poorly seismic zone**- The Deccan plateau or the peninsular India representing the ancient and stable land mass may be termed as ‘poorly seismic zone’.

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Static Load: The static load may be defined as the type of load, which remain constant with time. Example weight of roof on posts of a house, dead load of super structure.

Dynamic loading- A load on structural system that is not constant, such as moving live load or wind load.

This dynamic load is further subdivided into:

a) **Periodic load**: The load, which either harmonic or non harmonic, repeat after certain time.

Example: Harmonic- machine operation

Non- Harmonic - Human motion

b) **Non periodic load**: The load which is non periodic and may be either transient or impulsive.

Example: Transient- Earthquake, water wave

Impulsive-pile driving load.

Fundamental period: The time taken by a building structure in seconds for complete cycle of oscillation during the effect of dynamic loading. Fundamental period also known as natural period. It is denoted by 'T'. Fundamental period 'T' usually varies from 0.05 second to 2.00 second.

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On the basis of T, building may be classified as

1. Rigid (T less than 0.3 seconds)
2. Semi rigid (T less between 0.3 seconds and 1.0 seconds)
3. Flexible (T greater than 1.0 seconds)

Unit-2 Seismic Behavior of traditionally built construction of India

Introduction-

The traditionally built constructions of India include small structure constructed in brick ,stone ,mud or a combination thereof. The masonry building which are brittle structure have to prove to be the most vulnerable to strong seismic forces. This construction simply built by local masons, without guidance from professional expert such type of construction known as non engineered construction. These structure have suffered extensive damage during earthquake.

Performance of building during earthquakes

Study of the past earthquake in recent year bhuj (gujrat)-2001, Jabalpur (Madhya pardesh)-1997,Chamoli (uttaranchal)-1999 have proven that the seismic response of traditionally built structure is very poor. Some important factors responsible for low seismic efficiency of the structure:

1. Failure of connection between walls

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2. Large size of opening
3. Irregular plans of building

Mode of failure

1. **out of plane failure**- These type of failure occurs when the shock waves in the ground move in any direction other than the direction of plane. The risk of an out-of- plane is reduced if we provide distance between wall support are reduced.

Causes of out-of-plane failure

a) improper joining of vertical walls with the roof structure.

b) Construction of long span slab.

2. **In-plane failure**- It is a type of failure in which structural walls situated parallel to earthquake motion are subjected to bending and shear force development of horizontal and diagonal cracks in the walls.

Causes of in-plane failure

a)Excessive bending

b)Excessive shear

3.**Diaphragm failure**:- These type of failure rarely occurs when seismic motion happen. Less tension produced a non bending cantilever action at the base of the wall, due to this wall is push against diaphragm. This

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type of failure can be prevented by sufficient anchoring the diaphragm with reaction walls by use of shear bolts.

4.**connection failure**:- Inadequate and improper connection between horizontal diaphragms and vertical components of the building leading to failure of masonry walls under the attack of seismic ground motion.

Causes of connection failure

a) Increasing size and numbers of wall opening.

b) Insufficient connection of floor with external wall.

Non- structural component-

Non structural component are those which are attached to or housed in a building or building system but are not part of the main load resisting structural system of the building.
Types of non- structural component

1. Architectural element- for example parapets, cladding system, sign board etc.

2. Mechanical component- for example boilers storage tanks, piping system.

3. Electrical component- for example electric motors ,light fixture etc.

Objective

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The objective of the separation of non- structural component in building is to-

1. Avoid damage in moderate earthquake
2. Minimise damage in serve earthquake and thereby prevent possible panic or injury and loss of life to person in and around building.