Case Study of Earthquake Resistant Building

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ABSTRACT

This paper deals with the study of criteria for providing earthquake resisting structure. Earthquakes are very serious problems since they affect human life in various ways. There are structural requirements which a building should have in order to resist earthquakes. Here are various designs of structures which cause damages during earthquake the present paper deals with the Study of effect, causes and guidelines for providing earthquake resisting building.

Key words- *Seismic Waves, Hypocenter, Epicenter, Causes of Earthquake, Fault Scrap.*

I. INTRODUCTION

The sudden shaking or rolling of the earth's surface is called an earthquake. Actually earthquakes occur daily around the world (according to one estimate, about 8000 occur every year), but most of them are too mild to be noticeable. We know of them only because they are recorded by instruments called seismographs (the Greek word seismos means 'earthquake'). An earthquake (also known as a quake, tremor) is the shaking of the surface of the Earth resulting from a sudden release of energy in the Earth's lithosphere that creates seismic waves. Earthquakes can range in size from those that are so weak that they cannot be felt to those violent enough to propel objects and people into the air, and wreak destruction across entire cities. The seismicity, or seismic activity, of an area is the frequency, type, and size of earthquakes experienced over a period of time. The word *tremor* is also used for non-earthquake seismic rumbling.At the Earth's surface; earthquakes manifest themselves by shaking and displacing or disrupting the ground. When the epicentre of a large earthquake is located offshore, the sea bed may be displaced sufficiently to cause a tsunami. Earthquakes can also trigger landslides and occasionally, volcanic activity. In its most general sense, the word *earthquake* is used to describe any seismic event whether natural or caused by humans that generate seismic waves. Earthquakes are caused mostly by rupture of geological faults but also by other events such as volcanic activity, landslides, mine blasts, and nuclear tests. An earthquake's point of initial rupture is called its hypocentre or focus. The epicentre is the point at ground level directly above the hypocentre. An earthquake is the sudden movement of the ground that releases elastic energy stored in rocks and generates seismic waves. These elastic waves radiate outward from the "source" and vibrate the ground. Earthquakes are not the exclusive cause of seismic wave; explosions, planes, wind, storms, and people also vibrate the ground. An earthquake is a sudden shaking movement of the surface of the earth. Earthquakes can range in size from those that are so weak that they cannot be felt to those violent enough to toss people around and destroy whole cities. The seismicity or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time.

Fig. 1- Effect of Earthquake

II. DISTRIBUTION OF EARTHQUAKES:-

- There are two well-defined belts where earthquakes frequently occur – The Circum-Pacific Belt and The Mid-World Mountain Belt.
- About 68% of earthquakes in the world occur in the Circum-Pacific Belt.
- Mid-World Mountain belt extends from the Alps with their extension into Mediterranean, the Caucasus, and the Himalayan region and continues to Indonesia.
- 21% of earthquakes are occurring in this belt.
- The remaining 11% occur in the other parts of the world.

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III. BASIC TERMINOLOGY OF EARTHQUAKE:-

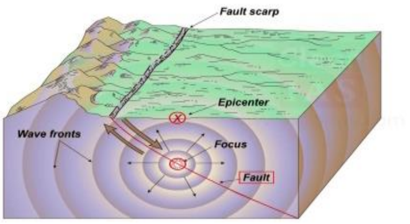

Fig. 2- Basic Terminology of Earthquake

A. Epicentre: - It is the point on the (free) surface of the earth vertically above the place of origin (hypocentre) of an earthquake. This point is expressed by its geographical latitude and longitude.

B. Hypocenter or Focus:-

It is the point within the earth from where seismic waves originate. Focal depth is the vertical distance between the hypocenter and epicentre.

C. Magnitude:-

It is the quantity to measure the size of an earthquake in terms of its energy and is independent of the place of the observation.

D. Fault:-

Fault is a planar fracture or discontinuity in a volume of rock across which there has been significant displacement as a result of rock-mass movement.

E. Intensity:-

It is the rating of the effects of an earthquake at a particular place based on the observations of the affected areas, using a descriptive scale like Modified Mercalli Scale.

F. Fault scarp :-

A *fault scarp* is a small step or offset on the ground surface where one side of a *fault* has moved vertically with respect to the other. They are exhibited either by differential movement and subsequent erosion along an old inactive geologic *fault* (a sort of old rupture), or by a movement on a recent active *fault*

G. Faults & Earthquakes :-

In an earthquake, the initial movement that causes seismic vibrations occurs when two sides of a fault suddenly slide past each other. A fault is a large fracture in rocks, across which the rocks have moved.

Faults can be microscopic or hundreds-to-thousands of kilometres long and tens of kilometers deep. The width of the fault is usually much smaller, on the order of a few millimetres to meters.

IV. MEASURING AN EARTHQUAKE

A. Richter Scale

We can realize that the destruction caused by an earthquake depends on many factors. One major factor is its intensity. Geologists usually express the intensity of an earthquake in terms of a magnitude on a scale known as the Richter Scale. The Richter scale, named after Dr. Charles F. Richter, is the scale used for measuring the strength of an earthquake, in terms of the amplitude of its seismic waves. This scale is not a simple scale. On this scale, an increase of two in the magnitude means 100 times more destructive energy

Magnitude is measured on the basis of ground motion recorded by an instrument and applying standard correction for the epicentral distance from recording station. It is linearly related to the logarithm of amount of energy released by an earthquake and expressed in Richter Scale.

B. Earthquake Size

The size of an earthquake depends on

- The area of the fault that ruptured.
- The distance that the rocks on the two sides of the fault slide past one another.

C. Earthquake Magnitude and Frequency:-

The most commonly used quantification of earthquake size is the magnitude.

Magnitude is an instrumental measure of the amplitude of ground shaking; that is, you must have an instrument called a seismograph to measure the magnitude of an earthquake.

Descriptor	Magnitude Range	Frequency per Year
Great	8.0 or more	1
Major	7.0-7.9	18
Strong	6.0-6.9	120
Moderate	5.0-5.9	800
Light	4.0-4.9	6200
Minor	3.0-3.9	490000
Very Minor	2.9 or less	Thousands per day

D. Seismic Waves:-

Seismic Waves are divided into following types-

a) Body waves:-

- They are generated due to the release of energy at the focus and moves in all directions traveling through the body of the earth.
- They travel only through the interior of the earth.
- Body waves are divided following types-

i) Primary waves (p-waves) :-

- Primary waves are the fastest body waves (twice the speed of s-waves) and are the first to reach during an earthquake.
- They are similar to sound waves, i.e., they are longitudinal waves.

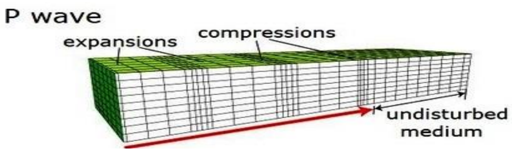

Fig-3- P waves

ii) Secondary waves (s-waves) :-

- They arrive at the surface with some time-lag after primary waves.
- They are slower than primary waves and can pass only through solid materials.
- This property of s-waves led seismologists to conclude that the earth's outer core is in a liquid state. (the entire zone beyond 105^{o} from the epicenter does not receive S-waves)
- They are transverse waves in which directions of particle movement and wave propagation are perpendicular to each other.

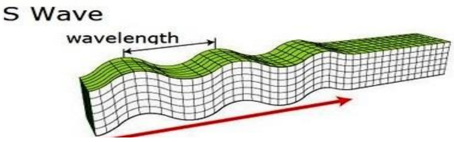

Fig-4- S-waves

b) Surface Waves:-

- When the body waves interact with surface rocks, a new set of waves is generated called as surface waves.
- These waves move along the earth surface.
- Surface waves are also transverse waves in which particle movement is perpendicular to the wave propagation.
- Hence, they create crests and troughs in the material through which they pass.
- Surface waves are considered to be the most damaging waves.
- Two common surface waves are Love waves and Rayleigh waves.

i) Love waves :-

- This kind of surface waves causes horizontal shifting of the earth during an earthquake.
- They have much slower than body waves but are faster than Rayleigh.
- They exist only in the presence of semi-infinite medium overlain by an upper finite thickness.
- Confined to the surface of the crust, Love waves produce entirely horizontal motion.

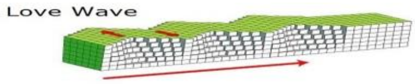

Fig-5- L- waves

ii) Rayleigh waves :-

- These waves follow an elliptical motion.
- A Rayleigh wave rolls along the ground just like a wave rolls across a lake or an ocean.
- Because it rolls, it moves the ground up and down and side-to-side in the same direction that the wave is moving.
- Most of the shaking felt from an earthquake is due to the Rayleigh wave, which can be much larger than the other waves.

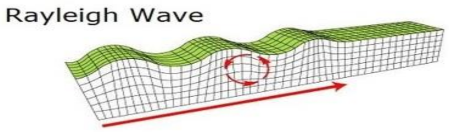

Fig-6- Rayleigh waves

V. SHADOW REGIONS OF WAVES:-

- We already discussed that p-waves pass through all medium while S-waves passes only through solid medium.
- With the help of these properties of primary waves, seismologists have a fair idea about the interior of the earth.
- Even though p-waves pass through all mediums, it causes reflection when it enters from one medium to another.
- The variations in the direction of waves are inferred with the help of their record on seismographs.
- The area where the seismograph records no waves is called as 'shadow zone' of that wave.

Accordingly, it is observed that the area beyond 105^{0} does not receive S-waves and the area in between 105^{0} to 140^{0} does not receive P-waves.

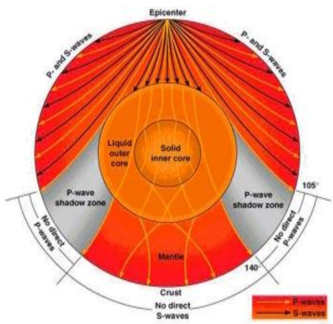

Fig-7- Interior Core of Earth

VI. CAUSES OF EARTHQUAKES:-

- Earthquakes are the result of slow-moving processes that operate within Earth.
- Earth was hot when it formed, and has been cooling ever since (near the surface, for each km into Earth, the temperature rises by about 30 deg. Celsius).
- Earth's cooling causes the portions of Earth to move, and that movement is what we call an earthquake.

Fig-8- Effect of an Earthquake

VII. GUIDELINES FOR EARTHQUAKE RESISTANT CONSTRUCTION:-

- Horizontal bands should be provided at plinth, lintel and roof levels as per code
- Providing vertical reinforcement at important locations such as corners, internal and external wall junctions as per code.
- Grade of mortar should be as per codes specified for different earthquake zones.
- Irregular shapes should be avoided both in plan and vertical configuration.
- Quality assurance and proper workmanship must be ensured at all cost without any compromise.

A. In RCC framed structures (IS-13920)

- The spacing of lateral ties should be kept closer as per the code
- The hook in the ties should be at 120 degree instead of 90 degree for better anchoragement.
- The arrangement of lateral ties in the columns should be as per code and must be continued through the joint as well.

  Whenever laps are to be provided, the lateral ties should be at closer spacing as per code.
- The spacing of stirrups should be kept closer as per the code
- The spacing of stirrups should be closed at L/4 span at the end on both side to avoid shear force.
- It is the maximum lateral displacement of the structure with respect to total height or relative inter-storey displacement.
- Higher the lateral stiffness lesser is the likely damage. The storey drift in any storey due to minimum specified design lateral force with partial safety factor of unity shall not exceed 0.004 times the storey height.

B. Effects of an earthquake:-

Earthquake produces various damaging effect in the areas the act upon. The list of some of the main effects caused by earthquakes are given below:

- Earthquake causes damage to the building, bridges, and dams.
- Earthquake in many cases can cause great loss of life
- Earthquake can also cause floods and landslides. Landslides, triggered by earthquake, often cause more destruction than the earthquake themselves
- If the earthquake happens to be beneath the ocean floor, they can lead to a tsunami

C. Safety precautions after the Earthquake:-

- Stay calm for a while. Expect aftershocks. These shocks can cause additional damage.
- Beware of possible tsunami, if you live in coastal area.
- Carefully inspect utilities/supplies.
- Use telephones only in emergency
- Stay away from damaged areas.
- Help the injured ones
- If you are outdoors, stay away from trees, buildings, poles, and so on.
- Be ready for the aftershocks that follow an earthquake

D. Main requirements for structural safety of buildings:-

- Horizontal reinforcement in walls is required for transferring their own out-of-plane inertia load horizontally to the shear walls.
- The walls must be effectively tied together to avoid separation at vertical joints due to ground shaking.
- Shear walls must be present along both axes of the building.
- A shear wall must be capable of resisting all horizontal forces due to its own mass and those transmitted to it.
- Roof or floor elements must be tied together and be capable of exhibiting diaphragm action.
- Trusses must be anchored to the supporting walls and have an arrangement for transferring their inertia force to the end walls.

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- During past earthquakes, reinforced concrete (RC) frame buildings that have columns of different heights within one storey, suffered more damage in the shorter columns as compared to taller columns in the same storey.
- Reinforcement Details beam -column joint for earthquake Resistant structure :-

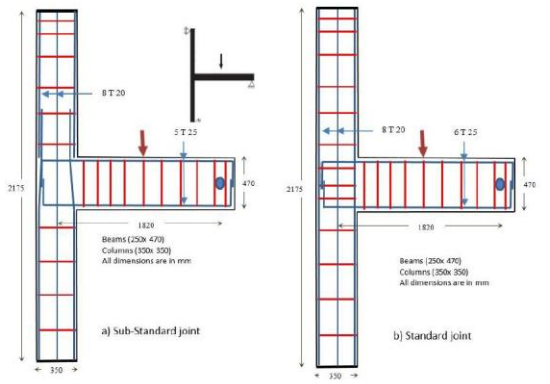

Fig.-9- Reinforcement Details of beam - column joint

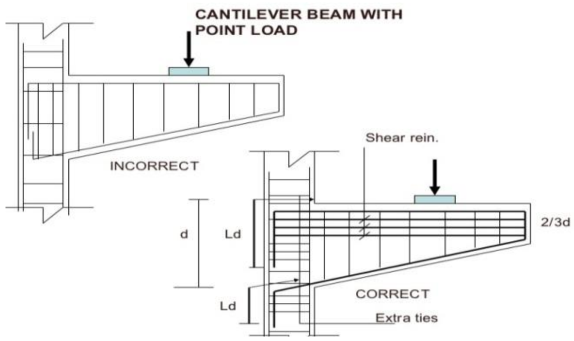

Fig-10- Reinforcement Details of cantilever beam for Earthquake Resistant structure

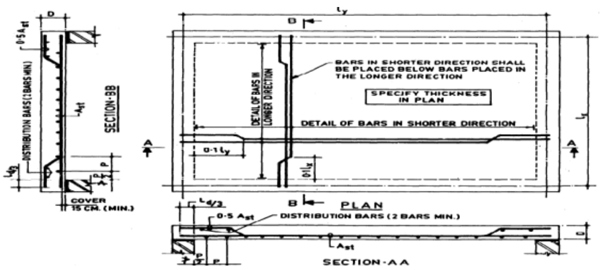

Fig.-11- Reinforcement Details of slab for Earthquake Resistant structure

VIII. CONCLUSION

This paper is a study for the earthquake resistant building structure of the construction technologies in various building construction. It gives guidelines regarding earthquake resistant structure and effect of earthquake on structure. The paper describes the circumstances leading to their development.

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