

Introduction to Engineering Seismology
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Lecture - 08
Types of Earthquakes, Causes of Earthquakes

So vanakkam. So last class we discussed about the seismic sources and fault. So where basically the earthquake occurs okay. So we also seen the how the active fault can be identified, what are the geological features you can do and then what are the deep drilling you can do for the doing that kind of identification of the active part. So today class so we will going to discuss about the types of earthquake.

So if you remember the last class video, I also told that there was a Koyna this kind of drilling is going on. So where people are drilling a hole and collecting a sample. Places where there was a reservoir induced earthquake. So what is that reservoir induced earthquake. You have seen only the earthquake we were been talking.

So there is a types of earthquake which we are going to discuss on this class to differentiate what are the different type of earthquake occurring. So how you can classify them so that for your analysis and finding the earthquake hazard prediction this classification knowledge will help you.

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Causes of Earthquakes

- An earthquake is manifested as ground shaking caused by the sudden release of energy in the Earth's crust.

- This energy may originate from different sources
 - Dislocations of the crust
 - Volcanic eruptions
 - Man-Made explosions
 - Collapse of Underground Cavities (Mines or karsts)

So the earthquake as we understand that it is a vibration okay or shaking caused by the sudden release of the elastic energy. So this happens at the earth crust. Sometime this vibration can happen by any means, not only by the breaking of the rock. So it can happen by the any means. So any vibration is called as a earthquake. So here also I want to stress you that so the earth and quakes can be separated.

So the quakes are vibration happens in the earth is called as earthquake. So that means there is a quake which is happening in some other planet, yes of course. So if you see the quakes which is happening in the moon, which is called as a moonquake. The quakes which is happening in the Mars is called as a Marsquake. So there are seismic instrument deployed at moon where it measures a moonquake.

Similarly, there are seismic instrument deployed with distance from the Mars or in the Mars, where it record a Marsquake. So any planet the quacks is occurring, like vibrations occurring. That planets name is put first. So earthquake is considered as quakes occurs at earth. Moonquake and the as well as a Marsquake and Jupiterquake. Like that you can say. So the quake is basically a vibration common.

So it happens in the earth, it is a earthquake. So the earth basically also indicate the earth as a soil also because we use a common term earth to tell soil in the ground, okay. Soil in the ground also we call it as a earth, okay. The earth is basically a planet. So what we are living. So the energy may be originate from the different source. So that means the vibration comes from different source.

So which may be because of the dislocation of the crust okay which is happening due to the tectonic force or the vibration happening due to the volcanic eruption or the vibration happens due to the manmade explosion or the vibration may happens to the collapse of the underground cavities. So these are all the causes where the vibration can happen. So not only these things will happen.

So there was vibration can be also expected due to the change of speed or a sound waves from one place to other place. So now actually the class what I am taking is actually today is actually 21st okay. So 21st of the May 2020. So people who are living in Bangalore okay, so they might have had read a news on the 20 May 2020

saying that there was a vibration and sound which sound has been reported in the Bangalore.

So the people got basically afraid. That was the time yesterday was I was recording my lectures. So we did not notice because I recorded the lecture in the completely shielded room with sound and as well as the vibration proof. So but this was reported outside so when I after finishing the lecture and I went outside there was an inquiry that what was that there was any earthquake, okay.

So then there was mystery, because there is no seismic record was found, but there was a vibration felt. So then there was a rumor that this was maybe due to the some kind of strange unmanned flight or something like that. So the finally the people tried to identify what was the reason behind that. So it has been officially told that there was a sonic flight okay so which the flight Jet Air flights.

So which was actually going from one speed to other speed which is above like 30, 40 kilometer above the earth. So this was changing from speed from one level to other level and moving from one zone to other zone. So that speed change caused a sound waves. That sound wave basically felt by the most of the Bangalore region and that also caused a vibrations okay.

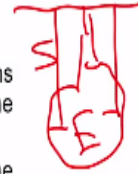
So like that the vibrations can be caused by any means. So depends upon the source of the vibration we should be able to characterize that this is due to the earthquake or a manmade or a volcanic eruption or due to the underground cavity explosion. So then based on that you can classify the earthquake type, okay.

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Types of Earthquake

The type of earthquake depends on the region where it occurs and the geological make-up of that region.

- **Tectonic earthquakes:** These occur when rocks in the earth's crust break due to geological forces created by movement of tectonic plates.
 - Study of earth interior
- **Volcanic earthquakes,** : occur in conjunction with volcanic activity.
- **Collapse Earthquakes:** small earthquakes in underground caverns and mines that are caused by seismic waves produced from the explosion of rock on the surface.
- **Explosion Earthquakes:** earthquakes which are the result of the detonation of nuclear and chemical devices.
- **Impact earthquakes:**



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So based on the type of the source so the first earthquake we can call it as a tectonic earthquake. So the tectonic earthquakes occurs when the rocks in the earth crust breaks due to the geological forces created by the movement of the tectonic plates, okay. So like we have seen that the earth is rotating. It stores a strain. So that exceed a strength of a material which stores, breaks and releases energy.

That kind of earthquakes are the tectonic earthquake which related to the plate tectonic of the region. The another one is a volcanic earthquake. It occurs conjunction with the volcanic activity of the, so the eruption of the volcano or the magma from the deep depth okay so puts lot of pressure and that pressure only comes up and releases the that magma outside. That causes a vibration.

Those kind of vibrations called as a volcanic earthquake. So the collapse earthquake these are all the small earthquakes generally happens in the caverns and mines. So basically, if you have the old mines okay. So where the mine means they will go deep and cut a material and bring the back. They leave that place empty. So there is a imbalance between the confining force at that particular place.

So for example, if this is the ground. So people will build a tunnel, okay. So then go inside and create a cavity and cut gold or coal or anything and they bring up. So then you can see that there is a solid here. So this is the empty space here. So there is a imbalance force at different places. If you see the force at different point that seem.

This imbalance can cause an adjusting force called as a so collapse earthquake or a mine, caverns earthquake.

So this generally happens in the mining area. So the people who are living in the Kolar region or close to the mine, Kolar is actually goldmine area where there was a big cavity was created due to the mining of gold. So those regions, this kind of collapsible earthquakes are frequently happening. So the another earthquake is an explosive earthquake.

Explosive earthquake means you can keep a bomb and create an explosion that creates a vibration. Those kind of vibrations and earthquakes are called as explosive earthquake. Even sometime this also dangerous because your building get damaged because of this kind of vibration. So the another one is the impact earthquake. So the impact earthquake means forcefully impacting a structure or ground by some means.

For example, those who are seen the building construction of the soft ground area, so people erect a pile foundation. Pile foundation means so there is a pile, you can see the video. So there is a pile like this. Then, so there is a big hammer, it comes and hit. When you are hitting it is basically penetrate pile to some level to the ground. So this is called as a pile driving procedure, okay.

So people who have studied the foundation engineering they will be knowing that what is meant by the pile driving. So this driving actually creates a vibration, okay. That vibration is called as an impact earthquake. Or you take a flight and go and hit a tall building that create a vibration. That is called as an impact earthquake like Twin Tower collapse in the US.

So these are all the way the earthquake can be classified depends upon the where the earthquakes are occurring, which geological formations are occurring, okay.

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Tectonic Earthquake

- ❖ Earthquake occurrence may be explained by the theory of large-scale tectonic processes, referred to as "plate tectonics"
- ❖ 95% of worldwide seismic energy release by plate tectonic
- ❖ Plate tectonic theory provides a simple and general geological explanation for plate boundary
- ❖ Plate is large and stable rigid rock slabs with a thickness of about 100km forming the crust or lithosphere and part of the upper mantle of the earth

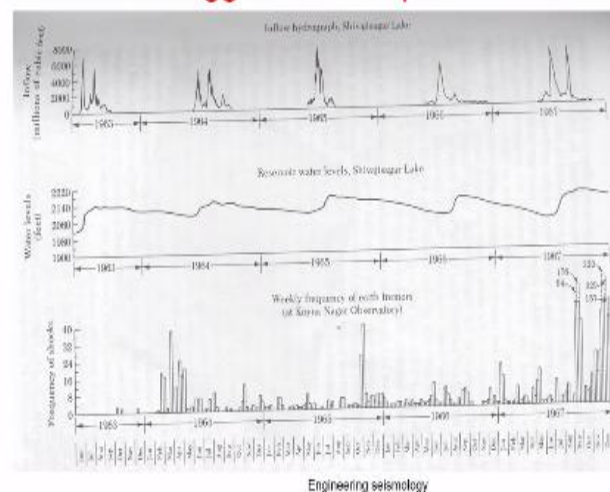
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So then we will see more about the tectonic earthquake. So the tectonic earthquake occurs may be explained by the theory of large scale tectonic process referred as a plate tectonics. 95% of the world earthquakes are tectonic earthquake. 95% of the seismic energy released by the world is due to the tectonic earthquake. Plate tectonics theory provide a simple and general geological explanation for the plate boundaries.

And plate is large and stable rigid rocks stable with thickness about 100 kilometer from the crust, lithosphere and part of the upper mantle of the crust which we have seen in the last class what is meant by the plate.

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Reservoir –Triggered Earthquakes



So the another earthquake is actually as I told you that reservoir induced earthquake. So the reservoir induced earthquake means basically when you construct a water

storage facilities like a dam okay reservoir, so you try to do what happen in nature actually it allows a river to flow, but what we are doing? We are constructing barrier and trying to store a water depends upon the height of the dam.

So because you store additional water, so basically for example, this is the river. So you construct here this one and try to store a water. So this will store a water this area. So this area will be like with 100 meter, 200 meter, 300 meter depth depends upon the valley, you store huge amount of the water which create a again a different pressure level in the below a ground.

If that area there is a weak rocks are present or faults are present, because of this imbalance that causes a seismic activity. That is called as a reservoir triggered earthquake. So from the Koyna, okay there was a Koyna earthquake. So they observed that the Koyna region whenever they fill the dam the number of seismic events are increased.

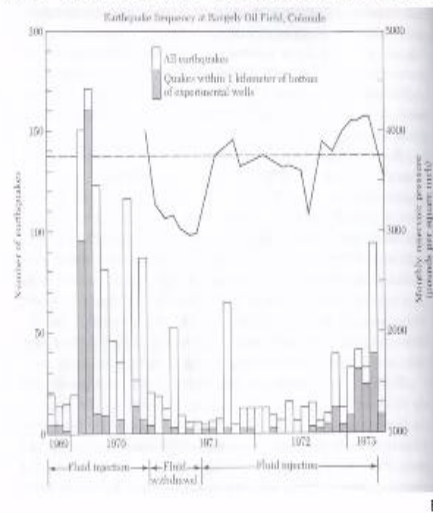
And once it was a big enough where there was a considerable damage was reported due to Koyna earthquake. So the Koyna earthquake basically, you can see this is actually the inflow in the year wise, reservoir level you can see there is a inflow and then become empty then inflow and all. So similarly the water level where you can see the level of the water with respect to the feet and the number of shocks.

So you can see that after filling you can see many number of shocks. After filling you will see a many number of shock. So after filling there is a many number of shocks, which indicate that this kind of imbalance can, but this is very peculiar phenomena. It is happening at only selected place. Not all the dam you will get a reservoir triggered earthquake. It depends upon the geological formation of the below dam area, okay.

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The effect water on the rock beneath the surface

- Fault Gouge



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So this earthquakes are very important because you can see the number of earthquakes and monthly reservoir pressure released by that. So this particular earthquake particularly on the Koyna region, so this earthquake was considerably high energy was released, where the nearby Koyna town many people died due to this Koyna earthquake, okay.

After that only the world realized that there is a need to understand the reservoir triggered earthquake and then based on that we can design our dam or people living with the dam area should be careful based on that. So this is the unique type of earthquake one can expect. So which can be grouped under the tectonic earthquake but it is mainly happens because of the storing of water at a particular place.

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Types based on Depth

- **Shallow focus** - Foci are less than 70 km depth. Most destructive earthquakes.
- **Intermediate focus** - Foci are between 70 and 300 km depth.
- **Deep focus** - Foci are greater than 300 km.
- About 90% of all earthquakes have depths < 100 km. Earthquakes can be grouped into three categories based on the depth of their foci:

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So then based on the depth you can classify a earthquake. So three categories. The shallow focus earthquake, intermediate focus earthquake and deep focus earthquake. Shallow means any earthquake which is occurring less than 70 kilometer is shallow focus earthquake. So intermediate means 70 to 300 kilometer intermediate. Any earthquakes are occurring above 300 kilometer is called as a deep focus earthquake.

So in the world about 90% of the all earthquakes which is having less than depth of 100 kilometer, which is more or less shallow focus earthquake, okay. So deep earthquakes are very rare.

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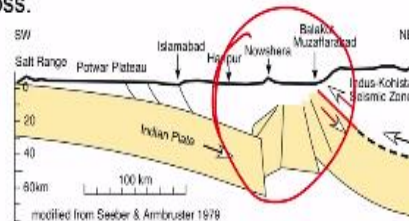
Types based on locations

- Based on location of epicenter, earthquakes are broadly divided into three

– **Interplate Earthquake:** An interplate earthquake is an earthquake that occurs at the boundary between two tectonic plates.

- About more than 80% of all earthquakes occur in this belt, including the world's most devastating in terms of life and property loss.

- Kashmir earthquake 8 October, 2005 Mw – 7.6
- Assam earthquake August 15, 1950 Mw – 8.6
- March 28, 1989, Chamoli earthquake Magnitude – 6.8
- Aug 21, 1988 Dihar Nepal Conder. Mw – 6.4
- October 20, 1991 Uttarkashi, Mw – 6.8



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So based on the location where the earthquakes are going to occur, you can divide. So based on the location means with respect to the a plate boundary and plate interior. So if the earthquakes are occurring, okay so in the edge of the plate or very close to the plate, that earthquake is called as a interplate earthquake. An interplate earthquake and earthquake that occurs boundary between the two tectonic plates.

About more than 80% of the earthquake occurs in the world are basically interplate earthquake. So basically our we discussed plate tectonic like Indian plate and there is the Hindu Kush seismic zone. So this junction whatever occurs is called as interplate earthquake.

So you can see that the Kashmir earthquake 2005, Assam earthquake 1950, and then the Somali earthquake 1999 and Bihar, Nepal earthquake in 1988 all are the classical example for the interplate earthquake, okay.

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- **Intraplate earthquake:** is an earthquake that occurs in the interior of a tectonic plate, whereas an interplate earthquake is one that occurs at a plate boundary.
 - The number of intraplate earthquakes are less when compared to interplate earthquakes.
 - Intraplate and Spreading Ridge Only about 5% of all earthquakes
 - A similar large earthquake, the 2001 Gujarat Earthquake, devastated the region of Gujarat, India, in 2001, resulting in a large loss of life especially in Kutch region.
 - 10km removed from the plate boundary
 - **Mid-plate earthquake:** the Intraplate often thousands of kilometers from plate boundaries that no relation to the divergent, convergent, or transform zones at plate boundary.

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So the earthquake which occurs in the boundary is called as a interplate earthquake. Earthquake which occurs away from the boundary is called as a intraplate earthquake. So it is basically occurs interior of the tectonic plate. The earthquake which occurs at the interior. Whereas the interplate earthquakes are occurring at the boundary of the place.

So the number of intraplate earthquakes are less when compared to the interplate earthquakes. So the intraplate earthquakes okay spreading ridge only about 5% of the all earthquake. Similar large earthquake, some of the major earthquake of intraplate earthquakes are Gujarat 2001 earthquake in the Kutch region. So where which was actually very away from that.

So generally if you want to say intraplate earthquake, earthquake 10 kilometer removed from the plate boundary, okay. So away from 10 kilometer only. So there are earthquake which is happening middle of the plate, okay. So the mid-plate earthquake, which is called as a mid-pate earthquake. So the intraplate often thousands of kilometer from the plate boundary no relation to the divergent, convergent, transform boundary of plate is called as a mid-plate earthquake.

So any earthquake, which happens thousand kilometer away from the plate boundary is called as a mid-plate earthquake. This happens in the very large plate kind of setups. So if you look at the Indian geological formation, so we can see that the earthquake which is happening on the Himalayan region, the plate boundary of the Himalayan regions are called as a interplate earthquake.

So earthquake which is happening at the Bhuj region and then the Bangalore or anywhere in the southern India is called as a intraplate earthquake, okay. So those are all the way we can differentiate inter and intraplate. Why because these seismic signals are completely different okay. So we have to know what type of earthquake we have to understand and estimate hazard for that. So this is the way we can classify a earthquake.

So which is essential basically when we talk about a region and where we are going to estimate a seismic hazard depends on that we should know that what type of earthquake we are going to expect. So it is a shallow focus earthquake or interplate earthquake or intraplate earthquake or mid-plate earthquake or reservoir triggered earthquake or a tectonic earthquake.

So these are all the way you should try to understand. For example, if you are willing to install a very sensitive equipment close to the Kolar zone, then one has to consider a the mine created earthquake like which is called as a collapsible earthquake into account. So that is why you need to know why the types of earthquake and what are the different type of earthquake we have to understand.

So with that, so we will close this class, okay. So we will be continue next class on how this earthquakes can causes a seismic waves, how we can understand the seismic wave like theory of wave propagation and then how the wave propagation can be used effectively to identify the earth interior in the coming classes. So today class we have studied about the type of earthquake which is very important to describe what type of earthquake.

You cannot classify everything as a earthquake, okay. So you have to specifically say that it is tectonic earthquake or collapsible earthquake or volcanic earthquake or impact earthquake or reservoir induced earthquake. Thank you.