Introduction to Engineering Seismology
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Lecture - 05
Earthquake Terminologies

So vanakkam. So we will start our continuation of the engineering seismology lectures. So last class we discussed about the different earthquake hazard okay. So that is like different earthquake hazards, okay means the hazard caused by the earthquake. So we have seen basically about seven hazards. So we also discussed about the how this earthquake hazards are distributed in the world due to the deadly earthquake.

We have seen the deadly earthquake basically the earthquake which caused more than death of 10 okay. Those are all the earthquakes are called so deadly earthquake. So we have noticed that okay so most of the deadly earthquakes are due to the direct ground shaking okay. So the estimation of the direct ground shakings are the prime important.

So then we also seen that the including the tsunami 2004 tsunami earthquake in the calculation and excluding the 2004 tsunami in the earthquake in the calculation. So we have seen that including of tsunami basically the percentage of the share by the tsunami is increased excluding is actually it is less. So if you remove that direct ground shaking hazard we also noticed that the tsunami hazard basically caused huge amount of the death okay and economic losses.

So which due to the 2004 tsunami mainly we understand, okay. So if you want to minimize the human and economic loss due to earthquake is basically you should know how to estimate this earthquake hazards, okay. So I basically do research on estimating this earthquake hazard specific to region. So most of my research okay so focusing on that basically I did my B.Tech project M.Tech project and the PhD on this earthquake hazard estimations, okay.

So I can proudly say that I am the one of the leading expert in this area. So where I the estimation done by my team and my research group is more reliable. We also come up with several new things, which is more suitable for a particular region, which is not applicable for universal kind of system.

So particularly India, we tried to bring the regional scale and national scale implementation of accurate prediction of the earthquake hazard. My team is actually working towards that. I published large number of papers. So those who wish to know about my research on this area, please google it Prof. Anbazhagan IISC, then you will find my website. From there, you can go to my personal publication list.

You can find all my published papers on this, okay where I work then the earthquake. So I felt after I mean the Bhuj 2001 earthquake myself that I should work on this area and try to contribute whatever way is possible. So that is why I choosen the my first B.Tech project itself on liquefaction assessment of the Asian game site at Delhi. So that is more or less the time period where before or the Bhuj earthquake time.

Many people even not about knowing many earthquake hazard parameters in the country. So where I started and we read, we did some project. Then I continued my MA project as a seismic microzonation of Chennai. So then I continued the seismic microzonation with enhanced knowledge and technical experience for the Bangalore. With that I completed my PhD. I become a faculty in IISC.

So I try to work on this area, try to establish myself on development of theoretical knowledge and experimental knowledge. So where I do have all facilities to predict all this earthquake hazards precisely particularly ground shaking. So right now, I have not done any work on the landslide and tsunami hazard as I had no opportunity to work on that.

But ground shaking I predominantly work where I predict very accurately liquefaction, very accurately amplification, very accurately the direct ground shaking. So this will help you to reduce this one. So this experience of this knowledge exchange started within me. So the similar way okay, so people after experiencing the

earthquake damages in the historic times okay people try to understand this earthquake okay.

How the earthquakes are happening, why it is happening, how to minimize. So if you want to see the how the engineering seismology itself started in history back, we have to go back to the how people felt on the earthquake. So the earthquake basically, those days are very problematic in the places where people are living close to the coast, particularly place like Japan, where they experience lot of frequent tsunamis.

So people in those places they try to see the tsunami waves are killing us. Why the tsunamis are occurring. So what they felt in olden days okay.

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Fishmongers selling flesh from a *namazu* (catfish), whose excessive movement they believe caused the large Edo (Tokyo) earthquake and killed it. The people complain of the profiteering from their tragedy.

So olden days what they felt basically. So they see that, okay, so the tsunamis are occurring okay. So or they believed that the tsunamis are occurring due to the excess movement of the a particular fish in the sea. It is called as a namazu okay, which is basically a catfish okay, so the catfish family. So this excessive movement is basically causes a earthquake in this region.

They believed that. So because of that they tried to kill this fish, okay. So you can see that this fish mongers selling a flesh from the namazu whose excessive movement, they believe caused the large Edo; Edo is earthquake in Japan, so killed it. The people complained profiteering from their tragedy. So people believed that catching of this fish and killing will reduce the tsunami effect or earthquake effect.

So anyway this concept is more or less true. And you can also see the similar practice now. Japan is the only country where they kill very big fish when compared to any other part in the world. So the rest of the world for example India people do not eat fish beyond some size okay but in Japan they kill a big fish okay and then cut it as a pieces and eat okay. That is how that practice still exist even though the fish is nowhere responsible for the earthquake.

After understanding of earthquake people are understood that nowhere relate fish and earthquake. Even maybe recently there was a news they told that there was some fish which is staying below the sea okay very deep floor level has appeared in the coast which may do to the future there may be big earthquake kind of thing they expected. This was reported maybe back to like two, three months.

But there is no big earthquake as of now. So there may not be direct relation between the this fish with the earthquake. But one thing we should very clear that when the animals are very sensitive, okay, including us very sensitive to the unusual situation around us. So particularly may when this earthquakes are going to happen this animals are able to sense them in advance and try to shelter them themselves.

So we do add that kind of sense, but due to our technology development, less usage of our brain and then the our sense, we basically not able to sense the this kind of hazard. But animals are capable of sensing that. So the animals it is well proved that animals are behave differently when earthquake going to occur, okay. So if you watch the animal behavior continuously, one can predict a earthquake.

But the problem is that how that particular animal is behaved for the last earthquake and then how it will behave for the next earthquake. Somebody has a history and study then you can use animal to predict the earthquake, okay. So particularly, most of you may be seeing the movie Dasavadharam, okay. So I generally quote some of the classical example which is directly related to the subject.

So during the Dasavadharam movie actually in the climax scene, okay before tsunami going to come, so you can see that they show the birds are moving away from the shore okay. So the birds are moving away from the seashore okay.

And that is not only the movies clippings, there are report, physical reports are found before tsunami wave going to come most of the animal which are tied and holded on some shed, tried to escape okay, by forcefully, okay. It tried to move by pulling that tie and all those things it tried to move away from the coast. That means it sensed that there is a tsunami going to come on that particular place.

The same way this fishes maybe sense the earthquake before and due to that it may be come to the shore and moving regularly okay to escape from the tsunami effect or whatever. This this people might have been watched and misunderstood that movement of this fish causing a earthquake okay. So that is why they tried to kill the earthquake.

This is how the human start understanding the engineering seismology subject, okay which is called as a early engineering seismology knowledge.

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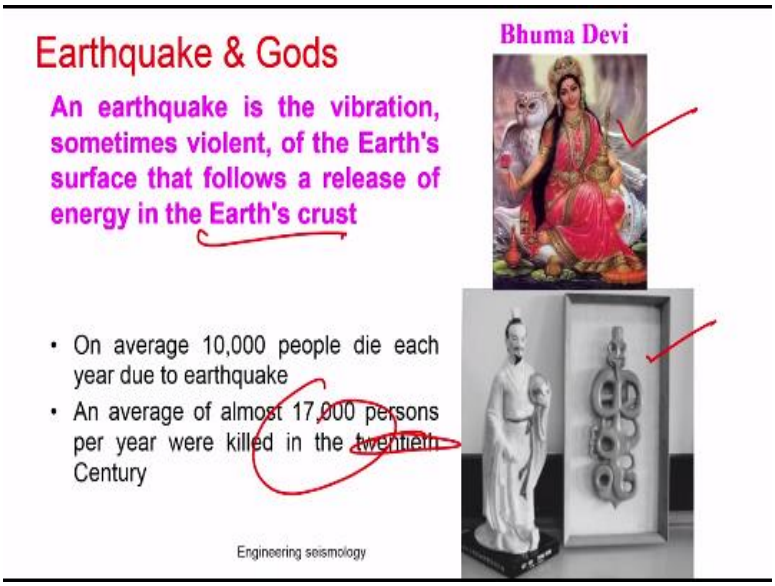

So then later they also as you know that, anything which is not controllable by us, we will make that as a God, okay. So as you know that the earthquake also we have the God called Bhuma Devi, who is responsible for the earth and earth rotation and splitting of earth.

So we used to say that if the Bhuma Devi is angry she will split a earth and you will go inside okay. Our forefather used to curse us or they used to tell know. So she is a woman God which is responsible for the earth and earthquake. The similar way okay the Chinese, those days actually the Japan, China and most of the Chinese regions are together so they also add a Chinese God okay for a earthquake.

Basically this is a Chinese God for a earthquake, you can see okay. So this is a God they use to worship from the save from earthquake. So this is our God where we worship a Bhuma Devi to get good things from the earth and to avoid bad things from the earth okay. So this is the God for basically earthquake. So basically what is mean by earthquake?

So the earthquake is basically a vibration, sometimes violent of the earth surface that follows a release of energy in the earth crust okay. You should note earth. So there is a release of energy in the earth crust, which is basically causes a vibration at different places. So that is called as a earthquake. So why we need to worry about earthquake? On average 10,000 people die each year due to earthquake on average throughout the world.

On average almost 17,000 person per year were killed in the 20th century due to the earthquake. So this was actually increased in the 20th century the number is gone high okay. So that is where we need to understand a earthquake scientifically and try to predict earthquake hazards.

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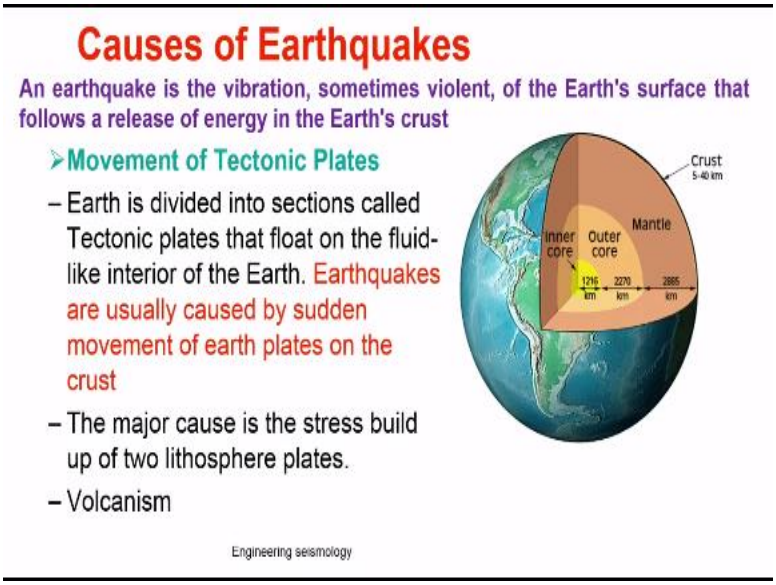

So if you want to understand earthquake first you have to understand earth. So most of you may be studied that the earth is a sphere which consist of the different layer. So when we have talked in the last slide, we told that it is undergo a crust we said. So in the earth basically it has a four different major layers or you can say that the if you divide cut a earthquake, earth as a piece you can see a group the material present in the earth as a four different layers okay.

So one is that the inner core which is having the radius of about 1260. The second one is outer core, which is 2270 kilometer. The next one is mantle, which is 2885 kilometer. The last one where you are resting or you are living is the crust, which varies from 5 to 40 kilometer. So generally this crust basically divided as a different segment which is called as a plates, okay.

So the movement of this segment basically is causes a earthquake, okay. That we are going to understand how the this earthquakes are occurring and why it is occurring. So the movement of this crest which divided as a different plate, okay is called as a so the plate movement. And this division of this plate and then understanding of that, okay is called as a tectonic plate studies, okay.

So the earth is divided into section called tectonic plates that float on a fluid like a interior of the earth. Basically the outer okay, the inner core and mantle. So these are all the composite materials, which is softer than the earth crust. So the earth crust

basically is the order material. So when compared to earth crust the material below that is basically softer or it is kind of fluid kind of things.

So fluid means not like water. Even you can see that like mercury also is a fluid okay. So that kind of a thick okay metal which is having the kind of this one. So the fluid called as a magma okay. So this earth crust sitting top up this magma which may be outer core or inner core or mantle depends upon the thickness of the plate and depth of the plate.

So the earthquakes are usually causes a sudden movement of this plate hitting each other or separating each other and the energy stored in that place is released, okay. That causes a vibration, okay. That stress built up is. So major cause of the stress built up the two lithosphere actually is causing a earthquake or movement of the tectonic plates.

So then the second is also volcanism like release of this the inner core materials okay, the magma to the this one causes a volcano. That also causes a earthquake. So the plate tectonic is a major causes of the earthquake.

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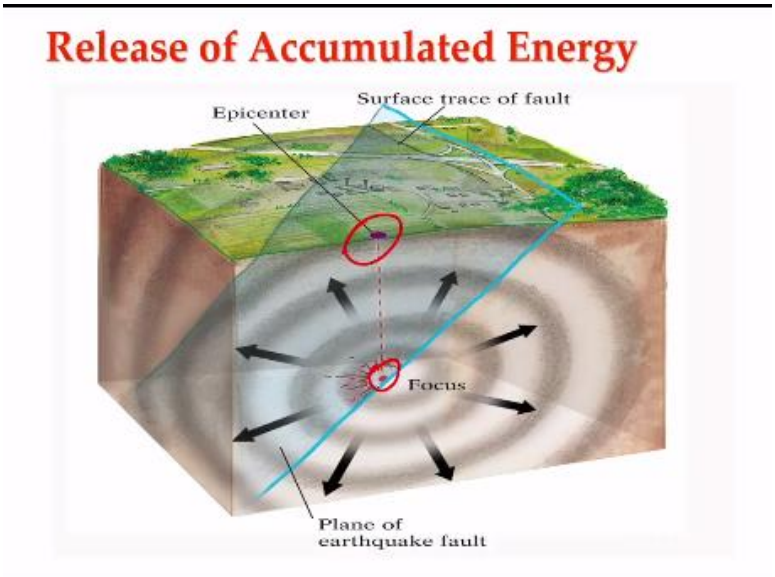

So this you can understand by why it releases energy. You look at very carefully this figure. So as we said that the crust is different plates are formed okay, the tectonic plates. So those plates keep moving because the earth is keep rotating correct. So this

movement basically causes a some kind of strain induced in that particular material, okay. So for example so this is a material.

So I try to bend okay, like this I try to bend. So where because I apply some stress, because the earth is bending, rotating, stress. So when I apply the stress, basically there is a resistance offered from this material. So this resistance okay try to compensate the applied energy okay. So that applied energy is more than the resistance of the material then it breaks. Due to breakage you will find there is a release of energy.

Because the whatever the material has the energy will try to release. That releases a vibration that causes a earthquake. So the point at which where the this occurs is called as a focus. The point at which where it occurs is called as a focus. The point where it occurs, okay that plane is called as a fault plane, okay. So the projection of that point in the surface is called as a epicenter.

So this is if you talk in the earth size okay, it is not a small point. It is a bigger surface or bigger area that is called as a surface trace fault or fault plane okay. We will discuss that in detail in the later of this class.

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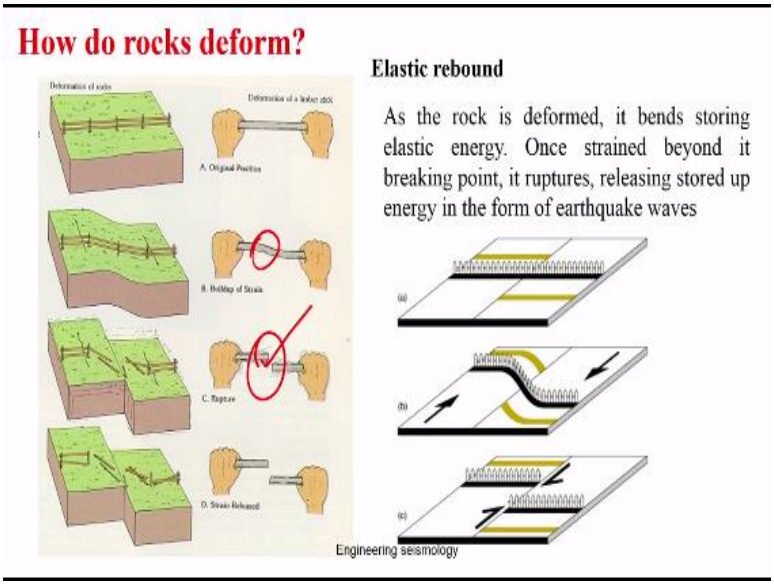

So if you want to understand whatever I explained right now in detail, so you take a typical rod, okay you can take a typical rod or a stick. You try to push it each other. So which indicate that basically you are trying to apply a force okay. So you try to

push it each other. So when you are pushing that basically you are applying a external force to the this one. So this is you assume that a plate, a single plate or a plate this one you apply a force.

So because the material has some internal resistance it tried to resist. So when the applied force is okay so going beyond the material strength it breaks okay. Then it breaks it become a two section that during the break there is a release of energy. That you call it as a earthquake. That energy carries a vibration waves to the ground. So as you know that as we told that the top surface of the earth is crust, which is very thick rock and soil formation.

So due to rotation of this earth this individual section plates undergo a stress okay or undergo a stain which is keep accumulating slowly. Because instead of applying the force suddenly you tried slowly bend okay. So it start accumulating. At one point of time the induced the force due to the this earth rotation and external means, okay exceed the strength of that particular rock material present in that location.

Then when it exceed obviously it has to break, okay. So that is what happens here. You can see it breaks. So when it breaks basically the energy releases and the broken piece become a two normal pieces okay. Then that try to again store a energy. So these sequences are keep happening. That is why the plates numbers are keep changing with million years.

It does not happen in our period of life because we average live around 60 to 80 years maximum okay? It does not happen. This is all geological period. Geological period means you should count your life is nothing in the geological period. Geological period is million years, trillion years. So those are all the geological periods where this kind of deformations are occurring and plates are breaking and joining and together and causing a earthquake.

So you can see most of the beautiful features in the earth surface. Today all those things are due to earthquake, okay. Starting from your Himalayan region, beautiful rivers, beautiful valleys, all those things are due to the natural hazard of earthquake. Earthquake only creates, breaks and then displays and then compose. So all the

phenomena earth does. So the formation of understanding of how the earthquake are occurring is called as a elastic rebound theory.

So you apply a force okay. So the force exceeding the material capacity like plate strength or rock strength. Then when it breaks that energy stored in that will be released and causing a earthquake. Then the plate became a two pieces. That keep continuing okay.

So if you understand this, okay from this, it is very clear that if one somebody knows what is the strength of material at particular depth and what was the accumulation due to the rotation of the earth, if you relate both of them you could able to predict a earthquake. But unfortunately the strength of rock is what we told was it varies from, crust thickness varies from 4 to 50 kilometer, 100 kilometer, 200 kilometer depends upon the place.

So knowing of strength of rock at 100 kilometer, 200 kilometer is not that easy, okay. So measuring how much strain energy built there due to rotation if you know today what is the strain energy and what was the rate of strain energy is occurring. So okay then if we relate that and this and when it can break when it can cause earthquake one can predict. But knowing and measuring that is not that easy.

It needs a huge amount of the investment as well as the technological development itself. As on now, the man can able to drill only up to maybe 2 kilometer or maximum 5 kilometer kind of things, not beyond that. But you have to know the strength of material at a minimum 10 kilometer, 5 kilometer, 15 kilometer or 100 kilometer depends upon the location where this deformations are occurring okay. So if you know that there is a possibility to predict a earthquake.

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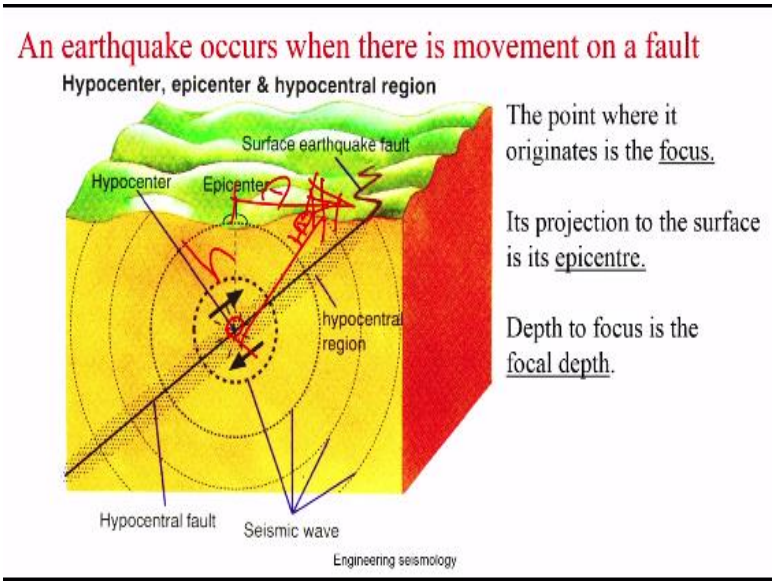

So with that, so we understand that the earthquake is actually a vibration caused by the release of energy due to breakage of the rocks okay. So then the point at which where the earthquake origin is called as a focus. The projection of that point to the surface is called as a epicenter okay.

So if you have the location where you talk that with respect to the particular place, okay then you can bring in the concept of hypocenter or hypodistance okay. So for example, so I have the so I have the house here or station here, okay. So this is my focus point or the hypocenter. This is the epicenter. The distance of this is actually epicenter, a distance of this is called hypocenter okay.

This is D, this is HD hypocenter. This is the depth of earthquake okay. So these are all the waves how the seismic waves get generated and propagates in the typical earth sections.

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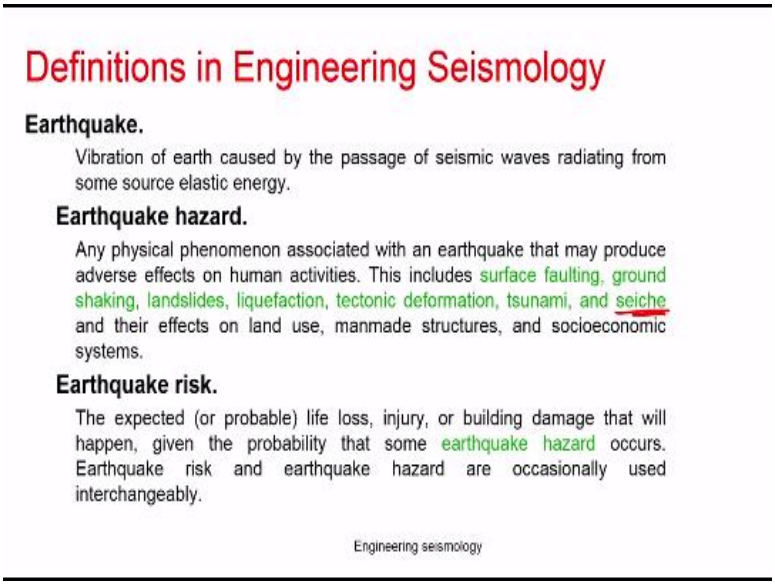

So before going to the study more about the earthquake we will try to understand some of the terms which we will be frequently using in the subject, the definitions in the engineering seismology. So I will be defining this whenever we discuss also. But overall we will see that so that whenever I talk this word, you should not I mean you should know what I am talking okay.

So the earthquake is actually the vibration of the earth caused by the passage of seismic waves radiating from the some source of elastic energy is the earthquake. So the earthquake hazard is any physical phenomena associated with earthquake that may produce adverse effect on human activities. This includes surface faulting, okay.

The surface faulting is basically the ground displacement at the surface, the ground shaking, landslide, liquefaction, tectonic deformation, tsunami and seiches and their effect on land use. The manmade structures are socioeconomical problem. So anything which causes a risk or hazardous situation to the human is called as a earthquake hazard. So here we define a this one, seiche.

This is actually the tsunami waves comes under the water body. So water body means, you know that in western countries and all they have the very big lake. So if the lake the earthquakes are occurring you will get a tsunami kind of wave which is not called as a tsunami, only the sea waves are called as a tsunami. These waves are called as a seiche, okay. So then the earthquake risk.

The earthquake risk is defined as expected or probable life loss, injuries or building damage will happen and given probability of the some earthquake hazard. If some earthquake hazard is happening how much the human and economic loss is actually the earthquake risk okay. The earthquake risk and earthquake hazards are occasionally used interchangeably.

Many people mention earthquake risk as a earthquake hazard, earthquake hazard as a risk. So the risk is basically a probable life loss and economic loss due to the earthquake hazard is actually earthquake risk. So you should not interchangeably use it. But people interchangeably use. Not only this I will also tell you how the news and other people use the quantification of the earthquake interchangeably when we are talking about the quantification of earthquake section, okay.

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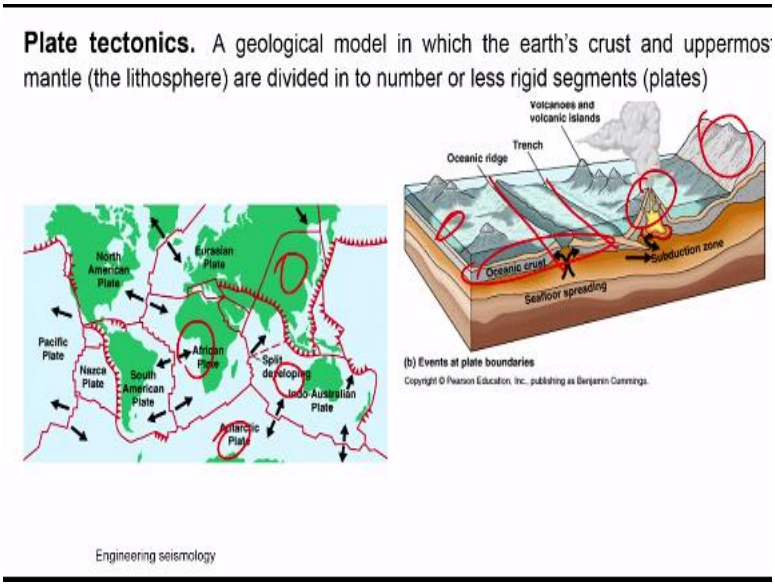

So the plate tectonic is one of the responsible major source of earthquake. Why because most of the this breakage of plate and releasing of energy happens at joints or it is happened it become a joint. So because of that, so the joints okay the geological model which earth crust, the uppermost mantle or lithosphere divided into number of less rigid segments is called as a plate.

So each plate you can see this plate how this moves, how this plate moves, how this plate moves, how this plate moves. So each plate moves its own direction is depends upon the position and the rotation speed of the earth, okay. So the earth rotation speed, the magnetic force all those things also contribute to the this kind of hazard. So

you can see if you make a the cut earth as a difference part of section so basically this is your upper crust.

This is very responsible for the earthquake where you can see the this oceanic ridge, the trench okay, then volcanoes and hills and valleys and landforms. So these are all the common features you can see in the surface of the earth, which is basically occurring due to the breakage and movement of this plate, which is causing a earthquake.

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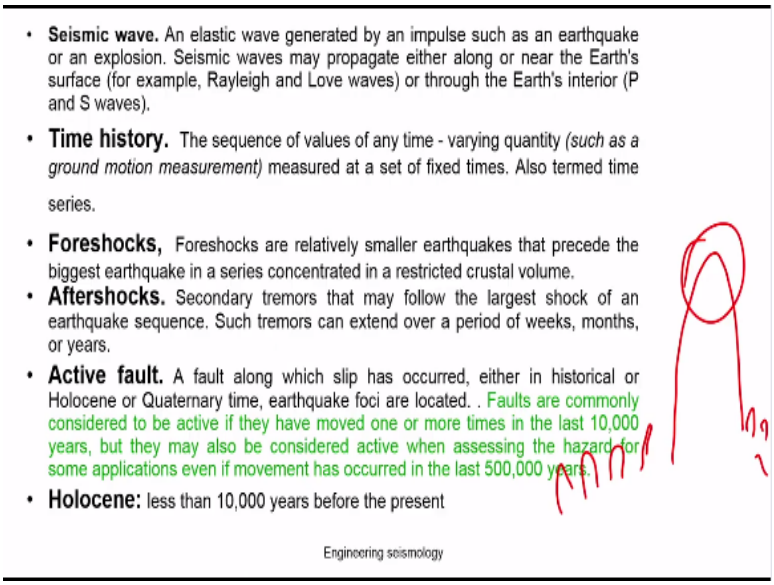

So the seismic waves, the seismic wave is defined as elastic wave generated by a impulse of such as an earthquake or explosion. The seismic waves propagate either along or near the earth surface. For example, the Rayleigh and Love wave and the surface waves through the earth interiors P and S wave or the body wave. So we will be discussing this in detail in the future classes.

The time history, the sequence of the value of any time is called as a time history. So the varying quantities such as a ground motion measurement, measured at a set of fixed time and also termed as a time series. So the time history means the varying quantity with time is represented as a time history. When the seismic waves comes basically, you can see the displacement of the ground or where you can say that in the form of velocity or in the form of acceleration.

If you say the acceleration versus time or velocity versus time or displacement versus time that is called as a time history. So that means, you can get acceleration time history, displacement time history and velocity time history due to the earthquake you can able to measure okay. The foreshock, the foreshocks are the relatively a smaller earthquake that precede the biggest earthquake series concerned in the restricted crustal volume.

In a given location there may be a smaller earthquakes are occurring before big earthquake. Those earthquakes are called as a foreshock. So after shock is basically a secondary tremor that may follow a largest shock on a earthquake sequence. Such tremors can extend over a period of week or month or year. So here, so you understand what is the earthquake and what is the foreshock and what is the aftershock.

So I can say that a this is your big earthquake going to occur. So these kind of smaller events are the your foreshock. The same thing after this whatever occurring is the called the aftershock. So why these things are very important? So why these things are very important? So you may be knowing that very recently there was a article that there was a smaller magnitude of earthquakes are occurring close to the Delhi region.

So this may be the foreshock. But the problem is that we do not know how many months or how many days or how many years before the foreshock can happen, okay. So that period sequence depends upon the region and several things, geological force involved in that kind of earthquake and thickness of the plate. So because of that even though foreshocks are recorded, we are not able to precisely predict a main earthquake, okay.

So that was the one of the knowledge you should have what is meant by the foreshock, what is meant by the aftershock. So the next is active fault. The fault along which the slip has occurred either historical or Holocene or Quaternary time the earthquake foci are located that called as a active fault. So the fault commonly considered to be active if they have movement one or more times in the last 10,000 years.

But there may be also consider active and assessing the hazard of some application even if the movement occurred in the last five lakhs years. So that means any movement occurred at a particular place okay, in the five lakh years you should consider that fault is active depends upon the what kind of hazard you want to predict or what for you are going to predict hazard.

For example, if I want to predict a hazard for construction of the my house, okay. So that for 10,000 years movement will be sufficient. Why because my house structure going to stay maximum of 50 years, not beyond that, okay. So but if I want to and even if that occurs only I will collapse my house only I will die and within my family members will die.

But if you are looking for the earthquake hazard for the nuclear power plant or dam, okay. Those are all the places where huge amount of the so water is stored and then the as you know that the nuclear power plant there is a radioactive material which is never die as its half-life period itself very large. So those kind of material if that breaks and release it causes a adverse effect.

If you are looking for hazard prediction of those kind of facilities, you should look for the active fault, which has any movement on five lakh years, okay. How do you find out this there is any movement or not. So you should basically dig and cut and take a material and carbon date it and if you find there is a contrast materials within the short section, which indicates that there is a movement and fast earthquake which caused these kind of things.

The Holocene is a period less than 10,000 years before the present is the Holocene period.

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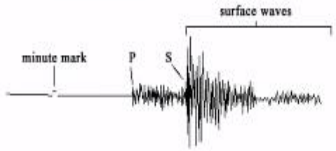
- **Quaternary time:** about 2 million years before the present
- **Seismicity.** The geographic and historical distribution of earthquakes.
- **Seismogram.** A record written by a seismograph in response to ground motions produced by an earthquake, explosion, or other ground-motion sources.



- **Seismometer or seismograph.** A seismometer is a damped oscillating mass, such as a damped mass-spring system, used to detect seismic-wave energy.
- **Accelerogram.** The record from an accelerograph showing ground acceleration as a function of time.
- **Accelerograph:** A compact, rugged, and relatively inexpensive instrument that records the signal from an accelerometer. Film is the most common recording medium.

Engineering seismology

So the quaternary time. So about 2 million years before the present is the quaternary time. The seismicity is basically the geography and historical distribution of the earthquake. So you should know what is the definition of seismicity. Seismicity means basically you plot earthquake data geographically okay and see the distribution of the earthquake, historic earthquake is called as a seismicity.

So the seismogram the record returned by the seismograph, the response of the ground motion produced by earthquake or explosion or any other ground motion source is called as seismograph. So seismogram is actually a plot, graph is instrument. You should not get confused with the graph and gram. Gram means is basically recorded data by the seismograph, okay.

So seismometer or seismograph is the instrument okay could able to record a vibration or seismic signal okay. A seismometer is a damped oscillating mass such as a damped mass spring system used to detect seismic wave energy, okay or seismic waves okay. That is a seismometer or seismograph. So this seismometer or seismogram is generally it can record velocity or acceleration or displacement.

Specifically it focused on the velocity okay so measurement is called as a seismometer. If you record only acceleration okay, so or when you specify only acceleration. So if the record which shows acceleration versus time or detect acceleration at a particular location that is called as a accelerogram. A record of a accelerograph okay is called as a accelerogram.

So the accelerograph is a compact rugged relative inexpensive instrument which can record a signal of acceleration okay. So the accelerometer it is also called as accelerometer where it can record what is the acceleration due to that particular vibration is called as a accelerograph.

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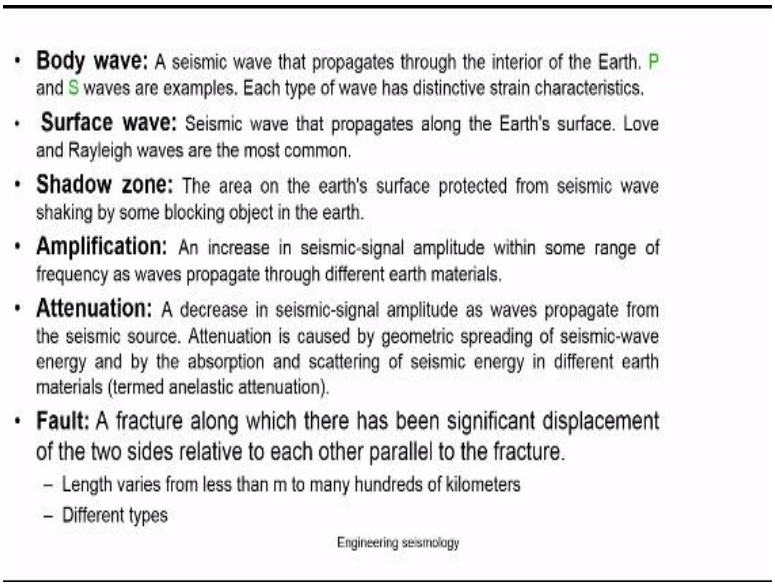

So the waves we have seen the seismic waves know, waves which is produced. So the seismic wave basically two type of seismic wave. One is the body wave. The seismic wave that propagates through a interior of the earth, such as a P and S wave are the example. The each type of wave has distinct strain characteristics okay, is called as a body wave.

So the surface wave seismic wave that propagates along the Earth's surface, the Love and Rayleigh wave is called as a surface wave. So we will be discussing this in detail and the theory of wave propagation and wave propagation properties. So the amplification and increase in the seismic signal amplitude with some range of frequency as the wave propagates through a different earth material which we have seen.

The amplification hazard we have seen no. Like that the increasing in the wave, seismic wave is called as a amplification. The decrease in the seismic wave, okay the wave like the wave amplitude, duration, or frequency is called as a attenuation. So a decrease of seismic signal amplitude as the wave propagates from the seismic source.

The attenuation caused by the geometric spreading of seismic wave and energy and by absorption and scattering of seismic wave in the different earth material. The fault a fracture along with there has been a significant displacement of two side relative to each other and parallel to the fracture is called as a fault. So the fault basically is a seismic event source or earthquake source is actually a fault plane or fault. The length varies from less than meter to the many 100 kilometers.

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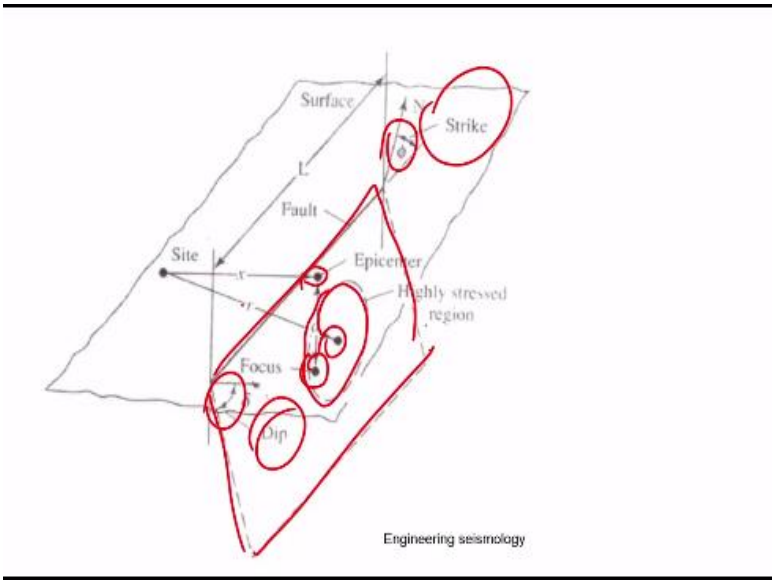

And there are different type of faults are there which we will be discussing. So again if you see that the how the fault like this is basically a fault plane. You can see this is the fault plane okay. So this point basically your focus. So the surface projection is basically epicenter. The focus also called as a hypocenter. The distance between this is hypocentral distance. This is epicenter distance.

So the fault projected at surface is called as a length of the fault. If the length remains same at surface and deeper level okay. So when you make the fault plane projected up to surface and then you draw a vertical line and measure a angle. That angle is called as a dip. The fault plane which makes angle with north direction is called as a strike. You can see dip and strike the angle responsible and this.

So these are all the terms which we will be using frequently. So basically this is the focus. So this is the hypocentral distance. This is the epicenter, epicentral distance. So

this is zone where the rupture is taking place which is called as a highly stressed region or rupture area.

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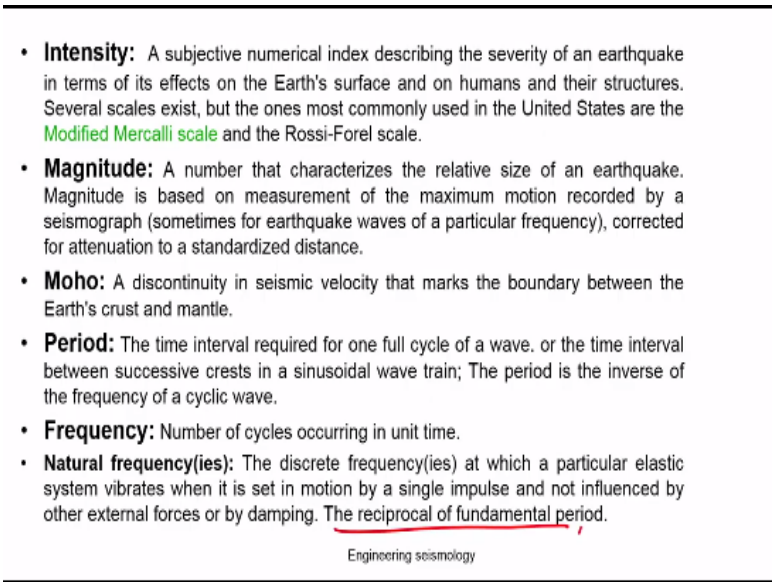

So the intensity, the intensity magnitude are the way you can express a earthquake okay, so quantify a earthquake. Intensity as a subjective numerical index describing the severity of the earthquake in terms of its effect on the earth's surface on human their structures. So the several scale exists, but one most commonly used in the United States are Modified Mercalli intensity scale or Rossi-Forel scale.

So we will be discussing about the intensity in detail in the one of the classes. So the magnitude a number that characterize the relative size of the earthquake. Magnitude is based on the measurement of the maximum motion recorded by the seismograph, okay. The sometime earthquake waves of particular frequency corrected for attenuation and standardized distance.

So the intensity and magnitude are basically measurement of the earthquake or indicative size of the earthquake. So the magnitude based on the actual record of the seismic record after development of the seismic instrument. Intensity also quantitive but it is only based on the damage. It is not based on the measurement. Moho is a discontinuity of the seismic velocity that marks boundary between the earth crust and mantle.

So Moho is actually a discontinuity between the earth crust and mantle is called as a Moho. The period, the time interval required one full cycle of the wave or the time interval between the successive crests of the sinusoidal wave train is called as a period. We will be discussing all those things in detail. Frequency, a number of cycle occurring in the unit time.

The natural frequency, a discrete frequencies that which the particular elastic system vibrates okay set to motion a single pulse not influenced by the other external forces or by damping is called as a natural frequency. So the reciprocal of this reciprocal of natural frequency is actually a fundamental period, okay. So this you should know.

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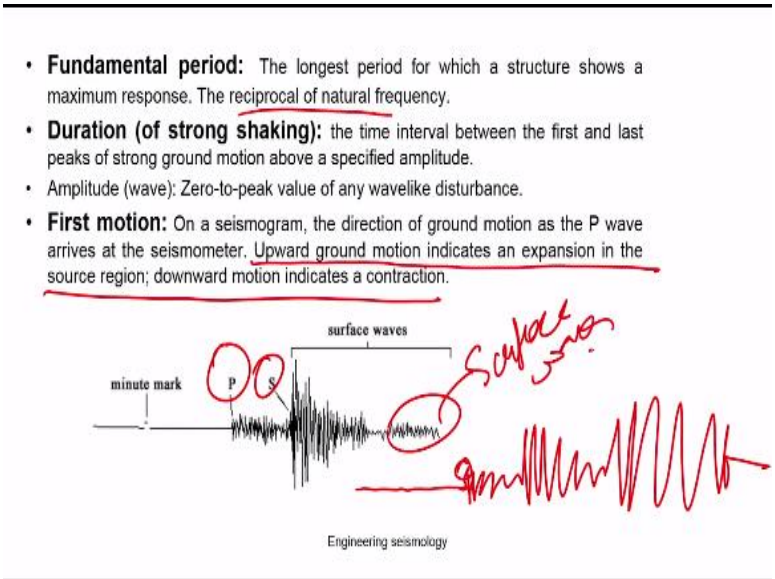

So the fundamental period the longest period for which the structure show a maximum response, or reciprocal of natural frequency is the fundamental period. Duration, a time interval between the first and last peak of the shaking ground motion is the duration. Amplitude is the wave zero-to-peak value is called as a amplitude wave like disturbance.

The first motion on a seismogram that direct ground motion as a P wave arrive in the seismometer. The upward ground motion indicates expansion of the source region and downward movement indicates contraction. So these details are required to know that the whatever waves recorded in the seismogram is compression wave or tension wave. So if you look at a typical earthquake recorded at particular place, you can see like this.

So basically the when there is no earthquake like this, you will have the straight line movement. Then when the earthquakes are occurring so first you will experience a P wave okay. So then you will experience a S wave. So then followed by you will also experience a surface wave depends upon the location. This is a typical earthquake plot where you can see P, S okay waves and followed by the surface wave.

So this wave amplitude and the amplitude wave height depends upon the where instrument and earthquake origin is located, the distance between that. Some places you can see P wave is very high, some place you can see S wave is very high, some place you can see surface waves are very high, surface waves are very high at some places.

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- **Isoseismal:** Refering to a line on a map bounding points of equal intensity for a particular earthquake.
- **Seismic zonation:** Geographic delineation of areas having different potentials for hazardous effects from future earthquakes. Seismic zonation can be done at any scale - national, regional, local, or site.
- **Source:** (1) The geologic structure that generates a particular earthquake. (2) The explosion used to generate acoustic or seismic waves.
- **Fourier amplitude spectrum:** The relative amplitude at different component frequencies that are derived from a time history by Fourier analysis.
- **Geodetic:** Referring to the determination of the size and shape of the Earth and the precise location of points on its surface.
- **Paleoseismic:** Referring to the prehistoric seismic record as inferred from young geologic sediments.
- **Seiche:** Oscillation of the surface of an enclosed body of water owing to earthquake shaking.
- **Stress drop:** The difference between the stress across a fault before and after an earthquake.
  - A parameter in many models of the earthquake source that has a bearing on the level of high-frequency shaking that the fault radiates. Commonly stated in units termed bars or megapascals (1 bar equals 1 kg/cm2, and 1 megapascal equals 10 bars).

Engineering seismology

So Isoseismal referring to the line on map bounding points of equal intensity particular earthquake. So isoseismal is actually if you connect all the equal intensity at particular earthquake, that is called as a isoseismal. So the mapping of all intensity isoseismal lines is called as a isoseismal map or intensity map.

Seismic zonation basically is a geographical delineation of the area having different potential for hazardous effect of the future earthquake. So the seismic zone, last class I told you that Indian seismic code present is not up to state of art knowledge. So the seismic zonation should consider all the different earthquake hazard in the region and map those hazard and group them based on the similarities, okay.

That is called as a seismic zonation. Seismic zonation can be done at any scale, national, regional, local, and site scale. The source the geological structure that generate a particular earthquake, the explosion used to generate a acoustic or seismic wave is called as a source. So as we said that earthquake is a vibration. So if it is the natural one it is a geological based tectonic earthquakes.

If it is the manmade one it may be due to the explosion. The Fourier amplitude spectrum the relative amplitude at different component of frequency that are derived from the time history of the Fourier analysis is called as a Fourier amplitude spectrum. Geodetic okay is the referring to the determination of size and shape of the earth, precise location points its surface is called geodetic.

Paleoseismic is actually I told you that paleoseismology study on last class. So paleoseismic is referring to the prehistoric seismic record as inferred from the young geological sediment. So studying the old earthquake is called as a paleoseismic based on the geological deposit aging. Sieches, I told that oscillating of surface of the enclosed body of water owing to the earthquake shaking, okay.

Tsunami in the enclosed body is called as a sieche, is not a tsunami. Stress drop, the difference between the stress across a fault before and after earthquake is called as a stress drop. This stress drop is specific to region. So before earthquake and after earthquake what is the stress difference is called as a stress drop. So because of due to the release of energy.

That is depends upon the region. Some location will have the very high, some location will have the very low, which will be useful. We will discuss in the source characterization time. So with this definitions you should go through all of them. We will also frequently define and use this definition. So we close this class. So these definitions you need to know so that whenever we refer and we discuss you should be aware okay.

So to this class we basically discussed about the what is meant by earthquake and how earthquakes are understand in the historic time. That is a earlier engineering

seismology, okay. We have seen that people used to kill a namazu fish in Japan assuming that the fish movement will cause the earthquake, okay. The fish might have moved due to the earthquake but not caused the earthquake, okay.

So then we tried to understand how the earth interior and which causes a earthquake. So we basically elastic rebound theory okay. So which gives a clear idea how the earthquakes are occurring. So by knowing this now, I have the question for you. So can earthquake occur at specific place or earthquake can be expected anywhere in the world, okay. Can I say that a particular place I cannot expect earthquake by knowing the elastic rebound theory.

So that is the question. You think and try to come back with the answer on next class. While starting the class I will tell you what is the answer. So with that I thank you. We will see in the next class.