Introduction to Engineering Seismology
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Lecture – 37
Earthquake Prediction

So, vanakkam. So we have been recapped all the lectures what we discussed so far in the last couple of classes. So that is you to enable to understand the earthquake, the importance and also how we measure and what is a parameters we are looking for the design to prevent earthquake disaster, okay. So, if you look at overall all the discussion what we made. So the major things we look at as a size of the earthquake basically a magnitude okay.

So, the magnitude basically obtained from the acceleration time history of the data, so the record of that earthquake is very important input for record for engineering analysis. So this record of earthquake basically we can get a peak ground acceleration, peak ground velocity, peak ground displacement so which we have seen that these parameters are can be used as a single parameter to estimate a force expected okay due to the earthquake and then consider that into the design of civil engineering structures or any mechanical engineering structures which is rest on the earth which has to handle an earthquake vibrations, okay.

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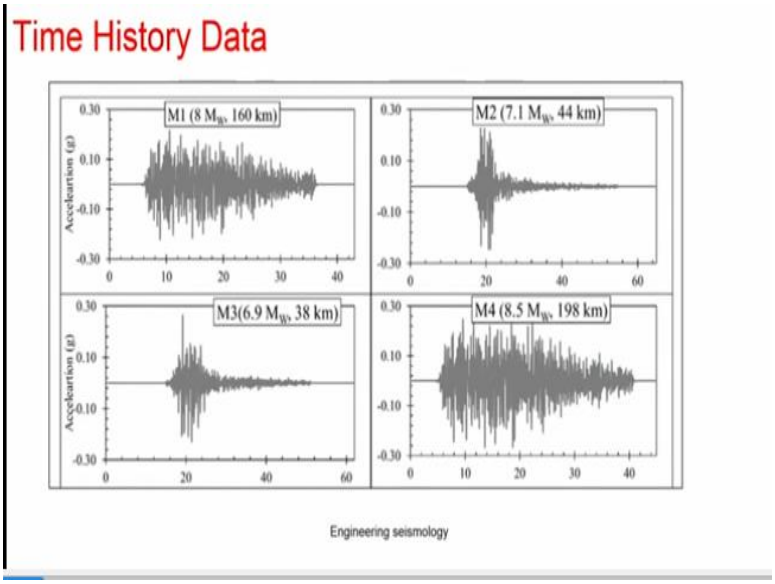

So, but we have seen that so these amplitudes will not only the important parameters, the duration also important parameters, so where the amplitude repeats a several times. Okay, so that we have seen a duration also important parameter. So, further the duration and amplitude has been clubbed together to the natural frequency of the structures. Okay, so that is what we call it as a natural period or natural frequency of the structures where the response spectrums are very important.

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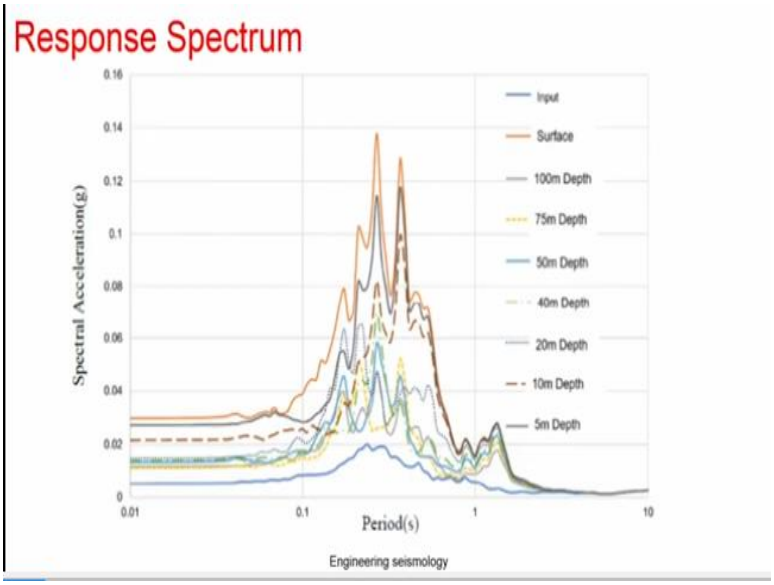

So, if you look at all these things okay, so the acceleration time history, response spectrum, so everything put together actually the important input for record for the design of buildings. Okay, so then we have seen that from the response spectrum it is a single ground motion, response of the single degree freedom structures.

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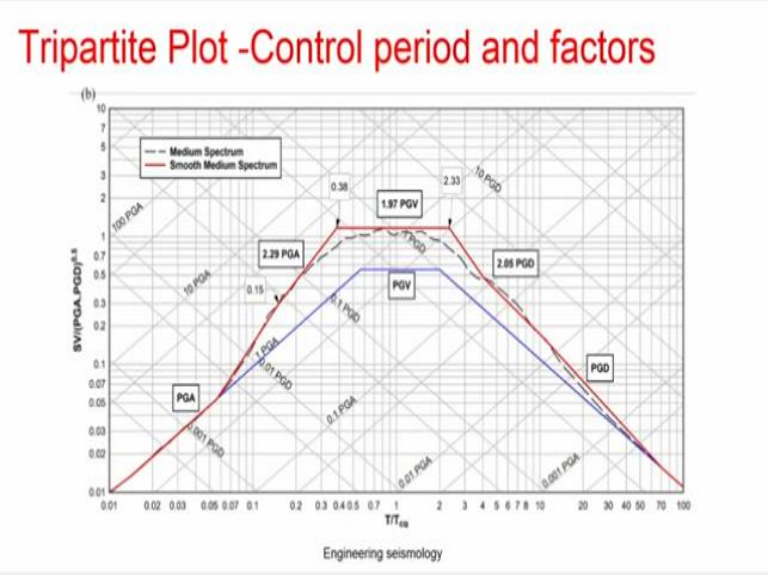

So, if you want to have the multiple ground motions into the effect of design, so one can go for the design spectrum in the tripartite plot, so this also we have discussed in detail. So, if you look at overall all these discussion, so we finally converge that there is a need to assess this parameters or estimate this parameters, so that you can minimise damage okay, so I mean the force experienced by the structure, it may be civil, or mechanical or electrical does not matter, so it has to be reduced.

So, these parameters if you have you can reduce, so since many of the earthquakes are happened in the fast and the future earthquake if you have the similar kind of fast earthquake, you are expecting then you can design but some of the location there is no earthquake data at all okay. So, there are 2 way we can minimise the this kind of hazard okay, so by predicting earthquake, another is predicting earthquake hazard parameters okay.

So, we are going to talk about all these 2 aspects in the coming classes, so up to the end of the class. So, the predicting earthquake actually so you try to predict any of these values okay, so from the known knowledge or whatever way it is possible that is the predicting of earthquake. But as on now, the predicting of earthquake is not possible okay, so even though there are about 9 method people are basically discussing and then given the prediction of earthquake.

But as on universally it is accepted that earthquake prediction is not possible okay, the only way to reduce an earthquake is actually you can predict the earthquake hazard values, okay or earthquake hazard parameters. So, there is a difference between the earthquake prediction and the earthquake hazard prediction.

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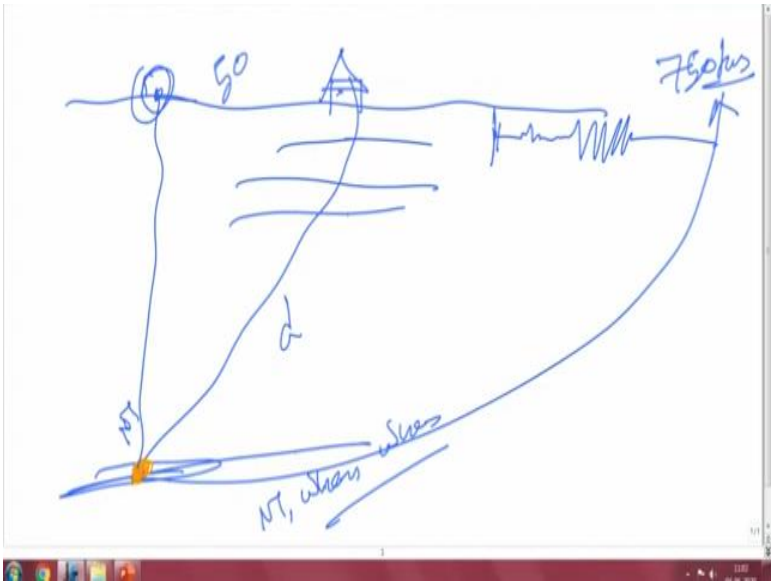

So, what is the difference actually, so the earthquake prediction is basically, so this location earthquake going to happen, okay so this is the earthquake going to happen, so as we know that we are in the surface, so this waves travels and then reaches a place where it is expected to come. So, if you look at the; so this waves travels; this wave character only we have seen as a, the wave form, okay.

So, now the prediction of earthquake is actually this is the earthquake which origin, so the magnitude and this is the distance okay, so then it may happen the time okay. So, the prediction of earthquake means what magnitude, when it occur and where it occur, so that means when, where and what magnitude going to occur is a earthquake prediction okay. For this prediction your previous earthquake knowledge may be sufficient or may not be sufficient okay, it is depends upon the different concept people talking about the prediction of the earthquake, so that is a prediction of earthquake, okay.

So, by even a predicting earthquake without knowledge what you studied so far it useless, you cannot define for example, somebody predict an earthquake magnitude of 6 going to happen close to Bangalore in the next month, so it is okay, 6 is going to happen you know that building going to fail and then people going to suffer all those things but this 6 magnitude what type of waveform it can cause, so that knowledge only you studied.

So, how your location for example you are located 50 kilometer away from the predicted location, how you are going to expect what magnitude of, what amplitude of waveform we are going to expect when it going to hit okay, so what is the energy it carries, what is the duration it is okay, so that kind of knowledge is only we have been covered. So, the predicting earthquake may not alone solve the problem, only it will solve some extent saying that so while predicted, if you have predicted earthquake, it is very sure that it going to happen, you can ask a people to move from that location.

But the issue is that even as I told you that if you I have told that the 50 kilometres, so this is the location, the earthquake and cause damage up to the several kilometres, so far the highest damage reported was around even 750 kilometre and above. So that means, so predicting this point okay, so not only the problem with this location, it also problem in and around area that you should know how much area it going to affect.

So, although since the knowledge what we gained so far is whatever we reviewed, recapped all those informations are useful for this kind of aspects, so that is about the prediction of the earthquake. So, the another this one is actually, this is only a prediction okay. So, the this is right now it is not possible very accurately predict but we are going to discuss today class, what are the different methods are available to predict, so how the prediction are reliable okay, so how you can say that the prediction are accurate okay.

So, then followed by you can also see like you can basically, look at so what are the socio-economical problem for the prediction of the earthquake, so that is also we can see, so that is about the prediction of the earthquake.

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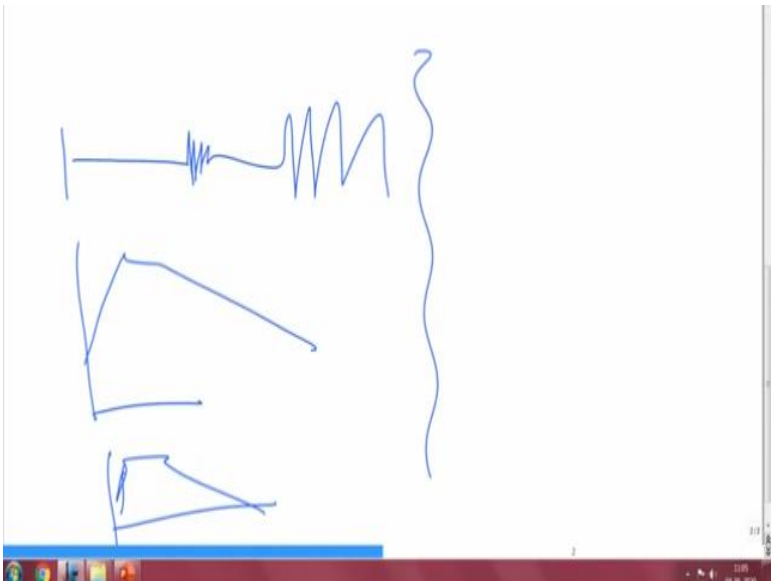

So, the another aspect is prediction of earthquake hazard, so the earthquake hazard prediction is basically you will be predicting what type of acceleration time history you are going to get, okay. So, what is the response spectrum you are going to get, what is the design spectrum okay you are going to get, so these are all the aspects, the earthquake hazard parameters prediction. So, quite this is now possible because you are only going to predict that it will be for the next 50 years, 100 years, not the next month, next year kind of thing.

So, the overall based on the knowledge what we gained one can predict an earthquake hazard very accurately okay, so that is what as on now it is possible. But since the prediction also plays a major role in several aspects okay, so it is necessary to understand that the prediction of earthquake part of your study this also basically help you on several future related for example, some of you want to work on the earthquake prediction and then breakthrough the this one, so we will discuss the prediction problems and how it is possible, what are the things, why it is fails, everything.

So, if you understand overall the earthquake how it is happening, where it is happening and all, so if you try to assess those things very precisely which is practically not possible, then you can some extent predict very accurately the earthquake, okay so that anyway the future research, many scientists are working but as on now the engineers believe that the prediction of the earthquake does not solve the problem.

So, even if you predict an earthquake, if your house is not strong, you are anyway going to, your house going to collapse, only you can save the life but the people may get affected because of the earthquake okay. So, what is mean by the earthquake prediction?

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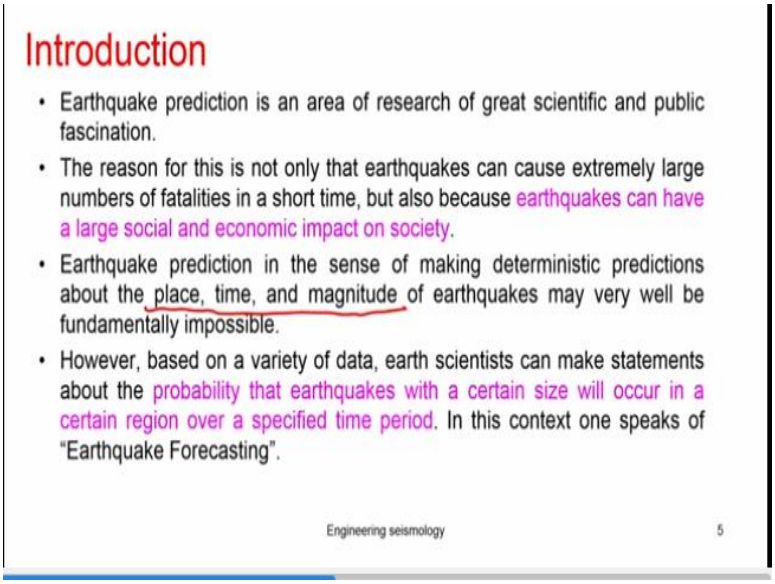

So, the earthquake prediction is an area of research of great scientific and public fascination, so many people actually say that the earthquake prediction is very important, many general public even curious to work on the earthquake prediction even without having knowledge about the earthquake, okay. We see those things, even there are Google if you go on and Google it, find out what is the earthquake prediction and how it is done and all, you can see that many common man kind of people also give like this astrology based earthquake prediction, planet position based earthquake prediction like that there are so many, this on even there are websites people are maintaining to announce that when earthquakes going to occur, okay.

So, those are all the way also but these are all as I told you that sometime it happen, sometime it may not happen, so but the scientists never worry too much about the earthquake prediction announcement and forecasting released by the different agencies actually, okay. So, most of the time the scientist believe that the earthquakes occurring, going to occur it will better to be prepared and be yourself the resilience building and this one.

So, the reason for this is not only the earthquake can cause extreme damage okay, so why it is public fascination, so this not only causes the fatality in the short time and also the earthquake can have large social and economical impact of the society. So, what is the social and economical impact? So, there are many history of the nation has been changed because of the earthquake okay, so like some of the areas are completely vanish from the map itself because that area was completely gone.

And some of the people use because soon after the earthquake many people gave a grant and aid from the other countries it will support, so many people use that money to build their nation well and also attacked their enemies or terrorist kind of thing, so these are all the things where the history of the nation itself going to change okay that is like a large social and economical impact in the society that is why the earthquake predictions are many people interested.

So, the earthquake prediction is a sense of making deterministic prediction about the place, time and magnitude, so the earthquake prediction basically should tell the place, time and the magnitude very accurately, so that using that one can see that how they can reduce a fatality cause because of the earthquakes we have seen there are several deadly earthquake in the world which is so many people have died, okay that can be minimised, first priority.

Second; the infrastructures can be damage can be also minimised or people can evacuate with the valuables, so the last will be reduced economical loss will be reduced, so these are all, but as I keep insisting that as on now, it is a fundamentally not possible to predict accurately these parameters. So, however based on the variety of data and earth scientific make statement about the probability of the earthquake with certain size will occur in the certain region over a specified period which is a purely based on the prognostic model which can be called as an earthquake forecasting, okay.

The forecasting means like the occurrence of earthquake in the 2% probability in the next year, so what is the, that you can say that depends upon your data, so if a data is wrong basically you cannot predict. So, I can give you the example so, for example peninsular India; peninsular India has an average return period of 300 to 500 years earthquake okay, so 6 magnitude, 6.5

magnitude. If we have the complete 500 years earthquake data okay, then you can predict what is the expected earthquake in the next year.

But if you have the only last 100 years data, as we seen that the India has a poor seismic record of only 1960 onwards, they start recording the data, so if using that kind of like 60 years data whatever you predict, then it will be more accurate okay, so that is the one problem with even an accurate forecasting of the earthquake hazards, okay.

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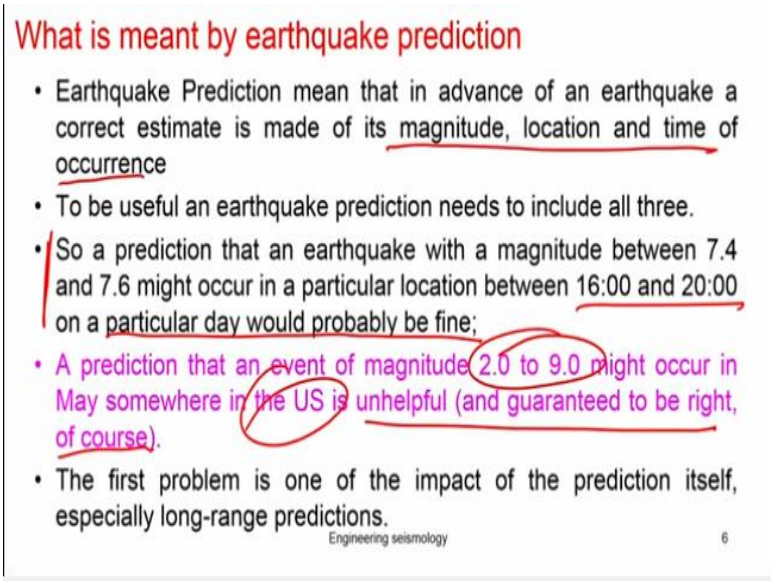

So but still this predictions is the well-known subject many people working on that okay, the prediction of the earthquake is well know subject, many scientists working on that there are places where people formed big research group so, they worked towards all approve update in this model and theories and understanding of that, so that is how the prediction they work. So, earthquake prediction mean that in advance an earthquake correct estimate made in magnitude and location and time, so these are to keep on telling.

To be useful, the earthquake prediction need to be include all the 3, so the prediction of earthquake with magnitude of between 7 to 7.6 might occur particular location between so and so time at particular day would be probably fine. So, this is what you should report as a prediction, so this is the magnitude should, we should not say that magnitude 8 will occur but finally, the magnitude 5 occurs which is not a prediction.

Because as you know that the magnitude of 8 is 1000 times larger than the magnitude of 5 as it is a log base 10 okay, similarly the time if you say that it going to occur on a specific period like the a small variation in the time not a very big variation. If you say that tomorrow going to occur earthquake at 10'o clock, but it occurs even today 5'o clock, it create a lot of huge impact or it occurs after 1 month that create a lot of huge impact.

Similarly, the location so you say that the earthquake going to occur on so and so latitude and longitude but it occurs about under 100, 200 kilometres out away from that as we know that the each place, a city or urban settlements are very small in diameter. So, such huge variation in the spatial can create lot of impact that we will be discussing in the earthquake prediction problems and then what are the socio-economical issues, so then a prediction okay, so the prediction of, so the event magnitude 2 to 9 might occur, some may somewhere in US and unhelpful were guaranteed to be right.

So, this kind of prediction okay, so these range okay, this broader scale may not be so much useful if even say that the earthquakes are predicted. The first problem is one of the impact of the prediction itself especially long-range prediction okay. So, the scientist found that the long-range prediction okay, long range wrong prediction can cause a socio economic problems like impact which is more than the actual earthquake even if it is not predicted.

So, what it means that I predict a magnitude of 7 going to happen in the next year at Bangalore, okay but so it has been believed people have believed and then because of that there will be some socio-economic problem will happen. So that will discuss in detail what is the socio-economical problem, so this will lead to the okay, the impact whatever the economic loss and the human loss what we are going to suffer okay, so because of this prediction okay, will be larger than the actual earthquake.

So, that is how scientist notice from the several wrong prediction and improper this one, so they believe that such kind of wrong prediction lead to the more impact than the actual earthquake, so

it better to not venture into that unless otherwise it is very accurate okay that is what the scientist believe.

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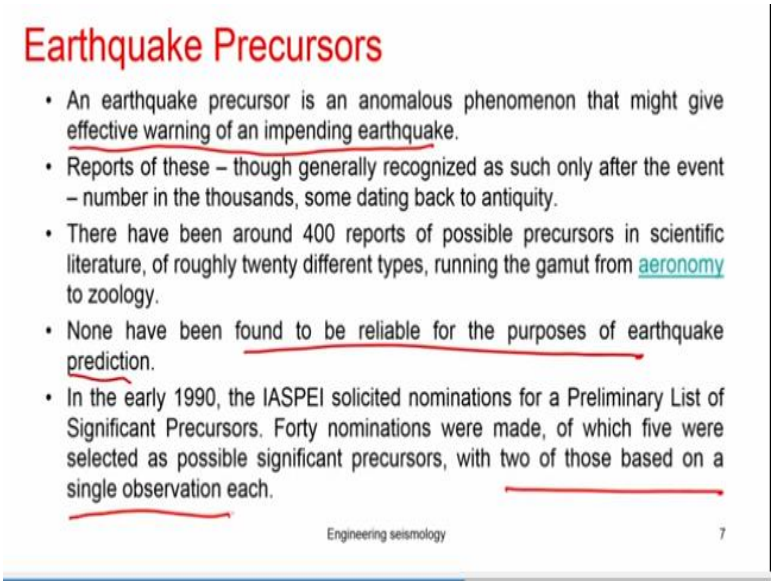

So, they call it this earthquake, the prediction of the earthquake precursor okay, an earthquake precursor is anomaly phenomena okay, so that might give the effective warning of the expected earthquake, so there is a some kind of a precursors, which is going to say this kind of earthquake occur to happen, so report of this though generally recognised as a only after event of number of thousands or some dating back antiquity, there was been about 400 reports of possible precursors in the seismic literature.

So, roughly scientific literature, roughly 20 different types running gamut from the aeronomy to the zoology, so this is precursor like they say that there was a this kind of anomaly has been observed before that earthquake, generally the report after the earthquake, so there are several cases those kind of report but not before the earthquake, so this kind of reports basically starts mostly on astronomy with zoology.

Somebody say that the moon okay, is on this position okay, so because during this earthquake because of that only earthquakes are occurring, they do not tell because they relate this phenomena after the earthquake and publishes a paper or whatever that but that is not so much

helpful similarly, the zoology; zoology means the animal behaviour okay, animal pattern moving all those things also people are (()) (19:07) that will be discussing in our class.

So, none have been found to be reliable for the purpose of the earthquake prediction, so in the early 1990s, so okay IASPEI solicited, so nomination for the preliminary list of significant precursors, so the forty nominations were made of which 5 were selected as a possible significant precursor and 2 of this based on the signal observation of the earthquake, okay, so the signal observation of the age, so these are all the things are the some of the committee people made and working on that.

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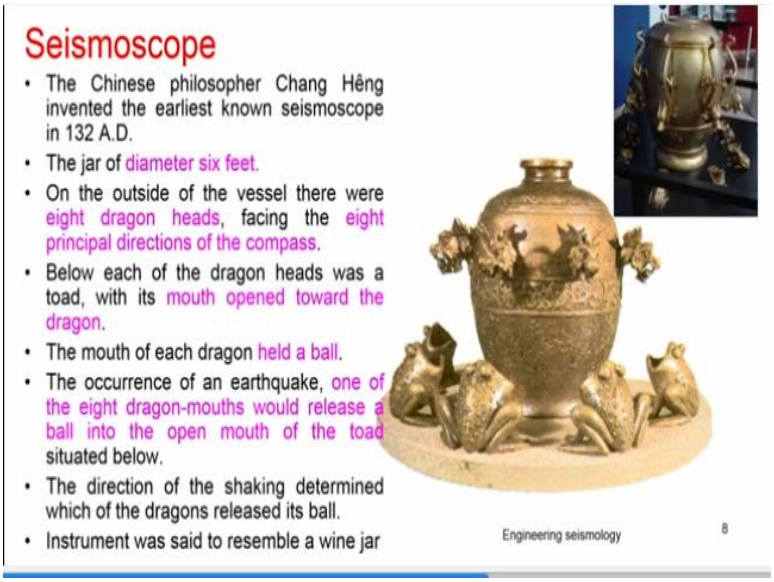

But as on I keep telling you that as on that it is not very successful, okay. So, one of the best or most reliable prediction people have made in the olden days was actually seismoscope, so maybe when we are discussing about the seismometer, we discussed of the seismoscope. So, if you understand how it works basically, it gives warning about soon after earthquake, it gives a warning that which direction earthquake is occurred.

So, even though it is not before earthquake but it is before the earthquake hazard okay, like for example, Tsunami, people can escape, so this is the more advanced okay, the olden days technology to predict earthquake basically. So, they might have been knowing that 600, 400 miles away the earthquakes are happen, so which is happened in the sea, they expect a Tsunami,

it would happens in the land at least they expect a vibration, so they get alert okay before that comes but they have very maybe less time.

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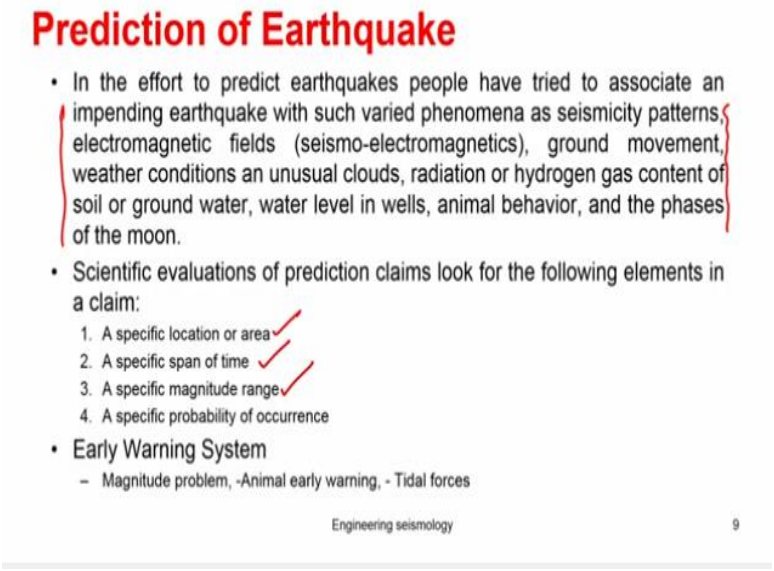

But this is may be the first origin where the scientist started working on earthquake prediction, okay, so the prediction of the earthquake as I told you that so it consists of the specifying some of the parameters very accurately based on the some kind of pattern in the earthquake location or near the earthquake regions like epicenter region or something like that. So what are those basically, the electromagnetic field okay.

So, the electromagnetic field variation in the earthquake location has been observed as one of the prediction method people are used, the ground movement and weather condition and unusual cloud and radiation or radiation or hydrogen gas content, soil or groundwater, water level in the wells, animal behaviour and phase of the moon. So, these are all the some of the way people try to see that earthquake and relate that and say that this even.

But none of this method will give the specific location area, space time and magnitude range even though they define does not happen like that and then the specific probability of, so the because of that the earthquake prediction is still under developing or a developing area of research, okay. So, those who are interested to work on earthquake prediction, so if you predict

earthquake very accurately, you will end up in getting a Nobel prize basically okay, so such interesting topic on this.

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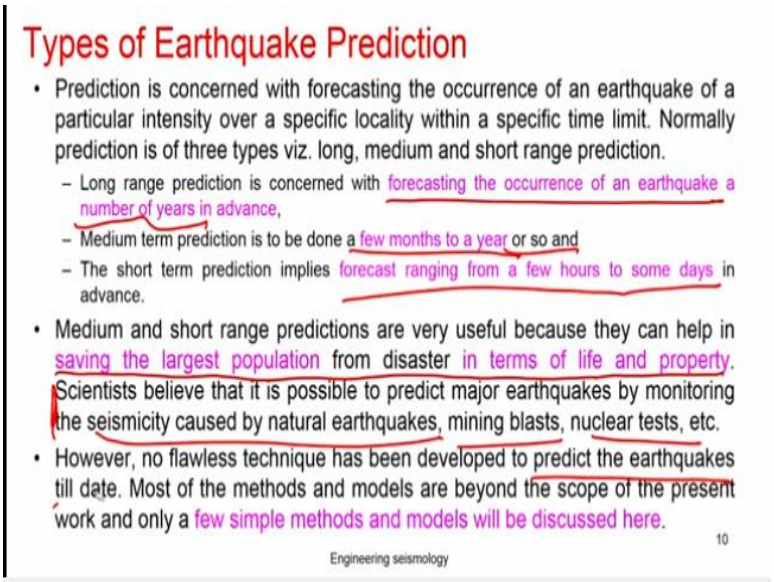

So, what are the different type of earthquake prediction? So, the prediction concentrate on with forecasting of the occurrence of earthquake of particular in intensity over a specific locality with the specific time limit. So, normally the prediction of 3 type we can say; long, medium and short range prediction. So, the long-range prediction means the forecasting of occurrence of earthquake okay, so earthquake a number of years in advance, like 2 years, 3 years, 4 years something like that is a long-range prediction.

So, the medium term prediction is actually done few months to a year, okay. So, within a year somebody predicts then that is called as a medium-range prediction, short range prediction is forecasting ranging from a few hours to the some days okay that is the forecasting of the earthquake, so month to year okay, so to a year is actually medium, above year is actually long term, so within a month is the short term prediction.

So, the medium and short range predictions are very useful because they can help to saving the larger population from disaster, the term of life and property. So, basically the short and medium range is there you can save the people death, so scientist believe that it is possible to predict

major earthquake by monitoring the seismicity caused by the natural earthquake and mining blasts and nuclear test okay by looking at a data and all.

But for that you need to have the proper data, so we are talking about the earthquake hazard parameter prediction know, so like hazard and (()) (23:43) these are all basically the scientific way of predicting the earthquake. If you have the proper data, you get a proper prediction in probabilistic and deterministic hazard parameter's. So, however no flawless technique has been developed to predict the earthquake, so till date okay.

So, most of the method and models are beyond the scope of the present work, only few simple methods and models will be discussed here. So, there are many models which is like a very complicated but that is not record anyway, because as I it told you that none of the models are working very well to prediction of the earthquake so, the earthquake prediction methods, so 9 methods to predict the earthquake.

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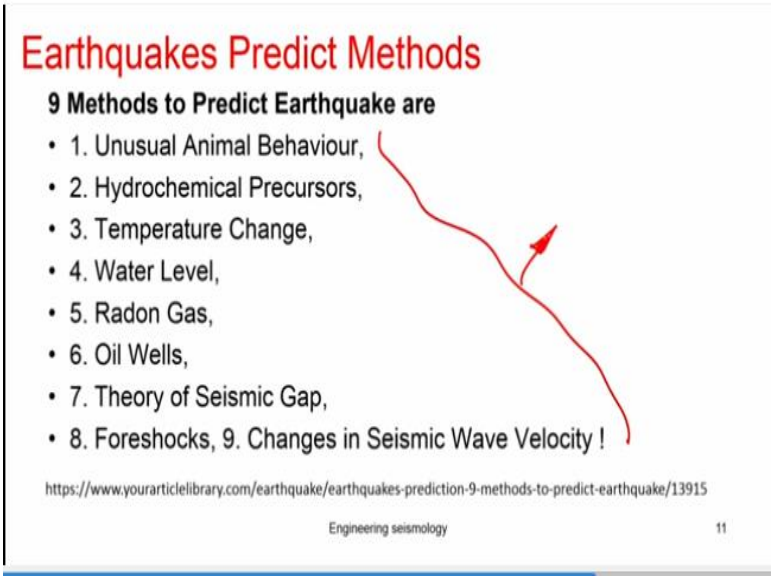

So, unusual animal behaviour, hydro chemical precursor, temperature change, water level okay, radon gas and oil wells and theory of seismic gap and foreshock and changes in the seismic wave velocity so, these are all the well-known 9 method people believe that okay, so the earthquakes are able to predict or people claim but the accuracy of prediction again is a question, since we are

talking about the earthquake prediction, so we will be discussing all these method one by one in our class.

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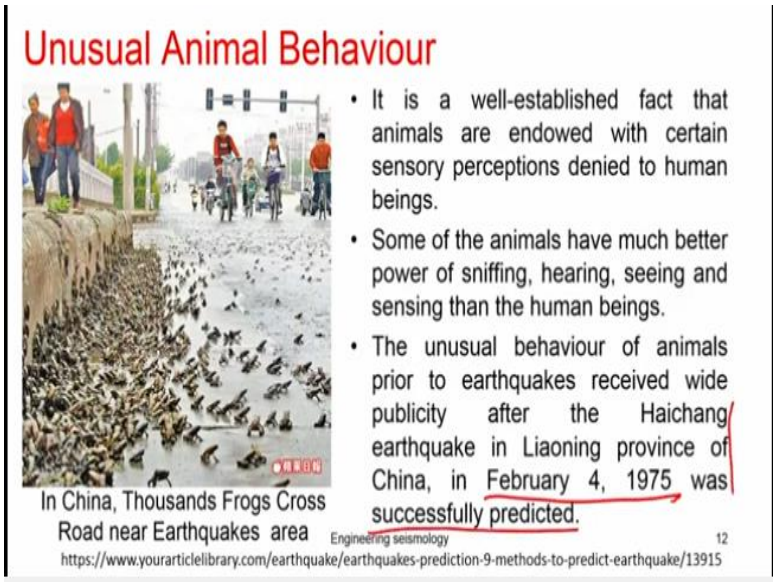

So, the first observation of the animal behaviour even started before the ancient siesmoscope itself, so that is what we have seen that the Japan people are killed the fish okay, cat fish, Namazu okay assuming that the excessive movement of the fish causes an earthquake. As I told you that time that animals are restless due to the any natural phenomena, so that observation is somebody makes they can predict an earthquake well.

So, such kind of behaviour of animal is unusual animal behaviour, so this is the first way people try to predict an earthquake. So, this is actually in china, thousands of frog crossed the road near earthquake area, so it is looks like that from the epicentre location, many frogs are start moving away by sensing that there is going to be an earthquake in that location, okay. So that was observed by the scientist; Chinese scientist, so okay then they establish the fact that animals are endowed with certain sensory perception deny to the human.

As you know that animals are some of their capacities are much better that the human, for example the dog okay, so dog can sniff better than the any other animal, so eagle can see from very high distance to the any other animal. So, like that some animals has a some quality okay,

some talent which is not possessed by the human being but olden days our ancestors okay, for example Lord Shiva and Siddha's, Siddhargal they say know.

So, they are all people will sense everything because they have the more interaction with the nature, now modern generation we lost okay, we do not even interact with the nearby people as in nowadays you might have seen that so people have mobile and they do not even interact with each other by sitting in the same place. Now, anyway this interaction is become a problem because of the corona.

So, you cannot even interact with the people freely, you do not know that who has a corona which created a mental fearness among the people okay, so people always suspicions that he may have corona, if I touch him or speak with him, I may also get a corona, okay, it is very unfortunate actually because the world is running because of the love between the each living things okay, so which may be the human being to human being or human being to animal or animal to vegetation or human being to the vegetation, all these love and affection only makes the globe survey so far.

But that itself now started a human being actually has to be become a more fear to interact with each other, so with people will hereafter will interact with very cautioned way, okay, so because of this Covid 19, so hopefully this situation will vanish we will hope but we have to see that we are moved away from our natural interaction with the mother earth, so that may be the one of the reason that we could not be able to sense some of them where animal could sense very well.

So, some animals have a better power of sniffing, hearing, seeing, sensing, so than a human being, so this sensing character helped them to identify the earthquake in advance and it take a proper shelter or save themselves from this kind of natural hazard. So, the unusual behaviour of animal prior to the earthquake received wide publicity after the Haichang earthquake in Liaoning province, China in February 4, 1975.

So, the first earthquake was predicted by using animal movement is actually this earthquake, okay February 4, so this was the classical example animal behaviour can be used to predict earthquake okay.

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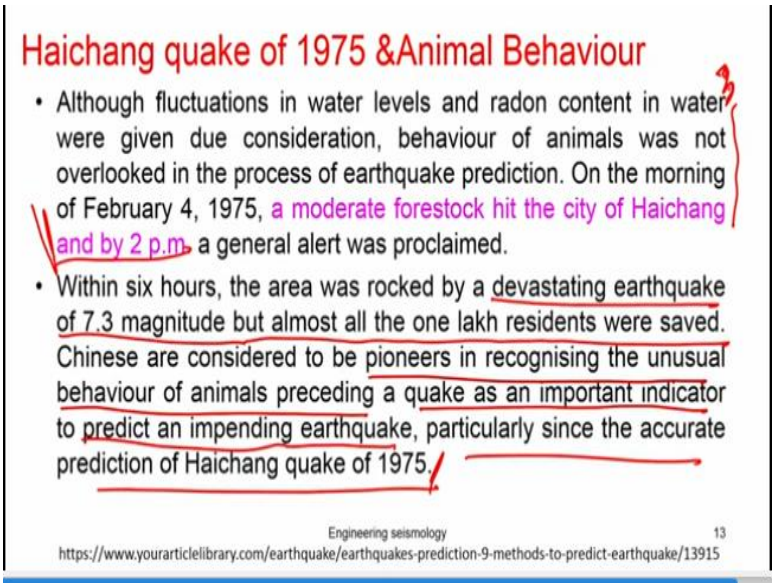

So, this animal behaviour okay, the Haichang earthquake in 1964 and what happen; so although the fluctuations of the water level and radon content of the water were given okay, so due to the consideration the behaviour of animal was not overlooked as a process of the prediction. So, what do they did actually; they did, observed the animal behaviour and also they observed a other prediction methods which is that time at least understood by the several people like fluctuation in the groundwater table and release of the radon gases all those things they related.

So, finally they try to say that there is an even a foreshock has occurred that day okay, so they said the behaviour of animal not overlooked the process. So, on the morning February 4, 1975, the moderate foreshock hit a city okay, so then followed by the issued warning saying that a big earthquake going to happen, so that is happen basically litter later okay. So, the alert was issued, so within 6 hours of the alert, the area was locked by a devastating earthquake okay of magnitude of 7.3 but almost 1 lakh residents were saved because of this forecast.

So the 2 pm they basically, released the warning, people are evacuated and people are tried to leave in the open space, as you know that open space leaving nothing will happen because the

earthquake never kill the people only the building collapses killing the people, so all of them are moved, so then it was helped to save, you can remember that here actually a 3 criteria has been okay, so satisfied to predict an earthquake, so that may be the one of the reason (()) (30:32).

So, the Chinese considered to be pioneer on recognising the unusual behaviour of animal, preceding to the earthquake important indicator of the prediction of the impending earthquake particularly, since accurate prediction of the this particular earthquake, okay, so this was a classical earthquake prediction, the first in the world, so people believed that this technology can be adapted to predict an earthquake okay.

But here we should also remember that they basically not only the animal behaviour they observe, so and they also observed like the change in the water level and radon gases which we will be discussing, these are all the different method and moreover very accurately, the foreshocks okay, the foreshocks, so which was occurred just about may be a 6 hours before the main shock, so this was the one of the indicate you okay so hint okay, one can predict an earthquake, this foreshock and after stock.

So, this was the classical prediction okay, so then people start thinking that why do not we train an animal and try to predict an earthquake or somebody can watch continuously animal and predict an earthquake okay, that is what the thought has been given, people even made favour of this watching this animal behaviour forming committee and research started in the direction this will be discussing in the next class, we will continue in that.

So, right now we have seen that the earthquake prediction, what is meant by prediction and then how people started understanding the earthquake prediction, we started also the best prediction by the unusual animal behaviour in the china for the 1975 earthquake of magnitude of 7.3. So, with this I thank you for watching this video, we will meet in the next class, continue this, thank you.