Introduction to Engineering Seismology
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Lecture – 38
Earthquake Prediction Continued

So vanakkam, so we will continue our lecture on engineering seismology, we have been discussing about the earthquake prediction okay, so we have seen why we need to predict an earthquake, so we have also seen the earthquake prediction reliability and how people are basically looking at an earthquake prediction. So, we also seen that the first effective prediction is happened in China in 1975 where the Haichang earthquake of magnitude 7.3, so which was basically identified first by the unusual animal behaviour.

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Because the animal has an extra I mean, the high level, so perception sensor is than a human being, okay, so some animals are better in sneezing, so sniffing, some animals are better in hearing, some animals are better in seeing, so okay, so which is we do not possess. So, we have seen that basically the Chinese try to observe the 1000's of frog crosses the road near the epicentre and then followed by they also observed a other precursors okay such as a water level and radon gas release.

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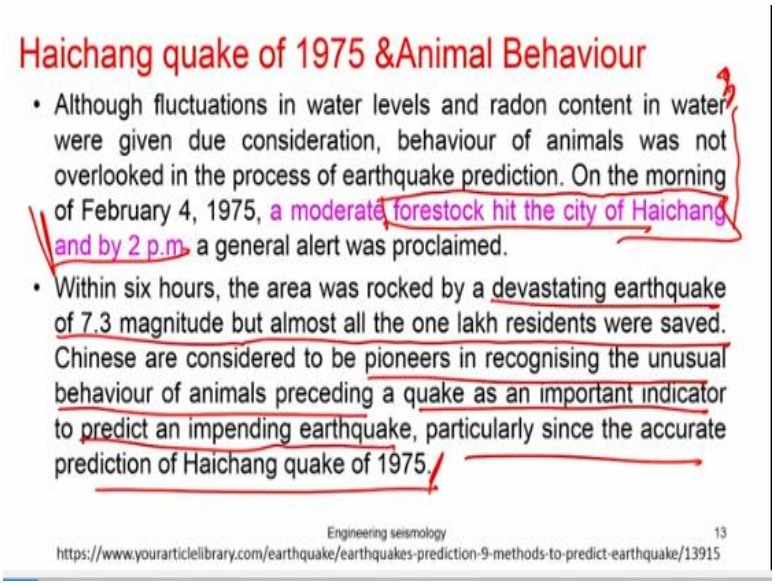

And then moreover, the foreshock also they found and then they issued a warning saying that there may be going to be an earthquake in this location soon okay, so then that was successful, so where the after 6 hours, there was a big magnitude of 7.6 occurred. So, the similar way they also predicted a big earthquake later stage but which was not happened, okay, so which caused a lot of wrong prediction impact okay that will be discussing in the next class, I mean the future this one.

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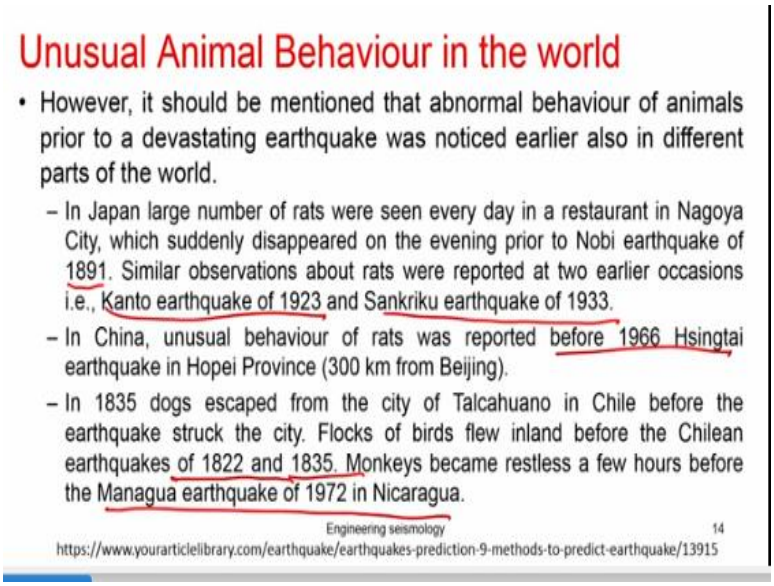

So, the similar to animal behaviour in China which is not very new okay, all over world there are several places unusual animal behaviour has been reported okay, it should be mentioned that abnormal behaviour of animals prior to the devastating earthquake was noticed earlier at a

different location but using that predicted was happened in only China. So, in Japan large number of rats were seen every day in the restaurant in the Nagoya city which is suddenly disappeared on the evening prior to the Nobi earthquake of 1891, you see the period, it is 1891, okay.

Similar observation about the rat was reported at the 2 earlier occasion of Kanto earthquake, see 1923 and Sankriku earthquake in 1933, so even the China predicted only on 1975 okay. So, in even Chinese literature, unusual behaviour of rat was reported before 1969 earthquakes, so in 1835 dog escaped from the city of Talcahuano in Chile before the earthquake struck the city, the flocks of birds flew inland before the Chilean earthquake of 1822 and 1835, monkeys became restless, few hours before the Managua earthquake of in Nicaragua okay.

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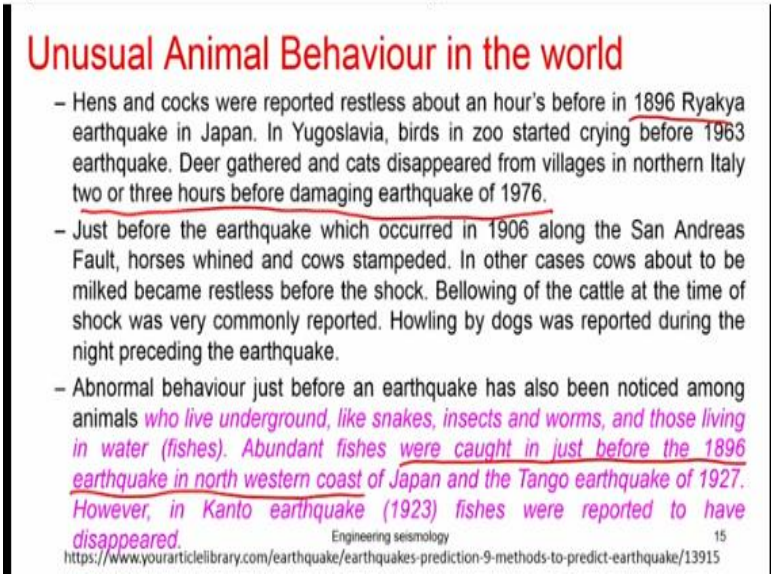

So, these are all the places where people reported after the earthquake, these are all the unusual animal behaviour they observed okay before the earthquake, so but they reported after the earthquake. So, then the hens and cocks were reported restless about the hour before 1896 Ryakya earthquake in Japan, so similarly the birds in zoo started crying before 1963 earthquake, so the deer gathered and cats disappeared from the villages on Northern Italy 2 or more 3 hours before the damaging earthquake of in 1979.

So, these are all the observation people have made but they noticed and told after the earthquake, so just before earthquake which has occurred in 1906 San Andreas Fault, horses whined and cows stamped and other even the areas they say that cow was automatically milk okay, I mean it milked suddenly without even attaching the milk machine or the milky by the man okay, so all those the restless behaviour of animal and cattle and large animals are; as you know howling of dogs, okay so all those things are reported many earthquakes okay.

So, this abnormal behaviour before an earthquake also been noticed in several places particularly India too, so these animals okay, so basically animals who live underground like a snakes, insects, worms those who are living in water, fishes, abundant fishes were caught in the just before 1896 earthquake in north-western coast of Japan. So, there is an unusual fish movement in the sea okay that is also reported in the Japan.

So, Tango earthquake 1927, however Kanto earthquake, fishes were reported to have the disappeared, so some earthquakes even the fishes are run away from the fishing area, so these are all the unusual behaviour being reported in the this one.

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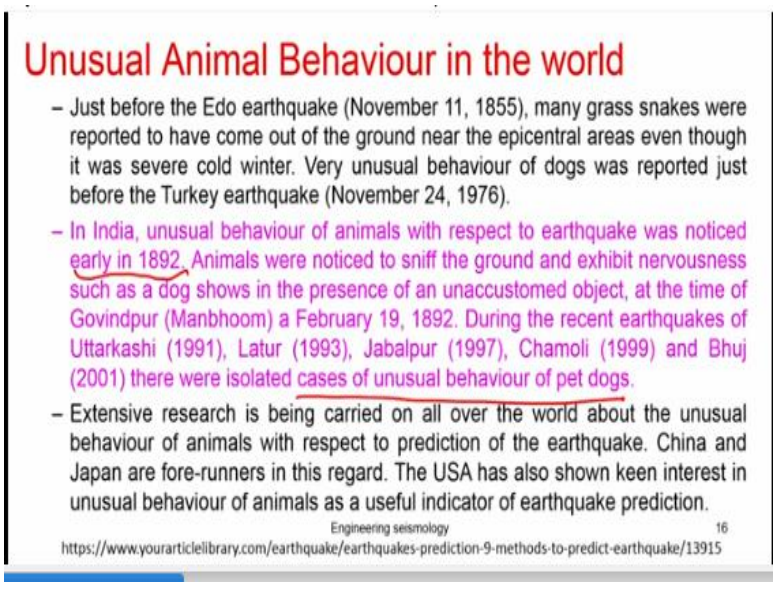

So, just before Edo earthquake in November 11, 1895 okay, the many grass snakes were reported to come out of the ground near the epicentral area, even though it was severe cold winter, very unusual behaviour of dogs were reported just before a Turkey earthquake in November 28, 1976

okay. So, India too, people are observed animal behaviour, unusual animal behaviour, so which is like unusual behaviour of animal with respect to the earthquake was noticed early in 1892 okay, during the British ruling.

Animal were noticed to sniff the ground and exhibit nervousness and such as a dog shows a presence of an unaccounted object in the ground like it is try to scratch and try to excavate kind of things. So, the time, the Govindpur okay, Manbhoom in February 19, 1892, during the recent earthquake of Uttarkashi, Latur, Jabalpur, Chamoli, Bhuj were also isolated cases unusual animal behaviour being reported okay, pet dogs and all, house people told that the dog was continuously barking, he try to pull away from the location all these.

So, the extensive research being carried out all over the world about the unusual behaviour of animal with respect to the prediction of earthquake, China Japan forerunners of this record, USA also shown keen interest in the unusual behaviour of animal useful to indicator of the earthquake prediction. So, the earthquake prediction whatever I am discussing here actually which is actually they taken from the website given here okay, so this is not the my own content.

So, I thank people who are provided this material in the website which has been taken and used for your teaching okay, so you can also refer those website for the more detailed content what we are teaching here.

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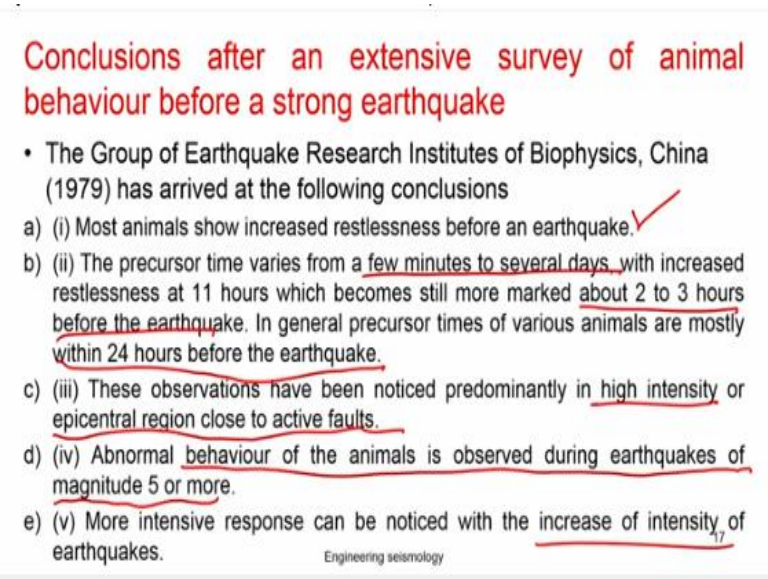

So, in conclusion okay, so after studying all these things okay, so the scientist arrived a conclusion okay. So, the conclusion after extensive survey of animal behaviour before a strong earthquake, the Group earthquake research institute okay, so biophysics in China has arrived the following conclusion. One is that most animals show increased restless before an earthquake okay, it was the first conclusion.

The precursor time varies from few minutes to several days, this you have to note okay, so which increased the restless at 11 hours, so which becomes still more marked about 2 to 3 hours and before an earthquake. So, the restless starts about 11 hours before and it is a remarkably high during the 2, 3 hours of the before earthquake. In general, precursor time varies animal are mostly within 24 hours are the this one.

So, animal behaviour should be; it shows that within next 24 hours, there is going to be earthquake, so even we have seen when we are talking about the Tsunami, I told that Dhasaavathaaram movie, so before Tsunami going to come in the movie, they show that when the Kamal, okay the hero Kamal and Villain Kamal, both of them are Kamal anyway. So, they are fighting toward a bio virus okay, so the artificial virus which also now Covid 19 kind of things people are afraid.

If they comes many people will die, those kind of stories built behind that movie, so in that movie when they are fighting actually, they show that lot of birds are flying away from the seashore okay, so soon after that scene comes actually, the fighting continue, then there is a another Kamal which is come from Japan, okay that fellow basically say a Tsunami because as I told you that Tsunami is not a common word in India before 2004.

Many people does not know what is mean by Tsunami but now anyway even the UG level, PG level and school level kids knowing the Tsunami because there is a portion of the earthquake okay, introduction about that earthquake is now added in the schools before 8th standard, so that is the very good sign on the education part of the earthquake engineering. So, these okay, so indicates that any unusual animal behaviour may happen within 24 hours okay.

That means, if you observe animal behaviour unusual now okay, before I mean next 24 hours within that there may be an earthquake okay. So, this animal behaviour increase with time, the unusual behaviour comes very large extent okay maybe 2, 3 hours you can expect an earthquake. So, these observations have been noticed predominantly in the high intensity epicentral region, this also you should note.

So, this is basically reported where there is going to be a very big damage or it is epicentre location that is above the focus point. So, the abnormal behaviour of animal is observed during an earthquake magnitude of 5 and more, so this is also one of the; they say that the bigger magnitude better will be the abnormal behaviour observation okay, that is the; another thing. So, the more intensive response can be noticed with increase in the intensity of the earthquake okay, so animals are behave very unusual way okay, so that in the bigger earthquake, it is easy to predict.

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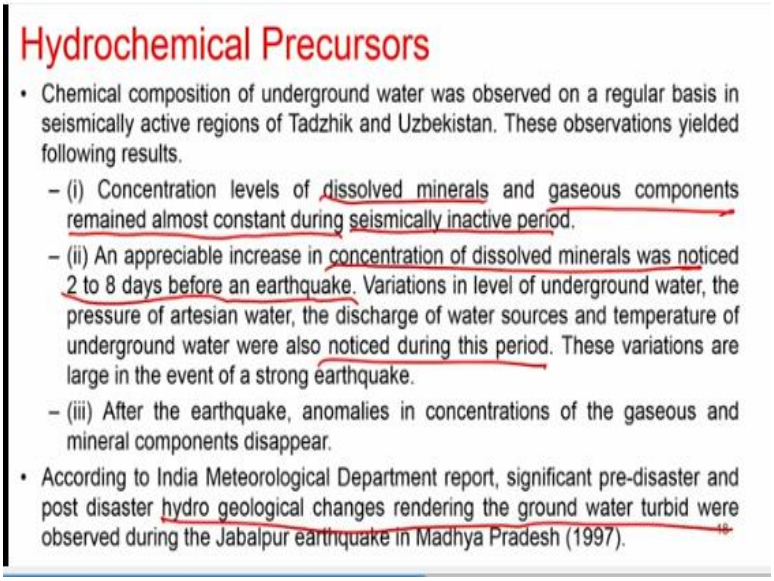

So, this is the basically animal behaviour and related research where people have carried out, so you can see that this, with this you can predict an epicentre of the earthquake almost okay, so the magnitude maybe if you very closely observe, some extent you can say that this will be a big or moderate earthquake but more or less the 5 and above only going to be happen, so it is more or less, the magnitude 5 and above is damaging earthquake, people in that area should be cautious. So, in this there is a another concern.

For example, the magnitude of 5 and above is right, so instead of magnitude of 6 should happen, it happens a magnitude of 9.5 for example, Himalayan region, some of the region you can say like that Bihar okay, so Bihar is some remote village, so they observed that there is a; these are all the close to the plate tectonics know that is why I am giving as example, so there was a 1000's of rat or snakes are start moving from particular area, people are observed.

So, they thought that okay, so this there is an earthquake going to occur in the area, people who are living in that area, there are small, small villages in those areas they try to move away from that location, it is a good those people are only saved but the Himalaya as I told you that it has a potential to cause earthquake magnitude of 8 and above, for example, so the animal behaves after 5 anyway this one because the magnitude you do not know exactly like how it is would be okay.

So, instead of happening a small magnitude, the magnitude of 8.5 or 9 happened in the same location, the people in the Lucknow, Kanpur which is very far from the Bihar okay, so can also get affected, around 750 kilometre Indo Gangetic Basin, people get affected which is also concern okay, with respect to the location and observation. So, how many people you can evacuate, how many people will be affected by this, all those things put a serious concern.

If somebody has a knowledge of intensity, isoseismal map and then which is the function of your magnitude and distance, if somebody predicts there okay this is the place, this is the expected magnitude of this place, if this is the prediction is happen okay, this many places people should issue warning okay, this many places people should issue a warning, so that people can save, so such kind of knowledge comes from the understanding of the earthquake engineering or engineering seismology subject okay, this is about the animal behaviour.

So, the next, so the advanced way of predicting earthquake is hydro chemical precursors, so what is the hydro chemical? So, the chemical composition of the underground water was observed on a regular basis seismically active region at Tadzhik and Uzbekistan okay, these observations are yield the following good prediction on the earthquake. What they seen that the concentration level of the dissolved minerals, and gaseous component remained almost constant during the seismically inactive period.

They found that dissolved minerals and gaseous component in the underground water okay is almost similar okay, during the seismically inactive period and appropriate increase of the concentration of the dissolved minerals was noticed 2 to 8 days before the earthquake, you can see 2 to 8 days of the earthquake. So, variation in the level of underground water, pressure and artesian water and discharge of water source and temperature underground water are also noticed during this period.

So, there is a variation of the dissolved minerals okay, so before earthquake and also the variation in the water level of the underground water and the pressure of artesian water, so the artesian water means from the artesian, the water will be pressure coming know, those who do

not know about the artesian well or artesian underground water storage, you please Google it and find out and read about that.

So, the discharge of water okay, so water sources okay, which is naturally come from; you might have seen in the open well and all, there maybe somewhere the water will be falling from the some kind of hole, those kind of discharges are increasing, the temperature of the water underground water also increase, so these are all the noticed before earthquake at a particular place.

These variations are large event strong earthquake, so particularly when bigger earthquakes, these are the very good this one, so after earthquake this anomalies of the concentration gases and mineral compositions are disappear. So, after the earthquakes are occurred these things are vanishes, okay it is not appearing. So, according to Indian meteorological Department okay report significant pre disaster and post disaster hydro geological changes okay, rendering a groundwater turbid were observed during the Jabalpur earthquake in Mandhya sorry, Madhya Pradesh 1997 okay.

So, they observed, Indian Meteorological Department reported that so these are all the hydro geological changes they observed. So, here we need to also give emphasise that as we have telling that the earthquake are happens due to the breakage of the crustal rock. So, if you have the crust rock projected at several place at one location, as you know that the earthquake going to occur that crust rock become a staining okay before it breaks, it is going to stain heavily.

That heavy stain basically, induce a fluctuation in the pressure, water level and related chemical okay that is why this kind of precursors are observed in those location. So, that means if the area where the crust rock is not visible or not having the well in the crust rock, this kind of prediction may not help or may not possible. So, this is if you understand the physics of the earthquake, you can very well relate that this is basically related to the physics of the earthquake where the crust undergo a deformation before earthquake and before breaking.

That deformation causes all this unusual changes okay, all these changes going to take place that means it is going to break okay, so that is possible only places where there is a crust were exposed or crust were involved in the digging up well, well are digged in the rock, that rock actually crust rock okay, not the several layers of soil deposits then above that some aquifer all those, those kind of place it may not happen okay.

So, that is the significant inference and then conclusion derived from this hydrological precursor, this is also very successful, we have seen that in China apart from animal behaviour they also seen a hydro chemical precursors okay.

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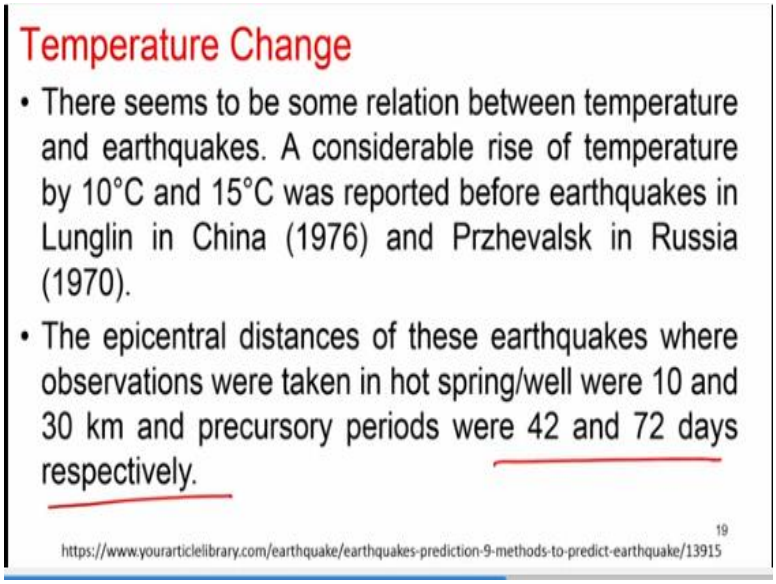

So, the another one is temperature change okay, this is the another thing people used to predict an earthquake. So, there seems to be some relation between the temperature and earthquake, a considerable rise of temperature by 10 degree to 15 degree was reported before the earthquake in Lunglin in China and then the Przhevalsk in Russia okay, so where they noticed that in that particular area, epicentral area, there is a considerable raise in temperature, okay.

So, the epicentral distance of these earthquakes were observed were taken in hot springs and well before 10 and 12 kilometre and the precursor period of 42, 72 days. So, this even this observation made in some of the Indian earthquake too, people observed that Tirana satellite image, the temperature and the chemical composition of the surface changed considerably, okay. So,

monitoring of these changes can one can inform warning system that this place there may be earthquake, okay.

So, again you can see here that this is not related with the size of the earthquake like your other animal behaviour and so here only you can say roughly the area earthquake going to affect not a magnitude, not a time, okay. Since the 42, 72 days are the very big period okay to predict an earthquake, so this temperature raise also observed, this has been used as the one of the method to predict an earthquake. There are some people told after earthquake that this is the temperature raise, noticed by the satellite image on this period on this location where the earthquake was reported okay that was the things being used for prediction of earthquake.

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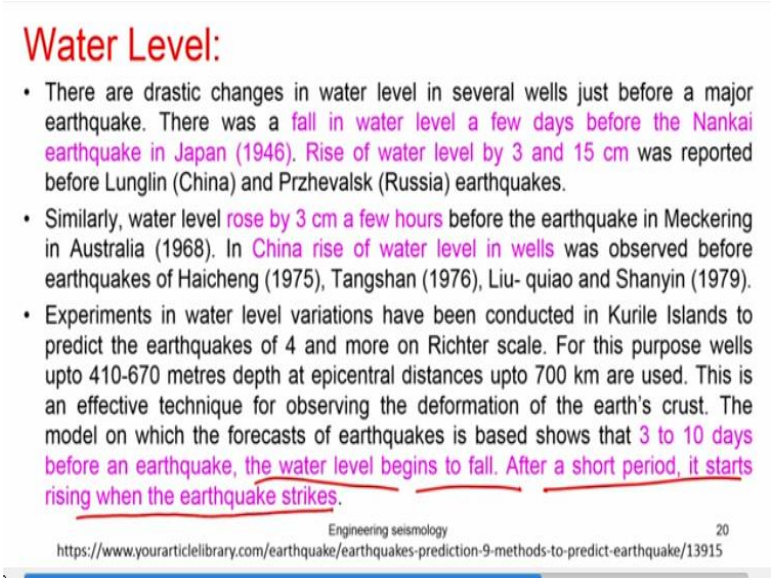

So, the another one is the water level, so we have seen in the hydro chemical process itself the water level, so there are a drastic changes in the water level in the several wells just before major earthquake. So, there was a fall in water level few days before Nankai earthquake in Japan in 1946, rise of water level by 3 and 4 centimetre okay was reported before Lunglin China and then the Przhevalsk Russia, these places the rise of water has been reported.

Similar water level rose by 3 centimetre few months before the earthquake in Meckering in Australia, China rise water level in wells was also observed by the Haichang earthquake and the Tangshan earthquake and Li-quiao, Shanyin earthquake, so experimental of water level variation

have been conducted at Kurile Island to predict earthquake of 4 and more on Richter scale, for this purpose well up to 410, 670 metres depth at epicentre, up to 700 kilometre are used.

This an effective technique to observing the deformation of the earth crust, the model of which the forecast earth crust based shows that the 3 to 10 days before the earthquake, the water level begins fall, after short period, it starts rising when the earthquake is strikes. So, initially the water goes inside and then it rises again. So, this is what even happens in the Tsunami, we told that the water recedes inside first and then it raises up.

So, the imbalance caused in the crystal rock okay, the stress and deformation caused in the crystal rock basically makes this water level to go down and come up, so the continuous monitoring of well water okay with whatever that pumping this one and all, if there is a variation if you have a alert sensor for that, then there could be a possible to predict an earthquake.

So, as I told you that this entire class we have been copied from different website, we have been taken from different site for the teaching purpose, so you can, I acknowledge here the website which are used for this one, thank you for them to providing enormous content to teach to the in this subject.

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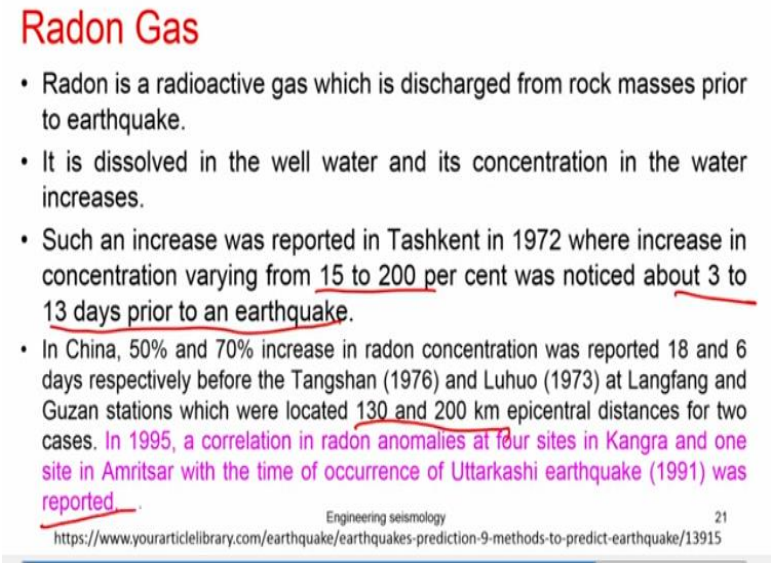

So, the another way of predicting the earthquake hazard is the radon gases okay, so radon gases is actually is a radioactive gas which is discharged from the rock mass prior to the earthquake. So, it is dissolved in well water and its concentration of the water increases, so this radon gases one is that it emits from the open space or in the water also, if there is a radon gas in the water, during the earthquake, this concentration increase such as an increase was reported in Tashkent in 1972 where increasing in the concentration varies from 5, 15 to 200; 15 to 200% was noticed about 3 to 13 days prior to the earthquake.

In China 50 to 70% increase in the radon concentrating was reported, 18 to 6 days respectively before the Tangshan earthquake and then Luhuo earthquake and the Langfang and then Guzan station were also located 130 to 200 kilometre distance for the cases, in 1995 correlation in the radon animals at 4 sites, okay, radon gas and animals; radon gas and animals 4 sites in Kangra and the site of Amritsar where time occurrence of Uttarkashi earthquake was also reported.

So, people reported that there is a this kind of gas variation as well as the animal behaviour difference in the Uttarkashi earthquake in 1991 in India okay. So, this kind of research paper may give the more details but all these are reported soon after the earthquake not before the earthquake that also be we have to remember okay.

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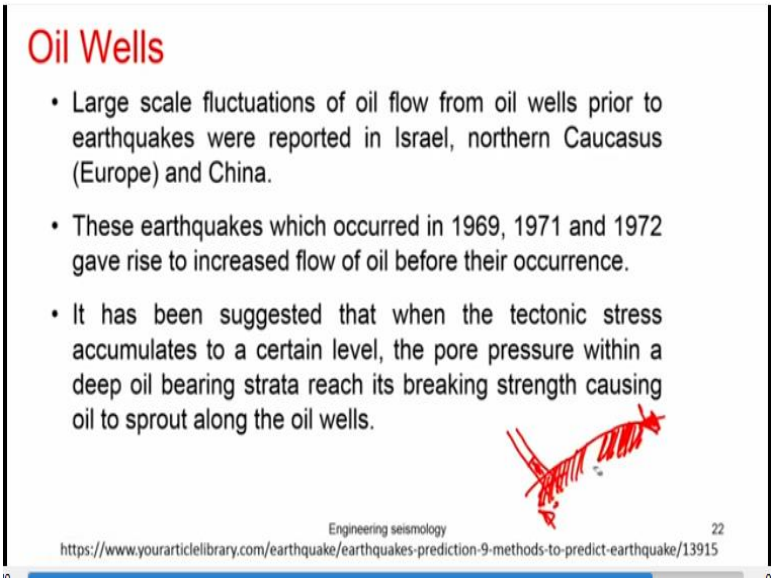

Then oil wells as we have seen that the water wells are very common in the places, most of the places in the world but the places where the oil is rich, there is no water like this Gulf countries oil wells are very common. So, the large scale fluctuation of oil flow from the oil wells prior to the earthquake were reported in Israel, northern Caucasus and Europe and China, so these earthquake which occurred in 1969, 1971 okay, so 1972 gave rise in increase the flow of the oil before the occurrence.

So, there was a fluctuation in the oil level and increased water oil levels in the oil wells has been observed which has been considered as a one of the precursor for prediction of the earthquake. So, it has been suggested that when the tectonics stress accumulate to a certain level, the pore pressure within the deep oil bearing strata reach breaking strength causing the oil to sprout along the oil well. So, as we have seen that the earth crust moves okay, as we have seen that both this is the plate okay, so it is keep on bending due to the application of this unusual forces in that.

So, when it stored energy, okay this forces are going to close to the strength of the rock okay, close to the like it is highly stressed okay, so close to the strength of the rock. So, then it going to break, so before break because this has stress and strains which may induce basically a deformation okay, staining level increase in the pressure, so the force will be different form it will be reflected around this rock area.

So, if you have the wells; water wells or oil wells of this, this also reflected in the water and oil in the well. So, when it breaks basically this there will be changes in the; so there will be changes in the, so this one, okay. So, it breaks then there will be changes, so this kind of fluctuation will basically help you to identify a predict an earthquake. If somebody monitors these things very accurately, very closely even there is a possibility to predict a magnitude and location very precisely.

The problem is that how many location you watch for example, if you have to watch the wells in India, so you should have the wells at least with some specific intervals like seismometer, all the wells you should have the digital controlled sensor to monitor, that monitoring should be overall done in the country level. Then there will be knowing the fluctuation very immediately and then

they observed and see that okay this is the fluctuation, earthquake going to occur they will inform.

But the money what you are going to invest on this okay, will be much, much, much larger than the amount of economical saving you do because of the prediction, number of people die because of this prediction okay that is what this kind of things are the not implemented, even though the scientifically which is possible but because of the amount of money need to be invested to monitor all these things, as we know that putting the sensor in the water also causes a lot of uncertainty okay.

So, putting the water in the sensor also causes a lot of uncertainties and it also makes more expensive okay, so that is why the well monitoring, radon gas, water level, oil level changes are even though scientifically which is correct but practically it is not possible to implement okay, so because the cost will go very high okay, the economic loss even the earthquake comes what you are happening will be you have 100 times or 1000 times lower than the cost to incur to predict that will be okay.

So that is the reason this kind of technology even though well understood and applicable and possible but since the cost associated which are very large, many of the country is not doing this kind of monitoring, okay only the report soon after the earthquake from some data that is a usual way they do. So, this is about the crust, rock deformation and associated link between the chemical variation, water variation, temperature variation, oil variation apart from unusual animal behaviour in that region.

So, these are all the well together if you do everything with there is a possibility to predict very accurately the earthquake but you have to invest large amount of the money okay that is the one main concern with respect to prediction of earthquake using all these technique that is why none of the governments are very keen on investing this kind of monitoring. As per my knowledge I do not think India anybody monitors all these wells for predicting earthquake.

Because even though we have several places the crystal rock appearing in the ground, as I told you that Bangalore, the Lal Bagh Rock, IISc rocks are the crystal rock which is connected to the plates, so the deformation in that obviously will help you to predict an earthquake like fluctuation in the water level, fluctuation in the radon gas okay, so all those things, hydro chemical process involved.

If somebody keep on monitoring, they observe a variation immediately they can issue a warning and this one but the monitoring is very expensive nobody does okay. So, with this discussion we will close this lecture, so we will continue in the earthquake prediction lectures in the next class, thank you very much for watching this video, we look forward your participation in the next class, thank you.