Introduction to Engineering Seismology
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Module No# 04
Lecture No # 18
Energy released due to earthquakes

So vanakkam, so we will continue our discussion on earthquake quantification. We discuss that the magnitude, ok so one of the quantitative way to describe the earthquake sizes. So initially the Richter was developed a magnitude called Richter magnitude. So which has been invented similar to the astronomer how they evaluate a star of size constraining the brightness. So here they used a wave form recorded amplitude, the size of amplitude to quantify a magnitude.

So later it is found that the distance earthquake does not have a proper P and S wave record. So in that case the surface wave magnitude has been play, becoming a very important. So similarly for the deep earthquake where the S wave may not be the very predominant only the P wave amplitude will be there. So the P wave magnitude was invented. So all these magnitude basically undergo a saturation. That means after some value this magnitude will remains constant irrespective of the amplitude increase or irrespective of the energy released.

So this has been identified a new way of estimate in the magnitude has been invented which is basically a seismic moment, ok. So people try to estimate a seismic moment by knowing the stiffness of the fault and how much rupture it is taken place, ok. Then the slip ok the force into the rupture length they taken into account the seismic moment. Then they also converted seismic moment into the seismic moment magnitude, which is very robust. At today all the earthquakes are the end of the report they give in the terms of seismic moment magnitude.

So initially, they may release the magnitude in terms of ML or MS or MD depends upon the where the earthquakes was recorded. But finally the report magnitude as a MW that is International practice now going towards that. So we should also remember that any earthquake which you collect from the historic time that may be reported in intensity that may be reported in ML. That may be reported in MS that may be reported in MP.

But when you use for particular application, all these earthquake need to be converted to the uniform magnitude scale which is called as a moment magnitude, ok that is what the present practice. So there is a conversion equation and conversion graph which we have also discussed in the last class, ok.

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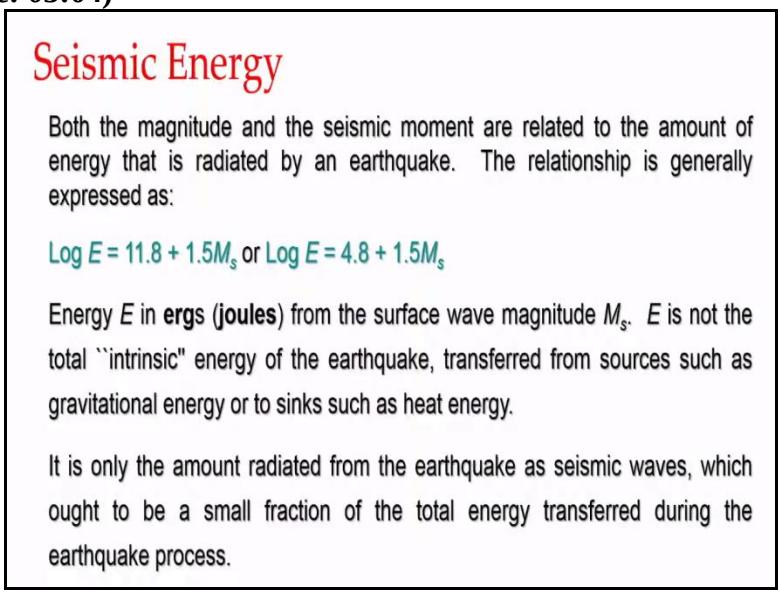

So here we should remember that these magnitudes are showing how much the earthquake is stronger and how much the earthquake is weaker, ok. So that is what it indicates basically how the earthquake is stronger and how the earthquake is weaker. So these earthquakes as we have seen that the magnitude in the form of log base 10. So these waves basically reflect how much the seismic energy released at source?

How much energy released? So the part of the energy only converted as a seismic waves. So the remaining energy basically consumed by eating up the medium while it travels. That means what wave you are seeing at particular so location is different from the energy what it carried from the starting point of the earthquake, ok. So the beginning or focus earthquake, the energy will be so much when reach a shorter distance or a longer distance the energy will be different.

So there are energy relations are developed which basically is the function of your MS or so other magnitude, ok. The energy is basically the like it is joules from the surface magnitude you can estimate. There are people who measured the energy and reported this kind of relation. The E is not a total intrinsic energy of the earthquake, but it is transferred from sources such as

gravitational energy or to sinks such as heat energy, after deducting the heat energy at particular place.

It is only the amount of radiation from earthquake as seismic waves, which ought to be a small fraction of the total energy transformed during the earthquake process. So why these energies are important to know that how the earthquakes are so big and so small depends upon the energy released. So here we can also remember that this energy is the function of log base E, ok it is not base 10.

So that means the energy of 1 magnitude is actually 33.3 times, ok lower than or higher than the energy of the other magnitude. For example the energy released by the earthquake magnitude 6 is actually 33.3% larger than the earthquake magnitude 5. Similarly the other scale, ok the square of 32.3% for the energy released by the earthquake magnitude of 7 when compared to earthquake magnitude of 5. So that is the things we should remember this is the function of the base E not base 10. So there is a difference between the magnitude scale as well as the energy scale.

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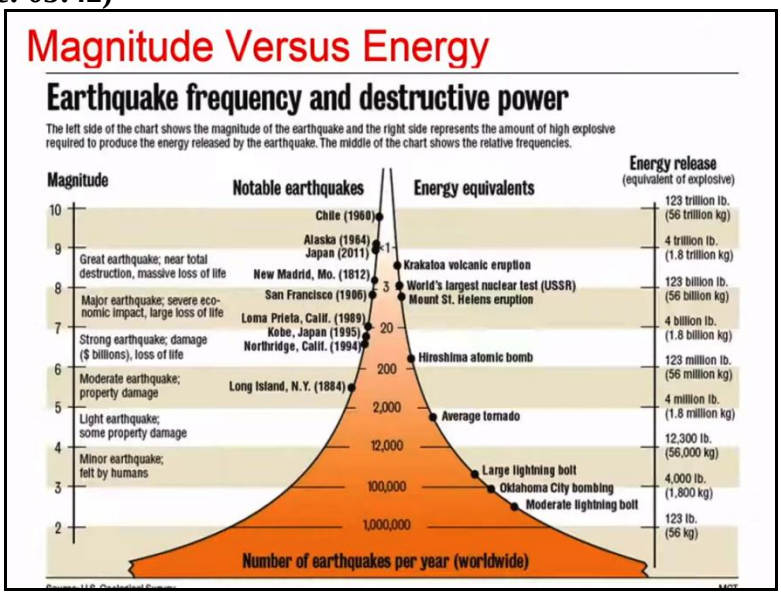

So these energies, ok whatever we see these energies basically helps to define magnitude, ok so types which commonly described throughout the world same. For example there any earthquake which is up to magnitude 4, ok so they felt by human is called as a minor earthquake. So, this minor earthquake basically will occur very frequently throughout the world, ok. So this particular graph you should basically try to understand this entire graph.

This entire graph actually has a 4 components so the left side basically gives the earthquake magnitude scale from 2 to 10, ok, so this is basically a magnitude of, so MW, okay. So then so from this point if you go straight to the right side it gives how much energy released. So here the energy is actually express in terms of equivalent explosion needed to cause that particular magnitude, ok.

For example if you want to create earthquake magnitude of 2 at particular location you need to basically explode 56 KG of explosion material, then you may get a magnitude of 2, ok. So the top one is LPS because generally US system they use the unit of LPS. The bracket one was the KG which is universally used, KG of the explosion you should see. Similarly magnitude of 3 which is basically need 1800 KG of explosion, you can see the different.

So this is only 56 KG but this need so much KG because your energy release this 33 times larger than the this two units, that is why. So then the centre one basically gives how many numbers of earthquakes occurring per year in the world, ok. This, basically indicate how many number of earthquakes occurring per year in the world, and similarly the left side of centre portion will give the Global earthquake of the particular magnitude? Okay.

The right side give the equivalent the other activity than a earthquake, so such as a the lightning bolt or the volcanic eruption or a nuclear explosion, ok. So these are all the things are right given. So that the energy equivalent how much it is released will be known. So this is the very classical and unique chart system one can understand how the earthquake magnitude, how much energy it is released, if you want to generate similar kind of earthquake how much explosion you need to explode.

So these explosions are not basically ever nuclear explosion, this is explosion with normal this one. Nuclear explosion quantity will be different, ok. So you can see the earthquake magnitude of two in this graph and you can see that these earthquakes are occurring actually almost close to thousand thousands, ok so thousand thousands of earthquakes are occurring every year in the world wide, magnitude up to which need to be 56 KG of explosion to create similar kind of energy.

So since there was many there was no such earthquakes are noted here. So then the magnitude of 3 so it needs basically 1800 KG of exploration so there are similar kind of activity which is happened, ok due to the man-made activity or nature which is that moderate lightning bolt occurred on one place that was having a similar kind of energy release. And large lightning bolt which has also having the above 3.

And then the Oklahoma city bombing which happened, which is equal to so much magnitude of 3, so much KG has been exploded, ok. So then the another earthquake category above 4 to 5 which is called as a light earthquake. So it causes some property damage. So you can see that these earthquakes are occurring close to less than 12000 but up to 2000 even every year it occurring. That means 4 to 5 magnitude are above 2000 earthquakes are occurring every year.

So one of this one is needs actually 1.8 million KG of explosion need to create magnitude of 5, so magnitude of 4, 56000 KG you need, you can see the how it drastically increases. So the average tornado in US basically has so much kind of energy equivalent to this kind of scenario, which is from 4 to 5. So that is why in US soon after the tornado you can see there is lot of disaster, ok many houses got collapse, peoples are get disturbed and then even sometimes people will die.

If they do not have the proper precaution and evacuation process, so these are all the big issue in the US. So the magnitude 5 to 6 basically called as a moderate earthquake damage. So moderate earthquakes which, basically causes a damage to property, ok. So this damage description basically with respect to US damage level. Basically India these damages are may be much higher, as we discussed earlier that the developing countries having the one magnitude greater damage than the developed countries.

For example, the earthquake magnitude 6 occurred in US, if you assume that 10 house fails, the earthquake magnitude 7 occurs it may assume that 100 houses are failing. The 6 magnitude occurred in India will cause 100 houses fail, which is equivalent to 7 magnitude in US, which we have discussed earlier also. Similarly the 5 magnitude may cause 10 houses fail, which is equivalent to 6 magnitude in the developed countries or US.

So that is how our preparedness and the construction practice that is what the difference has been observed, not only in India in many of the developing countries, ok. So similarly the number of people death also similarly it will be equivalent. So the moderate earthquake 6 which is occurs roughly about 200 earthquakes every year okay. So the long island New York 1984 earthquake is basically 5.7 okay which needs actually 56 million KG of explosion to cause such kind of energy equivalent okay.

So the 6 to 7 magnitude is called as a strong earthquake which basically causes a damage and billion rupees damages, ok millions billions rupee damages causes and it also create a loss of life large extent, ok. So with the 7 magnitude requires 1.8 billion KG of explosion ok. So the example where the 7 magnitude of North ridge earthquake in California ok, Kobe earthquake and the Loma Prieta earthquake these are all in this range, you can see, ok.

So this about 20 earthquakes in average worldwide in the range of 6 to 7 is expected in the world. So the Hiroshima atomic bomb which caused the so much disaster in the Japan basically had equivalent energy of 56 million KG above, ok, which is closed to magnitude of 6.2 and above earthquake level energy has been created, ok. So this is what we get from this graph, so you can, this is like unique graph as I told you that you can get all the information you needed.

So 7 to 8 magnitude which is called as a major earthquake, ok, which causes a severe economic impact and large loss of life. So these are all very big earthquakes, like the Loma Prieta, California earthquake and San Francisco earthquake. So these are all the example of this kind of thing. So which needs 56 million KG of explosion so the world largest nuclear test USSR has been having close to magnitude of 8 and then Mount Helens eruption, which is also a volcanic action this is be equivalent to the 7 to 8 range of energy released.

So above 8 magnitude is called as a greater earthquake, so near total destruction, massive loss of life, ok when earthquakes are occurred. So the New Maryland magnitude, ok that is the example and Japan 2011 earthquake is the another example for the magnitude of 9 okay 8 to 9. And then the Krakatoa volcanic eruption is actually equivalent amount of energy has been released. So if you want to create a magnitude of 9 you should basically 1 point trillion KG of explosion we should do.

That is what is written here you can see. So the above 9 magnitude basically very few earthquakes are reported in the world, which is basically not even one earthquake per year but it is once in a while that occurred, ok. So it may in 5 years once or 10 years once depends upon the period. The earthquake which is above 9 is actually the Alaska earthquake and then the Chile earthquake, which is happened during the sixties not before that.

So the Sumathra earthquake is one of the known modern era earthquake, which is more than magnitude of 9, ok. So which, is causes a enormous amount of the energy release. So which; needs about 1 point trillion KG of explosion above explosion to be exploded to cause this kind of earthquakes. So this graph will give you the overall how this earthquake or how much energy it released from earthquake.

And also, how can, you can describe for the common map like a light, minor light, moderate, strong, major and great, ok. So basically this strong, ok or upto a major earthquake, one can expect in the relatively the intra break region kind of things like Bangalore, Peninsular India, Southern India kind of things. So the greater earthquake generally occurs in the plate boundaries where their magnitude 8 and above on can expect in those regions. So that is what the historic evidence shows as on now.

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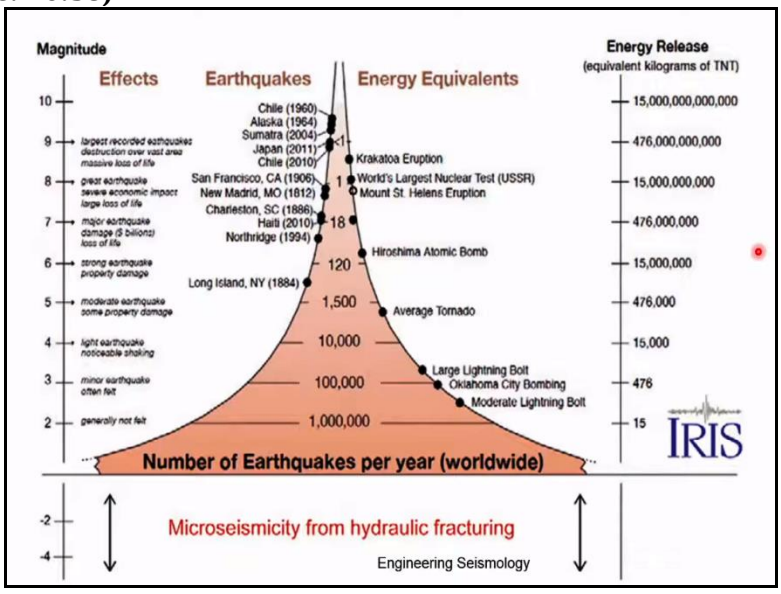

So apart from this earthquake so there is a earthquake which can be also created by the micro seismic activity by hydro fracturing. So what is the hydro fracturing tracking, so you might have

seen that you use Petrol as well as the diesel, oil from the ground, people will extract by making, drilling a hole and then getting the oils you know. So when they drill, ok, the holes are actually in several meters deep, ok and the oil will be located at several places not exactly below the borehole align.

So in order to make that connection and then fracture that rock to bring that oil to the bore hole level they do some kind of fracturing which is called as a hydro fracturing work. So these hydro fracturing work also releases energy, which is basically in terms of negative energy, which is causes a negative earthquake magnitude, you can see. So this hydro fracturing actually causes -2 to -4 negative earthquake which is equivalent KG of explosion you need to do this. This is a generally done on the deep bore hole when they want to extract a natural gas as well as natural oil, ok.

So this also give the typical earthquake whatever we discussed similar to that and then now the energy was released at different places in this different earthquake in the world. So you should remember that so the more energy released, ok there will be more destructive mass. So since the earthquake needs the large amount of the explosion equivalent energies released, so that is why the experimental earthquake research is not so much famous.

So for example as we told you that magnitude of 4 and 5 above only you can see the building damage. So if you want to study how the building damages if by the real earthquake not the scaled earthquake. That means you have to basically use so much of explosion and make the blasting should happen, then you can see the real signal how it is coming by, which is practically impossible and you need to, also it will also disturb lot of people around that.

That is why those kinds of researches are not taken. So instead of that they try to simulate a earthquake rather than create a explosion and the see the earthquake. But recently there was a studies going on artificial earthquake or man-made earthquakes in the US people are try to create this kind of explosion or studies using the this one and kind of things are going, well advanced may be after few years that kind of practice also India somebody can do.

So today we discussed about that, what is mean by earthquake energy and how many earthquakes per year is happening and different scale of magnitude, how this earthquakes are

basically occur, how many explosion cage you need and what are the equivalent warming or the natural event occurred similar to the earthquake. And then we also discussed about the hydro fracturing. So with this we will close the earthquake, quantification topic. So now we have seen earthquake quantification.

Earlier we have seen the seismic instrumentation and how the waves are recording. So in the next class we are going to see how we can interpret a earthquake record, ok. So now we know quantify, we know how to record. So now how the recorded data we can use and interpret for the engineering application. So that is what we going to discuss in the next class. So with this I close this class. Thank you very much for watching, we will see you in the next class.