Introduction to Engineering Seismology

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Lecture No-33
Recapitulation - 5

So Vanakkam, so we will continue our lecture on engineering seismology. So we are basically doing revision before going for the application. So why we are doing revision because you have to know how we can predict or the earthquake hazard or earthquake. So that involves like the understanding of whatever we studied so far. So as we said that, so the earthquake hazard creating lot of causality is as well as the economic loss, so all those things.

So the one of the way to reduce this is actually to understand how the earthquakes are happening? How the wave propagation happens, all those in understanding the physics. So the other way is to forecast, so to predict the earthquake and the earthquake hazard. So as on today the science, it is a very clear that the earthquake cannot be predicted. So the only way is to basically to take care of the reduce and minimize the impact of that earthquake is basically we have to forecast very accurately.

That forecasting involves understanding of the earthquake. So that is what we study to so far. So still we are want to make sure that whatever we studied you understand properly. So we are recapping the all the subject whatever we studied on different topic. So last class we have discussed on the wave propagation. So it is very clear from the wave propagation that so the wave travel controlled by the medium what it travels.

Basically the stiffness and the thickness of the medium. So the another parameter which is controls the wave propagation, actually the wave speed and wave character. So the some wave will reach first somewhere will reach later kind of things. So the when you understand the earthquake is wave propagation here. So the way of recording the earthquake is basically you are to try to have the instrument, which is called as a seismic instrument, seismometer seismoscope.

Where you can try to record the waves which you produced by the earthquake. So then you can quantify the earthquake. So today a couple of lectures. So whatever we are going to, see is actually the portion which you covered after the wave characteristics. So if you look at the this earthquake damages since historic times the humans settlement are human being are try to escape from the earthquake.

So we have been seen that in olden days people actually had a seismoscope which is called as a Chinese seismoscope. So in the age of 1832 AD, which is basically reassembles here big wine jar.

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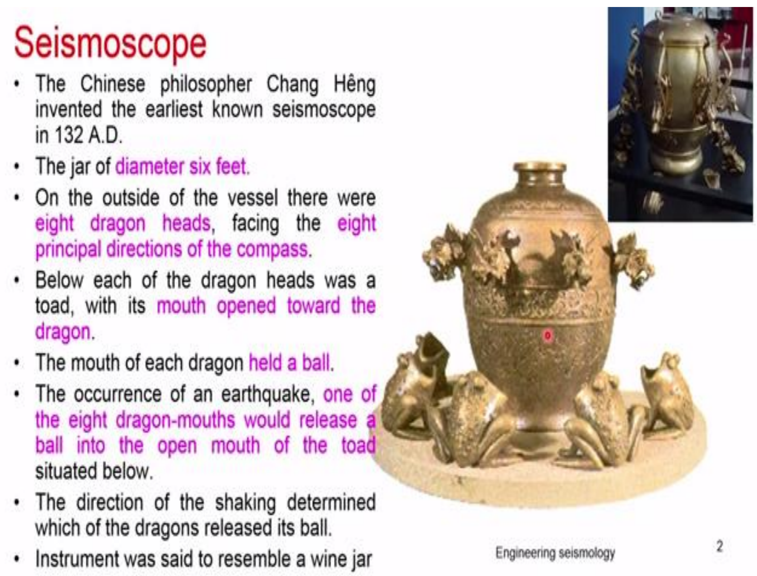

So this is the wine jar which is resemble the seismoscope, so in this actually there was say eight dragon that is what we have seen the eight dragons are there. So each dragon hold a ball, so this ball it holds so when this ball holds there is a eight toad down the, so this instrument, it is basically a metallic kind of instrument so which source anywhere in the nearby area about close to so 400 miles, so if any seismic events are taking place this dragon will drop a ball on particular that direction.

So that is how it has been, so you can see that this seismoscope more or less tried to predict the earthquake, so only thing the time what it predicts may be the lower when considering the, earthquake, the time period all those things. So generally if the earthquakes are happening anywhere 0 to 400 miles. So this can detect. So immediately drop a ball. So I may be thinking that. I am thinking that this may be invented purposefully in China those days Chinese called Japan China and all those regions.

So there was a lot of Tsunami, so all the earthquakes which happened to the Tsunami happened in the sea used to cause a Tsunami, so this people might have you used this system, to know that the earthquake has happened in the sea. As we have seen that even though the seismic wave reaches first, but the Tsunami waves reaches very late, sometime it has 1 hour, 2 hour depends upon the location.

As you know that the Sumatra earthquake 2004 the Tsunami reached about two and a half hours to the Chennai and East coast. So which indicates that you have sufficient time to move the people. So, only you cannot get the waveform may reach very fast as the waves are traveling with the speed of like, so the P wave is actually travels close to like 5,7 kilometer per hour. So the S wave travels to 3, 4 kilometer per hour.

So but the Tsunami waves travels very less speed, so when you look at the Tsunami what we discussed we are doing earthquake hazard it travels very speed so generally it takes very long time to reach here, the particular place. So this seismoscope, they might be invented or to predict earthquake, but this was a origin for the seismic research on seismic instrumentation part.

So many scientists try to understand how it is working, many British scientists try to understand how it is working, so it is not possible very clearly to find out how it is working.

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So basically they figure it out that it is working a concept of a symbol pendulum, so that pendulum basically so connected to the ground so, it stays horizontal as stationary position one is inertia mass, so when there is no movement when there is a moment, so accordingly the pendulum will move. So the relative moment will be used to know what is the size of earthquake. So depends upon the frequency of the waves.

So the mass and the damping can be vary to get here reliable this one. So this is how the come up with the conclusion that the pendulum kind of concept might be used in seismograph. But it may be inverted as we are seeing that ball was dropping from top of the jar, but this is still speculated that this may be true may not be true something like that.

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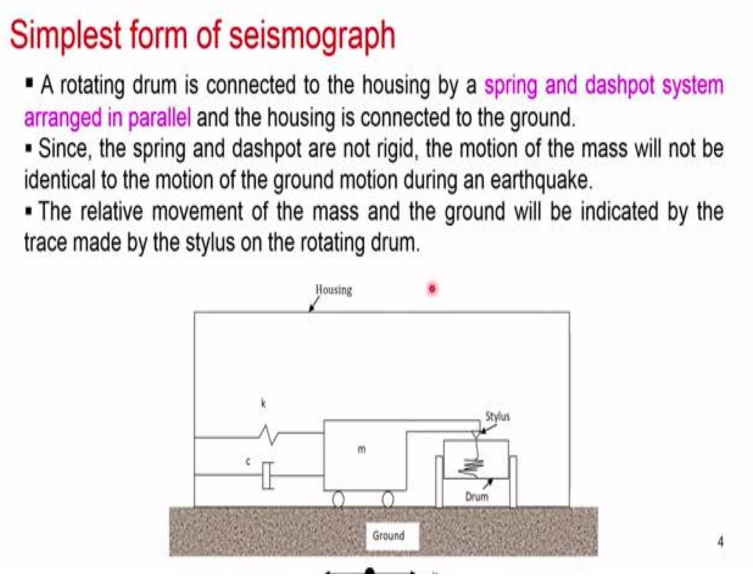

So the simplest the modern seismogram basically, they consists of the mass and spring constant and damping. So then, these are housed in the system, which is connected to the drum where it can draw a whatever moment it is happening. So when the ground moves, there is no ground moment mass and then the stiffness and the damping is kept such a that it does not create any zigzag motion.

It creates a some kind of straight line motion kind of things. So when the ground moves the relative movement. So basically taking into place that create a zigzag waveform, whatever it happens accordingly the ground moves. So due to the P wave, S wave and Surface wave that portion was actually recorded in the drum. So that is how the simplest form of seismogram has been there.

So dependents of the direction of the recording you can have the single sensor and multiple sensor seismic instrument.

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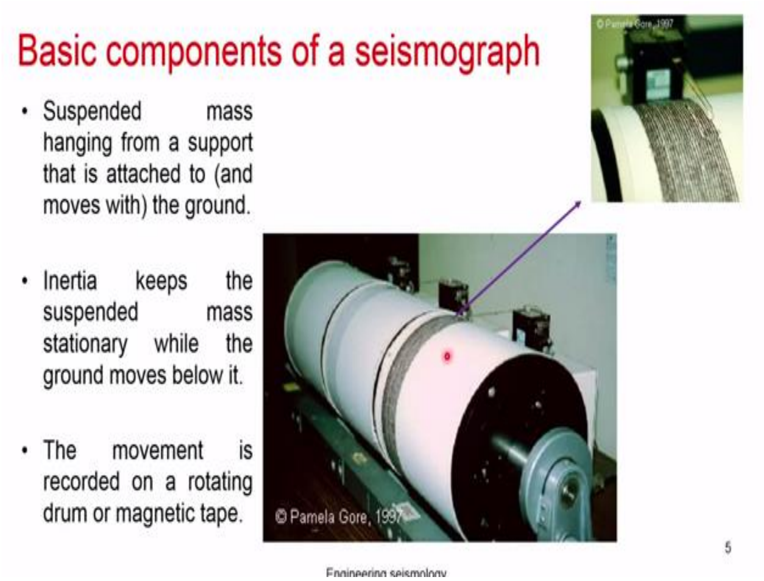

So basically the any seismic instrument, so it consist of the suspended mass hanging from the support the attached to the ground. And inertia to keep the suspended mass stationary while ground moves below it and the moment of the recorded rotating drum or magnetic tape. So, basically the system which sense the vibration and then reflect that vibration in the form of waveform.

And then that wave form writing, the drum or magnetic tape or digital record is another component. So in apart from this, you should also need to have time system, so that you will know when and where the waves are arrived. That system also integrated. So, this is a typical old seismogram. You can see with paper. This is basically a magnetic tape the zoomed portion of that paper writing can have things.

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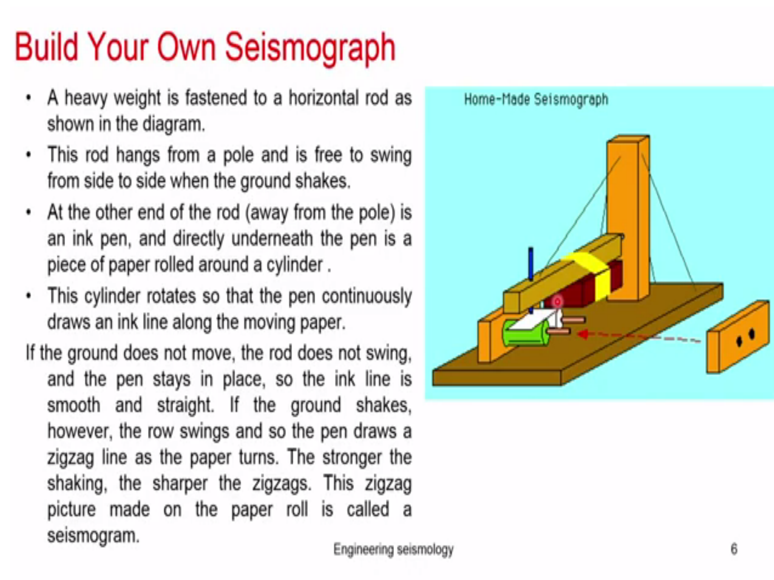

So this is a very common when the olden days seismometer was involved. They had analog system where it draws here signal in that. So the simple way of working this actually can be understood from the building your own seismograph concept. So where there is a mass, so which is suspended here. So when the ground is this one this mount does not move when the ground vibrates basically this moves back and forth this create a response.

So this is the simple wooden, home made seismograph you can make and you can shake here you can see that this one so if this related video the seismogram explanation and then there discussion you can find plenty of videos and explanation in the YouTube. So you can refer that and get enhanced your knowledge and this subject.

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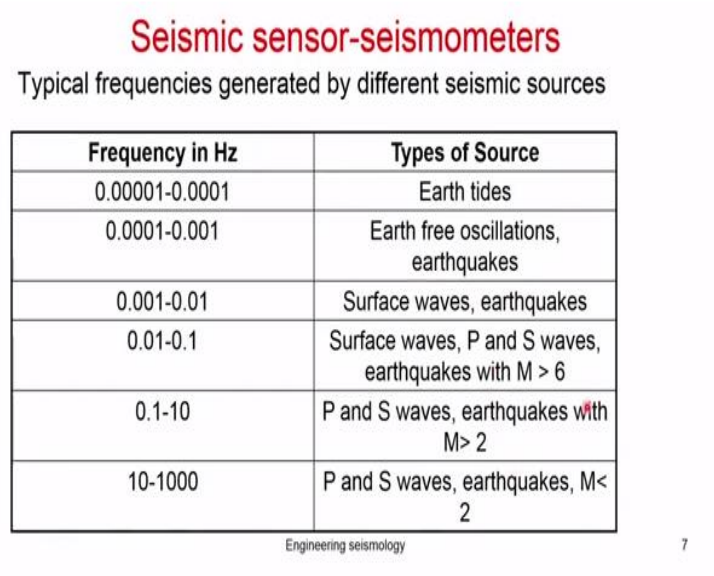

Frequency in Hz	Types of Source
0.00001-0.0001	Earth tides
0.0001-0.001	Earth free oscillations, earthquakes
0.001-0.01	Surface waves, earthquakes
0.01-0.1	Surface waves, P and S waves, earthquakes with M > 6
0.1-10	P and S waves, earthquakes with M> 2
10-1000	P and S waves, earthquakes, M< 2

So the wave coming on the different frequencies, so accordingly the seismic sensor which detects should also have a particular frequency of interest where, which wave you are looking at. So this is the typical frequency generated by the different seismic source, and then the corresponding ness, so if you want to record a particular type of seismic waves, which is created by the respective source you should have the corresponding frequency capacity of the equipment.

You can see that the Earth tides vibrates in the 10 to the power of -5 to 10 to the power of - 4. So the earth free oscillation earthquakes or 10 to the power of - 4 to 10 to the power of - 3 and then surface wave at earthquakes 10 the power of - 3 to 10 to the power of 2, so then 10 to the power of - 1 to the 10 to the power - 2 is the surface P and S wave with the earthquake magnitude of 6 and the earthquake magnitude 2 and 6; 0.1 to 10 and then P and S wave the earthquake magnitude less than 2.

So you can understand that depends upon the what type of earthquake you want to record you should have the respective the frequency in the selection or sensor should be installed in the seismometer, what you are looking for.

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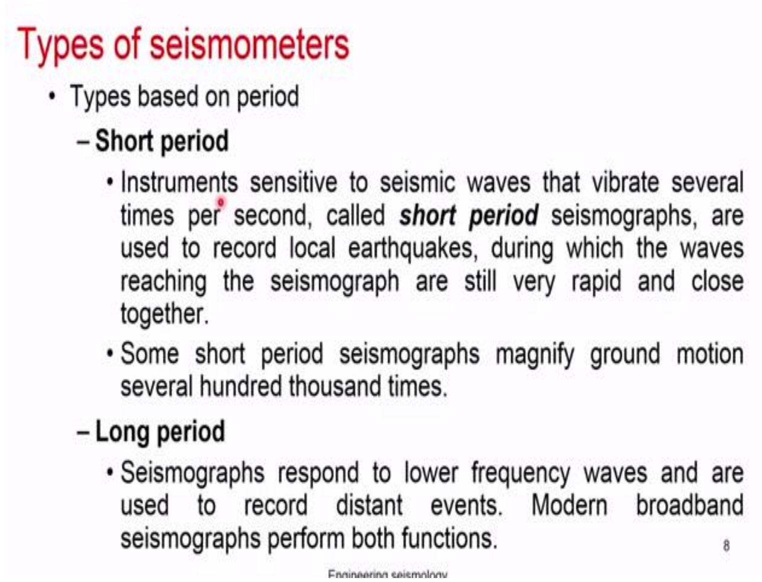

So based on the sensor type, the seismometer has been classified; one of the short periods sensor where the instruments sensitive to the seismic wave that vibrate several times per second called as a short period seismograph. And the used to record mostly on the local earthquake which is reporting within the few hundreds kilometers like 100 kilometer 200 kilometer, 300 kilometer those are the local earthquake.

So this short period sensors are basically as the magnifying the ground motion level under 1000 times it depends upon the instrument and to show you the waveform which is occurring on the particular earthquake. So the another sensor is long period sensor, long period sensor basically respond to the lower frequency waves and are used to record distance, so most of the modern broad band seismographs perform the both short as well as the long period operation.

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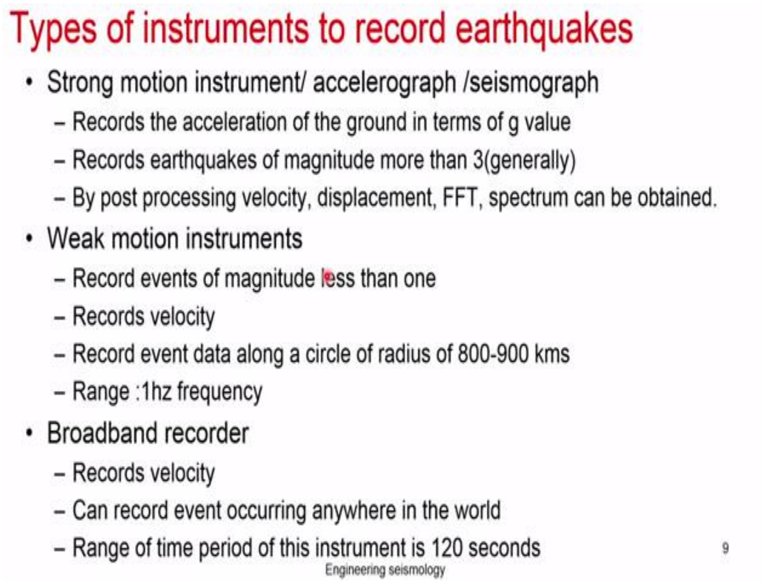

So based on this actually, so the type of data it records we can classify the instrument; one is the strong motion instrument, accelerograph or seismograph. So the strong motion instrument basically records a strong vibration signal basically acceleration of the ground motion, The g value record magnitude more than three under by post processing you can get velocity displacement and FFT spectrum can be obtained using this data.

So for example the accelerograph always measures a, the acceleration value. So the weak motion instrument are seismograph which records a velocity value, the both the value as we have seen that add a impact and requirement for the, your engineering prospective. So the another one is the broadband station, so it records velocity can record event occurring anywhere in the world and range of time period of this instrument is 120 seconds.

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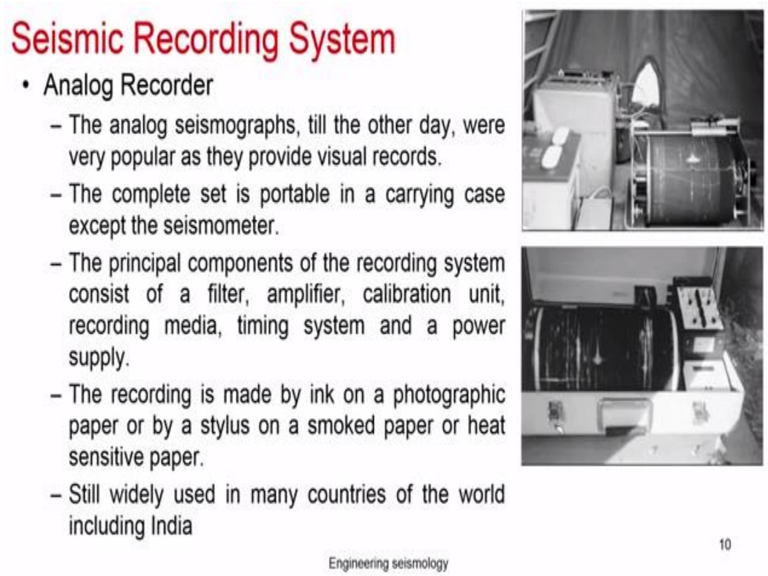

So, as I told you that these instruments are the modern today, digital there are a lot of instruments are there. So we can get this data's recorded in this. So this instrument when the initially developed there is a analogue recording system where all the records are made in the kind some kind of paper roll or magnetic tape or some kind of recording where the analog sensors will be so moving like this.

So the analog sensors will be so moving like this, like this, like this in the given drum like this is the analog tool say so there will be drum so, which detects its portion of the data on the recorder that is analog. So after electronic development in the this one these are this is actually a typical. So typical analog system you can see this is a portable seismometer, so which was used with the very early stage of the seismometer.

So this may be very few places you can find actually as I told you that it is available in the IIT Roorkee. If you want to see this instrument and whenever next time if you go, you can go to the earthquake engineering department at IIT Roorkee, you can see this instrument.

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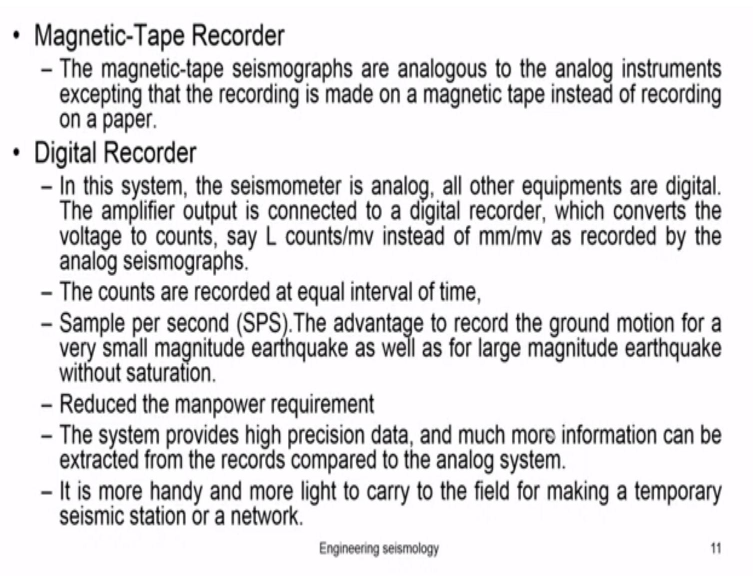

So then later due to the development in the recording system magnetic tape as come, then digital record has come. So now a days the most of the instruments are digital record, so the analogue and digital it has its own the advantage, so for example analog somebody can see physically data soon after the earthquake and understand how it is good. So the digital record you need a computer so where it has to be transformed to the computing facility and that computer required a power.

So in in case if the earthquakes are occurring there is no power, so then you cannot see that data until power comes. But the analog system so you can see immediately so these are all the advantages, but only things storing of data processing and all those things analog system, it is a problem. And a digital system even you have the control over samples per second, so how will the time period changes? How you can pick up a different waveform parameters? So all those things can be extracted in the digital system.

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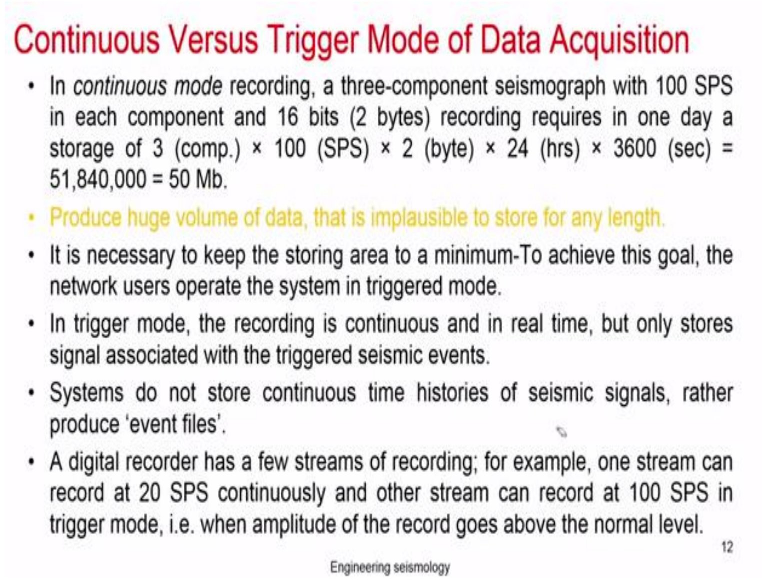

So this when the digital system is coming to picture, so the continuous recording raised question because the olden days the computer had very less storage facilities not like now. Now you can get a several terabyte GB, gigabyte in the small pen drive, the data's are now. But the olden days where they used to worry and unnecessary data storing in the instrument or computer, so they specify that sample rate and then the, how many bits each sample take?

What is the data? How many data is produces? How many earthquakes you can store using that? So then afterwards you have to replace the system, which store the data like storage device you should say. So there is a this digital system brought into the concept of continuous versus triggered mode of data acquisitions. So continuous means the data which is started, when the instrument is started it will keep on recording irrespective of that earthquake occurring or not. The triggered system basically involves to;

Make a provision so it will monitor the vibration but only record as per we give instruction saying that only record a the 0.20051 g, at a particular place. Then the it will is see the record and the pre event time you can give. So that is from this value whatever pre 10 minutes you record and from this value end up this value record one more year something like that, you can basically make a provision.

So that pre-event, post event all those things are easily controllable in the continuous versus trigger mode. So, they trigger modes are very effective to optimize the equipment storage capacity and get the record information from the storage. So the samples per second is another important parameter apart from storage which decides your size of the file.

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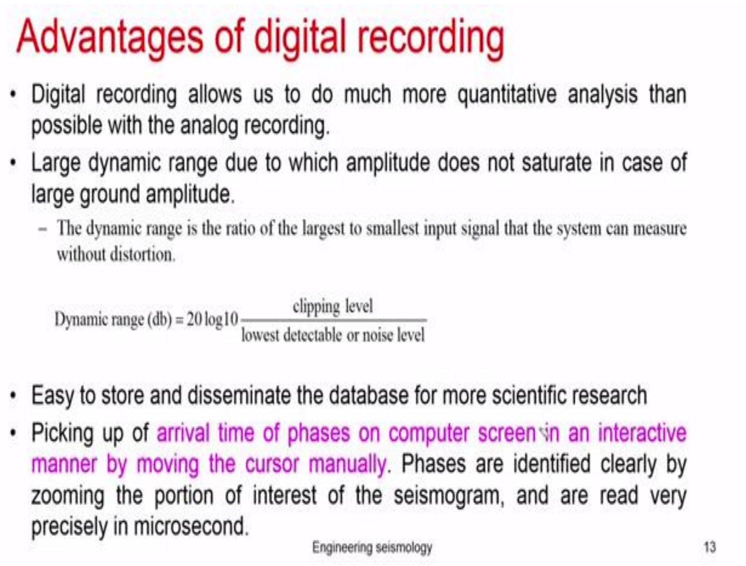

So the digital recording system basically you can control your dynamic range which is the ratio of the largest smallest input signal system can measure without distortion. So these are all having the several application in the engineering seismology. Easy to store and disseminate the data for the scientific approach. Packing of the arrival time for phase computer screen in the interactive manner by removing the cursor manually. So the phases are identified clearly in the digital system where you can get a clear wavelet characters.

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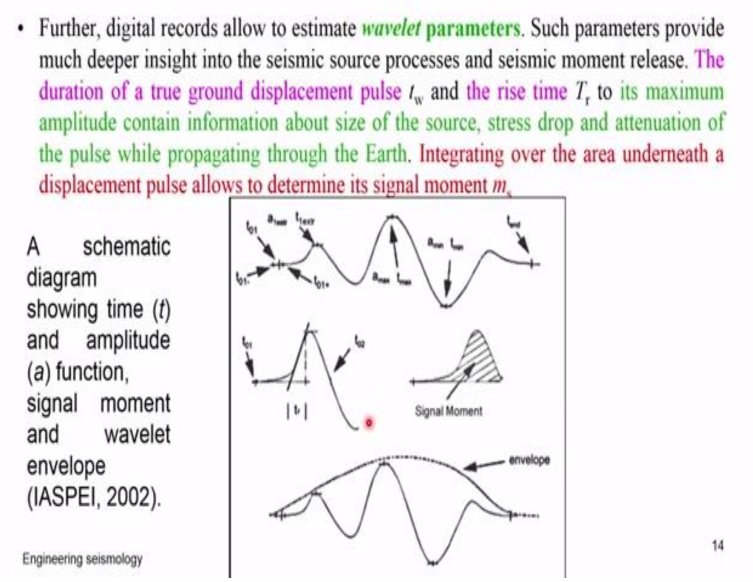

These are all the wavelet characteristics you can see, so these are all the wavelet characters. So the digital system has capacity to basically get a your wavelet parameters. So which has here like the duration. So the true ground displacement pulse tw the rise time TT and also a signal movement, by integrating the signal. So all those things and then the envelope we have accurate measurement of the wave amplitude.

So, all those things are possible very accurately in the digital system when compared to analog system. So which gives a flexibility to map your source and estimate a ground motion parameters. So time domain parameter, frequency domain parameter, very accurately from the digital data. So that way the digital system basically requires a more advantage. This will give you more advantage. It has been almost adapted throughout the world most of the stations

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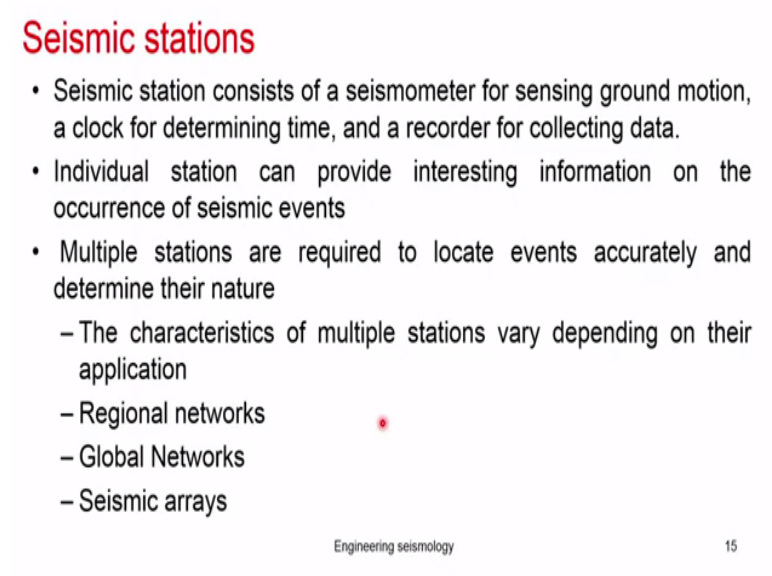

So the seismic moment, so the seismic station, so seismic data so these are all basically interlinked all of them reflected in the waveform. So the recording data interpreting the data are very important. So the place where these seismic instruments are kept is called as a seismic station. If the one instrument kept at one place that is called as a seismic station or seismic instrument location or something like that.

So the seismic station consists of the seismometer, by sensing the ground motion clock to determine the time and recorded to collecting a data. So individual station can provide interesting information on occurrence of seismic events multiple stations are required to locate event accurately determine their nature. So the seismic stations, many seismic stations will be clubbed together and called as a seismic network.

So the seismic network basically as a three category; regional network, global network and seismic array.

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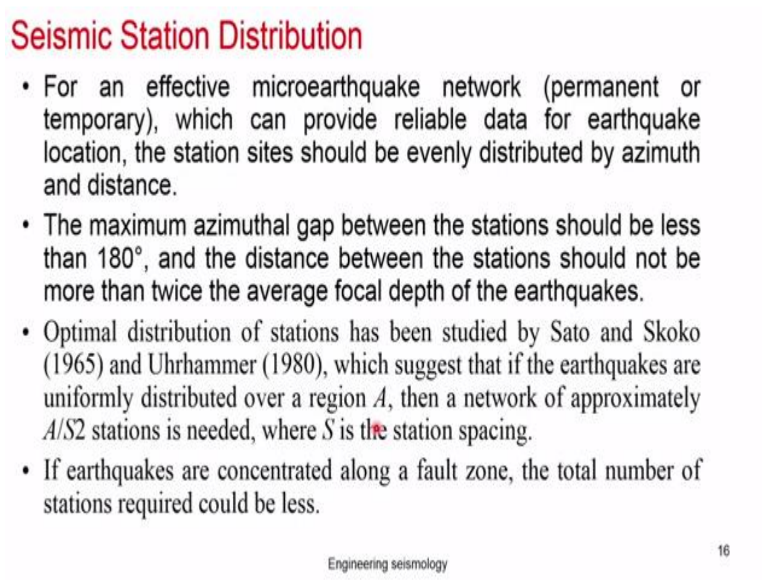

So the regional network is basically so the seismic instrument number of instrument from 10 to a few hundreds will use to deployed at a particular place to measure a regional earthquake data, that is a regional earthquake. So the global network is a funded by the global funding agency. So which you like each country will have one or two these instruments which record earthquakes at anywhere in the world.

So anywhere in the world it will record that record, with data will be helpful to identify the earthquake in the world, but as I told you that this is not simply not only record the data this global networks are basically funded by the USGS and the other big organization where they will also know that the other unusual vibrations created by the human activities, we have been discussing that during Abdul Kalam period.

So the Rajasthan Pokhran test was possible and but it was detected because of the there is a global seismic network in the India.

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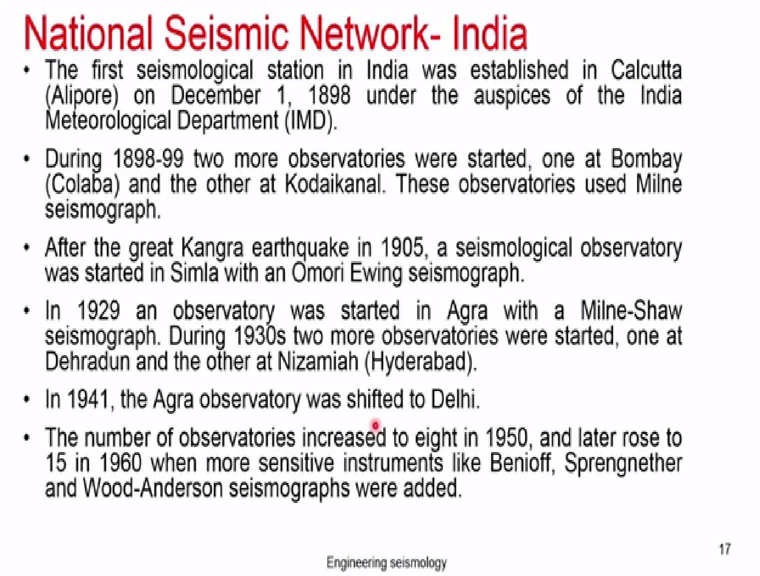

So with that we also see your seismic array, try to understand the how the wave character changes in the small scale level 50 meter, 100 meter, 20, that is why seismic array is used basically to understand amplification and liquefaction related studies. So the India, so this seismic instruments in India basically has been taken from the historic time, but the first seismic instrument was installed soon after the Shillong earthquake.

So during December 1 1998, so later this instrument keep updated and then keep modified, then it has been shifted and several places and all. So overall, we can see that before 1960 there is not much seismic instrumentation was deployed in India.

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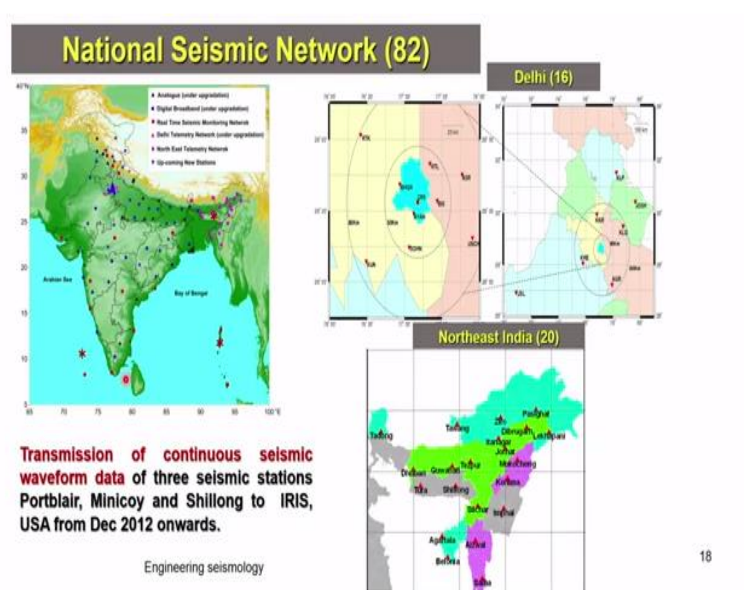

So which gives the idea that when you have the seismic instrument, so history and knowledge you can decide that whatever data somebody claimed that is recorded is a possible to record not possible to record. There are several agency we discussed that they maintain here national seismic network the permanently at different the permanently or temporarily depends upon the application of the project and study of the interests.

So, this is the typical Indian map, shows a difference seismic station, operated in the whole India by the Indian metallurgical department. So apart from this, they also operate here dense regional network in the Delhi region. So then the other regions were North East region where there is a frequent earthquakes are expected so this give you the brief idea about those things.

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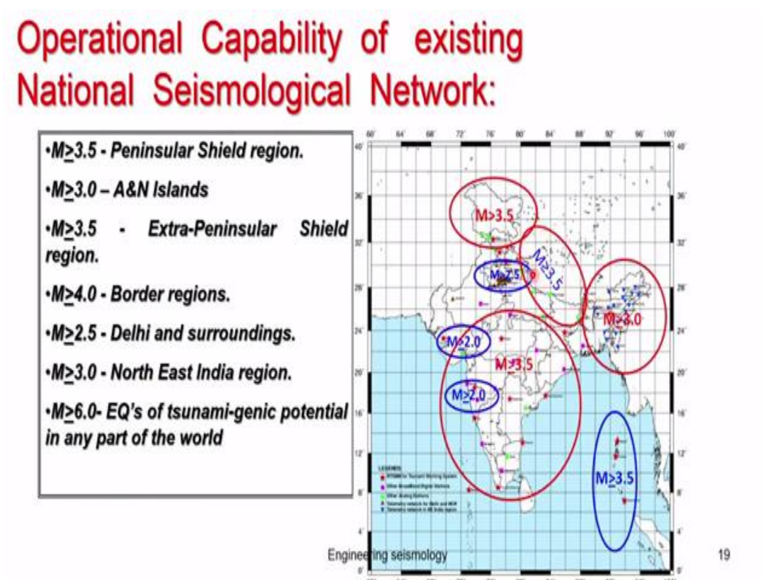

So this station in India, whatever station we are talking in India has a different capacity, so you can see that the right side India map marked with the circle the circle indicates like how much magnitude you will get, how many times before they will tell you. So that is the information you can get from here, you can see here. So they how the differentiations are there, but there was a dense network in a Nepal which is maintained by the IIT Roorkee. But now I am not very sure that network is operated or not.

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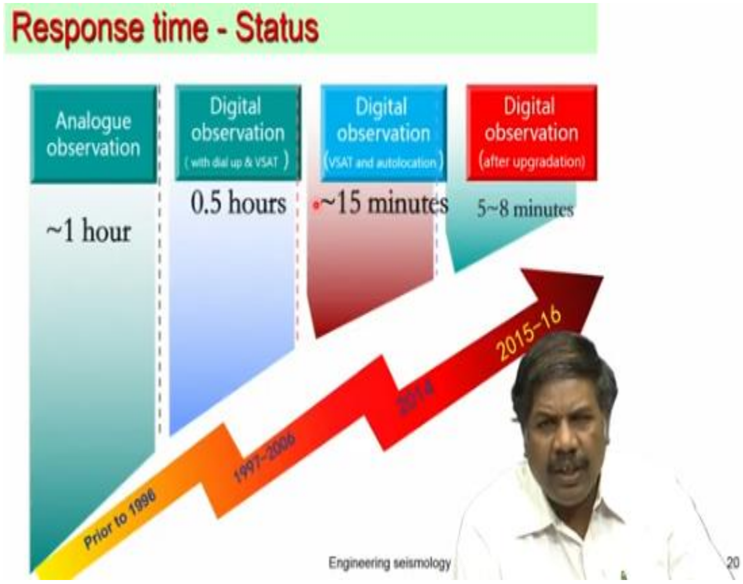

So these seismic stations as we said that it is from analog to digital since historic times. So how the seismic stations will basically inform to the decision maker and political people and scientists about the earthquake. So there is a time, so which required. So as olden days all analogue system 1 hour is to take. So then the digital observation change the 0.5. Then the digital observation change with 15 minutes.

And finally the today online whatever we are doing, whatever we are seeing a watch and other things now where these are digital observatory kind of things where you can find the earthquake occurrence, soon after 5 to 8 minutes time which will give you the idea about how the particular earthquake was recorded? How the earthquake are useful not or not? What is the time of arrival or warning system given to the people?

So you can look at this group, the time period very carefully prior to 1999 and the 1999 to 2000 to 2014 onwards, so this is the response time of that. So by looking at this we can know that nowadays if we have the earthquake within 5 to 8 minutes you will come to know what earthquakes occurred where it is occurred, which is not possible in the olden days it will give you the earthquake size and then location.

But the damage and other things one has to go physically and observe. So with this basically we can close our class on seismic instrumentation recapping this chapter. So you might have understand that the recording a particular type of frequency wave are very important to know the size of the earthquake, that is why you have the different variety of equipment you should choose appropriate equipment which is suitable to your region.

For example, you are using only getting the high frequency waves there is no frequency there is no point in investing those kind of instrument and the waste money. So the people generally want to install your seismometer before they do the preliminary analysis and temporarily run your station for some time and to find that the station information was they are giving is so useful for getting the earthquake data.

And used to get a any earthquake parameters so this has been practiced, so since beginning this instrumentation part here major role basically to sizing the earthquake so the wrong sizing will give the miss conception as well as the lot of damage so with this I close this video thank you very much for watching we will see you in the next class.