Introduction to Engineering Seismology
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Module No# 04
Lecture No # 19
Interpretation of Earthquake Records; Baseline Correction and Identification of Earthquake and Time Domain Parameters

So, vanakkam**,** so we will continue our lecture in the engineering seismology so last class we discussed about the quantification of the earthquake particularly. We talked about the magnitude and the energy released by the earthquake. So today class we are going to discuss how you can interpret a earthquake, ok. In the couple of classes in the coming session so today particularly we are going to see how we can identify earthquake signal when compared to this one.

As we know that the seismometer installed at any place can record any vibration which may be caused by moving up vehicle or it is may be caused due to the moving up any explosion nearby or it may be caused due to the real earthquake at that particular place, ok. So when the earthquakes occur basically the report a magnitude, ok.

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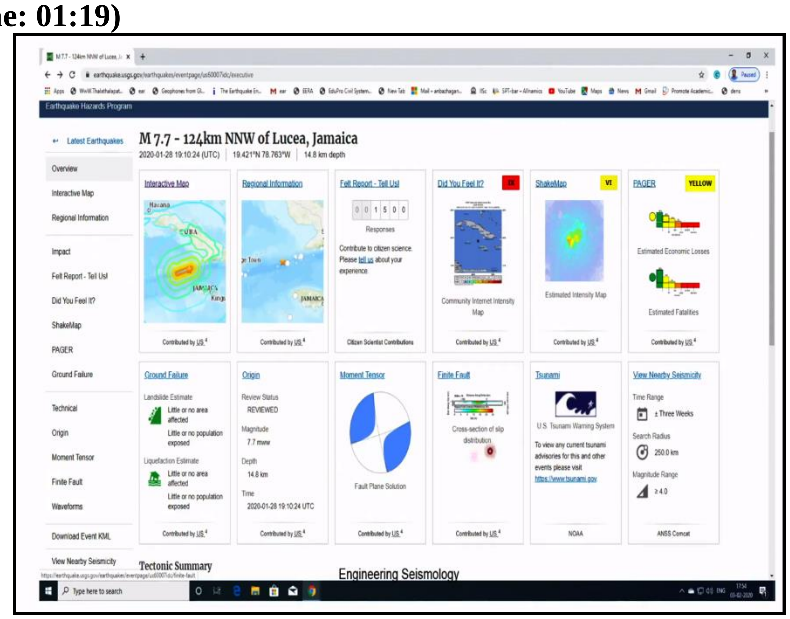

So this is the typical report, you can see from the earthquake. So report you can see basically the earthquake basically the report isoseismal maps which you know what is isoseismal map. So the report here location of the earthquake, which also we have seen that when you have the more than 4 seismic station, you can locate a earthquake precisely using that and then so they also report a shake map, which is estimated intensity and they also give a moment tensor, ok, and then the magnitude and then the fault, ok, then other warning system kind.

So how these data's are obtained. What are; the information they use from the typical earthquake to get all these information. So as we have seen that the so earthquake basically get you the waveform, ok.

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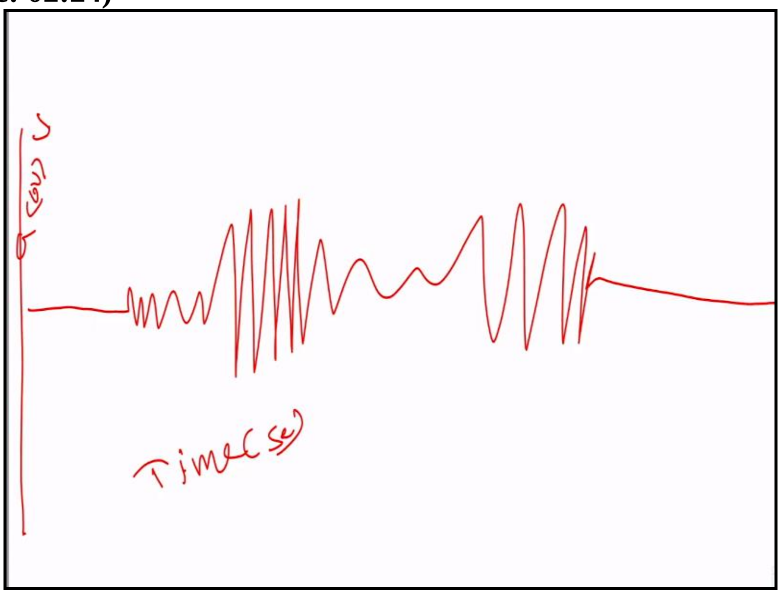

So that waveform basically so like this then, like this you get a typical wave form if it is recorded on this one. So this may be the acceleration or velocity. So this will be the time, ok time in seconds. So this is the typical record ever. From here how they go to other place. So any seismometer can record a waveform simply as a data, which is cause nearby the vibration.

Even there is a some kind of bike or truck or any motor is moving, then you will get a vibration signal recorder, and it will also have a acceleration velocity values which may be some time equivalent to the smaller magnitude are negative magnitude depends upon the vibration source. So the interpreting of earthquake is a one of the important aspect in the engineering seismology to understand the regional seismic activity.

So how to interpret a earthquake, ok. So the first form of interpreting earthquake is basically first you have to get a proper data, which is confirmed that a proper waveform we have, ok. The second is you have to identify that waveform is earthquake or due to any man-made activities. So once you identify that, next you can interpret a, useful parameters for the engineering application which are like time domain parameters and frequency domain parameters.

So, in the interpretation of the earthquake, we will be studying about the correction of the earthquake by baseline correction and we will be studying about the so the identification of the earthquake. Once you identify that is a earthquake, how to interpret a time domain parameters and frequency domain parameters in the part of interpretation of seismic record.

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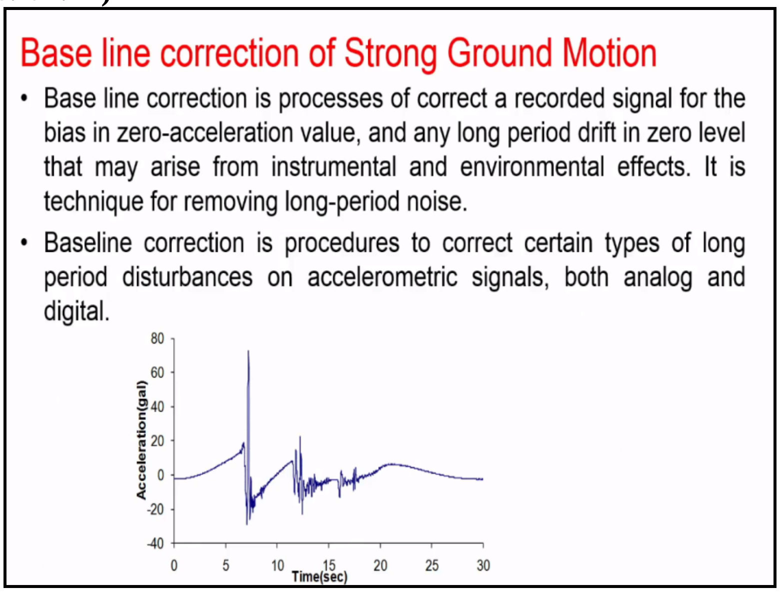

So when you look at any seismogram record which may not generally start from beginning as a 0. So you will look at very carefully here. You can see this portion so ok. So since this, seismic stations are located previously, it may be also recorded some vibration. So this the starting point, ok this should be always 0 because due to some kind of instrumental error and then site condition, it may not be the 0.

So you can get a vibration signal recorded like this. This is a typical vibration signal recorded by myself using the accelerogram, which is housed in IISC, ok. We have the accelerogram which we recorded. So this kind of signal now it is a earthquake are some other vibration signal to identify that, first you have to get a proper waveform signal. So for that you need to apply some correction, which is called as a baseline correction. Baseline correction means you are applying a correction to bring to the earthquake data into the some form.

So the Baseline correction is process of which correct year recorded signal for a bias of 0 acceleration value and any long period drift in a zero level that maybe arise from the instrumental or environmental effect its technique for removing the long period noise at a particular location, ok. That is the baseline. So the baseline correction is the procedure to correct certain type of long period disturbance on acceleromatic signal both analog and digital, ok.

So this is the time as you seen. You can use analog data as well as the digital data to get apply this kind of one.

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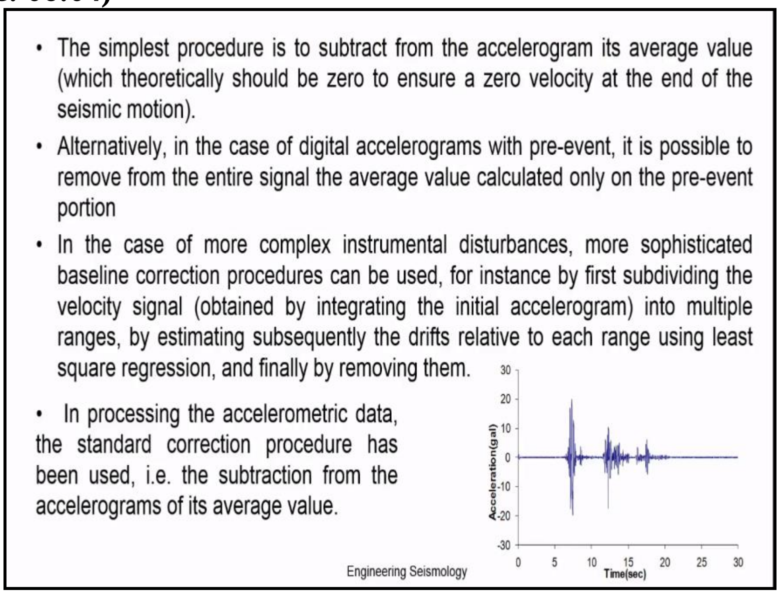

So the analog data basically you need to use some kind of graph sheet and try to match with that and try to correct. But it in the digital form, it is very easy to apply correction because it is a computer based excel or text file record. You can do the coding and try to get a precise application this one. So the simplest form is basically subtract the accelerogram its average value, which is theoretically should be 0 ensure that 0 velocity at the end of the seismic motion.

So if you have the acceleration or velocity, it has to start with 0 ends with 0. So that means the value which is average from different from 0 can be identified and that should be subtracted. That is the simplest way one can apply a correction. So the previous record what you have seen after applying the baseline correction this is what you can see. So now you could able to distinguish the signal time as well as the amplitude very precisely when compared to previous record given here. The same record after applying the baseline correction you can see.

So, alternatively that the simplest method I was saying. Alternatively in the case of digital accelerogram with the pre event it is possible to remove from the entire signal the average value calculated only in the pre even portion. So that means when you are studying the earthquake recording session we have seen that pre event and post event. So pre event means the earthquake is so much value you are minimum defining, the period before that we ask seismogram to start storing the data is the pre event.

Post event means after completing that desired level, we are telling the seismometer to record data up to that. That is the post event. For example, you want to data from 0.001g. So if you can fix a free event as a 5 second so any value which is before 0.005g, 5 second record will be retained. Similarly post event if you say 10 minutes, it will retain 10 minutes record. So that is the pre event and post event.

So the in the case of digital record with the pre event it is possible to remove the entire signal average value calculated only on the pre event. If the pre event supposed to be horizontal and 0 if it is not that, that value can be taken as a error in the station and apply digital record and try to get a baseline corrected data. In the case of more complex instrumental disturbance more sophisticated baseline correction procedure can be used.

So instance by first subdividing the velocity signal and into multiple ranges, the estimating subsequent drifts relate to each range of using least square regression final removing from them. So you can apply some complex mathematical form and try to get a reason. Okay so this is something like a signal processing and removing the noise. So this area processing the seismic data and applying baseline correction is basically more of pure seismological in nature.

Those who are willing to work on processing of seismic record, all those things you can go for this kind of studies. So as on India very few people as expertise or do research on this kind of signal processing and do a things for seismic signal particularly I am talking about the seismic signal not some other signal. So the processing of acceleramatic data, the standard correction procedure has been used subtracted from the accelerogram in average values.

Finally you get corrected data like this. This is the baseline corrected data, ok. So once you correct a data and get this data, the next step is identify this particular data is earthquake or explosion. That is the next step.

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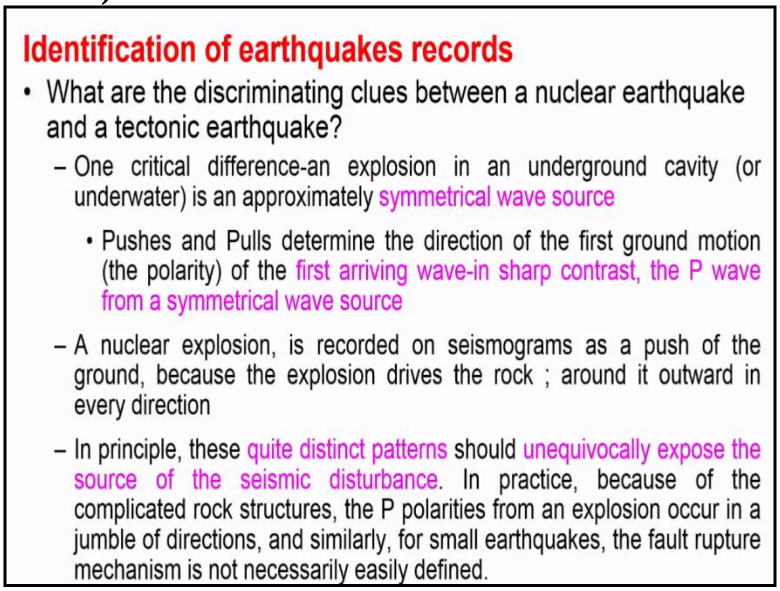

So what are the discriminating the clues between the nuclear explosion and the tectonic earthquake? So one of the critical differences between an explosion and an underground cavity or under water approximately symmetrical wave form. Why it is as a symmetrical wave form?

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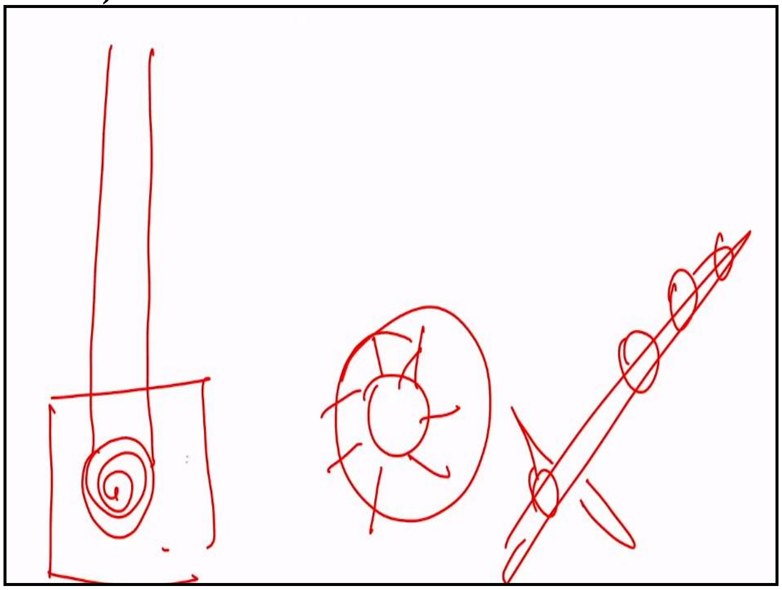

So when any explosion is done, generally, ok, so for example, if you call it explosion below the ground so they will drill a hole and that hole will be maximum size depends upon the drilling option that they cannot go very large drilling so then because of that so they drill and then they keep a nuclear this one or any explosion. And then they explode. So the area under which is exploded is very small since this explosion will radiate equivalent energy at all the direction, ok, and area is small because of that the waveform which is recorded here will have the symmetrical wave form ok,

That is a one of the clue which you can use to identify earthquake is explosion or a earthquake. Since the earthquake as occurring in the very large area, so depends upon the rock character. We have seen in the asperities and ridges so you will have the waveform compression or tension and the amplitude also different you may not get symmetrical wave form from the real earthquake even the magnitude is similar.

So that was the one of the clue which one can use to identify, this is basically a symmetrical wave form or non-symmetrical wave form. So generally the pushes and pulls determine the direction of the first ground motion polarity, the first arrival wave in the sharp contrast the P wave from the symmetrical wave source, ok, is basically used, ok. So, to get so basically the push is happened due to the explosion in the rock.

The rock, so basically it pushes like this in all the direction, so you get a push a compressional wave form from the explosion okay. So the nuclear explosion is recorded on seismogram as a push of the ground because of the explosion drives the rock around it outward in all the direction. So the principle this quite distinct pattern should unequally expose source of seismic disturbance. In practice because of the complicated rock structure, P wave polarities on explosion occurs in a jumbled direction and similarity for all the small earthquakes.

So the fault rupture mechanism not easily defined. So when your magnitudes are small some time with happens in the similar kind of rock, you will also get similar kind of equal waveform and compressional wave form in the earthquake also. Sometime this kind of clue will get a; confusion in interpreting the earthquake or explosion of the smaller magnitude, ok. So such kind of explosion; are even discriminations and the problem mysterious events are reported.

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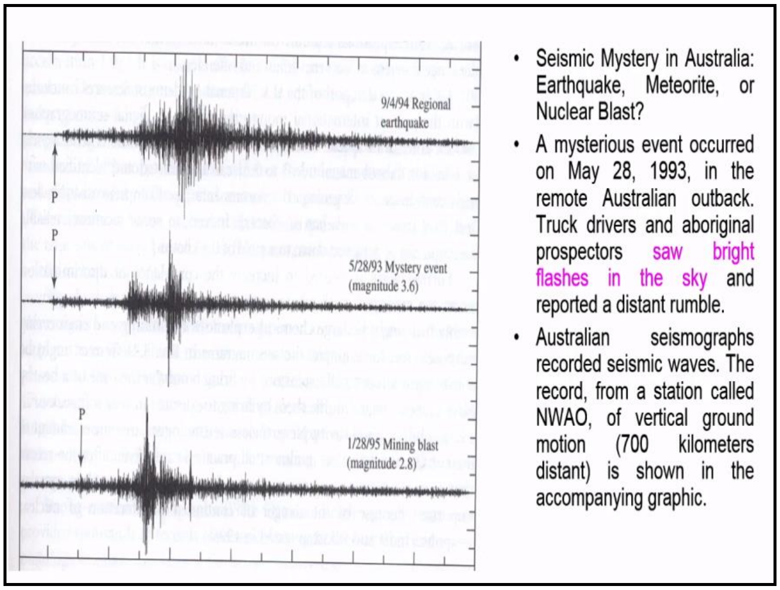

This is the typical Mysterious event reported in Australia, you can see here basically. The first one is basically 94 regional earthquakes in Australia. The seismic mysteric earthquake what one place where the nuclear blast or any other event, they are not very sure. You can see the similar recordings at below which was 5, 28, 93 it is called as a mysterious event, why because see this was happened in the remote Australian outback truck driver abnormally prospectors saws a bright flash in the sky and reported the distant rumble.

Okay in those places the Australian seismogram record seismic waves record from station, this NWAO station vertical ground motion about 700 kilometers away from that. So that called this kind of this one. So this is the regional blasting. So this particular data basically this data is unable to classify. This is the earthquake or it is a explosion. There is no clue still they did not able to distinguish properly this kind of sometimes mysterious events also can occur.

So the issues be here actually you can also notice that there was only one station record, which is very far from the earthquake origin or vibration origin. Because of this kind of the distance station location many times your real earthquake may not be noticed or it is very difficult to distinguish, which is earthquake or artificial explosion at a particular place. This is such kind of mysterious event.

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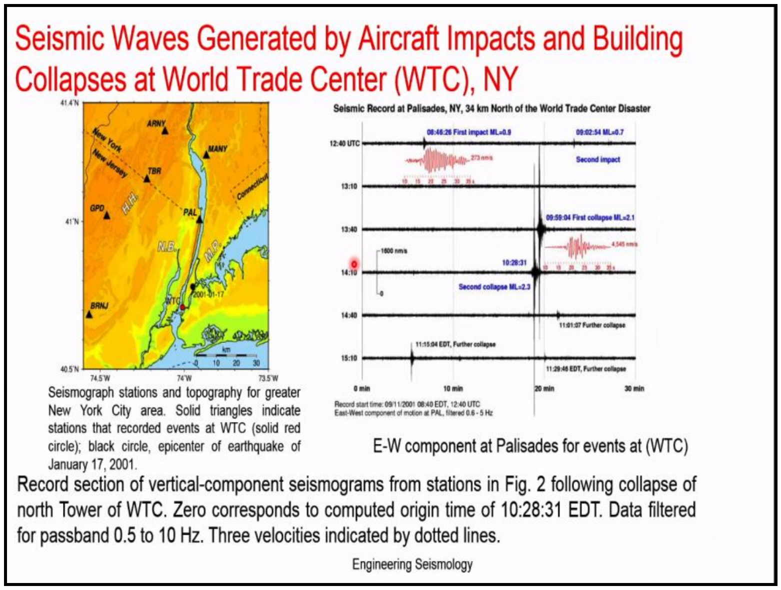

So if you have the proper instrumentation at one place, you can very precisely count it is a earthquake or explosions. Such example can be discussed now. The seismic waves generated by the aircraft impact and building collapse of the World Trade Center in New York. So you are maybe all aware that in 2001 there was a so World Trade Center collapsed taken place in US. So this is basically a location where you can see, this is actually the World Trade Center look at this is one of the real earthquake.

These are all the seismic station nearby. You can see the relatively the more; number of stations in the short distance. You can see 0 to 30 kilometer so you can see almost you have the good number of seismic station in the so 100 kilometer by 100 kilometer radius. You can see here this particular place, so where you the seismometer recorded the World Trade Center impact by the flight.

You can see this is the first impact at 8:46, ok, so it is been measured as a magnitude of 0.9, you can see the waveform so you can see a symmetrical wave form as we told that you can see a very symmetrical wave form. Then 9:02 the second impact you can see the again this one. So after this impact the World Trade Center start collapsing which happened almost close to about 40, 45 minutes later.

You can see 9:56 the first collapse of the World Trade Center which caused a vibration equal to local magnitude of 2.1. You can see this similar signal which is recorded in the seismometer.

Then 10:28 again after 30 minutes there was another collapse which this was you can see the waveform recorder which was equal to the magnitude of 2.3, ok. So then the further minor collapse which was 11 O'clock you can see.

So then the further collapse 11:15 and then there is a further collapse and 11:26. This is the entire activity starting from the hitting up flight to the building to the final destruction has been captured by all this seismometer. So which help, ok, the person who does not know this is the earthquake or explosion, because since this has the news has come we know. So in case if we do not know we have only record how we can interpret this details is actually clearly explained in the this research paper, which will be useful when you look at a data after some time where you do not have what happened during that period, ok. That kind of this analysis.

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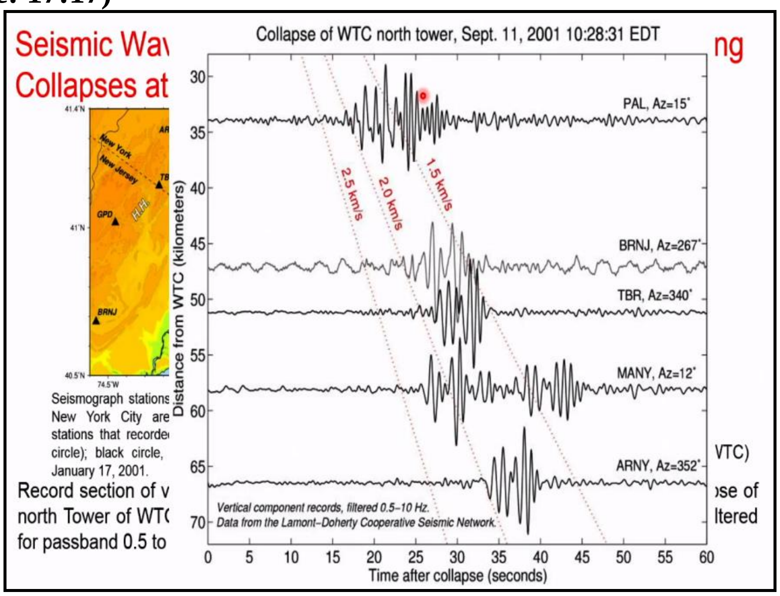

So this is you can see basically the distance from the World Trade Center and different seismic station what we discussed in this graph and here you can see the arrival of the waves are different wave we can see. You can see that these waves are basically so compression in nature and also it is having the similar symmetrical pattern. That 2 uniqueness you can observe here.

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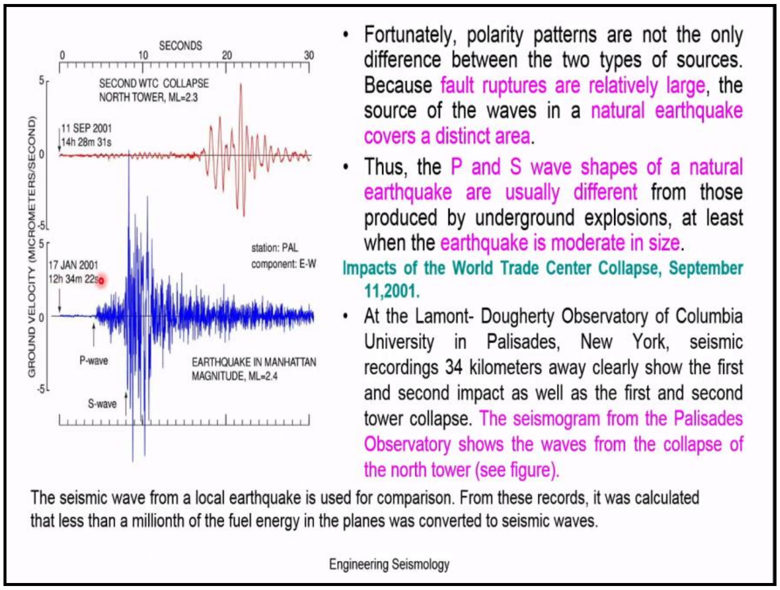

So the same place the record which is happened I was telling there was a similar kind of earthquake in that region. You can see the real earthquake data and then the collapse data you can see the distinct difference between that same, ok. This was the 17 January 2001 so there was a so earthquake so much has been reported the P wave S wave and you can see the this one. So the fortunately polarity pattern are not only the difference between the 2 type of source because the fault rupture are relatively large, the source of the waves in a natural earthquakes are covers a distinct the area and this is what you can see. It covers a large amount of the area.

Thus P wave and S wave shapes of natural earthquake are usually different from those are produced by the underground explosion. At least when the earthquakes in moderate in size. The impact of World Trade Center collapsed September 2000 is one of the classical example one can compare a real seismic record as well as the real seismic record as well as your the synthetic data or explosion based data where you can get comparison and see, understand how to explore the this one.

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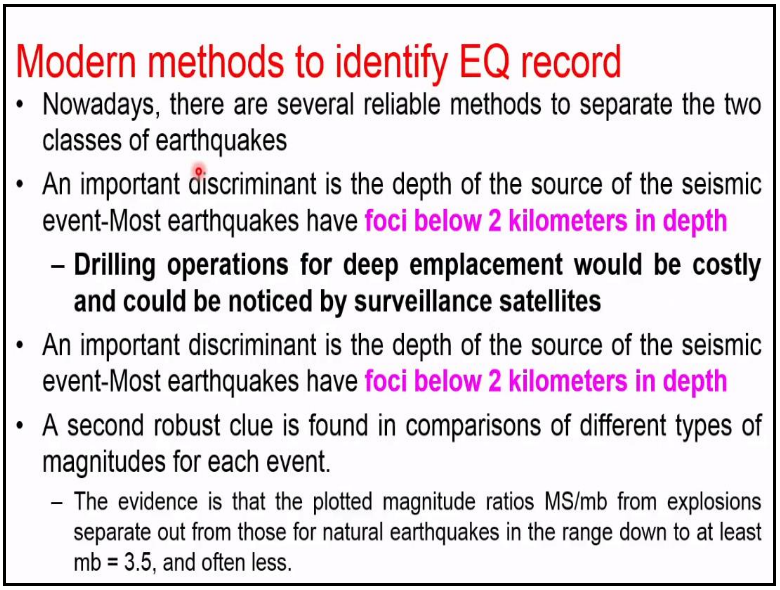

So these are all the visual observation or a qualitative way or some extend like a quantitative way based on this one. So now the modern seismologist so come up with the idea using the mb and MS magnitude measurement at lower level. So nowadays, there are several reliable method of separate 2 type of class of earthquake. An important discrimination is the depth of the source. So one is the first is actually you can find out a depth of the earthquake, we have the multiple record at particular location.

So you can see that any explosion needs a huge amount of drilling below the ground for example nuclear explosion and all. So generally this kind of a explosion will happen less than 2 kilometer depth. Beyond that they will not go because of you have to invest a lot of money and drilling. So because of that the earthquake depth generally goes above that. So if the depth you find out if based on that one can say that this is a earthquake or a explosion.

So, that is how when I was talking about the world global seismic network, I talked about our atomic bomb test in the Rajasthan. So those times I told you know. So the outside people by seeing the seismometer because, they do not know what was the sound and all those things, because it is very far. So by locating this earthquake wave form and try to identify a depth then they found that it was exploded very shallow under the equivalent energy they have calculated and waveform they studied they could know that it was a explosion.

That is why they asked our government. Finally it has been confirmed that it was from the nuclear explosion. So mainly the global seismic network set up to monitor this kind of nuclear or army related testing in the region. So drilling, all those things are problems. So that is, the second is basically you can find out mb, MS, ok in the smaller magnitude using the waveform and you can try to take ratio.

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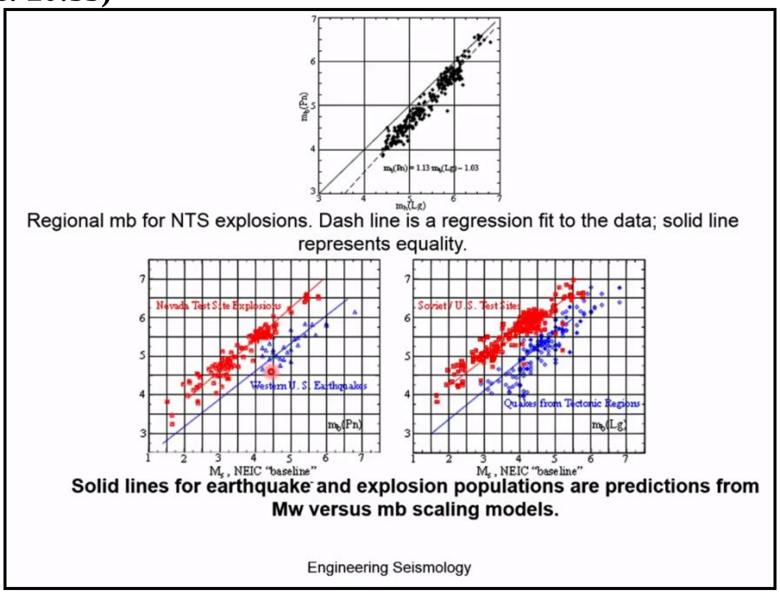

So you can see that the natural earthquake and artificial signal as a following a unique pattern. So based on that one can decide this is the earthquake or this one. This is actually the Western US region naturally earthquake pattern. So this is the Novada Test Site explosion, you can see the pattern. Similarly this is another place where you can, so this kind of comparison also can help you to get which is a earthquake or which is the explosion. For this you should have this kind of testing as well as this kind of large amount of data to identify.

So this is how you can identify a particular data is recorded at particular location is explosion or earthquake. So today we basically seen so how the seismic record looks like, we before applying a baseline correction and what is you should do for baseline correction. After baseline correction how the seismic record looks. Then after baseline correction you need to identify based on the recorded data, it is explosion or a earthquake.

So we have seen that generally explosion as a compressional wave and symmetrical wave form, ok, that is the one. Second the explosion will generally take care in the shallow depth. That is a second, ok. So third your mb, MS ratio can be taken into account to find. This 3 way you can distinguish, it is a earthquake signal or it is a explosion. Once you see explosion you no need to worry too much about that. So you can just discard

If it is the earthquake then you can use the data for different engineering application and design. So that is what interpretation of the earthquake data, we are going to discuss in the coming class. So with this I will close this class. Thank you for watching this video. So we will see you in the next class how to interpret a real earthquake data on different time domain parameter and frequency domain parameter, which will be useful for the engineering application. So thank you very much. We will see you in the next class.