

**Introduction to Engineering Seismology**  
**Prof. Anbazhagan P**  
**Department of Civil Engineering**  
**Indian Institute of Science Bangalore**

**Lecture No -35**  
**Recapitulation - 7**

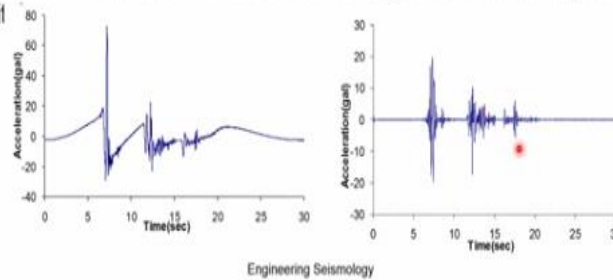
Vanakkam, so we have been recapping all our engineering seismology lectures so as I told you that so all this knowledge what we have studied we are going to use and apply to get a reliable estimation of the earthquake hazard, which is the prime importance for the safe design as well as disaster planning and management system. So in that aspect so the understanding of all the different aspects we are being summarizing by recapping of these classes actually.

So last class we have look at the earthquake measurement and then the quantification, sizing and all those things. So the today class we are going to talk about basically the interpretation of the earthquake record which comes from the seismometer or accelerogram record so the wave form data what we comes. So one of the major issue we discussed.

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### Base line correction of Strong Ground Motion

- Base line correction is processes of correct a recorded signal for the bias in zero-acceleration value, and any long period drift in zero level that may arise from instrumental and environmental effects. It is technique for removing long-period noise.
- Baseline correction is procedures to correct certain types of long period disturbances on accelerometric signals, both analog and digit



In the earthquake data interpretation that so most of the earthquake data what you are seeing, so what you are recording in the instrument so may not start with the zero due to the some physical problem in the station some kind of noise or bias kind of thing so you basically end up in the

recording the data's like this. So this is the typical record I found myself in the one of the strong motion acceleration data.

So this data first before using and interpretation this data first has to be corrected, that correction is called as a base line correction. So the baseline correction is the process to remove the drift so in the 0 level in station so most of the acceleration and the velocity value should start with 0 end with 0 that is the right record. In case if it does not have you have the drift in the record so you should apply a base line correction and try to remove that.

There are different type of baseline correction we have been discussed so one of the simplest way is basically, so take a average value and try to deduct and make it a 0, so or you can use a more complex based analysis also to get it, so finally this baseline corrected data looks like here this is the corrected data you can see how this corrected data so that wave sounds are very beautiful so that you can identify what type of wave and what is and all. Once you corrected the data;

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### Identification of earthquakes records

- What are the discriminating clues between a nuclear earthquake and a tectonic earthquake?
  - One critical difference-an explosion in an underground cavity (or underwater) is an approximately **symmetrical wave source**
    - Pushes and Pulls determine the direction of the first ground motion (the polarity) of the **first arriving wave-in sharp contrast, the P wave from a symmetrical wave source**
  - A nuclear explosion, is recorded on seismograms as a push of the ground, because the explosion drives the rock ; around it outward in every direction
  - In principle, these **quite distinct patterns** should **unequivocally expose the source of the seismic disturbance**. In practice, because of the complicated rock structures, the P polarities from an explosion occur in a jumble of directions, and similarly, for small earthquakes, the fault rupture mechanism is not necessarily easily defined.

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Next you have to confirm that whatever record vibration recorded by the seismometer or a accelerometer is a earthquake or a some other vibration which is caused during the type of the earthquake data we have seen that the earthquake data based on the source it can be classified as

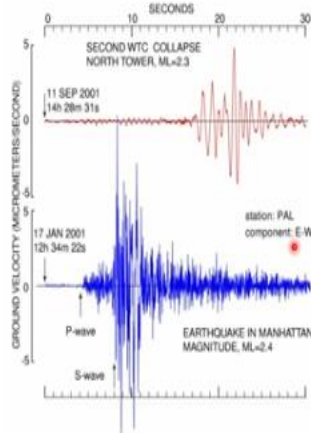
a five category, we have seen that the tectonic force is the responsible for the remaining. So responsible for the earthquake to create and that kind of vibration only we are interested.

So remaining are the collapsible earthquake, man-made earthquake, impact earthquake, earthquake created by some vibrations artificial. All those things we are not interested. Basically we have to remove those kind of data. So for that reason the wave form what you recorded itself as used as a parameters. So one is that so the explosion generally done in a shallow depth. So that depth of the earthquake will help you to identify it is earthquake or the explosion.

Second the wave type push and pull are basically originate from the source, the pushes generally happens when the blasting in the same rock so that means all the record what you get from the non-earthquake or explosion kind of things will have the push as a first arrival source and the waves also will be symmetrical since it travels under the rupture happens propagation happens on the smaller area, the waves are symmetrical.

So this kind of like a unique unity or equal way kind of things are unique in the explosion but in the earthquake it will be irregular because of the source propagation happens at longer distance and source rupture happens, which is controlled by the rock property and overburden thickness and pressure at the particular location. So that is why you need to identify that these are all the some of the;

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The seismic wave from a local earthquake is used for comparison. From these records, it was calculated that less than a millionth of the fuel energy in the planes was converted to seismic waves.

- Fortunately, polarity patterns are not the only difference between the two types of sources. Because fault ruptures are relatively large, the source of the waves in a natural earthquake covers a distinct area.
  - Thus, the P and S wave shapes of a natural earthquake are usually different from those produced by underground explosions, at least when the earthquake is moderate in size.
- Impacts of the World Trade Center Collapse, September 11, 2001.
- At the Lamont- Dougherty Observatory of Columbia University in Palisades, New York, seismic recordings 34 kilometers away clearly show the first and second impact as well as the first and second tower collapse. The seismogram from the Palisades Observatory shows the waves from the collapse of the north tower (see figure).

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Simple way you can identify we also discussed about the how the real earthquake under the impact due to the explosion. So with reference to the twin tower blast record in the USA. So, this is a typical earthquake waveform record. So this you can see the 2.4 magnitude at a earthquake Manhattan. So the same place there is a the twin tower nearby it has been same station the impact of the twin tower due to that blasting time has been recorded.

You can see the waveform symmetries can you see the waveforms here. The amplitude of the wave the particular the symmetry of the waves, you are almost in the equal and both side here is not like that. So these are all the way you can interpret here it is a earthquake record or non earthquake record. So there are some datas which is impossible to define it is earthquake or non-earthquake record.

Those are all called as a mysterious event. There are many such events are reported but generally this happens when you have very one equipment will locate that earthquake which may be happened very far from the seismometer. So all those things create a confusion that it is some kind of earthquake or it is a natural some kind of phenomena like a lightning or the impact or the terrorist attack kind of thing.

So, I may be also told you the example that in Bangalore, there was a vibration and sound felt by the seven several people and then finally they confirmed with seismology observatories and also

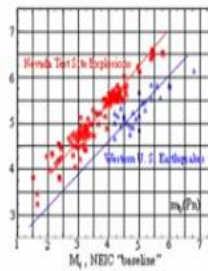
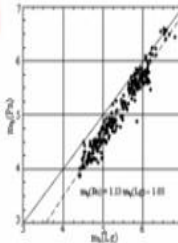
from other people. It is due to the fighter jet flight movement from swooning to other sonic waveform range because of that there is a big boom sound and followed by the vibrations also at a few locations.

So these are all the way the one can get the its recorded data is the earthquake. So apart from that in modern days;

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### Modern methods to identify EQ record

- An important discriminant is the depth of the source of the seismic event-Most earthquakes have foci below 2 kilometers in depth
  - Drilling operations for deep emplacement would be costly and could be noticed by surveillance satellites
- An important discriminant is the depth of the source of the seismic event-Most earthquakes have foci below 2 kilometers in depth
- A second robust clue is found in comparisons of different types of magnitudes for each event.
  - The evidence is that the plotted magnitude ratios  $M_s/m_b$  from explosions separate out from those for natural earthquakes in the range down to at least  $m_b = 3.5$ , and often less.



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So as you know that you can get a  $M_s$  and  $m_b$  and a magnitude from the recorded data which has anyway saturation capacity but the smaller magnitude  $M_s$  and  $m_b$  is a more reliable. Those plotting up this actual earthquake and then the experimental or explosion data you find a distinct pattern in the region, so this distinct fashion will help you to say that this is the earthquake data what you recorded is from the real earthquake or from the blasting then focal depth which we have already discussed.

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## Locating Earthquake using Wave form



Locating earthquakes by drawing three circles with radii of lengths determined from P-wave and S-wave travel times.

Station names (SOCO, TEIG, SSPA) correspond to seismograms in Figure 12.11. Source: IRIS (n.d.) "How Are Earthquakes Located?"

<https://openpress.usask.ca/physicalgeology/chapter/12-2-measuring-earthquakes/>

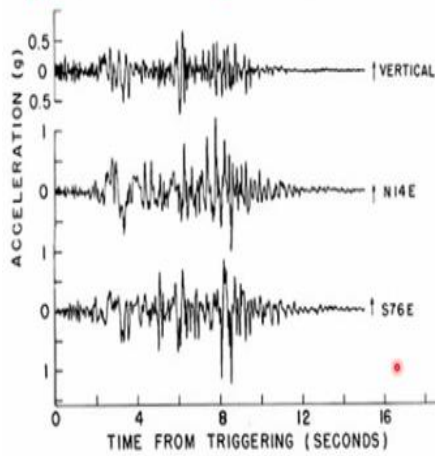
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So this data recorded at several stations once you identify this is the earthquake and then you can estimate a arrival of P wave and S wave which we have seen so then using the P wave and S wave arrival then taking a average velocity of the particular regions you can estimate what is the distance origin point to your station from the your data, the way form data. So then you draw a circle of that distance radius finally all the circle where it meets that point is called as a epicentre location when you has a three station.

When you coupled with the four and five station you can also get a depth perception that is a depth of earthquake so you can basically get a epicentral distance location of the locating the earthquake and then the hypocentral location, all these things are possible using the waveform data you get.

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## Typical Earthquake Record



- Three component records of acceleration, velocity, and displacement from the Pacoima Dam record of the San Fernando earthquake.
- The horizontal instruments are approximately parallel and perpendicular to the horizontal component of the rupture (N14E and S76E, respectively) and show accelerations exceeding 1 g.

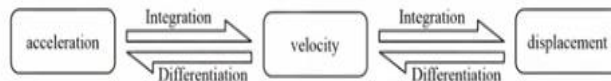
SOURCE: D.M. Boore and M.D. Zoback, Two dimensional kinematic fault modeling of the Pacoima Dam strong-motion recordings of February 9, 1971, San Fernando Earthquake, *Bull. Seis. Soc. Am.*, **64**, 555-570, 1974. Copyright Seismological Society of America.

So this waveform data basically looks like this here, this is a highest g recorded typical earthquake where you can see how the wave amplitudes are changes and with respect to them. So this data when interpreting that this data will tell you the size of the earthquake that is what we have seen amplitude.

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## Typical Earthquake Record

- Typically, we measure either acceleration or velocity.
- The other two parameters can be determined either from differentiation or integration of acquired data.



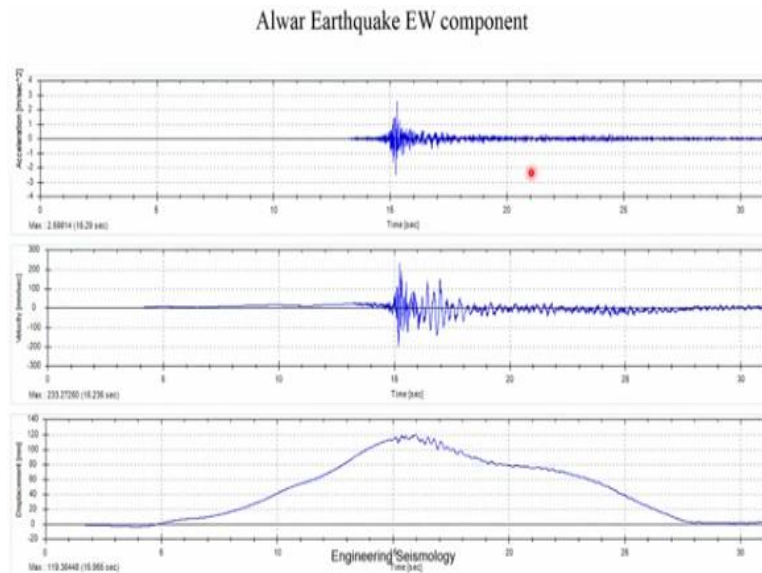
- Seismometers record velocity.
- Accelerometers record acceleration.

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So the earthquake data in each station you will be recording as a velocity or acceleration so you can convert from one unit to other unit by taking a integration and differentiation so this is the typical example. So from acceleration to velocity if you want integrate, velocity to displacement again integrate. So displacement to velocity differentiate velocity acceleration differentiate this one so this gives you that.

So all the any station which will have the 1 type of recording may be acceleration or velocity and it can be recording the 1 component or 3 component depends upon the instrument type so from that each data each component of the data can be converted into three form.

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So like velocity time history, acceleration time history and displacement time history. So this is the typical east west component of the Alwar earthquake which is reported you can see how the data's are changes, so one of them might be recorded remaining are basically obtained by integration or differentiation.

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### Characteristics of Strong Ground Motion

- Time Domain Characteristics of Strong Ground Motion
  - Peak ground acceleration (PGA), velocity (PGV) and displacement (PGD) are the most common and easily recognizable time domain parameters of the strong ground motion.
  - PGA, PGV and PGD are related to respectively high-, mid- and low-frequency ground motion components.
  - Maximum recorded peak accelerations vary between 1g and 3g. Peak ground velocities reaching 4 m/s have been measured in 1999 ChiChi, Taiwan earthquake.

### Frequency Domain Characteristics of Strong Ground Motion



So from this once you are done that this is then you can estimate a time domain parameters of peak ground acceleration, peak ground velocity and the peak ground displacement. So this is the just a single peak value in this plot. So single peak value which may be the positive or negative but the absolute value only will be reporting. So, why do you need to measure three component of the data?

So as you know that the waveform is controlled by the each frequency content of the waveform. So the acceleration is controlled by the high frequency wave. Velocities are controlled by the intermediate frequency, displacement controlled by the low frequency. So if you have the structure, which is has some natural frequency, then the ground motion of we should see that this frequency does not match with the ground motion frequencies.

So that is the reason this peak values are estimated which represent here different segment of the frequency so or controlled frequency kind of;

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### Effective Acceleration

- In some cases, damage may be closely related to the peak amplitude, but in others it may require several repeated cycles of high amplitude to develop.
- Newmark and Hall (1982) described the concept of an effective acceleration as 'that acceleration which is most closely related to structural response and to damage potential of an earthquake.
- It differs from and is less than the peak free-field ground acceleration.
- It is a function of the size of the loaded area, the frequency content of the excitation, which in turn depends on the closeness to the source of the earthquake, and to the weight, embedment, damping characteristic, and stiffness of the structure and its foundation."


Apart from that we also studied about the effective acceleration. In some cases the damage may be closely related to the peak amplitude, but in other it may be required several repeated cycle. So the repetition of the amplitude rather than taking a single value, so the repetition the amplitude taken into consideration, they come up with the idea of defining the effective acceleration.

So this is the acceleration where the most closely related to the structural response to the structural potential of the earthquake. It differs from it less than the peak free field the ground acceleration. If the function of the size loaded area and a frequency content of the excitation which is turned depends upon the closeness of the source of the earthquake and weight, embedment, damping characteristics, stiffness of the structure and its foundation.


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### Sustained Maximum Acceleration and Velocity

- Nuttlı (1979) used lower peaks of the accelerogram to characterize strong motion by defining the sustained maximum acceleration for three (or five) cycles as the third (or fifth) highest (absolute) value of acceleration in the time history.
- The sustained maximum velocity was defined similarly.



Accelerograms from the N29W Melendy Ranch record of the 1972 Stone Canyon (M = 4.6) earthquake



The longitudinal record from the 1967 Koyuna (M = 6.5) earthquake

- Although the PHA values for the 1972 Stone Canyon earthquake and 1967 Koyuna earthquake records were nearly the same.
- A quick visual inspection indicates that their sustained maximum accelerations (three- or five-cycle) were very different.
- For a structure that required several repeated cycles of strong motion to develop damage, the Koyuna motion would be much more damaging than the Stone Canyon motion, even though they had nearly the same PHA.

So the another one is a sustainable acceleration like a particular number of cycle, how particular values are repeating. So we have seen that a lower amplitude repeating several times will cause a more damage than the very large amplitude repeating once. So that is actually has to be accounted that is why the time domain parameters of sustained effective design acceleration.

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## Effective Design Acceleration

- The notion of an effective design acceleration, with different
- Benjamin and Associates (1988) proposed that an effective design acceleration be taken as the peak acceleration that remains after filtering out accelerations above 8 to 9 Hz.
- Kennedy (1980) proposed that the effective design acceleration be 25% greater than the third<sup>\*</sup> highest (absolute) peak acceleration obtained from a filtered time history.

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This is also again the design acceleration. So arrived for a processing a data filtering out your data for a particular frequency. So Kennedy proposed the effective design acceleration should be 25% greater than the third largest absolute peak acceleration obtained from the filtered time history. So these are all the data we get directly from the plot of the earthquake.

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## Duration of the Strong Ground Motion

- Application of duration of seismic performance characterization include:-
  - **Seismic displacements of landslide masses** . Slope displacements increase with duration. (Bray and Rathje 1998)
  - **Pore pressure generation in liquefiable soils and volumetric strain accumulation in unsaturated soils** (Silver and Seed 1971) –both increase with no. of cycles and thereby duration of shaking.
  - **Lateral spread displacements** resulting from soil liquefaction (Rauch and Martin 2000)-increase with duration.
  - **Damage of structural components** subjected to cyclic degradation(Iervolino et al. 2006)

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The other data is like since the amplitude does not represent properly the entire time history of the data, people come up with the concept of estimating the duration. So why because that is damage of the building depends upon the how many times the same cycle repeats and then the landslide and then the liquefaction pore pressure generation due to liquefaction, lateral spreading,

damage structural component, all those is affect actually affected by the number of times the particular amplitude repeats.

So that in order to define that a people come up with the idea called a duration estimation or duration.

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**Duration** is the time interval of the accelerogramic signal in which the seismic motion is significant.

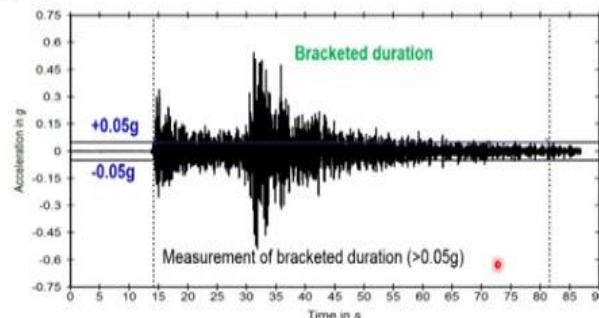
- Several definitions for duration are available based on the parameter used to classify them. Some of the most commonly used duration parameters are,
  - Bracketed Duration
  - Uniform Duration
  - Significant Duration
  - Effective Duration
  - Effective Shaking Duration

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So there are four variety of duration bracketed duration, uniform duration, significant duration, effective duration, effective shake duration. So depends upon the way in which you handle your data this duration type changes for example, bracketed duration.

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- **Bracketed Duration** is the total time elapsed between the first and last exceedance of a specified level of acceleration. Generally this threshold acceleration value will be 0.05g.



The Bracketed Duration is the interval between the two points in time where the acceleration amplitude first and last exceeds a prescribed level such as 0.03 g (Ambraseys and Sarma, 1967) and 0.05g (Bolt, 1969).

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Say some threshold acceleration values are given in the threshold value starting and end point is called as a bracketed duration. So initially, they have used 0.05 later, they shifted to 0.03g to define a bracketed duration. So this is the typical way of bracketed duration.

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- **Arias Intensity** is defined as the time-integral of the square of the ground acceleration and is given by

$$AI = \frac{\pi}{2g} \int_0^{T_d} (a(t))^2 dt \text{ (m / s)}$$

where,  $a(t)$  = acceleration in  $m/s^2$ ,  $t$  = time in  $s$ ,  $g$  is the acceleration due to gravity and  $T_d$  is the duration of signal above threshold.

- Theoretically the integral should be infinite. \*

**Husid Plot** is the time history of the normalized Arias Intensity i.e. Arias Intensity expressed as percentage of Total Arias Intensity represented as the normalised variable  $h(t)$

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So then the acceleration time history further converted as a acceleration square to and then defined to Arias intensity, you can see the Arias intensity here. So where you can time integral square ground motion is given here. So this Arias intensity plot of Arias intensity in the percentage with respect to time is called Husid plot.

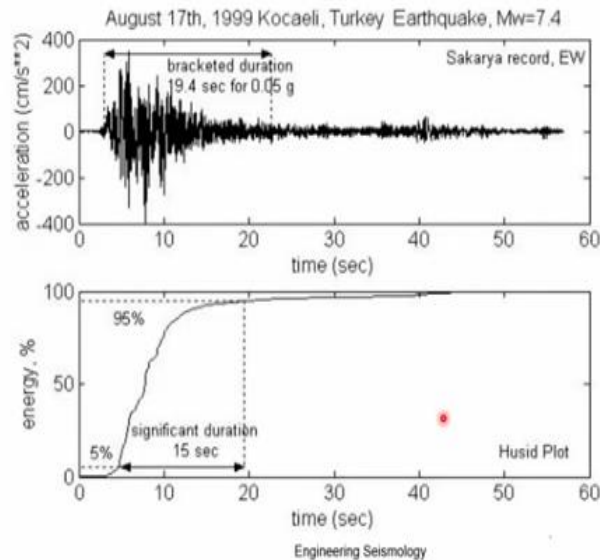
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- **Significant duration( $D_a$ )**- Based on the accumulation of energy in the accelerogram represented by the integral of the square of ground acceleration, velocity or displacement.
- It is the interval over which some proportion of the total integral is accumulated.
- The most commonly used are the interval between 5-95% ( $D_{a5-95\%}$ ) and 5-75% ( $D_{a5-75\%}$ ) of the Arias intensity. \*

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So the Husid plot will be used to get you know that how much energy so released in a time then they come up with the concept of significant duration. So where the 5 to 95% of the releasing time is taken into account or 5 to 75% of the Arias intensity. So this significant duration is also very important.

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So you can see that for a same data the significant and bracketed duration may not be the equal, there will be always difference.

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**Effective shaking duration (ESD)** - The time interval between the first and last amplitudes by considering values  $\geq 0.01$  g were noted.

Then, the accumulated energy of the three components produced the Effective shaking duration (ESD) for the time window, which has 5–95% of the total energy within the amplitude threshold.

- This definition considered the major energy part and the part with amplitudes  $> 0.01$ g.

So then the effective duration, the time interval between the first and last peak considering the value up to 0.01g effective shaking. So this was the new duration definition by looking at effective significant and shaking point of view and these definitions are given.

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**Effective shaking duration (ESD)** - The time interval between the first and last amplitudes by considering values  $\geq 0.01$  g were noted.

Then, the accumulated energy of the three components produced the Effective shaking duration (ESD) for the time window, which has 5–95% of the total energy within the amplitude threshold.

- This definition considered the major energy part and the part with amplitudes  $> 0.01$ g.

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You can see the effective duration definitions are given 5 to 95% above 0.01g so clubbing together, you can get an effective duration.

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### Frequency Domain Characteristics of Strong Ground Motion

- Earthquakes produce complicated loading with components of motion that span a broad range of frequencies.
- Only the simplest of analyses are required to show that the dynamic response of compliant objects, be they buildings, bridges, slopes, or soil deposits, is very sensitive to the frequency at which they are loaded.
- The frequency content describes **how the amplitude of a ground motion is distributed among different frequencies.**
- Since the frequency content of an earthquake motion will strongly influence the effects of that motion, characterization of the motion cannot be complete without consideration of its frequency content.

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So the frequency domain characteristics of the strong motion the earthquake produces a complicated loading system. So with the component of taking the in the infer the data only by looking at a 1 peak value or the how many times the peak 1 particular value repeated like

duration and then the amplitude based interpretation may not be sufficiently to reflect how the different frequency the amplitude changes.

So in order to find out that the frequency domain characteristics the processing has done. So here basically the complicated loading system so how the frequency spectrum reflect a amplitude and different frequency, the frequency content describe how the magnet amplitude of the ground motion is distributed among different frequency level.

So that means whatever data you are getting from the seismic record after you doing baseline correction filtering and everything you need to convert data into the Fourier transformation. Fast Fourier transformation or point Fourier transformation that transformed data can be give you the frequency domain characteristics or spectrum that is what we are going to discuss now.

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- In the frequency domain:
  - Fourier amplitude
  - Phase spectrum,
  - Power spectrum and
  - Several definitions of response spectra are used in the quantification of strong ground motion.
  - Five types of response spectra are defined:
    - Relative displacement ( $S_d$ ),
    - Relative velocity ( $S_v$ ),
    - Absolute acceleration ( $S_a$ ),
    - Pseudo-relative velocity (PSV), and
    - Pseudo-relative acceleration (PSA).

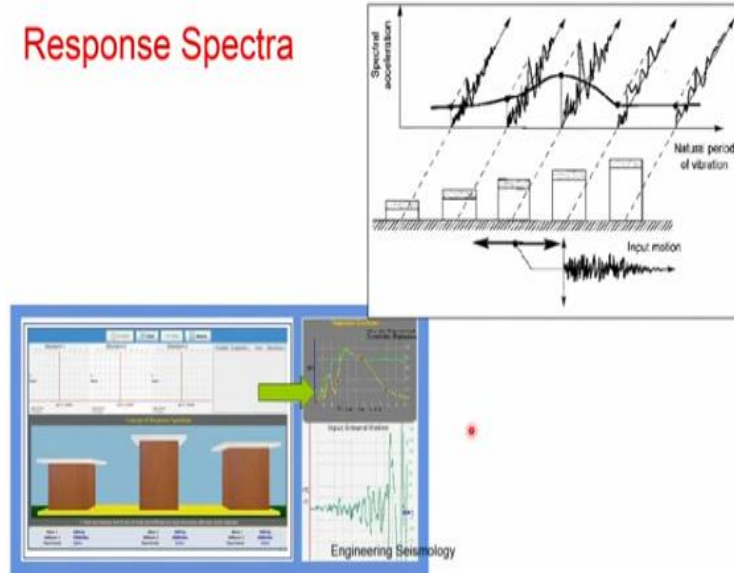
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So you can see a difference frequency domain parameter Fourier amplitude, Fourier spectrum and then Power spectrum several definitions of the response spectrum are used to quantify the strong motion record. 5 types of response spectrums are used relative displacement, relative velocity, absolute acceleration, Pseudo-relative velocity and the pseudo-relative acceleration and velocity.

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## Response Spectra



So this Fourier amplitude and spectrum will help to define basically your response spectrum, this is like response of the single degree freedom structures for a given period for the given earthquake. You can change your period again, you can keep the same single degree, you can get a response, that response together you generate that is called as a response spectra.

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### Spectral Parameters

- The response spectrum does not describe the actual ground motion, but it does provide valuable additional information on its potential effects on structures.
- Each of these spectra is a complicated function and, as with time histories, a great many data are required to describe them completely. A number of spectral parameters have been proposed to extract important pieces of information from each spectrum.

#### - Predominant Period

- A single parameter that provides a useful, although somewhat crude representation of the frequency content of a ground motion is the predominant period,  $T_p$ .
- The predominant period is defined as the period of vibration corresponding to the maximum value of the Fourier amplitude spectrum.
- To avoid undue influence of individual spikes of the Fourier amplitude spectrum, the predominant period is often obtained from a smoothed spectrum.
- While the predominant period provides some information regarding the frequency content, the motions with radically different frequency contents can have the same predominant period.

#### - Bandwidth -the range of frequency over which some level of Fourier amplitude is exceeded

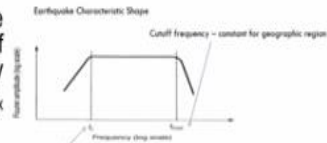
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So this response spectrum the frequency Fourier transformation of the data can be also used to estimate a predominant period, fundamental period of the system. So where you will be taking the H baby ratio from the data and try to get here this fundamental frequency.

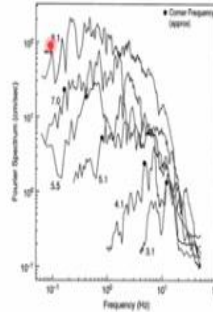
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## Corner and Cutoff frequency

- Fourier acceleration amplitudes tend to be largest over an intermediate range of frequencies bounded by the corner frequency  $f_c$  on the low side and the cutoff frequency  $f_{max}$  on the high side.
- The corner frequency can be shown theoretically (Brune, 1970, 1971) to be inversely proportional to the cube root of the seismic moment.
- This result indicates that large earthquakes produce greater low-frequency motions than do smaller earthquakes.
- The cutoff frequency is not well understood; it has been characterized both as a near-site effect (Hanks, 1982) and as a source effect (Papadogiorgiou and Aki, 1983) and is usually assumed to be constant for a given geographic region.



Corner Frequency - is proportional to the cube root of seismic moment (larger earthquake, lower freq)



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So that while designing you will not change the this one. Then another frequency domain parameters what we have seen was actually the corner and the cutoff frequency. So that is really related with the seismic moment of the a particular earthquake. But a large extent it is useful to interpret a source parameter and path parameter required for modeling the earthquake, the frequency.

So it has a corner frequency cutoff frequency. So where you can see this is the corner frequency, this is the cutoff frequency.

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## Fourier Spectrum Empirical Models

- Trifunac and Lee (1989) provide empirical models for scaling Fourier amplitude spectra in terms of earthquake magnitude, source to site distance, site intensity and recording site conditions.
- These models are based on the regression of the empirical amplitudes at specific frequencies.

## Fourier Spectrum theoretical Models

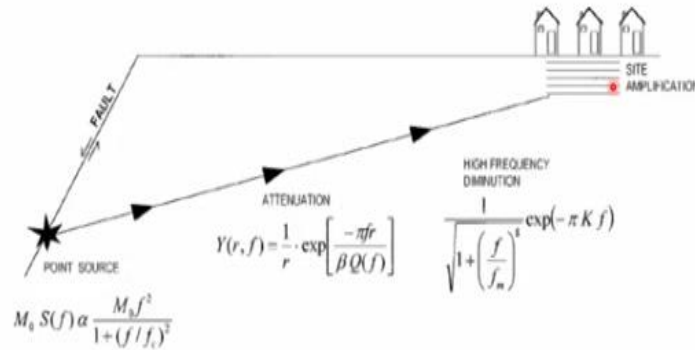
- Holistic theoretical models Fourier amplitude spectrum of the ground motion involves the elements of source, propagation path attenuation, high frequency diminution and site amplification.

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So the Fourier spectrum can be obtained by empirical model and theoretical based approach. So this theoretical approach basically.

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### Holistic theoretical models Fourier spectrum

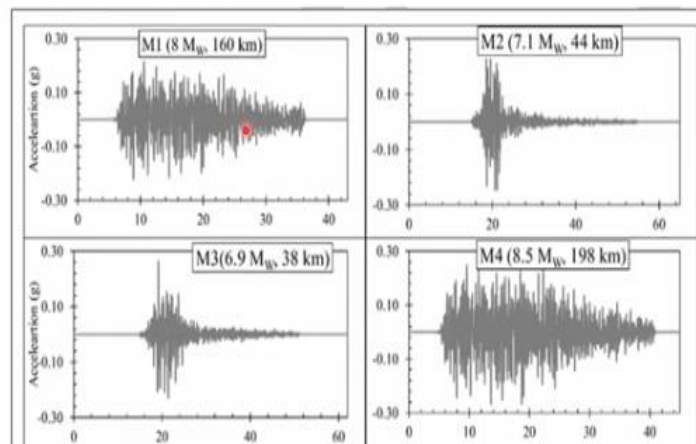


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Gives a source for the attenuation and high frequency domination factor then it recorded at site. So these are and so this mathematics if you get all this mathematics and know how to estimate this parameters you can do basically very good research on engineering seismology, particularly India this kind of model and arriving a practice are not very addressed, very well addressed.

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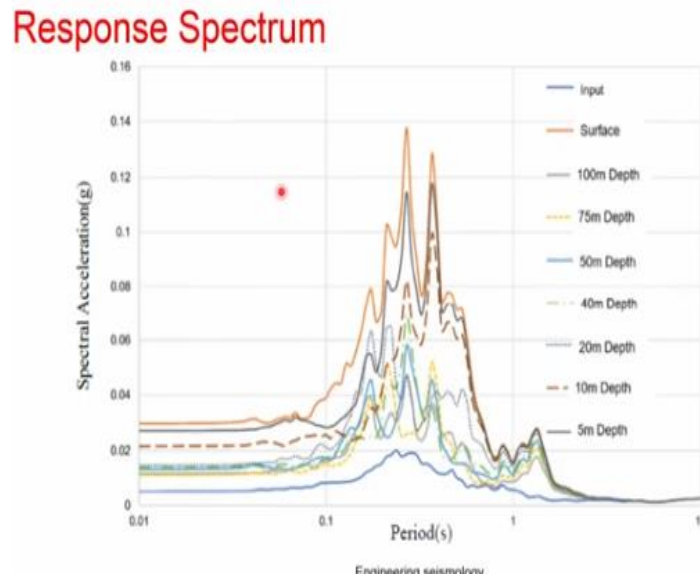
### Time History Data



Engineering seismology

So this is a typical time history data of different magnitude with different distance, which will give you the glimpse of idea, you can get a peak amplitude from the this one and as well as the you can get the duration.

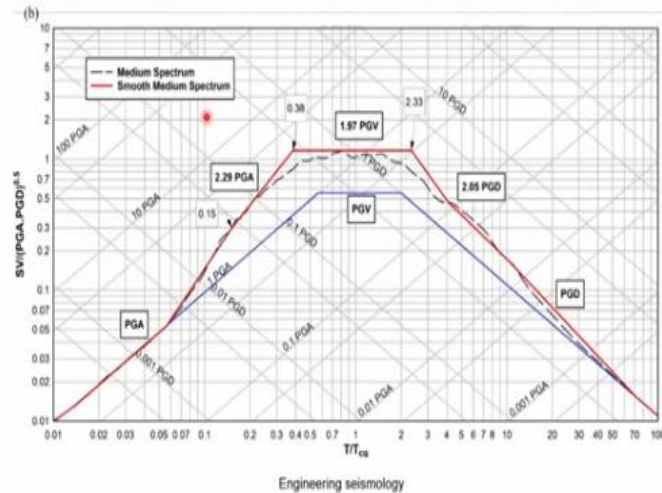
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So then we also discussed that this data further used to get a response spectrum this response spectrum also varies with the depth that means the response spectrum at surface at 5 meter, at 10 meter and 20 meter may not be the same. So by the time you finish your course, this course the you can see one of our paper where we estimated a depth-based amplification in the Indo-Gangetic basin using 275 location measures the area velocity and also some micro atomic studies. So that is what you can get a response spectrum. So once you get a response spectrum.

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## Tripartite Plot -Control period and factors



The next part is taking that response spectrum to the design level, so that is done by the Tripartite plot we have discussed what is mean by Tripartite plot. So what is the amplification factor? What is the cutoff period? How it is estimated? And what really mean a Tripartite plot? It shows basically the variation of the your amplitude and the also the duration taking into account. So this Tripartite plot is more advanced level.

So as per India concern this kind of development of spectrum itself, very limited. So this is about the interpretation of the seismic record. So this interpretation will help you basically to get more reliable parameters to design as well as to simulation purpose, that is what we have been discussed this parameters. So the more details of each and every aspect has been discussed in the respective class.

Here I am giving the overall view of the what we have discussed in the particular class. So with this we close this lecture. Thank you very much for watching. We will see the next class again. Thank you.