Seismic Analysis of Structures
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Lecture – 04
Seismology (Contd.)

In the last lecture we discussed about the seismic hazard analysis. There are 2 types of seismic hazard analysis one is deterministic seismic hazard analysis called DSHA, the other one either probabilistic seismic hazard analysis called PSHA. We described the DSHA with the help of an example and then outlined different steps with the help of which we perform PSHA. Now, where the PSHA is calculated will be explained with the help of this example. Before I go into the example let me repeat some of the basic formulas that are used for calculating the PSHA which we discussed in the last lecture.

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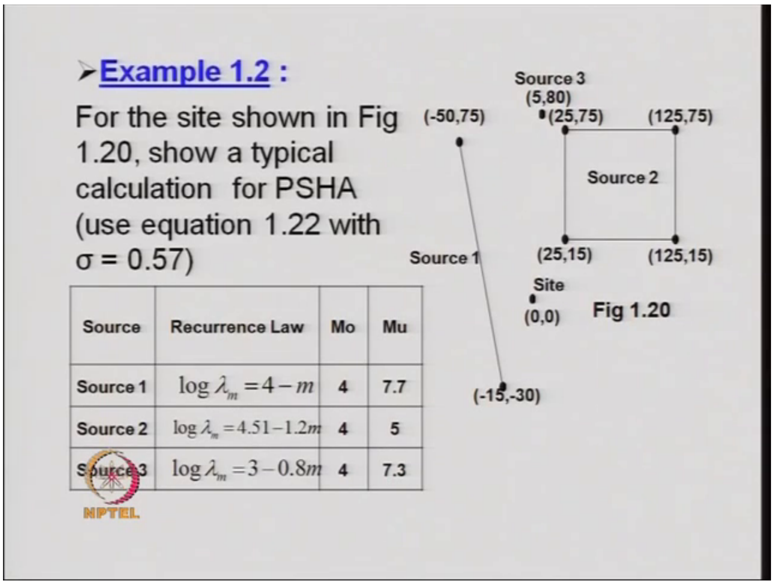

The average rate of accidents of earthquake of certain magnitude is given by Gutenberg relationship and this is lambda m is equal to 10 to the power a minus bm is equal to exponential of alpha minus beta m, where m is the magnitude of earthquake which is being excited.

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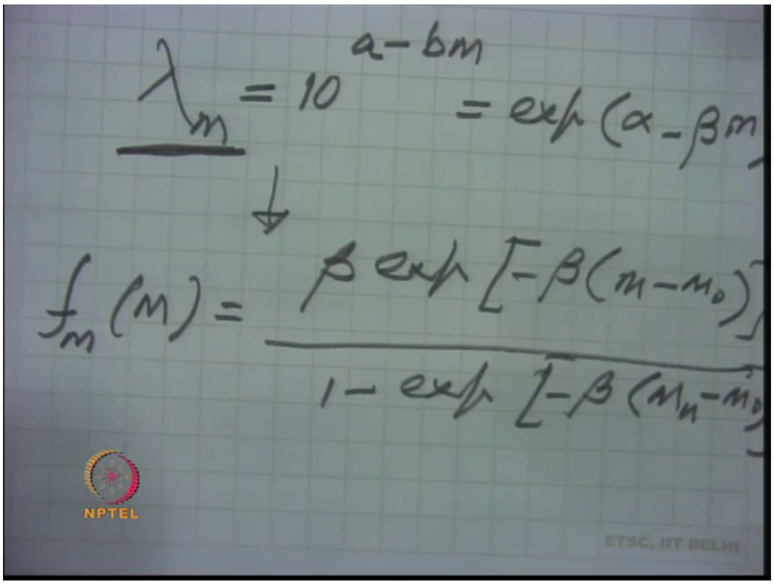

Now, using this rate average rate of accidents one can find out the probability density function of the magnitude of earthquake occurring from a particular source of earthquake and this is given by minus beta m minus m 0 divided by 1 minus minus beta m minus m 0. Where, m u is the upper limit of the magnitude of earthquake or the maximum magnitude of earthquake occurs in that particular source and m 0 is the minimum earthquake or the minimum level of earthquake that we consider for the analysis, and beta is the constant for this particular equation.

Now, apart from that we used another equation that is the about the arrival of the earthquake. The arrival of the earthquake is modeled as a (Refer Time: 03:51) model, the temporal distribution of the occurrence of rather than recurrence of an earthquake for some magnitude is given by the recurrence relationship of the P m f that is lambda t to the power n into e to the power minus lambda t divided by n factorial where the P N is equal to n means the probability mass function that is the number of the event occurring is equal to n.

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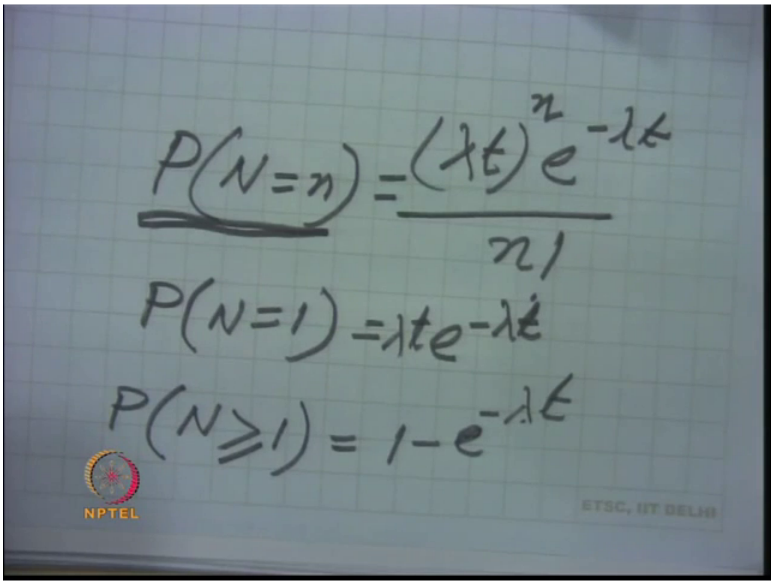

Now, from this one can show that P N is equal to 1 will be e to the power minus lambda t and probability of exceeding at least 1 event is given by this equation where e to the power minus lambda t is the probability of not exceeding 1 event and probability of exceedance is given by 1 minus e to the power minus lambda t. So, this particular equation where used to find out the what is the probability of exceedance of a certain peak ground acceleration in a given period of time t.

Now, we will use this equations in the solution of this problem the problem is the what the other site which is shown in figure 1.20. We have to perform a typical calculation for PSHA and for that the attenuation relationship that you used for the case of DSHA that is the, this equation ln PGA is equal to 6.74 plus 0.0859 m minus 1.80 ln of r plus 25 this attenuation relationship is will be used here with a standard deviation specified as sigma is equal to 0.57.

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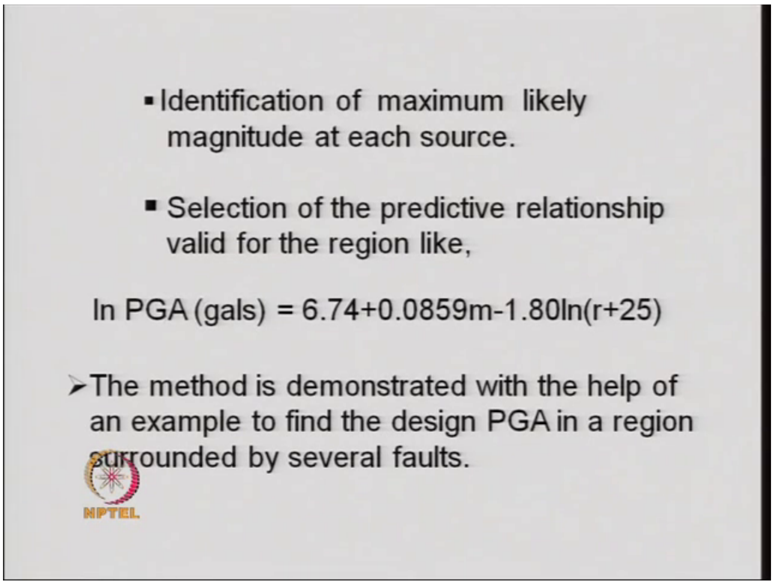

As I told you these attenuation relationship provides you the average value of the PGA and to this equation a standard deviation is specified because it is assumed that the peak ground acceleration and for a given magnitude of earth quake varies log normally.

The sources and the sites are shown in the figure the this is the site and source 1 is a line source source 2 is area source and source 3 is a point source. The recurrence law of the Gutenberg which gives the average rate of exceedance of certain magnet of earthquake is given by this and the mind you this log is of the best 10. So, this is the average rate of the exceedance of the earthquake of magnitude m. So, this is equal to 4 minus m for the source 1, for force 2 it is 4.51 minus 1.2 m and for source 3 it is 3 minus 0.8 m. The minimum value of the magnitude of earthquake is considered as 4 the maximum value of the magnitude of earthquake for each source is given over here for source 1 it is 7.7, for source 2 it is 5 and for the source 3 it is 7.3.

Now, for each source we can calculate the epicentral distance assuming that for the line source and the area source the earthquake has the equal probability of occurrence at every point or in other words we assume the it is a uniformly distributed; that means, distribution of the occurrence of earthquake over the line source or in the area source is assumed to be uniformly distributed.

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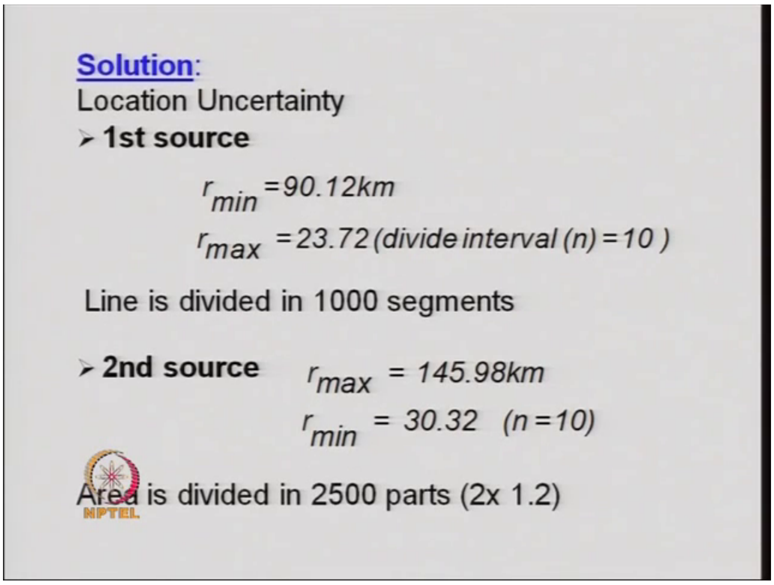

Now, first we take up the first uncertainty that is the location uncertainty. For the first source we calculate this will be the not minimum this will be the maximum and this will be not max this should be minimum. The maximum epicentral distance calculated is 90.12; that means, if I join these 2 points the distance should be 90.12 and the r minimum will be equal to if I draw a perpendicular from the side to this source then that perpendicular distance is 23.72.

Now, we divide this maximum r and the minimum r into a 10 equal divisions so that there is a pocket interval of certain value. Now, the epicentral distance would vary and if we assume that the line is divided into 1000 segments then for each segment we can assume the centre of the segment to be a source of earthquake and thus we will get 1000 values of the r. Now, these 1000 values of the r would lie between 23.72 to 90.12. So, we find out what is the probability of occurrence of the earthquake within a certain interval that interval we obtained by dividing the maximum value minus the minimum value by 10.

So, counting the total number of radial distance is lying within each interval we can find out the probability of occurrence of the epicentral distance lying within certain interval and the middle point of the interval is taken as the radial distance.

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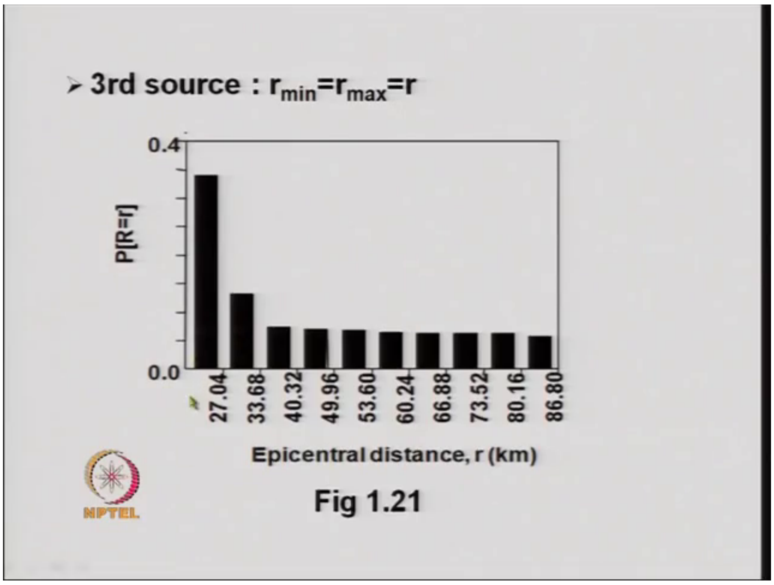

Fig 1.21

So, here for example, for the first source the probability of occurrence of earthquake with epicentral distance of 27.04 is about 0.336.

Similarly, for a radial distance of 33.68 the probability if occurrence is about 0.18. So, in this way one can calculate the probability of occurrence of an earthquake for what you call specified epicentral distance. The same kind of calculation is performed for source 2 here again we find out the maximum distance and the mini this will be the minimum distance. So, this maximum and minimum distance this interval is again divided into 10 equal division and assuming that the area is divided into 2500 parts of size 2 into 1.2 meter and assuming that the centre of each one of these sub areas of 2 into 1.2 is a point of earthquake then we can have 2500 epicentral distances for the source 2. And these 2500 epicentral distance is can be now, categorized into 10 divisions that we have obtained and we can find out the probability of occurrence of an earthquake with epicentral distance as specified for the middle of the what you call middle of the interval.

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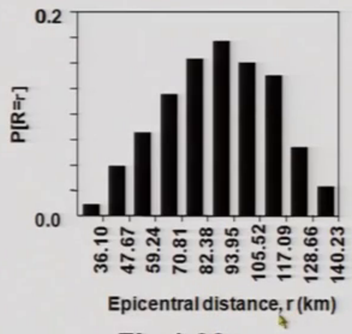

Fig 1.22

So, here say the epicentral distance 47.67 has a probability of occurrence nearly as 0.02. So, and a 59.24 has a probability of occurrence of about 0.03. In the same way the third probability of occurring the earthquake with a certain epicentral distance for the third source can be computed. But it is seen here that since it is a point source then it involves only 1 epicentral distance. So, the epicentral distance is since it is 1, so the probability of its occurrence is 1.

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Size Uncertainty :

$$\gamma_1 = 10^{4 - 1\times 4} = 1$$

$$\gamma_2 = 10^{4.5 - 1.2\times 4} = 0.501$$

$$\gamma_3 = 10^{3 - 0.8\times 4} = 0.631$$

For each source zone

$$P[m_1 < m < m_2] = \int_{m_1}^{m_2} f_M(m)\, dm$$

$$= f_m\left(\frac{m_1 + m_2}{2}\right)(m_2 - m_1) \qquad (1.29a)$$

For source zone 1, M_{max} and M_{min} are divided in 10 divisions.

Next we find out the size uncertainty the occurrence rate of the earthquake is given by this formula that is this formula. So, here we get the value of a as 4 and b is equal to 1 for this value of a is equal to 4.51 and the value of b is equal to 1.2 and for this the value of a is 3 and value of v equal to 0.8 for the equation that I have written on the top.

So, using this equation one can find out the value of lambda 1 or rather the nu 1, nu 2 and nu 3 this is same as lambda, lambda 2 and lambda 3. So, assuming the maximum magnitude of earthquake and the minimum magnitude of earthquake as 4, one can calculate what is the exceedance rate of the minimum magnitude of earthquake for different sources. So, they are 1.501 and 0.631 respectively.

Note that here the magnitude of earthquake that we put into this equation is the minimum magnitude of earthquake that we have specified because the exceedance of the earthquake of certain magnitude of earthquakes means here that at least the exceedance would be considered for the minimum magnitude of earthquake.

Now, for each source zone again we can calculate the probability of occurrence of certain magnitude of earthquake between 2 intervals that is a 1 and m 2 and this can be determined by integrating the probability density function fm which is shown again here this probability density function can be computed using this equation. And integrating this equation from m 1 to m 2 and this integration leads to this particular equation that is the magnitude of earthquake occurring between an integral of m 1 and m 2. So, for source zone 1 a max and a minimum are divided again into 10 divisions and centre of the division is considered as 1 magnitude that way we get 10 such magnitudes.

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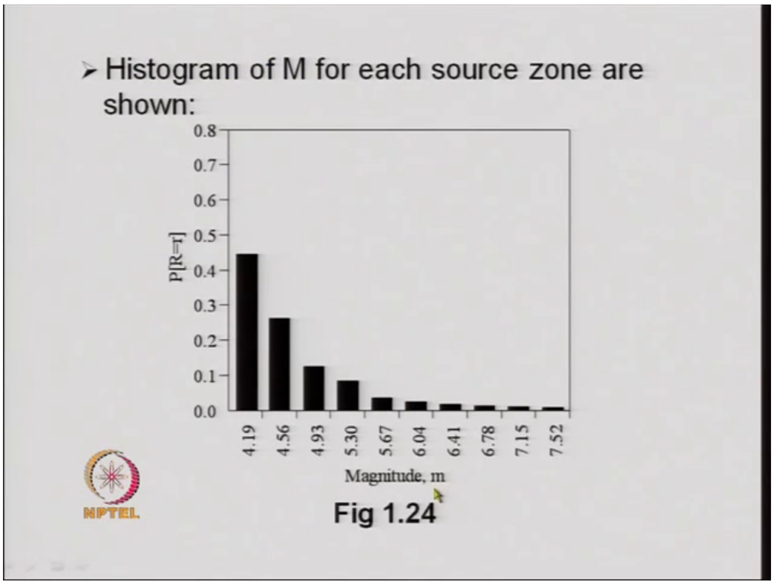

Fig 1.24

And one can find out the probability of occurrence of certain magnitude of earthquake and that magnitude of earthquake will be referred to the magnitude which lies at the centre of the division.

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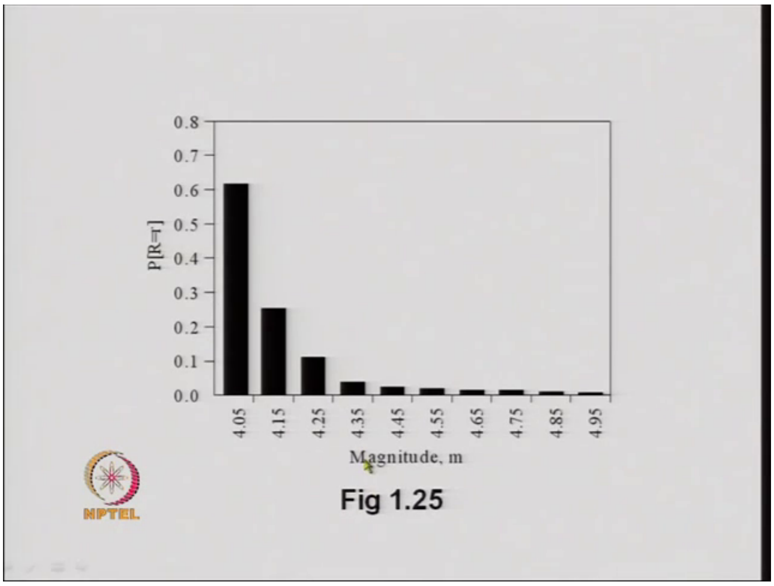

Fig 1.25

So, probability of occurrence of that magnitude of earthquake can be obtained for source 1, source 2 and source 3.

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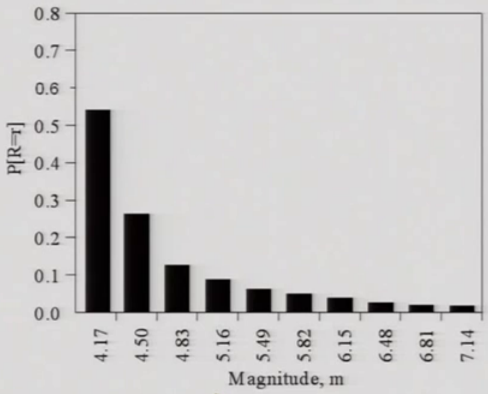

Fig 1.26

For all the 3 sources one can have this probability of occurrence of the magnitude of certain earthquake.

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- Say, Probability of exceedance of 0.01g is desired for m = 4.19, r = 27.04 km for source zone1

$$P\left[m = 4.19\right] = 0.551$$
$$P\left[r = 27.04\right] = 0.336$$

The above probability is given as

$$P\left[PGA > 0.01g \mid m = 4.19,\ r = 27.04\right] = 1 - F_Z(Z)$$
$$z = -1.65$$
$$1 - F_Z(Z) = 0.951$$

Now, once they are calculated then let us say we are interested in finding out the probability of exceedance of 0.01 g.

So, what we do is that for the probability of exceedance of 0.01 g for a magnitude of earthquake level 4.19 and an epicentral distance of 27.04 for source zone one can be calculated from the histograms that I have shown. For example, for a magnitude of earthquake of 4.19; that means, the centre of the first interval of the magnitude of earthquake that we obtained for source zone 1 is equal to 4.19, so for that the probability of occurrence is equal to 0.551. Similarly the probability of occurrence of the epicentral distance of 27.04, again 27.04 is the centre of the first interval of the epicentral distance that we computed for source zone 1 and that was computed as 0.336.

For example, here one can see the, this is the centre of the division for this centre the probability of occurrence is about 0.336. Now, once these 2 probabilities are obtained then we find out the probability of peak ground acceleration being greater than 0.01 g, condition upon magnitude of earthquake is equal to 4.19 and epicentral distance is equal to 27.04 that is obtained over here that is obtained from this relationship that is 1 minus F Z Z.

Now, F Z Z is the normalized distribution of the peak ground acceleration normalize distribution means these distribution refers to the any peak ground acceleration minus say.

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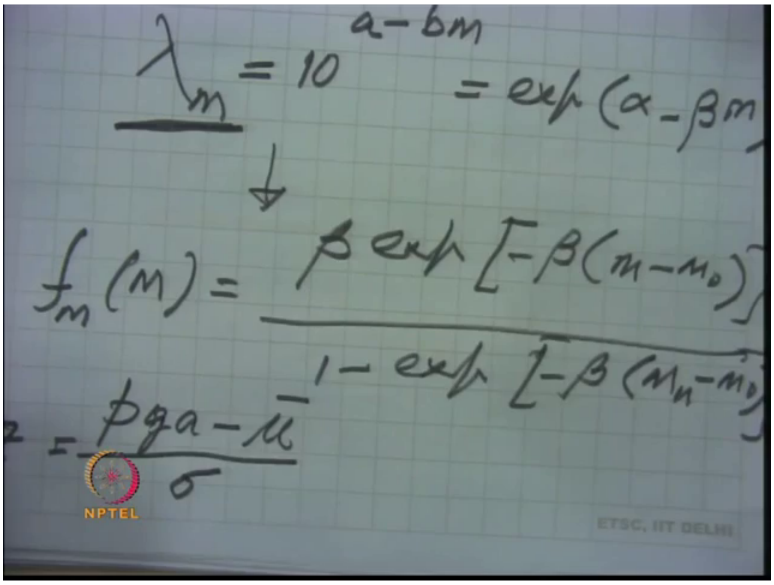

Any peak ground acceleration PGA minus is average value divided by its standard deviation this is the quantity z. Now, one can find out this normalized quantity and since it is assumed that the peak ground acceleration log normally varies, therefore this normalized quantity also varies log normally.

And there are standard tables from where one can find out these probability function that is F Z Z for a given value of the z. Now, if we calculate the value of z for 0.01 g, then these 0.01 g is first converted into centimeter per second square unit because the attenuation relationship that we have used in that the PGA value is calculated with a unit of centimeter per second square. So, therefore, converting this into a centimeter per second square and then finding out the its probability one can get the z value as minus 1.65 and from the table one can get the value of F Z Z and this leads to a probability of exceedance of 0.01 g as 0.951.

So, we see that the calculation follows like this first we find out the probability of occurrence of certain magnitude of earthquake from the equation that is given for source 1, then probability of occurrence of certain epicentral distance again from by considering that the earthquake can happen at any point within the line source or in the area source and from there we can calculate the probability of occurrence of certain epicentral distance and they are plotted as histograms. And for those combination of m and r one can find out the peak ground acceleration exceeding a value of 0.01 g conditioned upon these two quantities and for obtaining the this exceedance value.

We assume that the PGA is varying the log normally. So, from standard log normal tables one can get the value of F Z Z and one can calculate this quantity.

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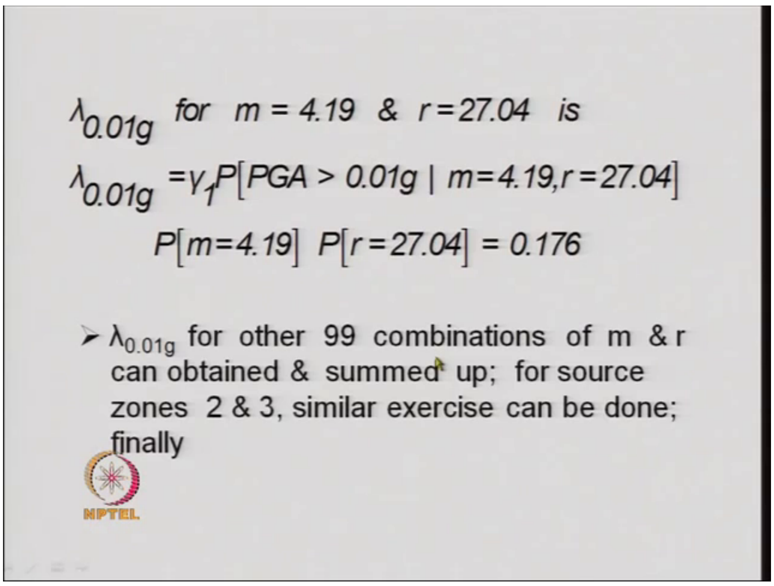

Now, if you wish to find out the value of the rate of exceedance of PGA level of 0.01 g then we use the summation equation that we have shown before that is the summation equation that is shown here.

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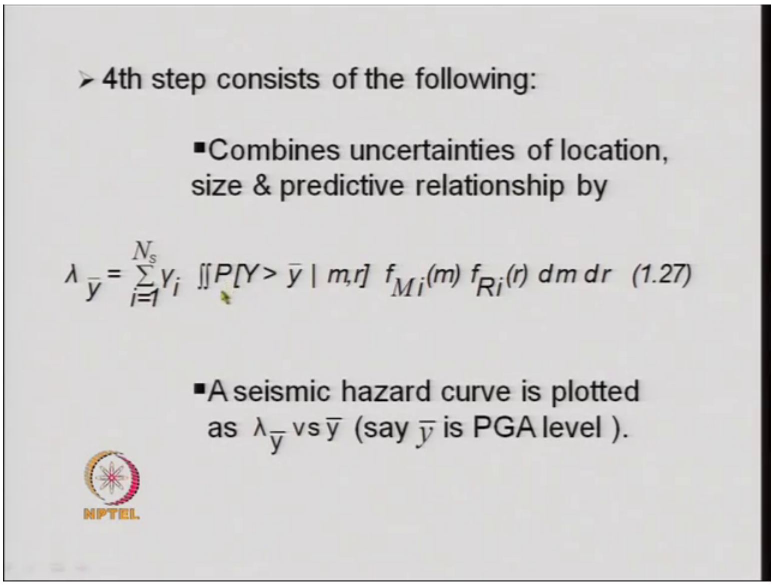

We integrate or sum up in this case integration will be replaced by summation. So, we will be summing up the product of these quantities that is probability of exceedance of certain level of peak ground acceleration conditioned upon a given set of value of m and r and then multiply it by the probability of occurrence of this particular m and probability of occurrence of this particular r.

So, these quantities are multiplied and then we sum up for all the events. So, here first we make this multiplication and this multiplication turns out to be 0.176 and in this the rate of occurrence of earthquake greater than magnitude m is equal r that is nu 1 that also we have calculated. So, we multiply these entire thing with nu 1 and the result is 0.176. So, the annual rate of exceedance of a peak ground acceleration of 0.01 g turns out to be 0.176 for source 1 given a pair of value of magnitude 4.19 and r is equal to 27.04.

Now, since we have made 10 intervals for the magnitudes and 10 intervals for the epicentral distance these intervals were obtained by deducting the minimum value from the maximum value and dividing it by 10, we have 10 intervals of magnitude of earthquake or 10 combinations of magnitude of earthquake and 10 combinations of epicentral distance. So, we have got total 100 such combination. So, out of that we have just taken only one. So, lambda 0.01 g for other 99 combinations of m and r can be obtained for source 1 and they can be summed up for source zone 2 and 3 similar calculations can be found out.

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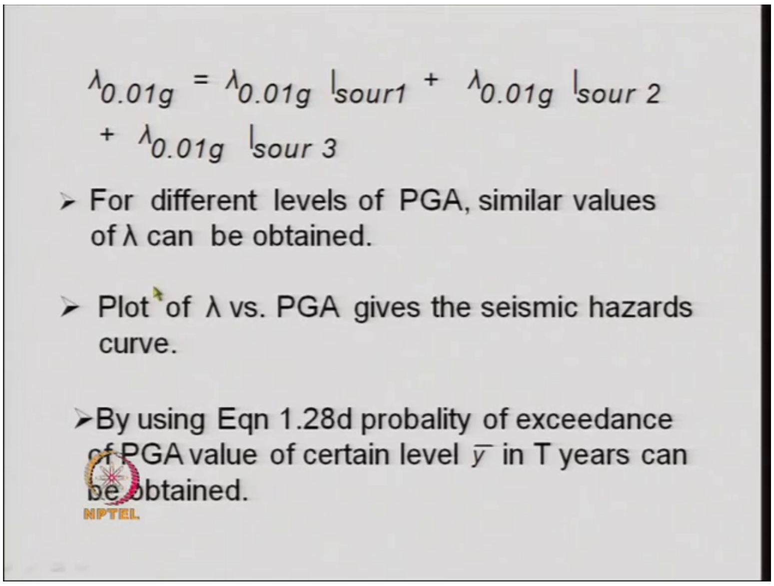

Finally, we get the value of the rate of exceedance of PGA 0.01 g equal to that we what will get for source 1, source 2 and source 3 they will be summed together and we will get finally, the value of this quantity lambda 0.01 g.

Now, we can consider next a peak ground acceleration level of 0.02 g, then 0.03 g, then 0.04 g and so on. So, for different levels of peak ground acceleration we can find out the lambda value and these lambda value then can be plotted against different levels of the peak ground acceleration. And this will give a curve and that curve is called the seismic hazard curve for peak round acceleration for the region.

Now, with this particular quantity known that where the seismic hazard curve for peak ground acceleration of for any other earthquake measurement parameter if we have the seismic hazard curve then for a given level of these seismic measurement parameter one can find out what is the annual probability exceedance of that level of the parameter.

Then one can consider also what is the probability of exceedance in T years of time by using the equation, this equation that we have obtained.

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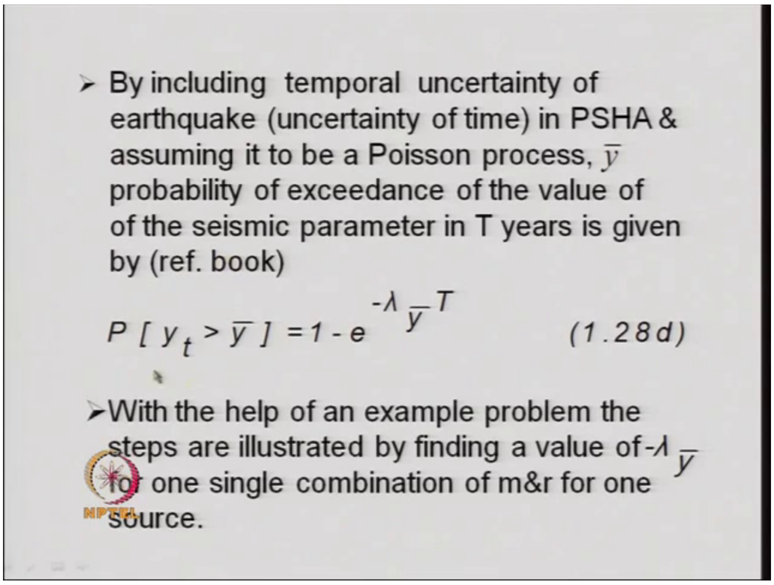

So, these equation provides the exceedance rate of, say for example, exceedance of a peak ground acceleration level what is the probability of exceedance of a peak ground acceleration level of y bar can be obtained using this equation where the lambda is equal to lambda y bar that is the lambda value that we calculated and is shown in the form of the seismic hazard curve.

So, using this temporal relationship of the occurrence of earthquake one can calculate what is the probability of excceedence of certain level of say peak ground acceleration in T years of time for a region.

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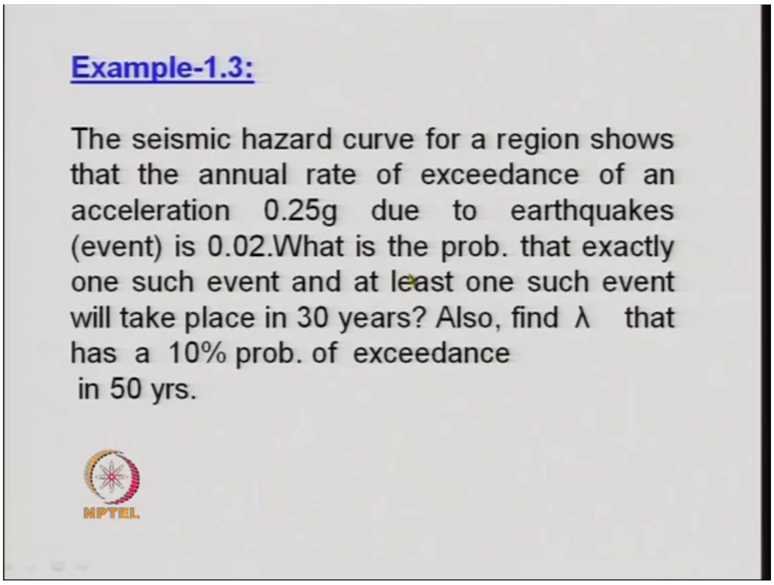

So, this is about the, these PSHA and therefore, we can see that by drawing some what you call the histograms showing the probability of occurrence of magnitude of earthquake and probability of occurrence of certain epicentral distance. And using pertinent equations one can obtain the seismic hazard curve for a particular region drawn for seismic measurement I mean parameter the seismic measurement parameter it could be a peak ground acceleration or peak ground displacement peak ground velocity or for that matter any other earth quake measurement parameter.

Now, let us look into the next example which is a very the simple straightforward example in order to clarify the temporal distribution of the earthquake which is assumed to be a (Refer Time: 35:48) model. So, here the problem is the seismic hazard curve for a region shows that annual rate of excceedence of an acceleration 0.25 g due to earth quake is 0.02.

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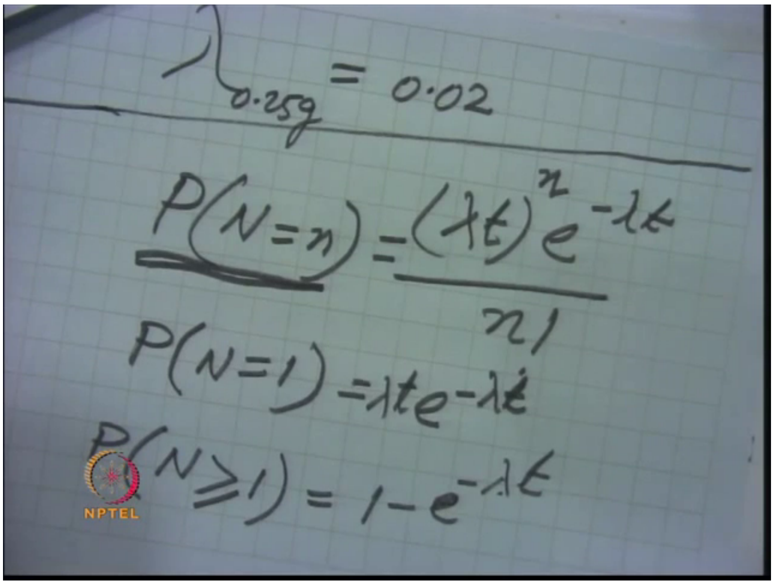

That is lambda 0.25 g is given as 0.02. So, from the hazard curve that is brought it for the region we get particular these value, this is given.

Now, what you have to find out is that what is the probability that exactly 1 such event; that means, only 1 event where the 0.25 of the peak ground acceleration we will take place in thirty years and the other one is that what is the probability that at least 1 such event that is 1 such event means at least once this peak ground level will be exceeded in thirty years of time.

Also find the value of lambda that has a probability 10 percent probability of exceedance in fifty years of time; that means, one has to calculate what is the value of these lambda for a 10 percent exceedance in 50 years of time. So, the answer to the first is the probability of occurrence of only 1 touch event such event is given by the equation that we have written this is the equation probability of occurrence of only 1 event and we put the appropriate value, the value of a lambda is given as 0.02, the time period is 30 years and then e to the power minus lambda t. So, that gives a result of 33 percent.

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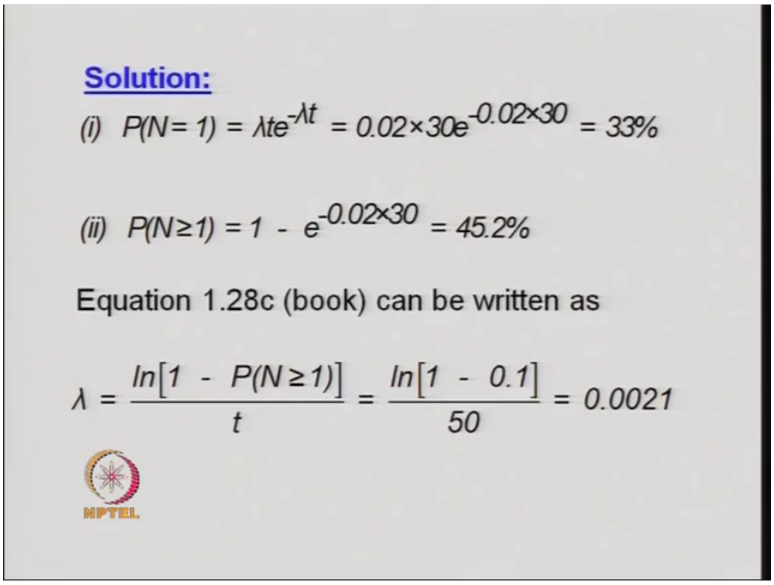

So, the answer to the first question that is the probability of occurrence of 1 event is 33 percent. The probability of at least once exceedance is given by again this equation and here we put the values that is lambda value as 0.02 and the time has 30 years and we get it has 45.02 percent.

Now, this equation N can be rewritten in the form of e to the power minus lambda t is equal to 1 minus P N greater than or equal to 1.

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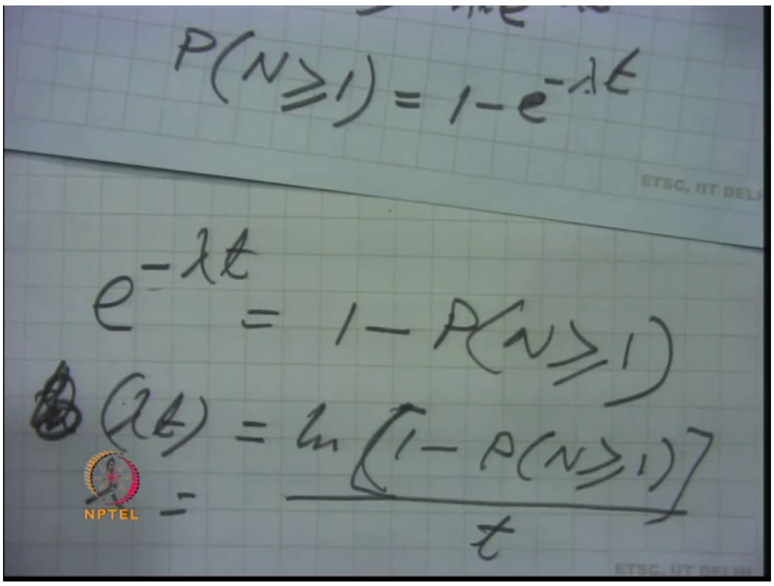

So, ln lambda t will be call to ln of 1 minus P N greater or equal to 1. Here we ignored the sign because the negative value for the occurrence rate that really does not make any meaning.

So, therefore, and ln will be equal to lambda t from there we can get the value of lambda is equal to this divided by t. So, that is what has been used here. The ln's the the occurrence exceedance occurrence rate lambda will be equal to ln of 1 minus P N greater than equal to 1 divided by t and this is given as 0 point 1 that is the find probability that has a probability of exceedance of 10 percent. So, 10 percent and the time is 50 years, so that is what we have done. So, 10 percent is 0.1 and time is 50 years and the lambda is calculated as 0.0021.

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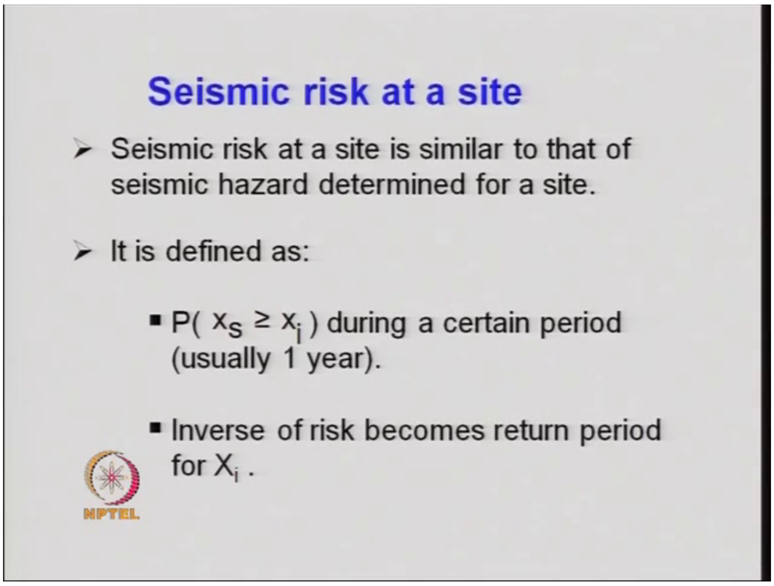

So, therefore, given the seismic hazard curve 1 one can find out the probability of occurrence of just 1 event and exceedance of at least 1 event and given the probability of exceedance for or the earthquake for a given period one can find out what is the average rate of exceedance the value of lambda that we have calculated in the second problem.

Now, let us come to the seismic risk at a site seismic risk at a site similar to that of seismic hazard determination. Now, the seismic risk means that again what is the probability of exceedance of certain earthquake measurement parameter. Now, based on that one can assess the seismic risk for a site and one can also bring in the period in to picture that is one can say what is the probability of exceedance of certain level of earth quake measurement parameter say peak ground acceleration in 50 years of time or hundred years time. So, in that case the previous example that you have done that kind of example would be useful.

So, by definition the seismic risk is that probability of a certain parameter say this is peak ground acceleration, exceeding a particular level during certain period and generally we take that period as 1 year so that we can say that it is the annual probability of exceedance and the universe of this annual probability of exceedance or inverse of this risk is called the return period.

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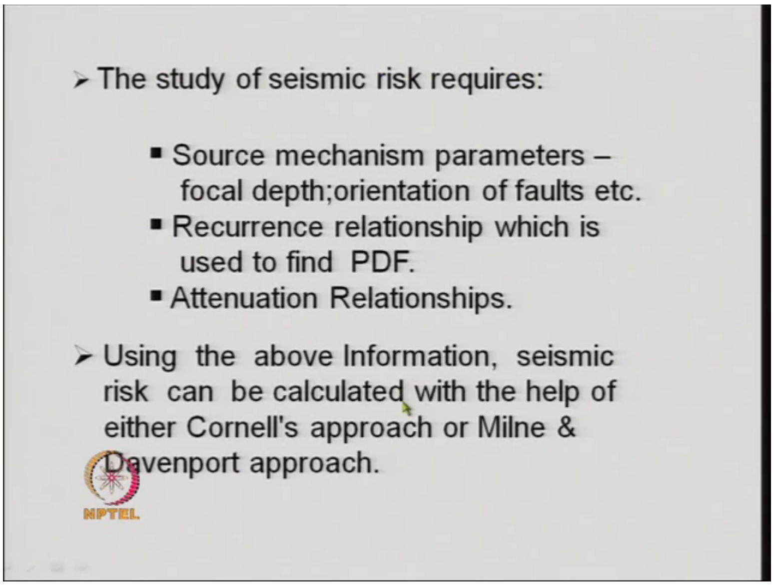

The study of seismic risk requires source mechanism parameters that is the focal depth orientation of fault etcetera, recurrence relationship which is used to find out the probability density function of the magnitude of earthquake that is what we have seen before and the attenuation relationships again we have used this attenuation relationship in connection with PSHA.

Now, using these information one can obtain the seismic risk either using a calculation like a probabilistic seismic hazard calculation or using Cornell's on Milne and davenports approach. So, they were a certain there were certain methods which were the classic classical methods and they were proposed by Cornell and Davenport.

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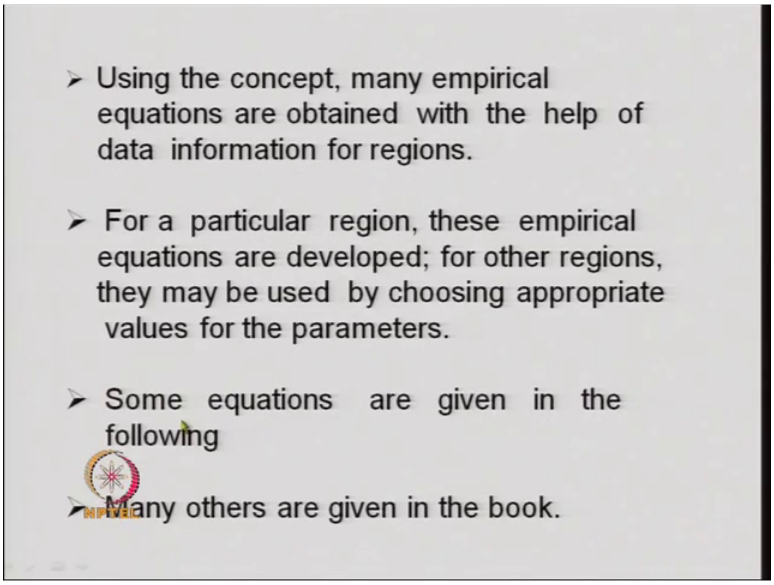

Using their concept many empirical equations were obtained with the help of data information for a particular region.

For a particular region these empirical equations have been developed if we used to wish use them for some other region then the constants of the equation or the values of the different parameters that have been used that the values must be accountingly adjusted. Now, I am giving you some equations over year, but many more equations are available of this nature and they are all given in the book.

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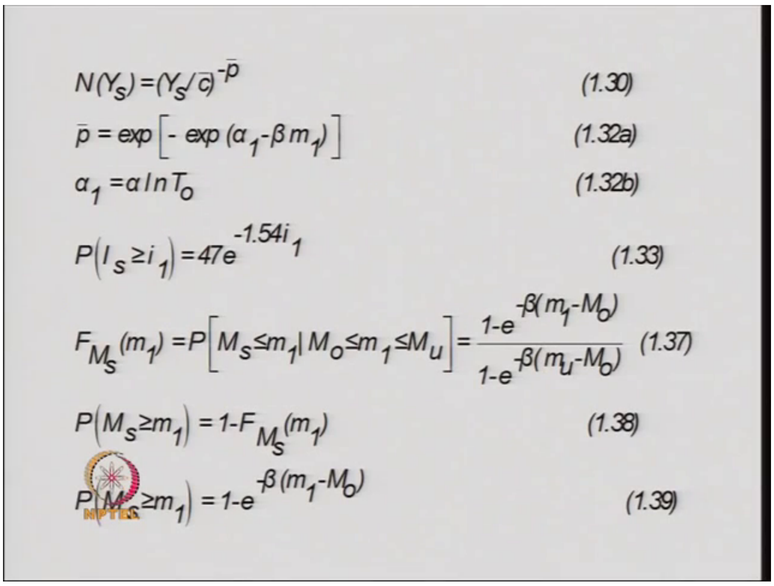

Now, the first equation talks of the annual occurrence of a particular event that is the number of the say magnitude of earthquake or peak ground acceleration of earthquake exceeding a value of Y s. So, Y s in general it indicates a earthquake measurement parameter, so let us say it is peak ground acceleration for all problem. So, then what is the annual rate at of occurrence of event specified by the exceedance of certain level of peak ground acceleration. So, with that number is given by this equation Y s my divided by c bar to the power minus p bar. So, here c bar and p bar they are the constants and these constants are obtained from the regional data and Y s say here is a level of the peak ground acceleration.

The next equation shows the probability of exceedance of a maximum magnitude of earthquake sat maximum magnitude of earth quake is specified by m 1 then the probability of exceedance of that magnitude maximum magnitude of earthquake is given again by a equation like this where alpha 1 beta are the constants and alpha 1 is related to the period of observation T 0 and another constant alpha.

This equation shows the probability of exceedance of the intensity of an earthquake. So, probability of exceedance of an intensity of earthquake for a level small i 1 is given by an equation like this again this is an empirical equation all of them are all in empirical equation empirical equation. So, i here, these values 1.54 and 47 these values are for a particular region say if the data is from United States, so for some reason in USA this particular values are valid for other regions one has to calculate the appropriate values of these parameters.

This equation shows the probability of the magnitude of earthquake. So, the magnitude of earthquake lying between and upper limit and lower limit the probability of the magnitude being less than equal to 1. So, that is given by an equation like this where m 1 is the magnitude in question the probability of which you are trying to find out that is what is the probability of the magnitude of earthquake being less than m 1. So, that is what we are trying to find out. So, this is m 1 and nu refers to the maximum magnitude of earthquake and m 0 is the minimum magnitude of earthquake that you consider for the analysis. And if we know what is the probability of the magnitude of earthquake being less than equal to certain value then one can calculate what is the probability of exceedance of the magnitude of earthquake for the same value of the magnitude that will be 1 minus this quantity.

Now, using this equation if I in this equation if we put the value of m u to be very large then this turns out to be almost equal to 1, this one and as a result of that one can simplify this equation to this particular form; that means, probability of the magnitude of earthquake being greater than equal to m 1 is equal to 1 minus e to the power minus beta m 1 minus m 0, so that comes from this particular equation. So, that way we have many such empirical equation which talks of the probability of occurrence of probability of exceedance of certain level of the earthquake parameters in a particular region and they are called the seismic risk for the region.

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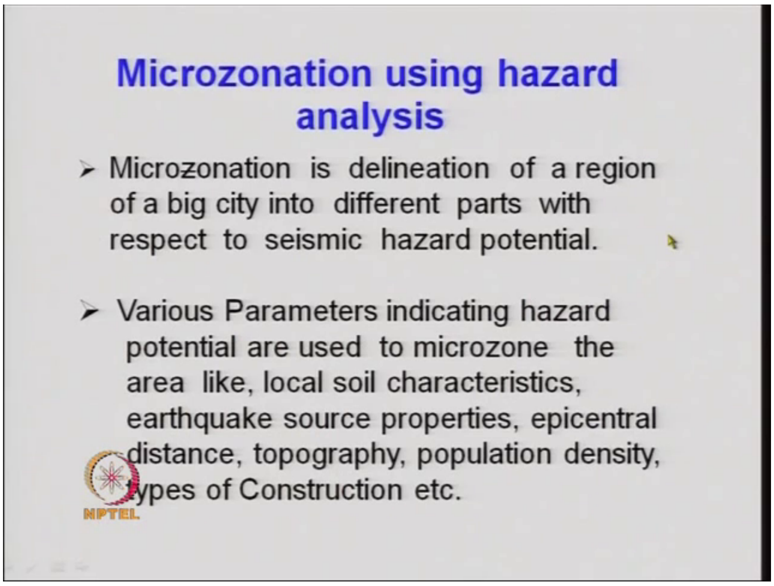

Next we come to a very important topic the microzonation using the hazard analysis. Now, the microzonation is a very useful concept for mitigating the earthquake disaster in a particular region and for that one should have a map for the region showing the relative vulnerability of the different sub regions in that particular area. The concept basically is like this say we take a city or a metropolitan area and divide into a number of sub areas and the centre of the sub areas are the points in question. So, here we at these points we attach some value which indicates the vulnerability of certain parameter that we will now discuss.

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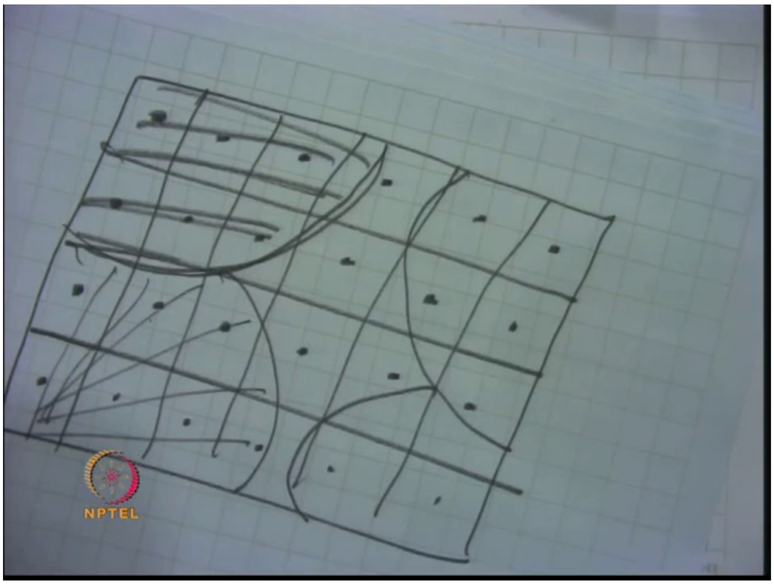

So, the microzonation say we are wanting to find out with respect to the probability density or the sorry population density.

So, what we do that in this region we calculate the population density and that way for all these places we calculate the population density of the region and then what we do the points which are having the similar popular density they are grouped together and from this grouping one can come out with areas showing the population density; that means, in this these area has one kind of population density this area is having another kind of population density and so on. So, this will be called a microzonation map of the city with respect to population density.

Similarly one can construct a microzonation map of a city for construction. So, the city can be divided into the type of construction that is a bad construction good construction or medium type of construction and one can have a microzonation map.

Similarly, for the old structure the new structure relatively old structure we can have can have these kinds of categories and then one can have a microzonation map for the type of the structures that is existing in the city. So, now, this concept can be extended to the microzonation of a region with respect to peak ground acceleration and the amplification factor of the ground motion due to soil condition. So, that is these two parameters are very important because for design purposes one should know what is in each sub region, what is the peak ground acceleration for which the structure should be designed in this region. And what is the likely amplification factor for that region because of the soil condition. So, if these two informations are there then one can and go ahead with a shape design of structures for those regions.

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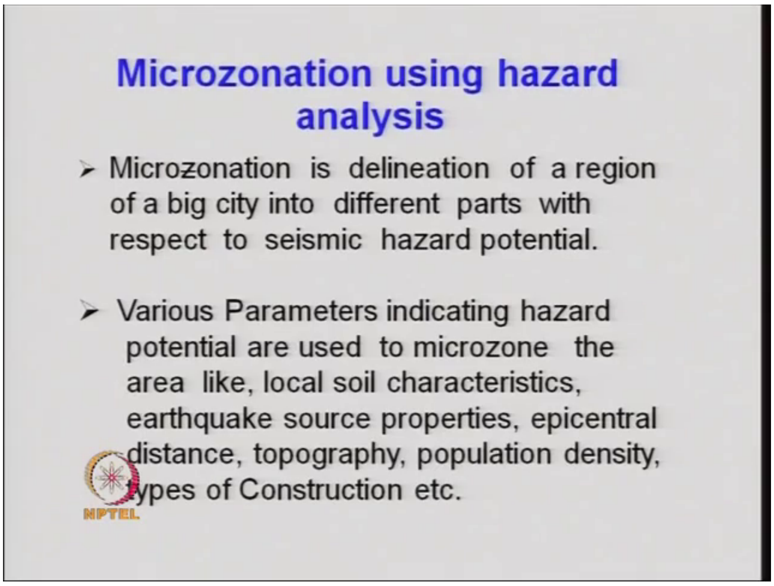

So, that is what is done in a microzonation. So, now, let us try to formally define the microzonation. Microzonation is delineation of a region of a big city in to different parts with respect to seismic hazard potential.

Various parameters indicating hazard potential are used to microzone the area like local soil characteristics, earthquake source properties, epicentral distance, topography, population density, types of construction etcetera.

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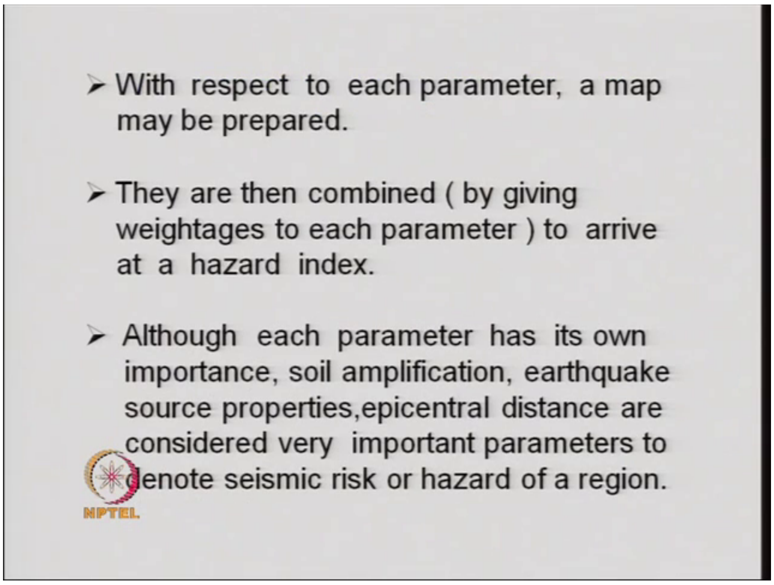

With respect to each parameter a map may be prepared. They are then combined by giving weightages to each parameter to arrive at a hazard index.

So, for each one of the sub area one can I calculate and hazard index by giving weightages to each one of these parameter. Although each parameter has its own importance soil amplification of earthquake source properties epicenteral distance are considered very important parameters to denote seismic risk or hazard of a particular region.

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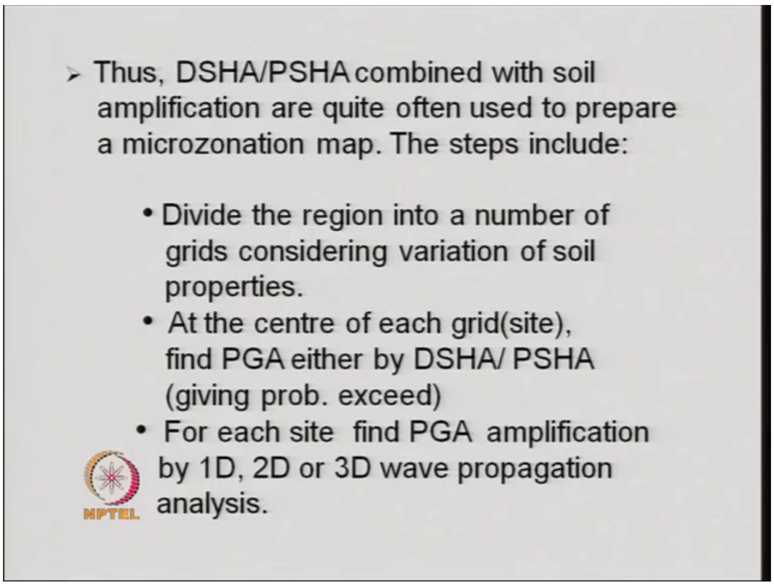

DPSHA or PSHA combined with soil amplification are quite often used to prepare a microzonation map. The steps include divide the region into a number of bits considering variation of soil properties as I have shown here then at the centre of each grid find PGA either by DSHA or PSHA procedure, giving the probability of exceedance in the case of PSHA. And then for each one of the site that is the centre of the grid one can find out the PGA amplification by performing a 1 dimensional, 2 dimensional, 3 dimensional wave propagation analysis that is what we discussed before.

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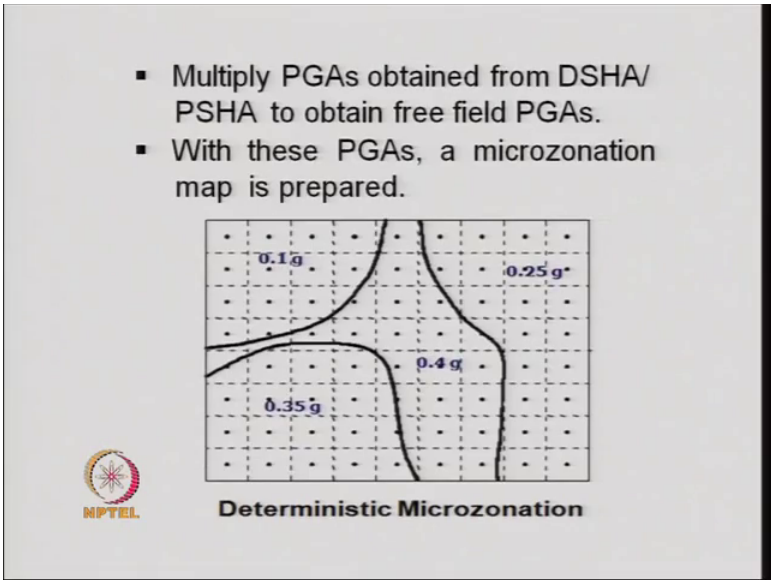

And multiply the PGAs that we have obtained and from the DSHA or PSHA analysis by the amplification factor and accordingly can prepare a microzonation map.

So, a deterministic microzonation map for a peak ground acceleration is shown over here in this figure you can see that this particular region is controlled by this PGA this region is controlled by this PGA and so on and therefore, if you have to construct a building then that the building should be designed with a PGA of 0.4 g.

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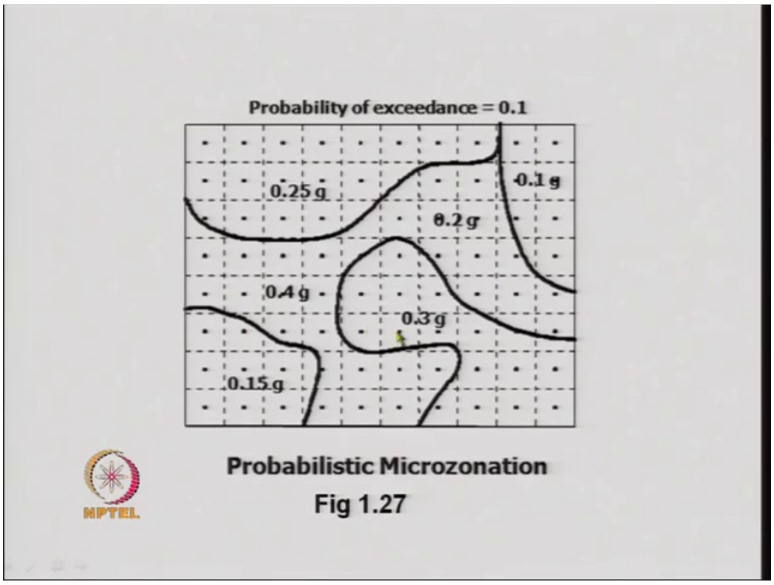

This one shows the probabilistic microzonation. Here the numbers over here associated with each sub region shows the probability of exceedance of 0.25 level of peak ground acceleration is 10 percent. So, we take 10 percent probability of exceedance that is 10 percent risk and based on that one can design the buildings with this peak ground acceleration.

So, let me summarize at this stage what we discussed today we have discussed a problem in which we have shown how probabilistic seismic hazard analysis can be carried out and it uses some of the equations probability equations and attenuation law. And by drawing certain histograms and using certain summation over all the sources one can find out a what is known as a seismic hazard curve for the region showing the proof annual probability of exceedance of certain earthquake measurement parameter with respect to the level of that earthquake measurement parameter.

Then we have discussed about the seismic risk expressions which are available in the literature for different quantities say magnitude of earthquake intensity of earthquake of peak acceleration and you will get in books and in the websites also a host of such chemical equations, if we do not have any particular data systematic data available for a particular site then one can use one of these empirical equations expressing the seismic hazard or seismic risk at a particular site. And then we discussed about the microzonation of a particular region what my microzonation means and how a microzonation of a region or a city can be obtained for a given level of for different levels of peak ground acceleration or the probability of occurrence of the peak ground acceleration and also in that we include the amplification effect due to soil condition.

Thank you.