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Structural Dynamics
Week 9: Module 02

Generation of Elastic Design Response Spectra

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Welcome to structural dynamics class. So in this class we will discuss about how to generate elastic designs response spectrum. So this design response spectrum is quite a useful concept in the application of structural dynamics knowledge to earthquake engineering or earthquake resistant design of buildings.

So quite often we need the maximum response which a structure will undergo under the action of earthquake. So we can read this design spectrum by using natural period of the building. So when we calculate natural period of the building either from like fundamental analysis or classical analysis or from empirical expression given in the relevant codes we take that natural period of the building and read the design spectrum values.

So this design spectrum values can be of values can be either displacement or velocity or acceleration depending on the application. But how do we develop this design spectrum we have studied the response spectrum. So I suggest students to refer to response spectrum class once and then again come to this design spectrum class.

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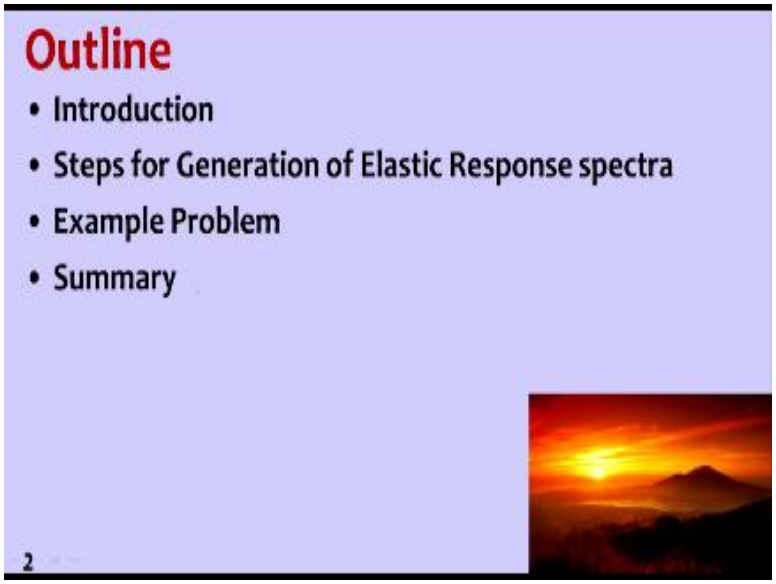

So we will discuss the steps for generating elastic response spectrum and then design spectrum.

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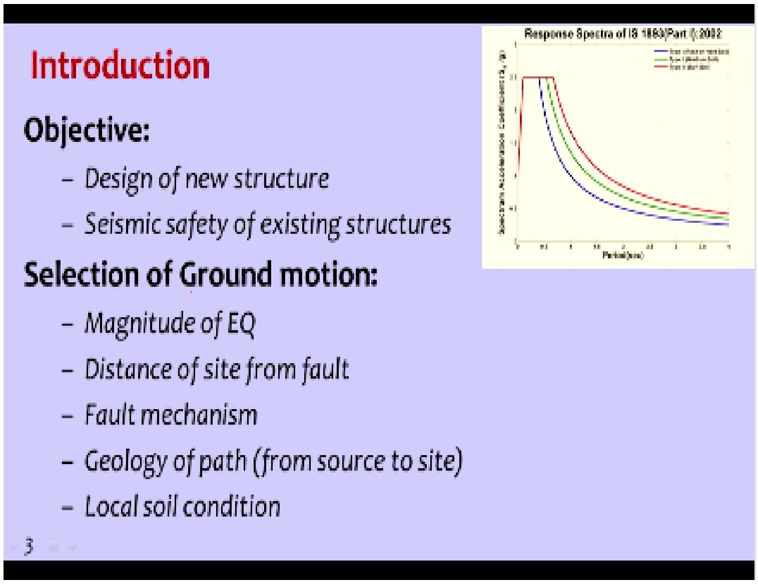

So the object to is this will be used for the design of new structures, it is required for seismic safety of existing buildings. So the given plot is the design response spectrum of given in IS 1893 code. So it is given for three types of soil conditions for 5% of damping and that natural period is ranging from 0 seconds to 4 seconds.

So how do we select the ground motion depending on magnitude of earthquake distance from the site fault mechanism geology and the path so all these things affect our design spectrum and local soil conditions.

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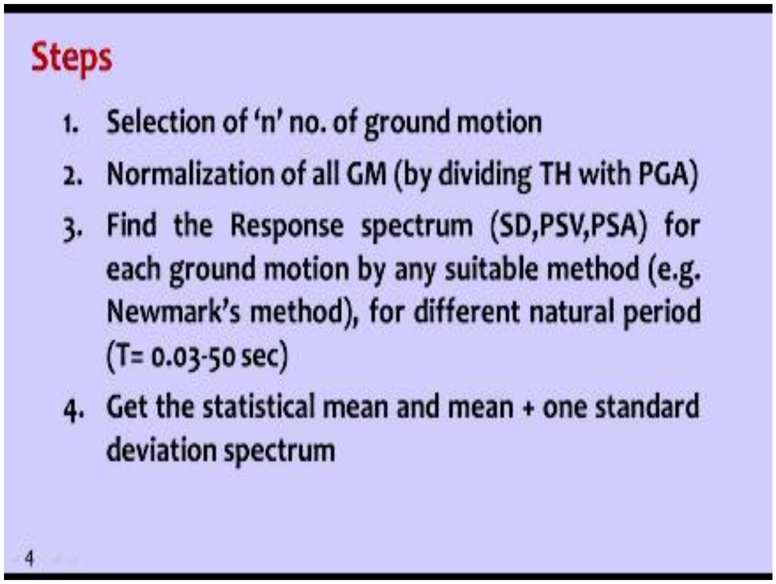

So first step in generating the design responsive spectrum that is selection of n number of ground motions so many ground motions we sell and then normalize all the ground motions that means what time history of that for a given PGA so say one PGA normalize it to one PG normalize it to 0.5 PGA so 2.5 g p ground acceleration or one GP ground acceleration and then later find response spectrum.

So response spectrum values can be spectral displacement pseudo spectral velocity or pseudo spectral acceleration for each ground motion by any suitable numerical method so we can use a new mark's method or we can use central difference method I use and then natural period for this one on the x axis can be arranged you can range from 0. 0 3 seconds up to 15 seconds so long natural period is there. And then step 4 in step 4 get the statistical mean and mean plus 1 standard deviation spectrum.

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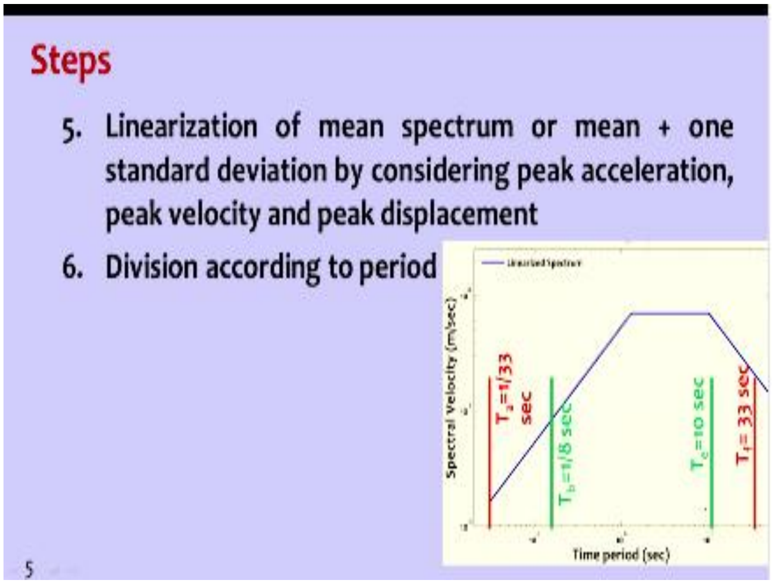

Then linearization of mean spectrum or mean plus 1 standard deviation by considering peak acceleration peak velocity and peak displacement depending on the type of the curve we are using and division according to the period, so new mark and hall has suggested certain periods where we can draw the straight lines in between those periods as you can see 1/33 seconds is one period and then 1/8 seconds 10 seconds and 33 seconds. So these are the we can call it as the control points.

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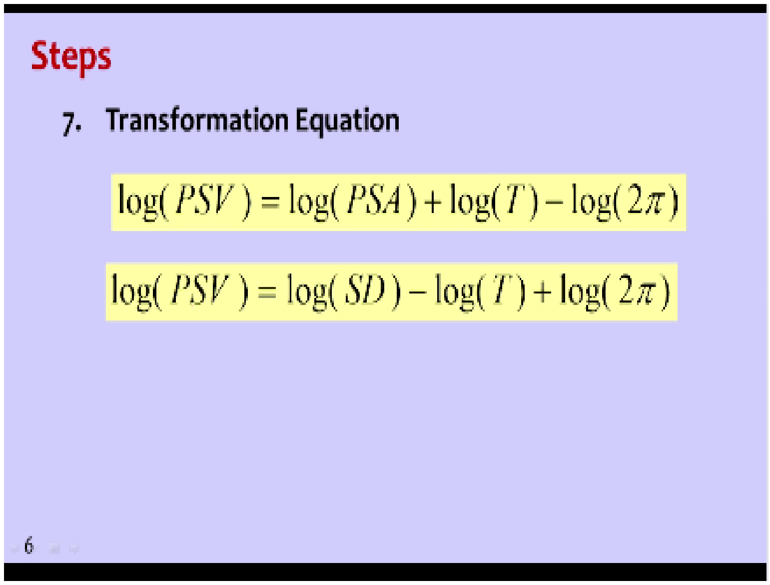

Then seven use transformation equation so that is what how do we get pseudo spectral velocity from pseudo spectral acceleration and natural period. So when we have pseudo spectral acceleration and corresponding period so we can use that plug in those values and get pseudo spectral velocity so it can also be converted from pseudo as displacement so spectral displacement to spectral velocity conversion formula.

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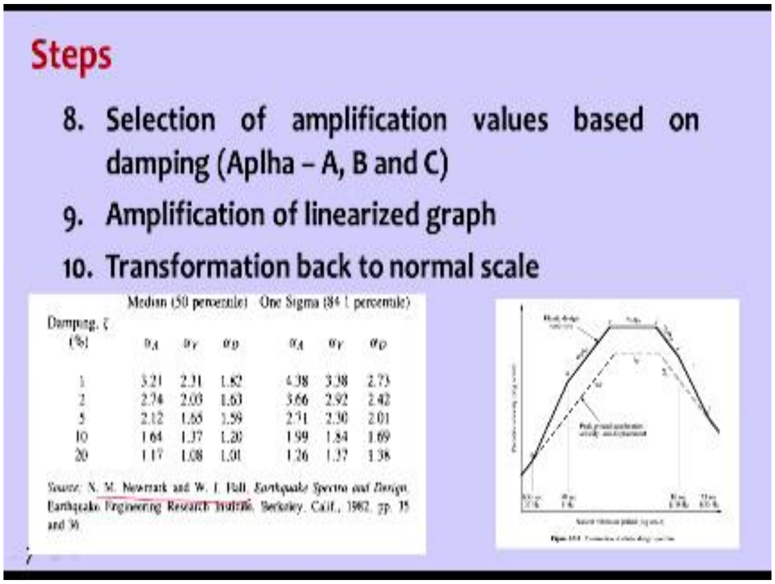

Step 8 selection of amplification values based on damping, so that is alpha A, Band C so these three values are there available, so acceleration velocity and displacement so this is mean values this is mean +1σ values. So these are suggested by Newmark and Hall, so amplification of linearized graph as you can see this one so this is a linearized graph the dotted one and then amplification of that is taken place. And transform back to normal scale, so first we will work it on the log-log scale and then we will convert that into linear scale.

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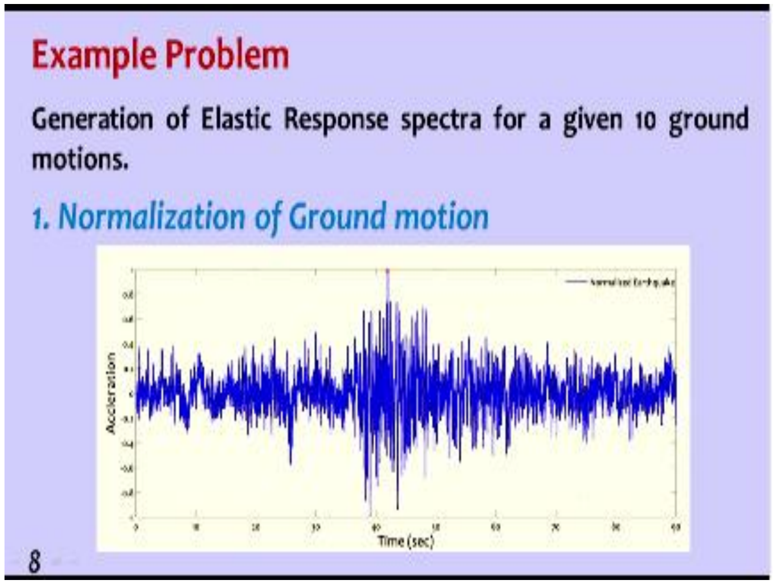

Let us develop one using an example problem, so generation of elastic response spectrum of a given say 10 ground motions. So first normalize ground motions as you can see here so this is normalized to 1g value so 90 seconds acceleration is given so all the acceleration values are normalized to this value.

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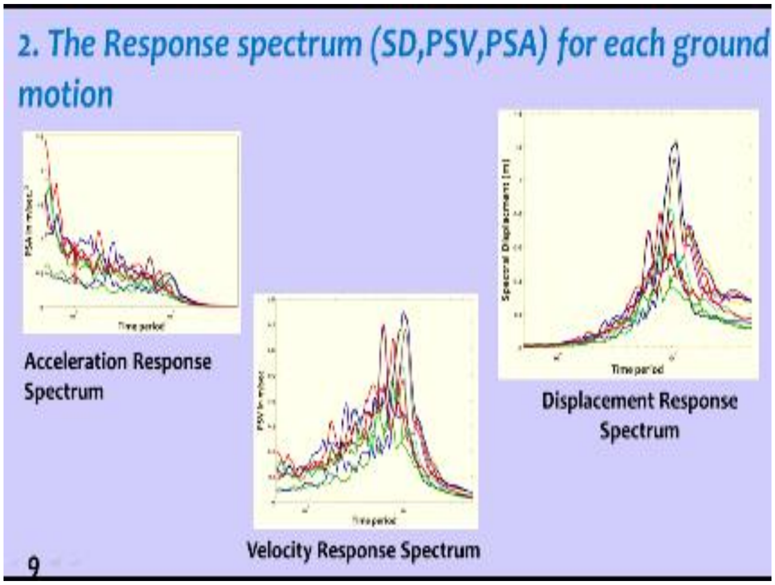

They are normalized in the acceleration amplitude not on time, so the response spectrum SD, PSV and PSA for each ground motion as you can see this is acceleration response spectrum velocity response spectrum and displacement response spectrum okay, so the mean at this point will be taken as all these values average so that is mean at that point.

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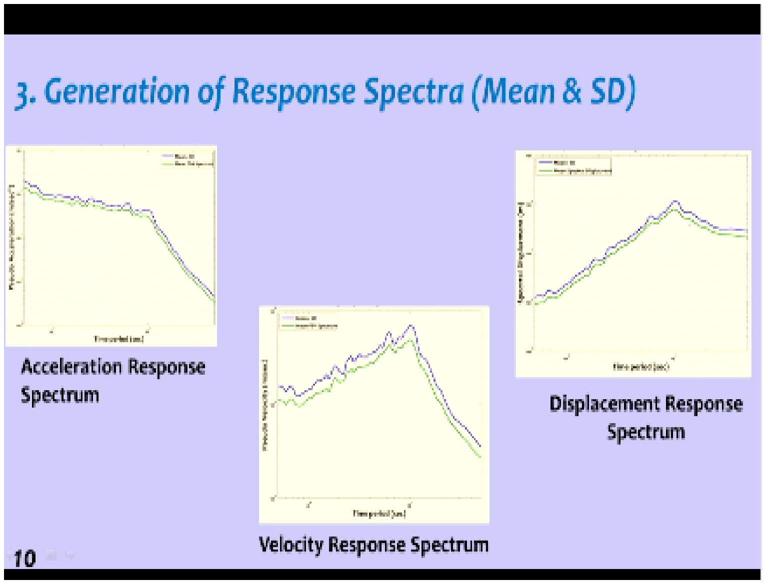

So like that at all points we take mean, so this is mean response spectrum and then mean plus 1 standard deviation response spectrum so both are there here now. So mean +SD mean PSA pseudo spectral acceleration spectrum and again similarly velocity spectrum and then displacement spectrum so this blue line is telling main place one standard deviation green line is telling us mean spectrum.

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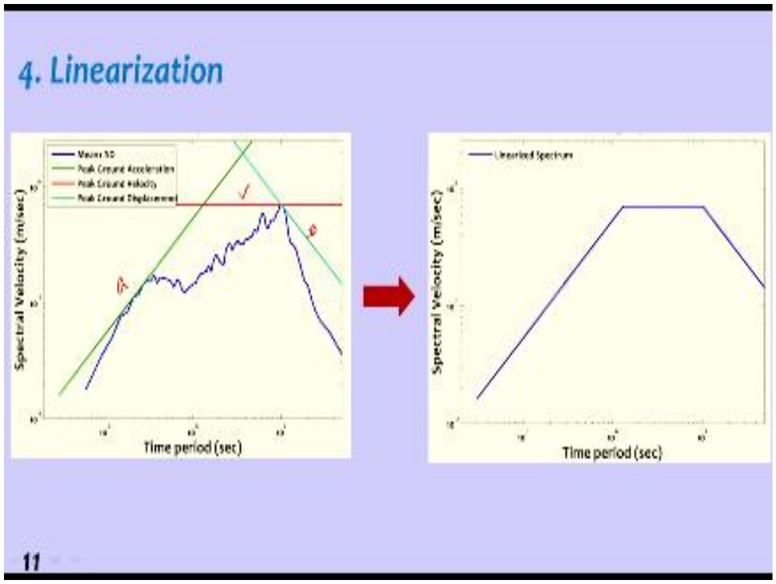

So linearization is done so linearization according to using this peak values you do linearization of this acceleration velocity and displacement region so peak ground displacement, peak ground acceleration and P ground velocity so this is velocity, this is a displacement, this is acceleration so this is a linear riser spectrum.

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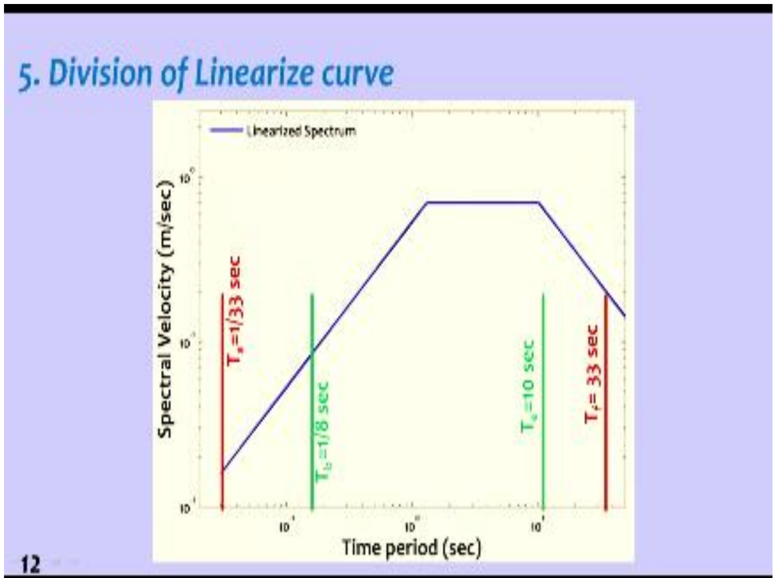

And then now we use the control points of time and then.

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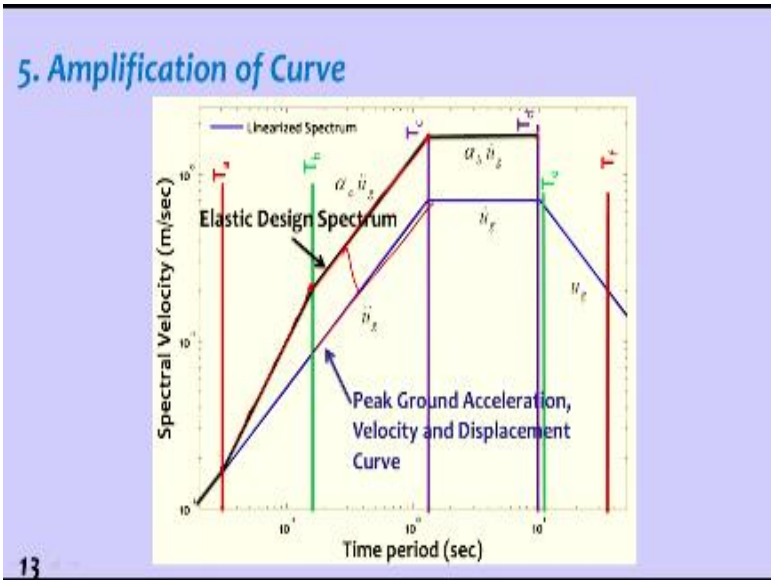

Amplification curve will develop or draw on this one using the amplification coefficient is given in Newmark and Hall so this you need to draw carefully, so this one is amplified using alpha and then parallel line is drawn here. So then we hit here and with hit here so from this point from this line we can directly take this line a linear line from here to here and then like that displacement so it comes here displacement so acceleration.

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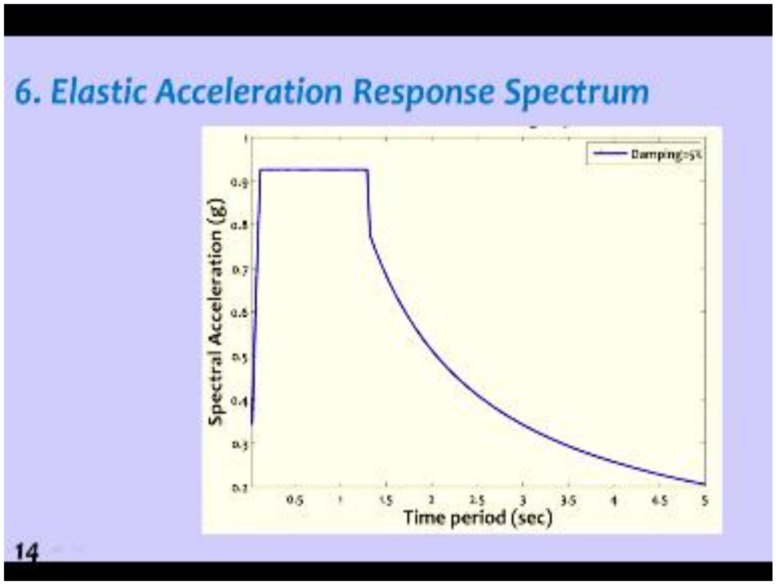

And displacement and velocity curve is drawn directly from there is it and then that that curve you convert that into linear scale so earlier one it is in the log.

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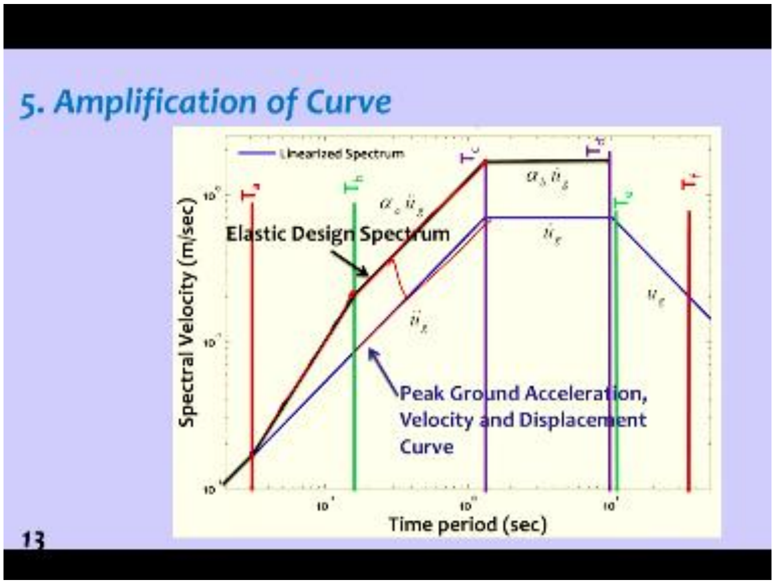

Scale as you can observe here this is log on the x-axis and log on y-axis so this we convert into linear scale.

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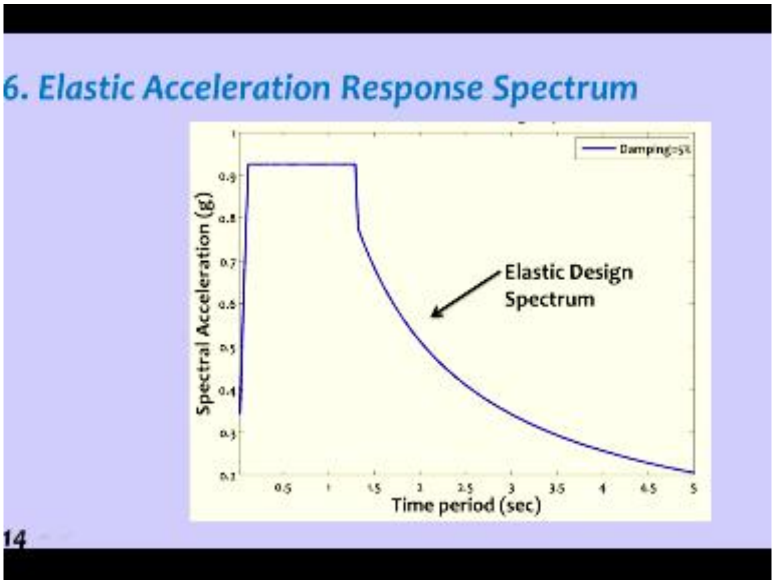

So we get this as elastic design response spectrum so this we use for all our applications so this is given for acceleration we use this for all our structural engineering earthquake engineering design applications.

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So what we have studied in this class is the procedure of construction of a design response spectrum okay our design spectrum so for that we need a sort of ground motions so for each ground motion first we do a normalization of PGA for a given PGA and then after that we find response spectrum velocity spectrum and displacement spectra for all these ten whatever number ground motions and then we take mean Vector.

And mean place one standard deviation spectrum and then later we find out peak values in that and do the linearization of that and by using the amplification coefficient values suggested by new mark in Hall we amplify this linear spectrum and then finally we convert that linear spectrum which is on the log-log scale into natural scale so that's how we get the design spectrum.

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