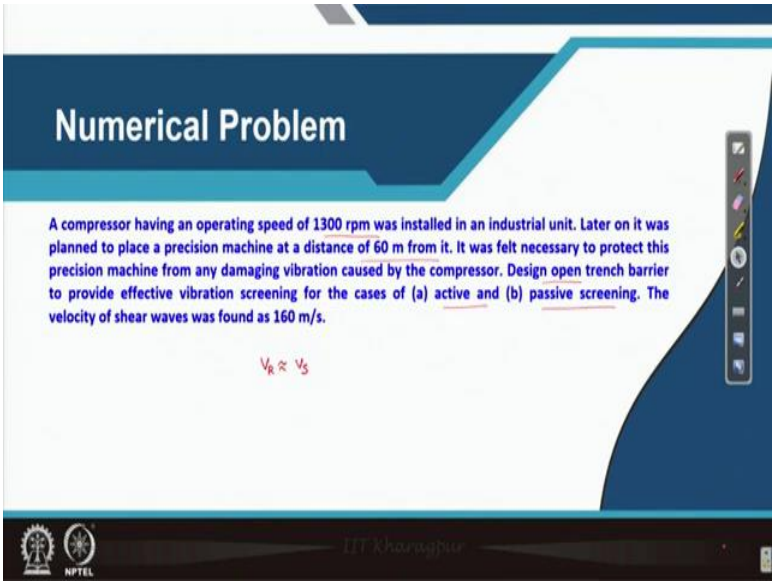
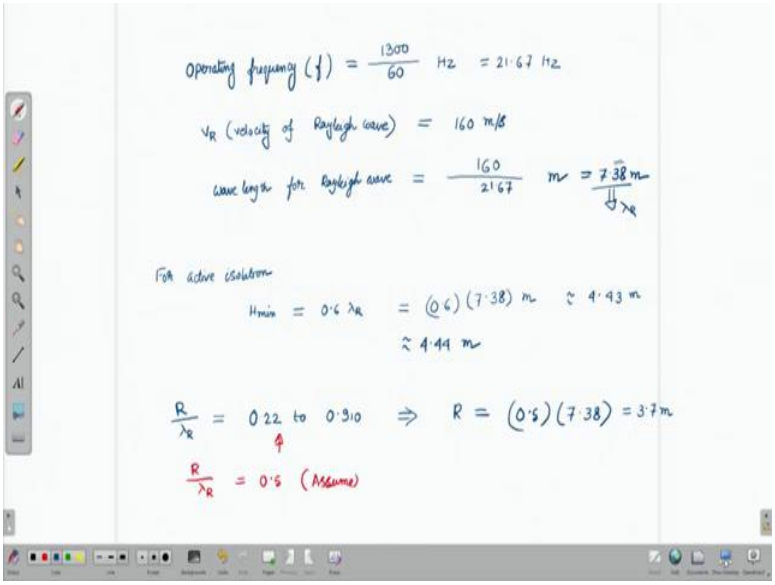
Solid Dynamics
Professor Paramita Bhattacharya
Department of Civil Engineering
Indian Institute of Technology, Kharagpur
Lecture - 59
Isolation of Vibration (Part 4)

Hello friends. Welcome to the class Soil Dynamics. Today we will discuss the topic Isolation of Vibration. Today is the last class on this topic. So, first we will see how we can design active and passive isolation for vibration screening.

(Refer Slide Time: 0:59)





So, let us take one numerical problem. So, in this problem what is asked - A compressor having an operating speed 1300 rpm was installed in an industrial unit. Later on, it was

planned to place a precision machine at a distance 60 meter away from it. That means already there was one machine, one compressor, later one precision machine was bring, was brought.

So, it was felt necessary to protect this precision machine from any damaging vibration caused by the compressor which is already there. So, we need to design an open trench or an open trench barrier to provide effective vibration screening for the cases of active and passive screening. So, we can use active screening or passive screening.

In this case the velocity of shear wave, it is not waves, because we can take waves also, was found 160 meter per second, better I write waves. So, I hope the problem is clear to us. Now, what we will do, we will solve this numerical problem. So, let us go to the white board. So, first thing which we will do here, first we need to find out the operating speed. Operating speed is given which is 1300 rpm from that we will find out operating frequency.

So, operating frequency, I can use the symbol f here that is equal to 1300 divided by 60. So, this is in hertz, so how much it is, let us see 1300 divided by 60, it is coming approximately 21.67. Now, if you see the velocity of shear waves is given which is 160 meter per second. We can take the velocity of the Rayleigh width is almost equal to velocity of the shear wave at the surf, near to the surface.

So, that means VR is approx close to VS. So, we this assumption now here I can write, VR which is velocity of Rayleigh wave is equal to 160 meter per second. Now, from these what we can find out? We need to find out wavelength of Rayleigh wave, wavelength for Rayleigh wave. How much it is? 160 divided by operating frequency, which is 21.67, and this is in then meter, so 160 divided by 21.67, it is coming 7.38 meter.

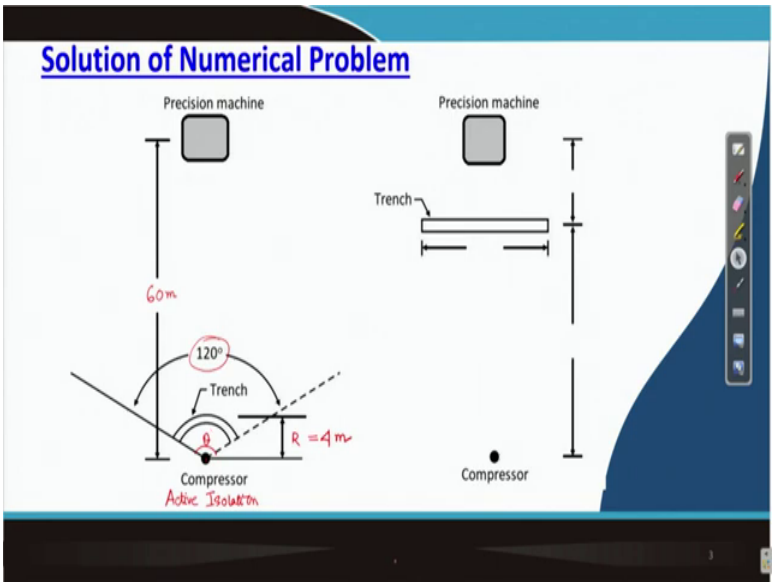
Now, first we will do, we will go for active isolation. So, for active isolation what is the guideline, it says that H minimum, what is H minimum that means minimum depth of the open trench is equal to 0.6 times of lambda R. So, this is lambda R, so H minimum, it means 0.6 times 7.38 in meter, so 0.6 times 7.38, it is coming approximately 4.428. I can do it more approximation and I can write it approximately 4 point.

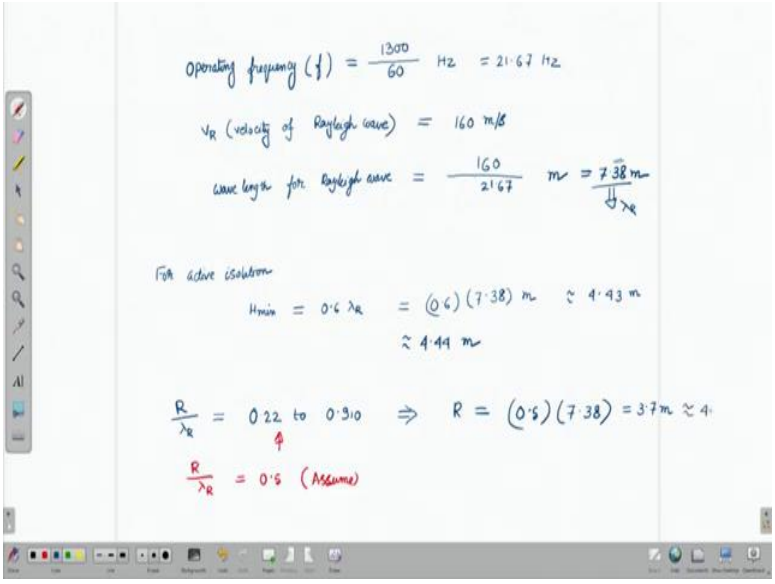
Actually 738, better I should take all the numbers, so just give me 1 minute, 60 divided by 21.67, so it is approximately 4.43, if I will not do here approximation, then it is coming 4.43 or I can take it up almost 44 meter also or 4.43. Now, each minimum is chosen. What is next?

Next is R divided by lambda R. What is R? R is the radius of the circular trench. So, how much this radius?

It says that it should be within 0 point, this ratio I can say, R divided by lambda R should be within 0.22, not 0.02. It is 0.22 to 0.910. So, from these if I will consider that the ratio of R divided by lambda R is 0.5, we can assume, then the aforesaid, this condition aforesaid condition will be satisfied. So, with this condition now what is R? So, this is now approximately 0.5 times lambda R, that means 7.38. So, it is coming approximately 3.69 or I can write it 3.7 meter. So, radius of the open trench is calculated. Now, so with this, now what I can say, if you go back to the problem, we can show you the figure for active isolation.

(Refer Slide Time: 9:14)

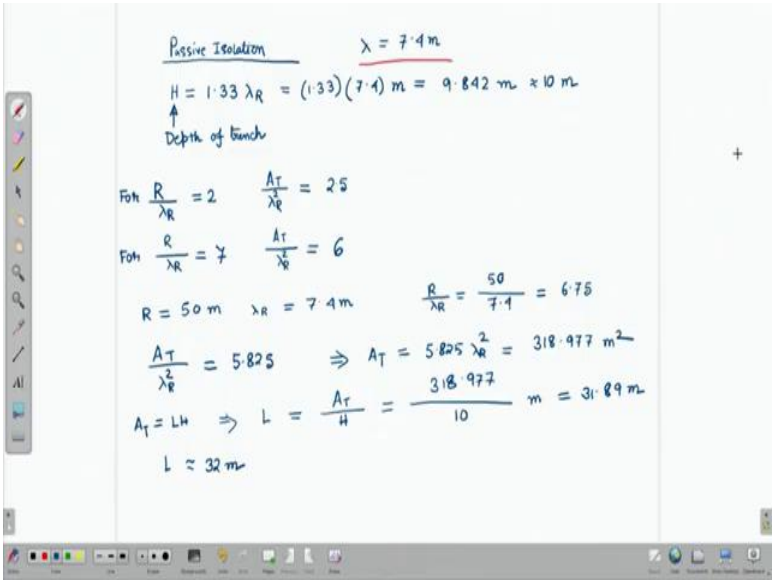


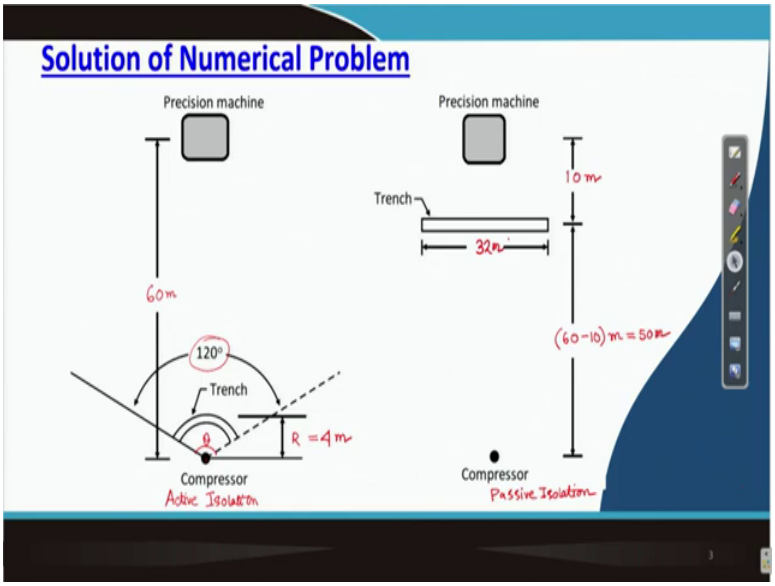


So, this is the case for active isolation. I made a spelling mistake, let me correct it. So, this is the case of active isolation. So, here you can see this is the source of vibration, which is trying to isolate. So, this, how it is doing by excavating a trench. Now, in this case what I need to mention, you can see already said the distance between compressor and this machine, it is 60 meter, so I can write here this is 60 meter which is given also.

And what is the radius of the trench? So, this is also calculated. It is coming 3.7 meter, so I can approximate it as 4 meter. So, it is 4 meter. So, with this and I am considering theta is, so this angle is actually theta which is 120 degree. Now, we next we will do passive isolation.

(Refer Slide Time: 10:52)





So, for passive isolation we have to follow a few steps to for the design. So, let us see what are the steps for passive isolation? So, first we will find out the depth of the trench that means H. We have already gone through the rules, so what it is said H should be equal to 1.33 times of lambda R. What is lambda R? It is the wavelength of the Rayleigh wave. So, already we have calculated lambda R, which is equal to 7.4 meter approximately.

So, from this now we can calculate depth of that trench which is H here. And it is coming 9.842 in meter. So, we can take the depth of that trench, so I can write here, it is depth of trench, we can take it approximately equal to 10 meter. Now, we have studied a few things, for different values of R divided by lambda R what will be the value of AT divided by lambda R square.

So, what we have studied, for R divided by lambda R is equal to 2, the value of AT divided by lambda R square should be 2.5. Also, for R divided by lambda R is equal to 7, the value of AT divided by lambda R square, this should be equal to 6. Now, for finding out AT divided by lambda R square, first we need to know what is the value of R divided by lambda R. So, we have already calculated lambda R which is 7.4 meter.

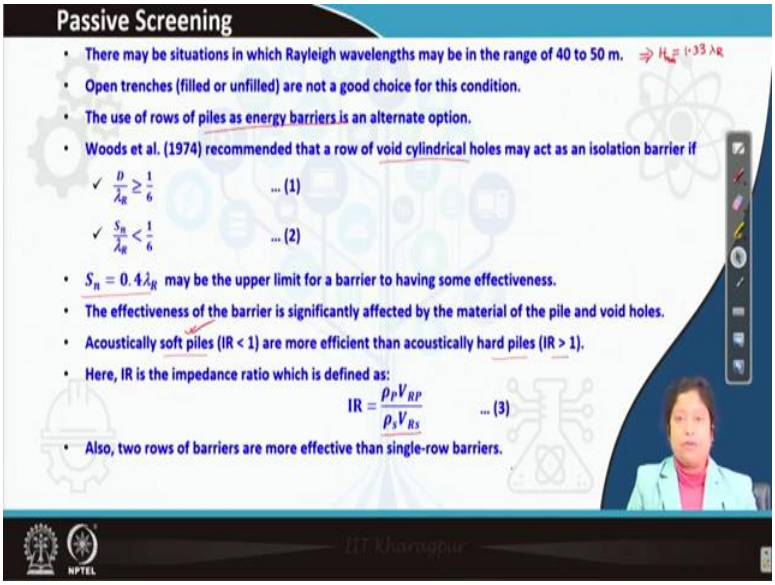
Now, we need to know the value of R. So, let us see the figure, so this figure is for passive isolation. So, here I can first write this is for passive isolation. Now, if we will provide that trench at a distance 10 meter from the precision machine that means this distance is 10 meter, then what will be the distance of the trench from the compressor, then it will be 60 minus 10 meter which is coming 50 meter.

So, in our case capital R is 50 meter and lambda R is 7.4 meter, so from this we can calculate R divided by lambda R, which is coming approximately 6.75. And it is a dimensionless number only. Now, for R divided by lambda R is equal to 6.75, we need to know what is the value of AT divided by lambda R square. So, we can interpolate and find out the value of AT divided by lambda R square.

I have already done it and it is coming equal, it is coming 5.825. So, from these, now we can calculate the value of 80, what is AT, AT is the area of the trench. So, AT is equal to 5.825 times lambda R square, so if we will use the value 7.4 meter for lambda R, then AT is equal to 318.977 square meter. Now, what is AT? Actually, AT is equal to L times H, where L is the length of the trench and H is the depth of that trench.

So, from this then we can find out L, which is equal to AT divided by H, here just make this T as subscript, so now then AT is 318.977 divided by capital H, which is 10 meter, so we are getting approximately 31.89 meter, so let us assume L is equal to the 32 meter. So, in this way we can calculate the value of the L. And I can write it here also, so L is 32 meter. And these trench having length 32 meter and depth 10 meter is kept at a distance 10 meter away from the precision machine as per this diagram. And the calculation which we have done just now.

(Refer Slide Time: 18:03)



Now, we can go to the next topic, actually this is important, we have seen how to calculate the H and L, that means depth and, how to calculate depth and length of the circular trench. Now, they are sometime what is happen, the wavelength of the Rayleigh wave may be found in the range of 40 to 50 meter, so if the wavelength is 40 to 30 meter, then you can imagine what is the H value, it is minimum 1, I can write minimum 1.33 times lambda R.

That means this value becomes, H minimum becomes 50 to 60 meter, so practically it is not possible to go with such a good, such a deeper depth. So, for that what we, in that case what we can do, we need to avoid this kind of open trenches and instead of that we can use the rows of piles as energy barriers.

In this topic Woods and others in 1974 recommend conducted a lot of model test and based upon that they have recommended that a row of void cylindrical holes may act as an isolation barrier if D divided by lambda R is greater than or equal to 1 by 6. What is D here? D is the

diameter of this void circular hole. It is also said that the ratio of Sn divided by lambda R should be less than 1 by 6.

So, what is Sn here? Sn is net spacing between the circular holes. Now, the upper limit for Sn is mentioned, it is 0.4 times of lambda R. If we exceed this then the void cylindrical holes may not be effective for this purpose. Now, the effectiveness of the barrier is significantly affected by the material of the pile and the void holes. So, it is expected that for acoustically soft piles IR value should be less than 1 are more efficient than acoustically hot piles having IR value greater than 1.

So, we go with soft piles, not hard one. What is IR here? IT is the impedance ratio which can be defined by this way. So, you can see rho P times VRP divided by rho S time VRS. So, this row S times VRS it is nothing but the impedance of the Rayleigh wave and here what is the meaning of different symbols, rho S is the density of the soil and VRS is the velocity of the Rayleigh wave through soil.

Whereas rho P is the density of the pile material and VRP is the velocity of the Rayleigh wave through pile material. It is also mentioned that the two rows of barriers are more effective than single row barriers. So, you can think for two rows of barriers if required.

(Refer Slide Time: 23:02)

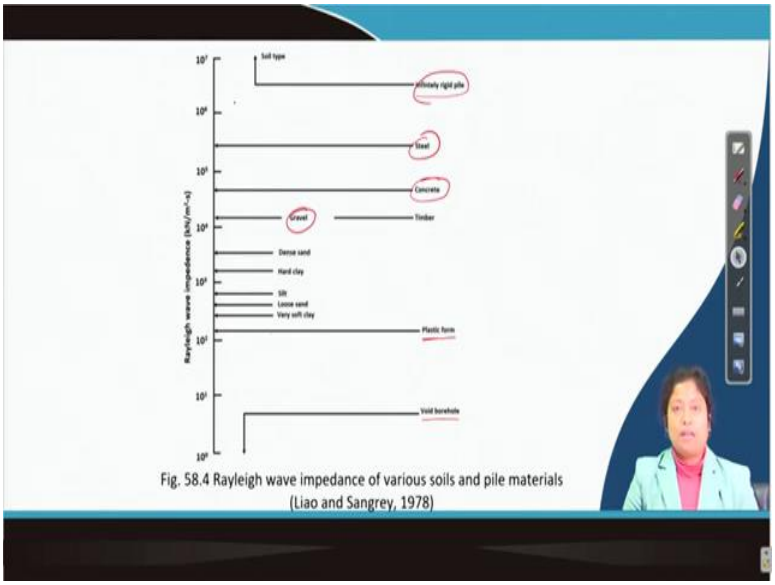


Fig. 58.4 Rayleigh wave impedance of various soils and pile materials
(Liao and Sangrey, 1978)

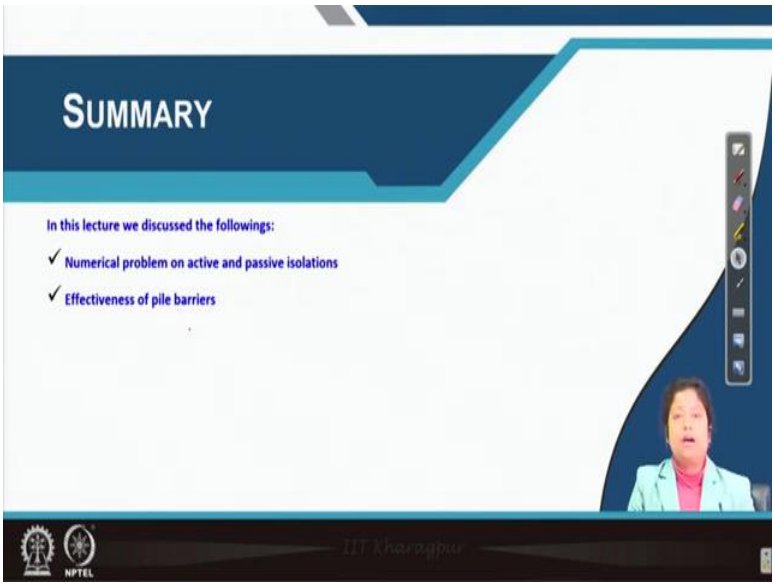
So, in this figure you can see the impedance of the, impedance value of the Rayleigh wave, impedance value of the Rayleigh wave in different materials, soils and different types of materials which may be used for pile materials. So, what we can see here for void borehole if

you see the impedances very low, whereas for then plastic form having very low impedance, you can see here, it is close to 10 to the power 2 in kilo Newton per meter square second.

10 to the power 2 means hundred or maybe 2000, like 100 to 5, maximum 300 you can see from this figure that is the zone. Now, for then which one is coming very soft clay, after very soft clay, loose sand, silt, hard clay, dense sand and gravel. Just like as the degree of softness or you can say degree of relative density of granular material as it is increasing, the impedance of the Rayleigh wave also increases.

And if you see among different types of soil gravel, through gravel impedance is maximum, and after that you can see the pile material, so among different type of pile materials concrete has the lowest value of or least value of the impedance, whereas Rayleigh wave has maximum impedance through steel. Now, if you can consider that the pile is infinitely rigid then you can see its impedance factor just increases. So, in this way we, using this chart basically you can select the material for the pile and you can use the, if required you can use soil material to fill the void of the hole.

(Refer Slide Time: 25:55)

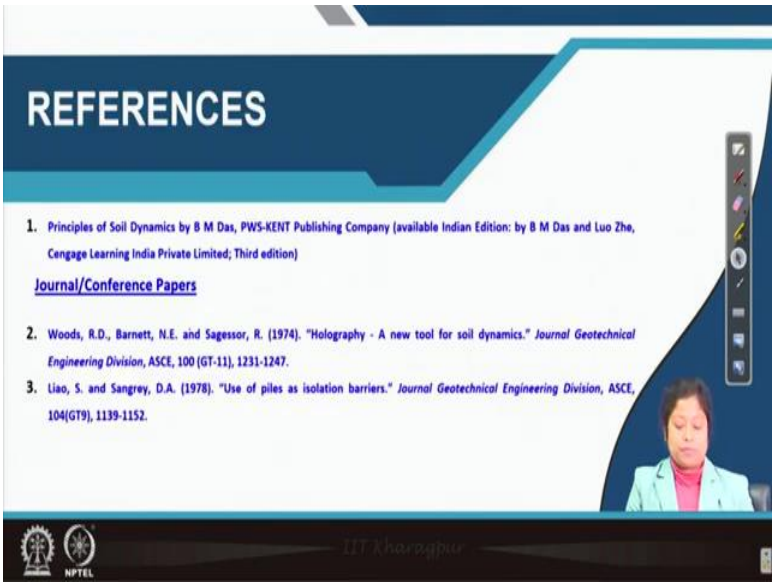


So, come to the summary of today's class. So, today we have discussed how to design the isolation, isolation means how to design active isolation and how to design passive isolation. In case of active isolation we need to use a few things, one is in case of active isolation, one, important thing is we need to find out the radius of the circular trench and also, we need to find out the minimum depth of the circular trench.

Similarly, for passive isolation we need to satisfy a few condition and from that we can calculate R value, we can calculate L which is the length of the trench and we can calculate the depth of the open trench. So, then we have discussed effectiveness of pile barriers, where we cannot use this kind of open trench, because I have already shown you that in some cases the velocity of the, sorry, wavelength of the Rayleigh wave is very high.

So, in order to fulfill the design criteria we can see that the depth of the open trench is very high which is practically not possible and for that case we can go for pile barriers. And for that we can either use different types of material in the void or we can keep it void depending upon the requirement.

(Refer Slide Time: 28:03)



So, these are the references that I have used in today's class. This is used to show the Rayleigh wave impedance and this is used to state the guidelines for the open trench. So, with this I am stopping today's class. It is not just stopping of today's class, actually I am stopping the topic of isolation of vibration. So, I hope it is you are able to follow me. In case if you have any doubt, we can discuss it in online session, next class we will I will try to summarize all the things which we have learned from this course. So, with this I am stopping now, thank you.