Solid Dynamics
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Lecture - 58
Isolation of Vibration (Part 3)

Hello friends. Today we will continue our discussion on Isolation of Vibration. So, last two classes we have studied about different types of vibration isolation. Then we have discussed force isolation and how to design a suitable isolator for force isolation that also we have seen. So, today we will discuss, first, we will discuss the motion isolation.

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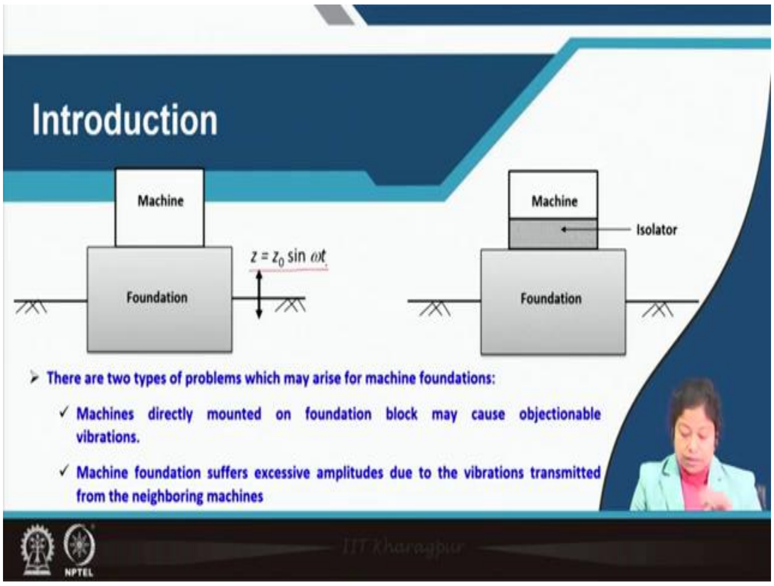

So, we already know what are the possible reasons and what are the problems that foundation soil system encounters because of the vibration. It may be because of the machine mounted on it or it may be because of the surrounding machine. Now, for motion isolation what is happened, the ground is subjected to excessive motion.

I mean, excessive amount of vibration. So, here you can see the ground vibration is represented by z, which is equal to z0 times sin omega t. Now, for this type of case what we can do, we can use isolator. Now, when we are using isolator, it can absorbs, it can help to absorb the energy coming from the machine or coming from the surrounding machine also.

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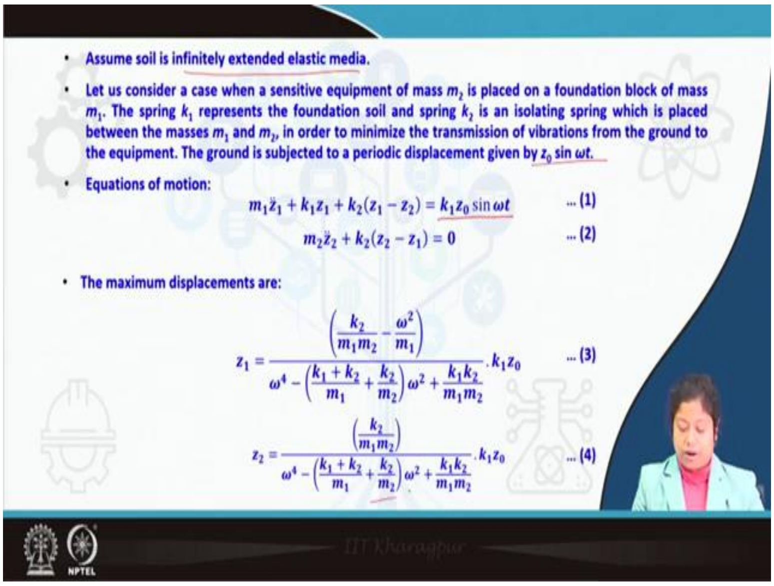

So, let us see how we can do the mathematical modeling for or how we can do the designing for this type of motion isolation. So, in this case also we are assuming that soil is infinitely extended elastic media. Because of this assumption only we need to represent soil by a stiffness which is k1. So, you can see the mass of the sensitive equipment is m2, which is placed on the foundation block of mass m1.

The spring k1 represents the foundation soil as I said, because of this assumption now spring k2 is an isolating spring, which is placed between the masses m1 and m2 in order to minimize the transmission of the vibration from the ground to the equipment. Because surrounding equipment can also be affected. The ground is subjected to periodic displacement, which is given by z0 times sin omega t that we have already seen in the previous slide.

Now, for this type of case we can represent it by the two degree of freedom system and the equations of motion can be written by equation 1 and equation 2. So, if you see in this case, this is k1z0 times sin omega t basically is the force. Now, the maximum displacement or we can call the amplitude of displacement can be represented by this equation, which you can see in equation 3. Similarly, z2 which is the maximum displacement for the mass m2, that means the machine can be represented by the second equation, that means equation 4 here.

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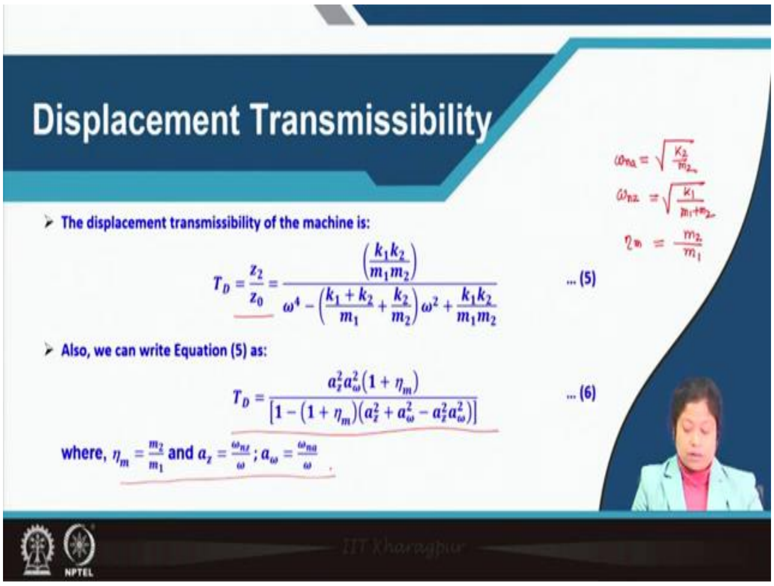

Now, how we will define displacement transmissibility? Last to last class we are introduced to the term force transmissibility, which is applicable for force isolation. Now, for motion isolation we need to define displacement transmissibility. So, the displacement transmissibility of the machine can be written this z2 divided by z0. What is z2 here? z2 is the displacement for the machine itself, maximum displacement.

So, we know the expression for z0, actually in this case z0 is the already the maximum displacement for the ground, so and z2 expression we have already seen in equation 4. So, from that we can find out TD which is the displacement transmissibility. Then we can write this equation 5 also as this way, so here I hope you can recall most of the terms, because it is already discussed. So, Az is the ratio of omega nz to omega.

Similarly, a omega is the ratio of omega na to omega. Now, what is omega na here? Omega na means, I am writing omega na means square root of k2 divided by m2, whereas omega nz means square root of k1 divided by m1 plus m2 and eta m hopefully we all know that is m2 divided by m1. So, it is mentioned also here. So, with this now, so with this now we can do the same exercise which we have done for force isolation and can find out the values, can design actually the isolator because that is the objective for vibration screening or I can say isolation of vibration.

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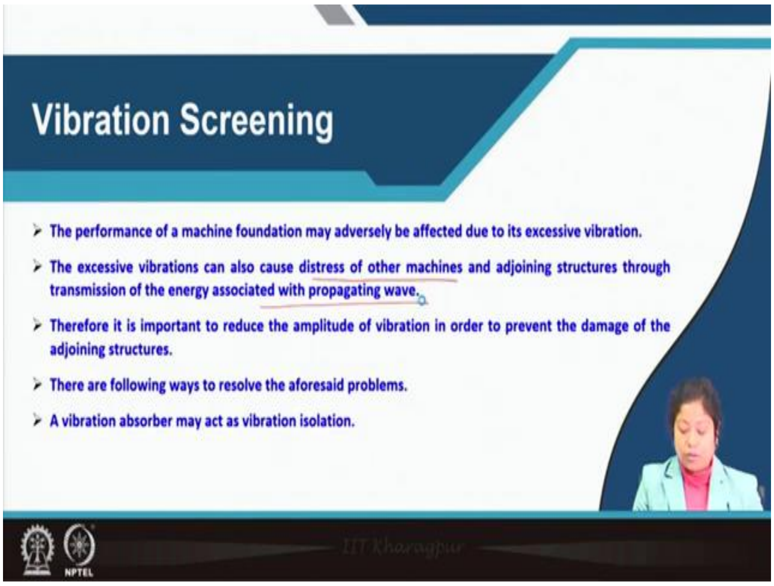

Now, vibration screening - So, the performance of a machine foundation may adversely be affected due to its excessive vibration. So, the excessive vibration can also cause distress of the other machine and adjoining structures, how, through transmission of the energy associated with propagating wave. Therefore, our objective is to isolate either the source or the important equipment, so that that should not be damaged. That means important equipment should remain safe from this kind of damages. Why? How we will do this kind of isolation? So, there are two ways to resolve the problems.

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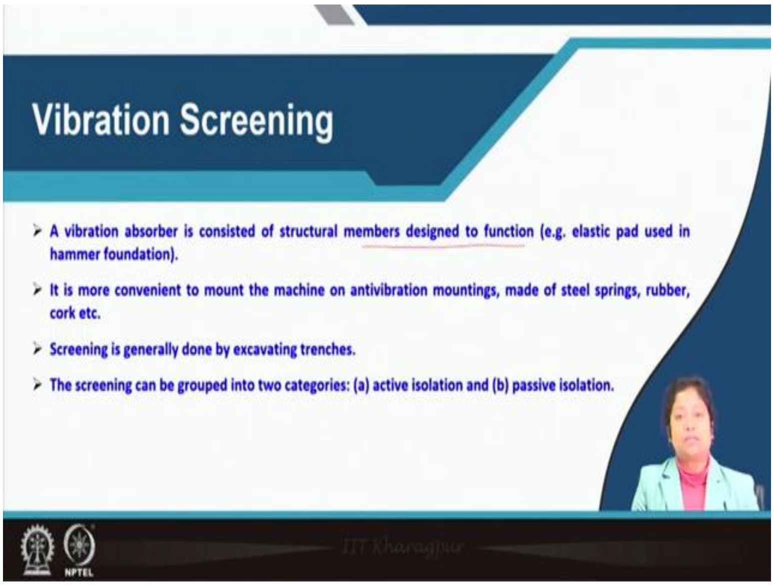

First, a vibration absorber may act as vibration isolation, so a vibration absorber is consisted of structural members designed to function. For an example, elastic pad used in hammer Foundation that we have already seen. It is more convenient to mount the machine on antivibration mountings, which are made of either steel springs or rubber or cork, etc. Screening is generally done by excavating trenches also. So, we will solve one numerical problem where we will see how we can design this trench. The screening can be grouped into two categories, one is called active isolation and the other one is called passive isolation.

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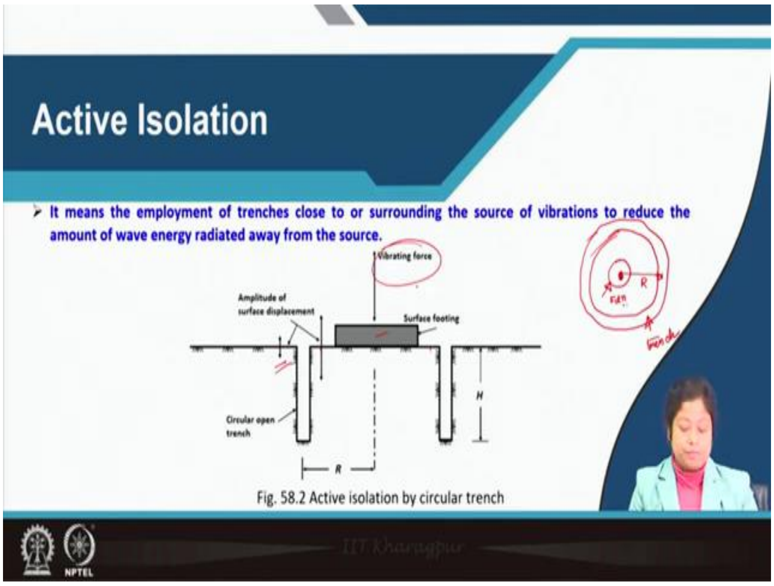

What is active isolation? So, it means that the employment of trenches close to or surrounding the source of vibrations to reduce the amount of wave energy radiated away from the source. That means we are providing or trenches or we are designing a trench surrounding the source, so that it reduce the amount of energy radiated from this source. Let u see the figure for this. So, here this is the foundation block on which some machine is constructed.

So, this is the source of vibration. Now, you can see just immediate outside the foundation that means this point or you can take this side also, what you can see, excessive amount of displacement of the ground. Now, for this type of cases what we can do, we can use opened range, you can see it this is a sectional view actually, so that is the reason the circular open trench you are seeing like this way.

So, from the top if you will see this is the source, so at a distance r you can provide a trench like this, this is not good circle, I am just trying to draw it roughly, so since it is a trench, so or I can do one thing, I can just reduce this radius of this side circle, so let us take, this is the outer and the same way this is the width of the trench. So, from center to center distance, so this is I can say the radius of this trench.

So, this is trench, circular trench obviously, this is foundation, so this is the source of vibration. So, here what we can see if we see the sectional view, after employment of the trench you can see the amplitude of surface displacement is reduced significantly. So, it is almost half or one fourth or one third of this magnitude.

So, in this way we can reduce the, we can protect, first, we can reduce the amplitude of the surface displacement by employment of trench and thus, we can protect the other precise, other important equipment from the source of vibration. So, the main point for active isolation is that in this case you are isolating the source itself and you are protecting, of course, the important equipment.

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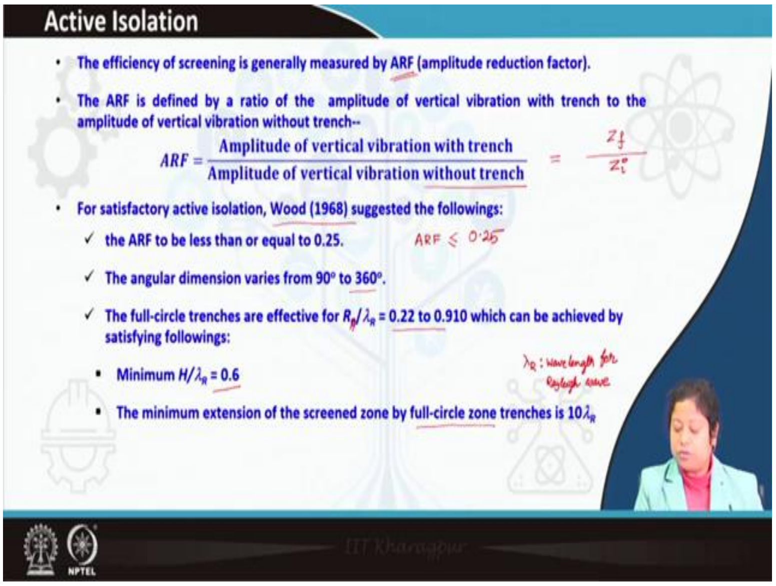

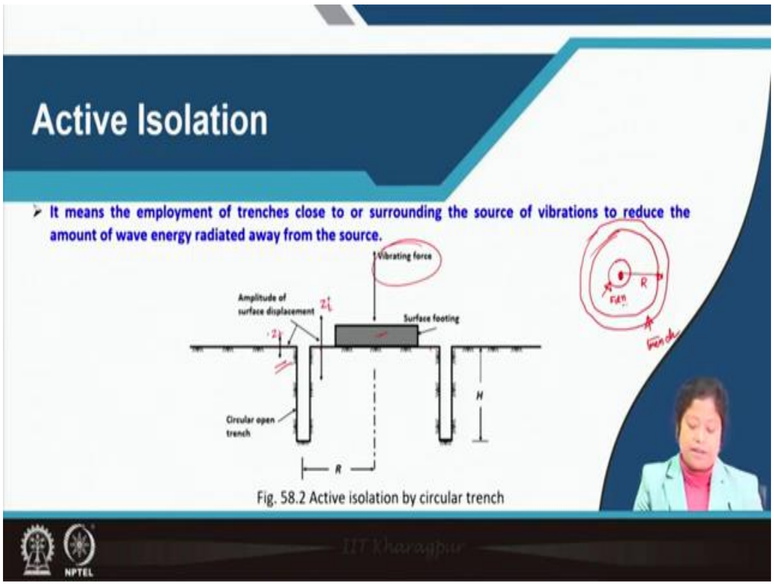

Now, there are a few conditions that we need to take care while designing an active isolation. What are those? The efficiency of screening is generally measured by amplitude reduction factor, you can write it as ARF. So, what is ARF? It is the amplitude of vertical vibration with trench and to the amplitude of vertical vibration without trench.

So, if I go back to this figure if this is our z1 and if this is z final, I can write z initial and z final, then here what we can write, zf divided by zi. So, zi is the amplitude of vertical vibration without trench. So, if there is no trench, then we will get probably zi amount of amplitude of vertical vibration. Now, there are lot of experiments done.

One of the important experiments was conducted by Wood in 1968 on this topic and from his result he has given some outlines, what is that, the ARA that means amplitude reduction factor should be less than or equal to 0.25. That means ARF cannot exceed 0.25. ARF is always less than this value. Another thing, the angular dimension varies from 0, 90 degree to 360 degree. So, although in the previous figure I have shown a full circular trench.

That means 360-degree theta but it may be 90-degree, 180-degree, 120 degree is also possible. Now, for the full circle trenches, which I have shown already are effective for, this is not r0, this is R, because in previous figure I have used R. So, are effective for R divided by lambda R equals to 0.22 to 0.910, which can be achieved by satisfying the following two criteria.

What are those? Minimum value of the ratio H divided by lambda R is 0.6. So, what is lambda R here? It is the wavelength of the Rayleigh wave. So, I am writing here wavelength for Rayleigh waves. And what is capital H here? Capital H is depth of the circular trench. It is also said that the minimum extension of the screened zone by full circle zone trenches is 10 times of lambda R.

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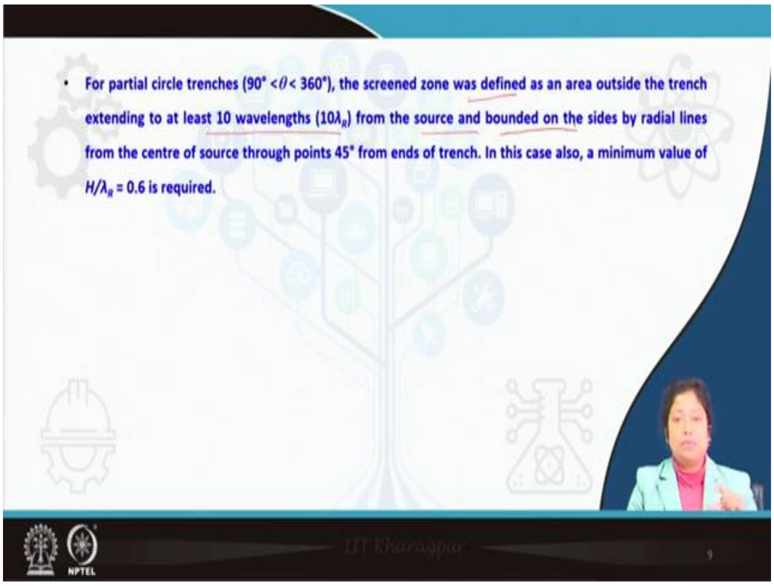

Now, for partial circle trenches that means theta in between 90 degree and 360 degree, the screened zone was defined, it is, since it is the work of Wood 1968, so he has defined as an area outside the trench extending to at least 10 times of wavelength, wavelength means wavelength of the Rayleigh wave, from the source and bounded on the sides by radial lines from the center of the source through 0.45 degree from ends of trench. So, in this case also, a minimum value of H by lambda R is 0.6. It may be more also, but minimum we need to provide, we need to keep 0.6.

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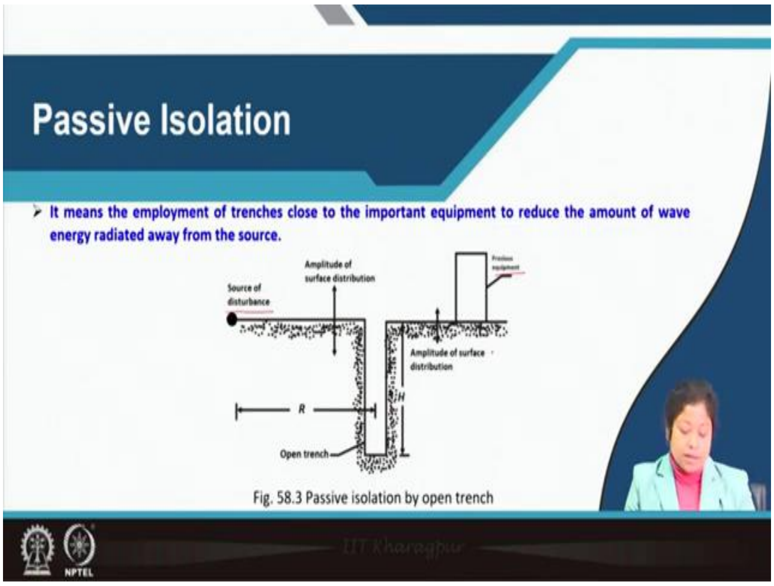

Next is passive isolation? So, so far we have discussed the active isolation. What we have seen for active isolation? We need to isolate the source of vibration. Now, in case of passive isolation we need to isolate the important equipment or instrument from the possible damage from the surrounding sources of vibration.

So, for that what are the different ways, the same thing we can use circular trench as you can see here. So, this is the source of disturbance and if you see, in this case the circular trench is not close to the source of these turbines, but it is close to the equipment, which we think which is important and which needs protection from excessive amount of these kind of ground vibration.

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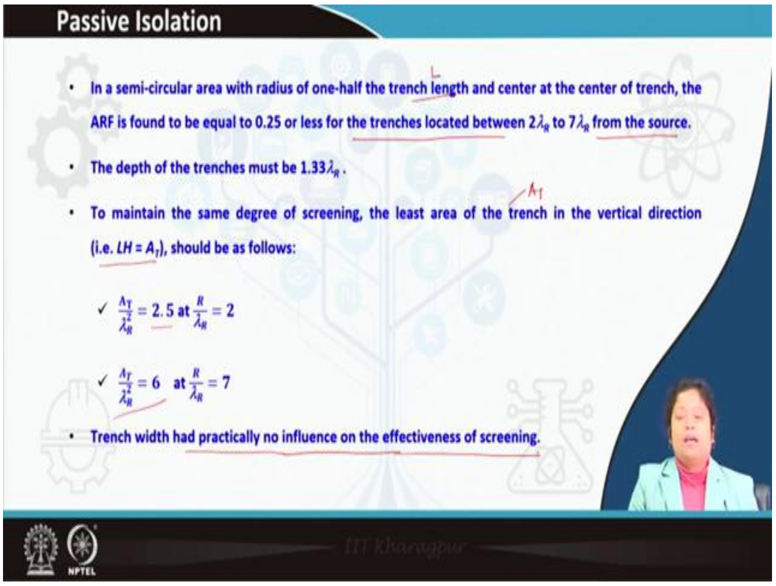

Now, what are the different guidelines that we need to follow for designing the passive isolation? So, here you can see the different guideline. In a semi-circular area with radius of one half the trench length, if we can take trench length is capital L, so in a semicircular area with radius of one half of this L and center at the, center of trench, the ARF is found to be equal to or less than 0.25.

For the trenches that is located in between 2 times of lambda R and in between 2 times of Lambda R and 7 times of lambda R. And this is measured from the source. Now, the depth of the trenches that means capital H must be 1.33 times lambda R. Lambda R is the wavelength of the Rayleigh wave. Now, to maintain the same degree of screening the least area of the trench, which is represented by AT.

You can see here AT is used. So, AT in the vertical direction should be as follows. What it is said? AT by lambda R square, this is equal to 0.25, sorry, this is equal to 2.5 when R by lambda R is equal to 2. At R by lambda R equals to saving, this AT divided by lambda R square is equal to 6. What about the width of the trench? It is noted that the trench width had practically no influence on the effectiveness of screening.

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Now, come to the summary of today's class. So, in this lecture we have discussed, first, we have discussed motion isolation, its mathematical modeling and how to define the displacement transmissibility. Then we have discussed vibration screening by active isolation and passive isolation.

So, active isolation means we are isolating the source of vibration, whereas passive isolation means we are isolating the important machines from such kind of excessive vibration. Now, here we need to remember, sometime the source of vibration generates vibration, but that vibration may not be harmful for all the equipment, but for some equipment it is harmful.

So, what we can do that time? That time we can think for passive isolation, that means if there is any equipment which should be protected from the vibration, then we can go for passive isolation. But if from the beginning itself we know that one machine causing excessive vibration and that is not tolerable for other machines, other structures. Then what we need to do, from the beginning itself we need to isolate this source of vibration by active isolation. I hope, it is clear to all of us.

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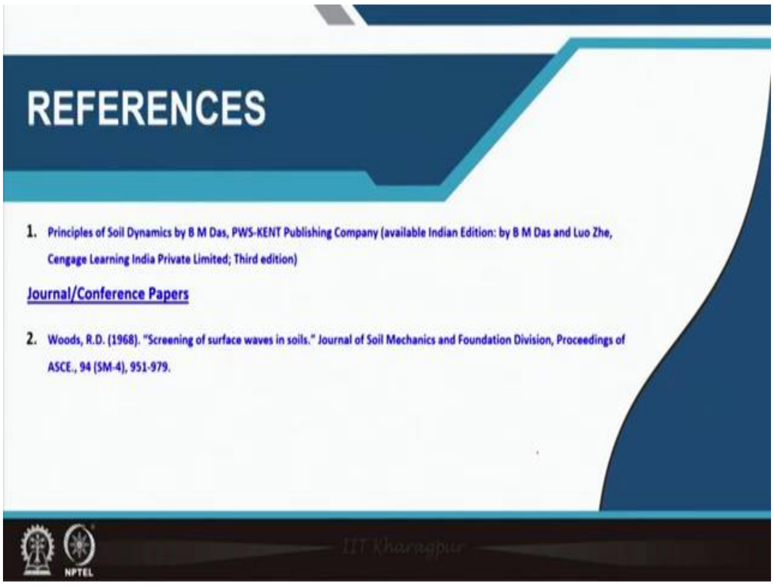

So, these are the references that I have used in today's lecture. So, in next class we will solve one numerical problem to understand how to design active and passive isolations. So, with this I am stopping today's class. Thank you.