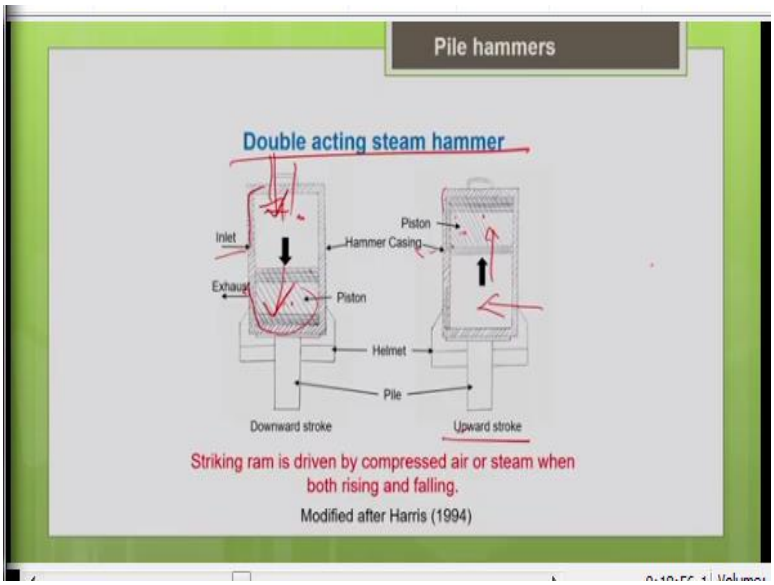

So, basically what to do here is, so this is a setup of the double acting steam hammer, you can see two cylinders one is the upper cylinder, other one is a lowest cylinder. Now in the upward stroke what you do is, you supply air into the lower cylinder. So, when you supply into this, this is a lowest cylinder, when you supply air into the lower cylinder, the hammer which was earlier in the lower cylinder will be pushed up into the upper cylinder.

So, the hammer is pushed up into the upper cylinder, the air which was already there in the upper cylinder will expel out to the exhaust. So, the air which was already there in the upper cylinder will be expelled out through the exhaust. So, basically what you are doing here is you supply air into the lower cylinder. So, that will push your hammer upward into the upper cylinder and the air which is already in the upper cylinder will be released through the exhaust, now your upward stroke is complete.

So, what are you doing the downward cylinder? You supply air through the inlet into the upper cylinder. So, when you are supply air into the upper cylinder, the hammer which was already there will be pushed into the lower cylinder. And air which was already in the lower cylinder will be expelled out through the exhaust. So, now that completes a downward stroke, so alternatively you are supplying air into a upper cylinder and the lower cylinder, so that you can have the rising and falling.

So, that was explained here in upward stroke air is supplied to the lower cylinder, your piston is raised, when the piston raises and occupies upper cylinder all the air which was in the upper cylinder will be expelled out. Similarly, in the downward stroke what you do, air is supplied to the upper cylinder and the hammer will be pushed into the lower cylinder**.** And the air which was already in the lower cylinder will be expelled out, so this is how you do it.

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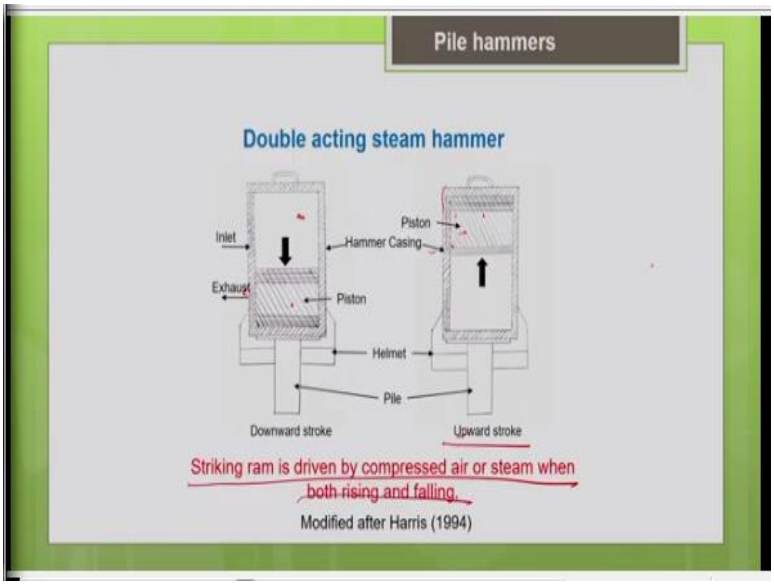

So, the striking ram is driven by compressed air or steam, when both rising and falling.

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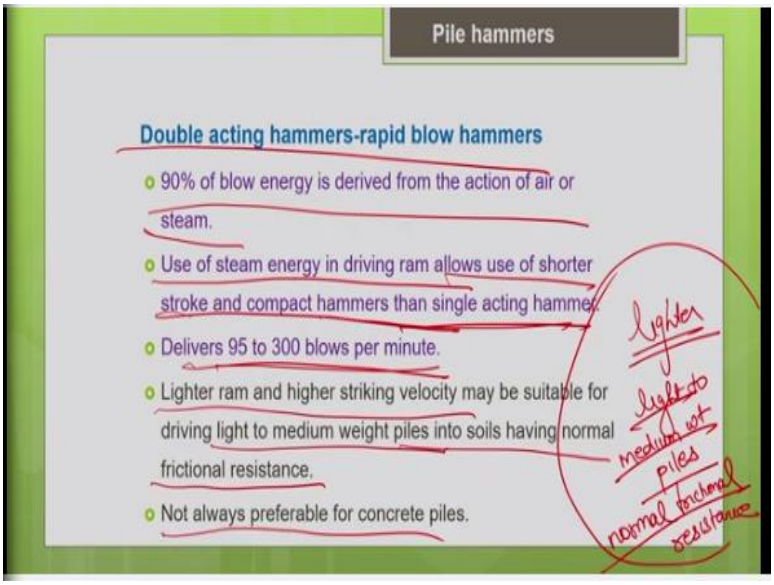

So, another important thing we need to know with respect to double acting hammer is in this most of the blow energy is the derived from the steam energy. Both for the upward stroke as well as for

the downward stroke, the blow energy is derived mainly from the steam energy**.** So, 90% of the blow energy is derived from the action of air or the steam. So, that is why, for the double acting hammer we need not for a heavier hammer.

We can go for lighter hammers, smaller in size and you can go for the shorter stroke or shorter height of fall. So, these hammers are basically designed to be lighter in weight. So, because most of the energy is derived for the upward stroke as well as for the downward stroke is derived from the steam energy. We are not mainly dependent upon the weight of the hammer, so we can go for lighter hammers in this case.

And this hammer is basically designed for I can say lighter conditions, lighter conditions in the sense. So, it is basically designed for light to medium weight piles and for soil with normal frictional resistance**.** So, very tight clay, hardened clay with very high frictional resistance, so we are not supposed to use these double acting hammers. Because these double acting hammers are designed for lighter conditions, that means for light to medium weight piles and for the normal soil with normal frictional resistance.

So, it is basically designed for this kind of conditions only, and you should never use this double acting hammer for concrete pile. Because these double acting hammers, they basically have a very high blow rate, if you look into the blow rate, you can see that the blow rate will be 95 to 300 blows per minute. So, it is very high when compared to the single acting hammer. So, such a high blow rate may can easily damage the concrete pile.

So, that is why it is not recommended for the concrete pile. So, let me summarize what we discussed, so your use of steam energy in driving the ram allows use of shorter stroke and compact hammer than single acting hammer. So, when compared to single acting hammer these hammers are more compact smaller in size, lighter in weight and they have a shorter stroke.

And they are designed for lighter conditions, they can deliver a blow rate of 95 to 300 blows. This lighter ram and highest striking velocity maybe suitable for driving light to medium weight piles into soil having normal frictional resistance. So, we cannot recommend this hammer for a tough

soil condition with very high frictional resistance**.** And not always preferable for concrete piles, as I told you high blow rate can result in damage of your concrete pile, which is basically weaken tension. So, it is not recommended for concrete pile but you can use it for steel piles.

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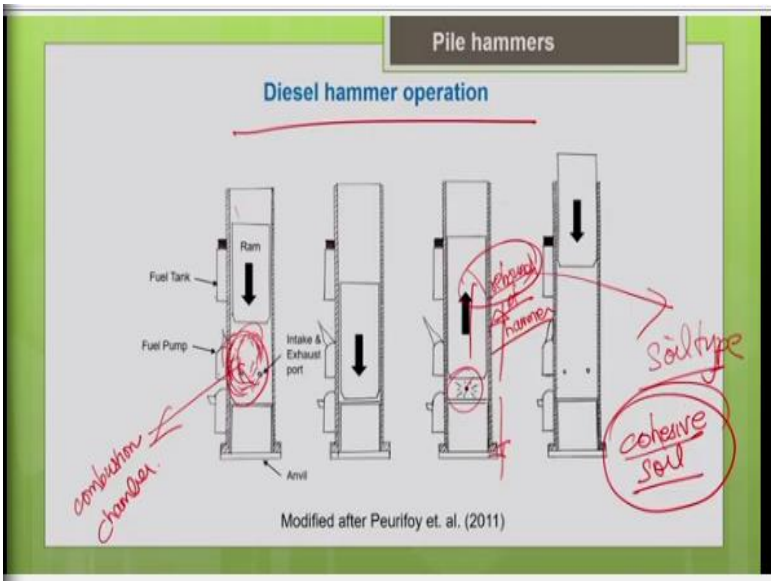

So, we have completed the double acting stream hammer, now let us move on to diesel hammer. So, basically this diesel hammer is a self-contained unit, that means everything is contained within a single assembly, I do not need a separate accessory a steam boiler or air compressor as we need it for the steam hammers. Everything is contained within a single unit you can see, so what will be the advantage?

So, it will be more compact and easier to move it in the site from one place to another, it is mobilization is very easier when compared to steam hammers which need a separate steam boiler or air compressor. So, now let us look into the operation of the diesel hammer. So, basically here what we do is, the ramp is lifted with some lifting mechanism to initiate the operation, any lifting mechanism you can use.

So, if you are going for a crane, so first with the help of a crane, you lift the hammer or the ramp to the required height and allow it to fall by gravity. So, you can see there is a fuel tank and a fuel pump and this is called as the combustion chamber. So, basically what happens is as the hammer

moves down, it activates the fuel pump and the fuel pump will spray the fuel into the combustion chamber.

This is a combustion chamber, the fuel is sprayed into this combustion chamber. Now as the ramp compresses the mixture of air and the fuel in the combustion chamber, so as it moves down it will compress the mixture of the air and the fuel mixture. So, what happens, it will result in ignition or explosion. So, this explosive energy what will happen? It will help you in driving your pile downward and also it helps you the rebound of you hammer.

So, it helps you in the rebound of your hammer. So, this explosive energy helps for both driving a pile downward as well as for the rebound of your hammer. So, the next cycle will continue on it is own, you need not lift it again with any lifting mechanism or crane. So, based upon the rebound, it will continue on it is own, the cycle will continue on it is own till the fuel is available. So, another important thing to be noted here is, this rebound will depend upon the soil type, this hammer is more suitable for the cohesive soil.

So, basically if the soil is more cohesive, the frictional resistance will be very high. So, the driving resistance will be very high, so that will result in a greater rebound of the hammer, that will deliver more energy from pile training. So, that is why in cohesive soil the cycle can continue easily when compared to lose sand.

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Let us see the picture of this diesel hammer you can see, this is a picture of the diesel hammer lifted by a crane. So, it is driving a steel pile, you can see this is a diesel hammer, this is a pile, it is lifted with the help of your crane.

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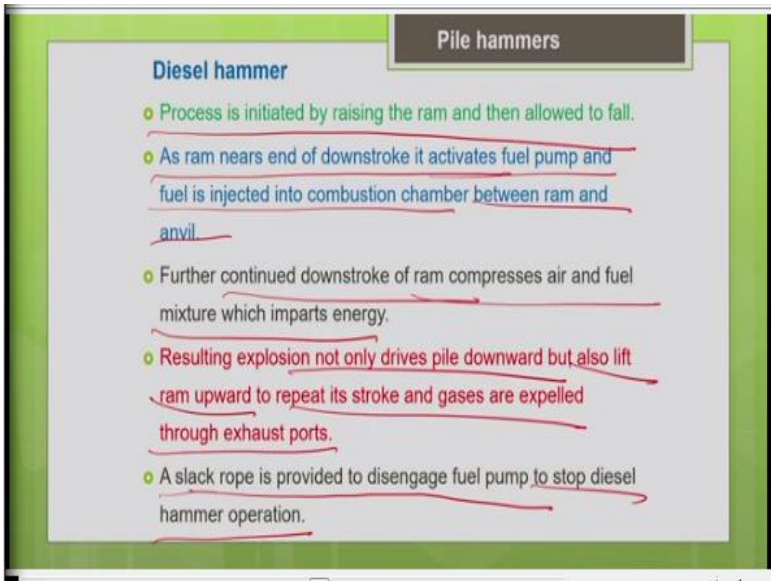

So, let me summarize the operation of the diesel hammer, this process is initiated by raising the ram and then it is allowed to fall. You have to raise the ram with help of any lifting mechanism the crane. As the ram nears the end of the downward stroke it activates a fuel pump, and the fuel is injected into the combustion chamber between the ram and the anvil. So, further continued downward stroke of the ram compresses the air and the fuel mixture, so that will impact the energy.

The resulting exposure, so not only drives the pile downward, but also lift your hammer of the ram upward to repeat it stroke, and the gases are expelled through the exhaust ports. So, if you want to stop the operation, there is a slack rope provided to disengage the fuel pump to stop the diesel hammer operation. So, there is a provision to stop the functioning of the hammer, so this is how the diesel hammer work.

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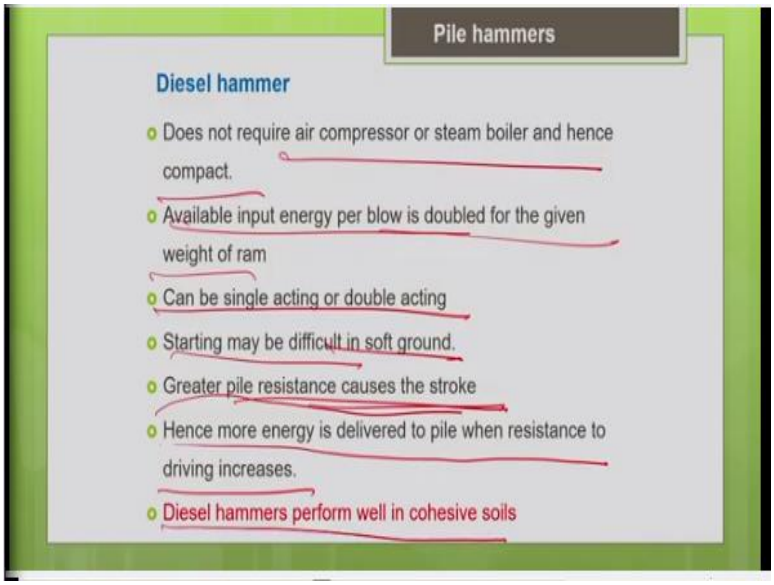

The main advantage is it does not require a separate air compressor or steam boiler and hence very compact. And the available input energy per blow is doubled for the given weight of ram, how it is double? Because of the explosive energy we get additional energy for driving, so it can be also either single acting or double acting. So, as I told you in a soft ground, the initiation of the process is difficult.

If the pile resistance is going to be greater, if the soil is more cohesive, if the driving resistance is more that will result in a better stroke, that will result in better rebound, that will result in more energy delivery. Hence more energy is delivered to the pile when the resistance to the driving increases, so this will happen in cohesive soil. So, diesel has performed well in cohesive soil than in soft ground.

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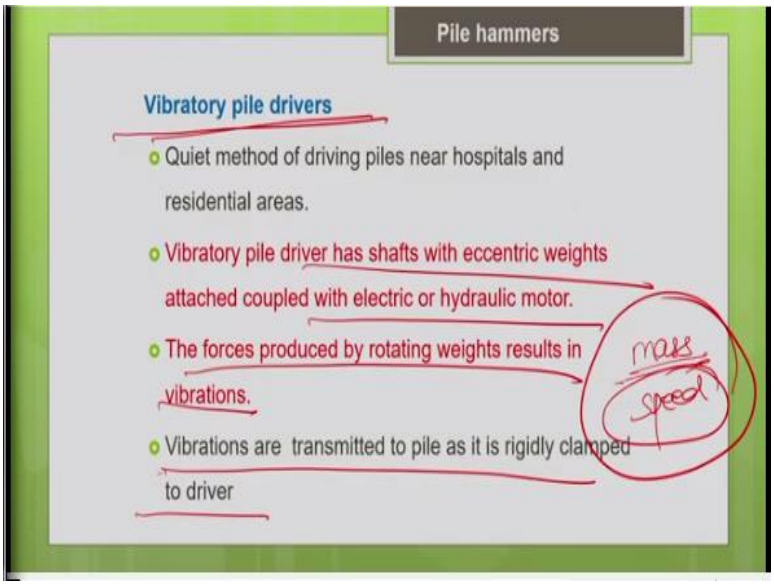

So, the last type of pile which we are going to discuss is about the vibratory pile driver. So, for whatever we discuss on impact hammers, which results in lot of noise production as we discussed earlier. And this method may not be feasible, if you are going to do a pile driving operation in a residential colony or near schools or hospitals where we need silent pile driving method**.**

Your vibratory pile driver is one such quiet method of pile driving. So, basically how do you create the vibration? So, this vibratory pile driver we have a casing, inside the casing there will be a shaft with rotating eccentric weights. These weights will be rotating in the opposite direction. So, this rotating eccentric weights it is rotating with the help of an electric or hydraulic motor.

So, the force produced by the rotating weights result in the vibration. So, this rotating weight results in the vibration generation. So, what will be the amplitude of the vibration or the frequency of vibration? That will depend upon your mass of the rotating weight and speed of the rotating weight. So, greater the mass of the rotating weight the amplitude will be more, greater the speed of the rotating weight your frequency of vibration will be more.

So, that will control your blowing efficiency, that is why we varying your mass and the speed of the rotating weight, you can vary the amplitude and the frequency that will help you to control the driving efficiency. So, depending upon your type of soil, you can vary the frequency. For very

tough soil conditions, for cohesive soil conditions it is preferable to go for a higher amplitude and lesser frequency.

So, according to a soil type and according to the pile type, there are now modern vibratory pile drivers which facilitates you to vary the frequency, you can vary the frequency according to your pile type and the pile soil. So, the vibrations basically you just clamp the vibrator tightly to the pile head. So, from the vibrator, the vibrations are transferred to the pile head, and from the pile the vibrations are transferred to the soil, your vibrations will result in agitation of a pile up and down.

This agitation will reduce the friction between the soil and your pile, that will easily facilitate the penetration of your pile into the ground. So, vibrations are transmitted to the pile as it is rigidly clamped to the driver, so pile is rigidly clamped to the driver. So, from the vibrator the vibrations are transferred to the pile.

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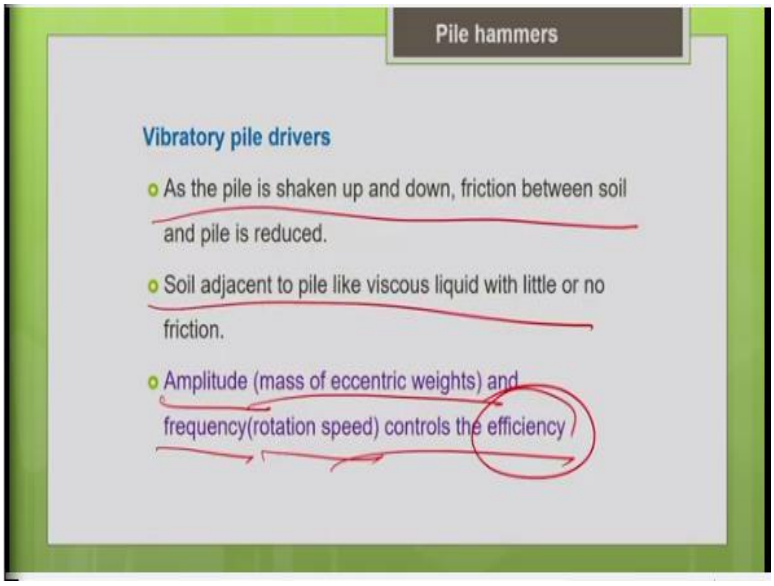

So, as your pile is shaken up and down, consider the friction between the soil and the pile will be reduced, so that will facilitate easy penetration of a pile into the ground**.** Because of the vibration, the soil adjacent to the pile will behave like a liquid, with little or no friction which facilitates penetration of the pile into the ground. Your amplitude of the vibration will depend upon your mass of the weights, eccentric weights inside your vibrator.

And the frequency of the vibration will depend upon the speed of the rotation of the eccentric weights and that is going to control the efficiency of driving. As I told you, depending upon the soil type and the pile type, you can choose the amplitude in the frequency accordingly.

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Unlike your other pile drivers what we discussed earlier, we do not need a crane for the vibratory pile driver, it is a very simple equipment, even a backhoe or excavator can assist in the holding the vibratory pile driver. So, the vibratory pile driver is tightly clamp to the backhoe and then it is tightly you can say it is then tightly clamped to your can see this is a steel sheet, steel sheet pile which is being driven into the ground with the help of this vibratory pile driver. So, this is your vibratory pile driver, so inside this there will be rotating weights which results in the vibration.

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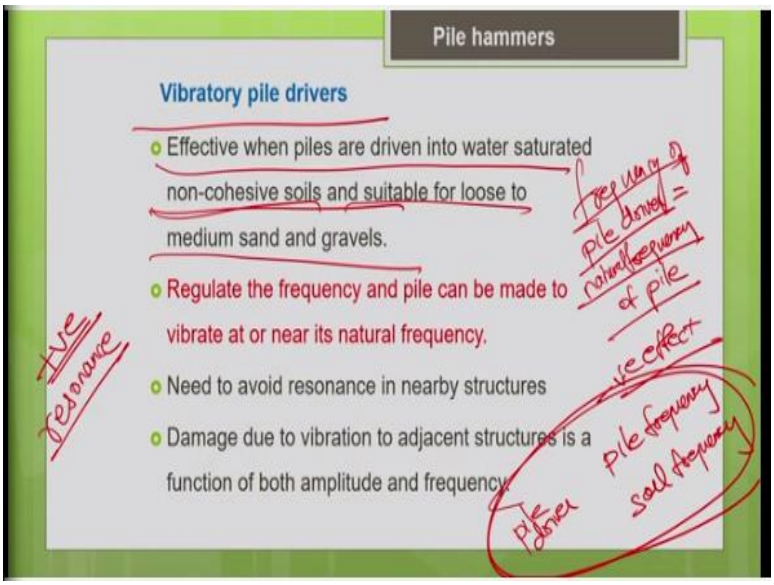

So, for what type of soil this is more preferable, this is more preferable for non-cohesive soil because that will respond easily to the vibration when compared to cohesive soil. So, this is particularly for water saturated soil, this is the right choice. So, this is effective in the piles are driven into water saturated non-cohesive soil and suitable for loose to medium sand and gravel because these kinds of soil will respond well to the vibration.

But nowadays with the help of modern vibratory pile driver where you can even vary the frequency the vibratory pile drivers can be even used for cohesive soil. So, you can regulate the frequency of the pile driving in such a way that it can be compatible with the cohesive soil also. So, there are some modern pile drivers vibratory pile drivers called as resonant vibratory drivers.

So, here we use a concept of resonance, you might have studied the concept of resonance during your schooling**,** basically what is this resonance when two bodies are vibrating at the same frequency, they have set to attain the condition called as resonance, that will result in larger amplitude or larger displacement. A simple example you might have already heard about this is when you try to push a swing in a play area, a child swing in a play area.

So, this swing has its own natural frequency, if you are going to push to swing at it is own natural frequency it will be very easily goes higher and higher. So, that is what is called as resonance, the both are operating at the your pushing frequency and the swing frequency is matched, it means

they are at resonance, then it will be very easier to push. The same concept applies to the pile driving also.

So, every material your pile or any structure every material has it is own natural frequency. So, when it is subjected to any load or earthquake of wind whatever, it is going to respond to that load or vibrate at it is own natural frequency. So, what you do is, when you do the pile driving, you match the frequency of a pile driving with a natural frequency of the pile. So, for that particular pile depending upon the stiffness and the length, it will have it is own natural frequency.

You can determine the natural frequency of the pile and match the frequency of a pile driver with the frequency of the pile. So, you match the frequency of your pile driver to the natural frequency of your pile, you have to estimate what will be the natural frequency of the pile depending upon the mass difference in length. So, you adjust the frequency of a pile driver to be matching with the natural frequency of the pile.

Now what happens it results in the condition of resonance, so it will result in huge displacement of your pile. So, very easily you can drive the pile into the ground, so that is why even for the tougher soil conditions, nowadays you can use the vibratory pile driver because of this advancement in the technology due to the invention of resonance pile driving method. So, you should vary the frequency in such a way it matches with the frequency of a pile.

So, this is one positive effect of the resonance, what will be the negative effect. Say for example but one thing you have to make sure that your pile frequency and the soil frequency. Soil also has it is own frequency, soil and the pile driver this should not match, if this is going to match what will happen? Both the pile in the soil will move together, so there would not be penetration of your pile into the soil this is negative effect.

So, we have to make sure that your pile frequency should not coincide with the frequency of your soil. So, what is the other negative effect of resonance is sometimes if there are some old monuments near the location where you are doing the pile driving. So, if the natural frequency of

the structure coincides with the frequency of a pile driving. In that case, it will result a huge displacement in your structural cracking of your structure.

So, that is why if some important monomers are there, we have to check for the natural frequency of the structure. And then make sure that there should not be any match in a pile driving frequency with the frequency of the structure. So, that is what is discussed in the slide.

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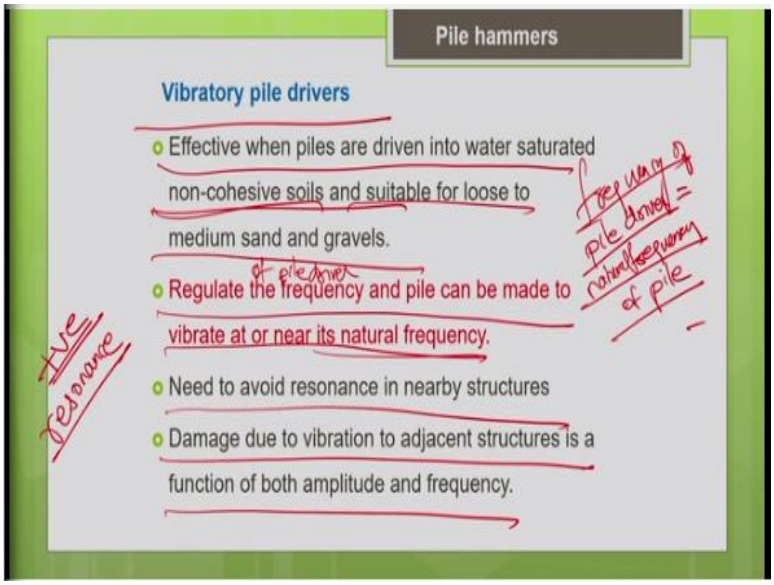

You regulate the frequency and the pile can be made to vibrate at or near it is natural frequency, you regulate the frequency of the pile driver and the pile can be made to vibrate at or near it is natural frequency. So, this will result in positive impact of resonance, which will make your pile driving operation easier. Another important thing is you need to avoid the resonance in the nearby structures, make sure that the frequency of the structure should not coincide with your pile driving.

So, the damage to due to vibration in the adjacent structures will be a function of both amplitude and the frequency. So, make sure it should not match with the frequency of the structure to avoid the negative effect of the resonance.

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