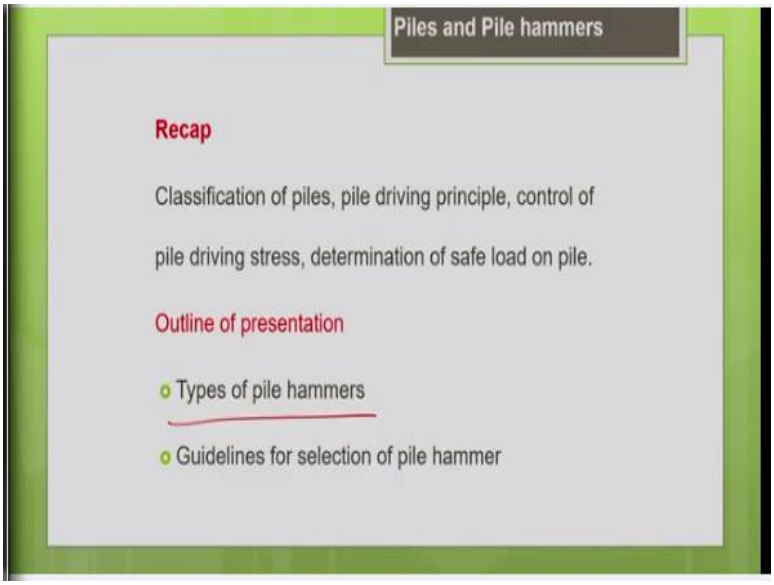
Construction Methods and Equipment Management
Prof. Dr. Indu Siva Ranjani
Department of Civil Engineering
Indian Institute of Technology-Guwahati

Lecture-17
Piles and Pile Driving Equipment (Part 2)

Hello everyone, I welcome you all to the lecture 17 of this course construction methods and equipment management. In this lecture we are going to discuss about the pile driving equipment. So, let us have a recap of what we discussed in the last lecture, the last lecture we discussed about the different types of piles merits and demerits of different types of piles.

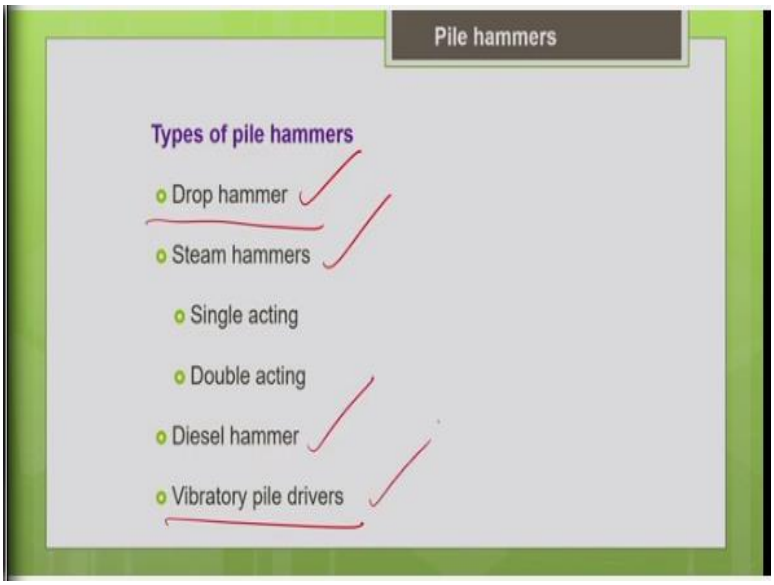
(Refer Slide Time: 00:45)



And about the basic pile driving principle and the methods of how to control the pile driving stress and how to determine the safe load on the pile. So, these are the important things which we have discussed in the last lecture. Now, let us look into the outline of today's presentation. In today's presentation, we will be discussing about the different types of pile hammers, and we will be also discussing about the guidelines for selection of the pile hammer.

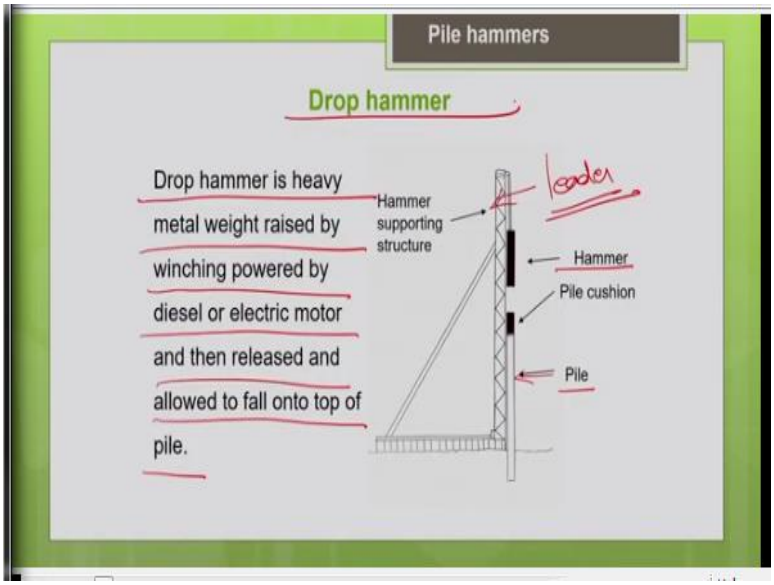
So, how to select the pile hammer for a particular type of soil and for a particular the length of pile and weight of pile for a particular material type, how to make the selection of pile hammer we are going to discuss in this lecture.

(Refer Slide Time: 01:29)



So, there are different types of pile hammer ranging from the oldest drop hammer method to the modern vibratory the pile drivers. So, we are going to discuss all these types of pile hammers one by one in this lecture. So firstly, we will be discussing about the drop hammer followed by the steam hammers, then we will be discussing about diesel hammer and the vibratory pile drivers.

(Refer Slide Time: 01:52)



So, first is about the drop hammer. So, basically and this is nothing but a heavy metal weight, so this has to be lifted with some lifting mechanism. You can go for any lifting mechanism depending upon your project size, depending upon your project budget or the availability of equipment. So, you can go for any lifting mechanism, you can go for a simple pulley and rope mechanism or you can go for a crane.

So, depending upon the availability of an equipment and a project budget, so you can go for the lifting mechanism. So basically, you are going to lift the hammer, that hammer is nothing but a heavy metal object. So, we are going to lift it with some lifting mechanism to a particular height, then allow it to fall on the pile height by gravity, allow it to freely fall on the height of the pile. So, you can look into this setup, so basically this is your hammer.

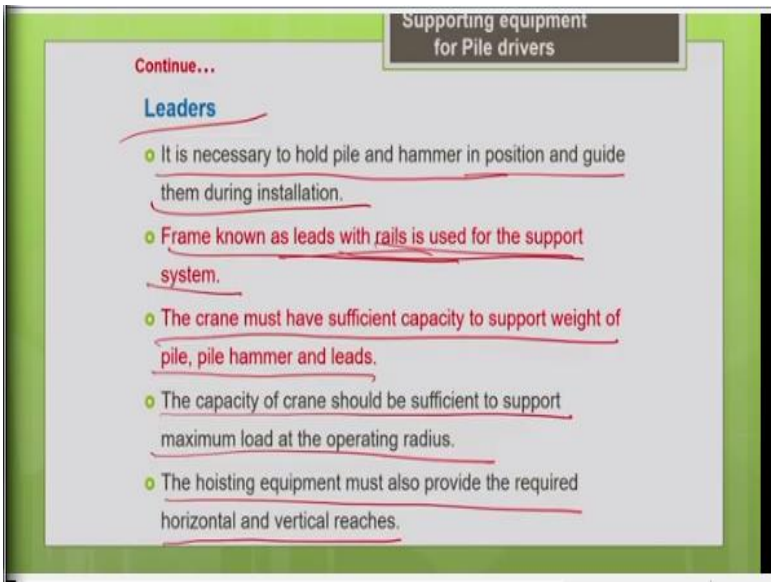
And this is your pile, in between the hammer and pile, you have the pile cushion to control the pile driving stress to protect the pile head from the damage, you put the pile cushion. So, you are going to lift this hammer with some lifting mechanism and then allow it to fall on the pile. So, and you can see some more supporting arrangement this is called as the leader or lead.

So, this frame structure, it is going to help you to place everything in right position, it helps you to hold the pile, pile hammer, everything in the right position helps you to maintain the alignment. So, for that you need the supporting arrangement called as leader so this is your leader, lead or leader**.** So, these are the supporting equipments you need. So, as I told you for the pile driving, we cannot just do the pile driving only with the pile hammer.

We need the supporting equipment like we may need some lifting equipment like crane, and you need a structural frame like leader to hold everything in position. So, what is this drop hammer, let me summarize what we discussed just now. Drop hammer is heavy metal weight, raised by winching, powered by diesel or electric motor and then released and allowed to fall on to the top of the pile.

So, winching mechanism, winching mechanism is a lifting mechanism as everyone knows. Basically, it is nothing but a rotating drum, this drum will be rotated by any motor diesel motor or electric motor, on this rotating drum, you can see the rope winding over. So, with the help of this rotating drum, I can either pulling the rope or pull out rope. So, this is a common mechanism which we use in the crane also. So, basically with any pulley, rope and winch mechanism, so you can just lift the hammer to a particular height and allow it to freely fall by gravity on the pile height, so that is what is a drop hammer.

(Refer Slide Time: 04:43)



So, as I told you it needs some supporting frame structure to hold everything in position, so that you can maintain the proper alignment of the pile, so for that you need help of the needles. So, it is necessary to hold the pile and the hammer in position and guide them during installation. So, for that we need the frame known as lead, it has a rail, you can see it has the rail kind of arrangement, it is used as a support system for the pile driving operation.

And one more important thing you need to know that whatever lifting mechanism, you are going to use maybe a crane. If you are going to use a crane, you have to check for this lifting capacity of the crane whether the crane has a sufficient lifting capacity to lift your pile, to lift your pile hammer and to hold your lead everything in position. So, for that the crane should have the sufficient capacity, crane must have the sufficient capacity to support the weight of pile, pile hammer and the leads.

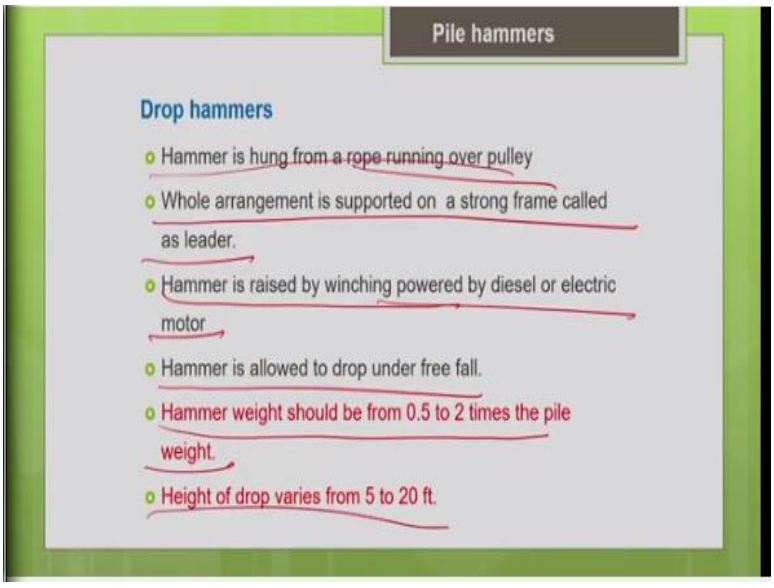
So, the capacity of the crane should be sufficient to support a maximum load at the operating radius. So, operating radius is nothing but the distance from the center of axis of rotation of the crane to the load line, that is a operating radius. This operating radius keeps varying depending upon your boom, crane boom inclination, just by changing the angle of inclination of the boom I can vary the operating radius.

I can either reduce the radius or I can increase operating radius by changing the angle of inclination of the boom. So, you know that when you reduce the operating radius, that means you are going to bring the load line towards the center of the crane. In that case the crane will be in a more stable position, so it is lifting capacity will be high. But when you are moving your load line away from the center of the crane, that means your operating radius is more.

In that case your crane will be relatively unstable, it is stability is relatively poor, so the lifting capacity will also be less. So, that is why we need to check whether the crane has a sufficient lifting capacity to lift your pile, pile hammer and the lead, so at various operating radius that we need to check before making the selection of your crane for the pile driving operation.

So, the hoisting equipment must also provide you the required horizontal and the vertical reaches. So, you need what is the working range needed, what is the horizontal and the vertical reach needed? And the crane what you are going to use must be able to satisfy that requirement. Accordingly, you have to make the selection of the supporting equipment for pile driving operation.

(Refer Slide Time: 07:21)



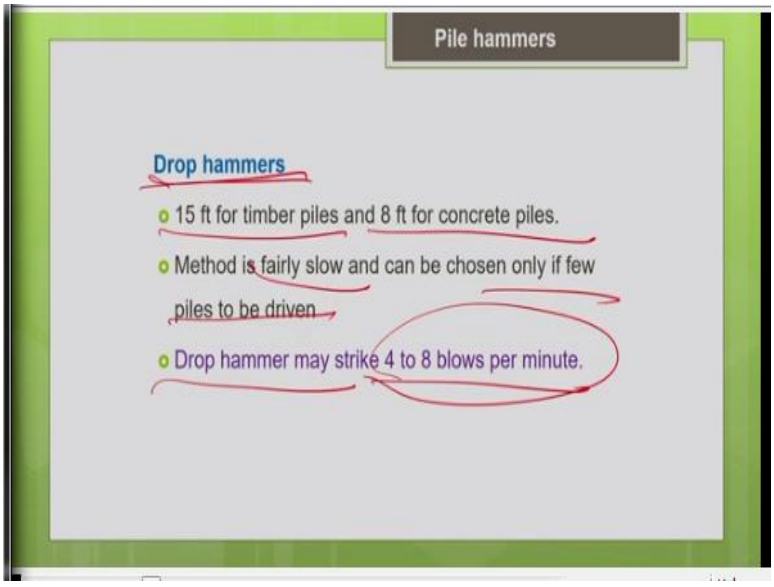
So, hammer is hung from a rope running over a pulley. So, the whole arrangement is supported on a strong frame called leader. Hammer is raised by winching and that is powered by either diesel motor or electric motor and hammer is allowed to drop under free fall on the pile. So, basically

when you select a weight of the hammer, it is advisable to select the weight of the hammer at least equal to the weight of your pile.

So, that you can get your desired blow energy. So, if your hammer weight is going to be lesser, then in that case you have to increase the height of fall to get the desired blow energy. So, you know the impact already when you increase the height of fall the impact velocity will be more. So, that is likely to create more driving stresses on your pile height particularly for the concrete pile we should be very careful with respect to the driving stresses and we have to restrict the stroke or the height of fall.

So, we have to select a heavy hammer at least equal to the weight of pile. So, for this drop hammer as per the literature you can see the hammer weight should be from 0.5 to two times the pile weight depending upon the availability of your hammer and you can make the selection. And the height of drop varies from 5 to 20 feet. So, like depending upon the material type there will be restriction on the height of fall. As I told you concrete is weak in tension it is more easily susceptible to shattering while ramming it the driving the pile.

(Refer Slide Time: 08:55)

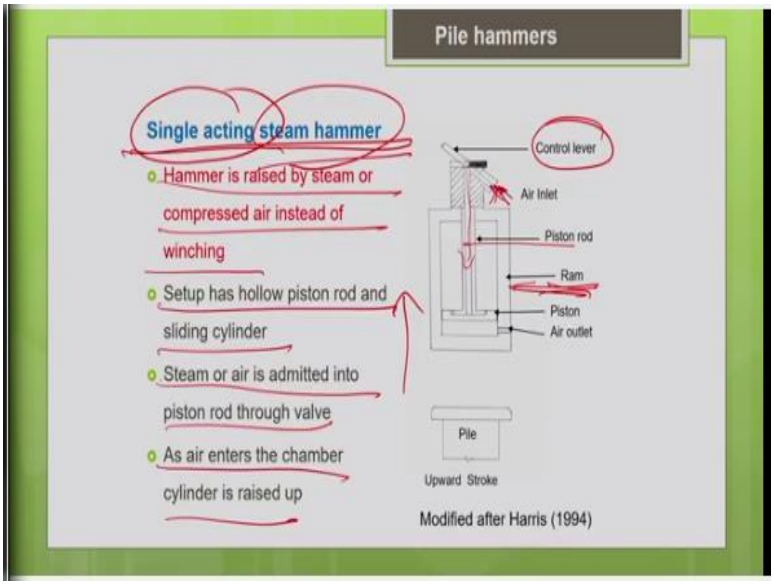


So, that is why for concrete piles the limitation of height of fall is given for the drop hammer as 8 feet, for timber pile it is 15 feet. And one more important thing to be noted is, this drop hammer method is very slow, it is fairly slow. So, if you have to drive only few piles, if you do not have a

very tight deadline, so if you are not very much concerned about the productivity, if you do not have a tight deadline.

In that case, you can go for the drop hammer method, because this is basically a slow method. So, you can see the blow rate number of blows you can make is only 4 to 8 blows per minute, the blow rate is relatively very less. So, that is why you can go for the drop hammer, if you have only very few piles to be driven, and if you do not have a very tight deadline, in that case you can go for the drop hammer method. It is an oldest method, nowadays we have lot of advanced techniques.

(Refer Slide Time: 09:48)



Next is your single acting steam hammer, so this is an improvement over the drop hammer. As a name indicates steam hammer, so it means you are going to use a steam energy, you can either go for steam energy or you can go for compressed air also. So accordingly, you may need a steam boiler or air compressor for this method. So, the name says single acting, that means you are going to use the steam energy only in the upward stroke.

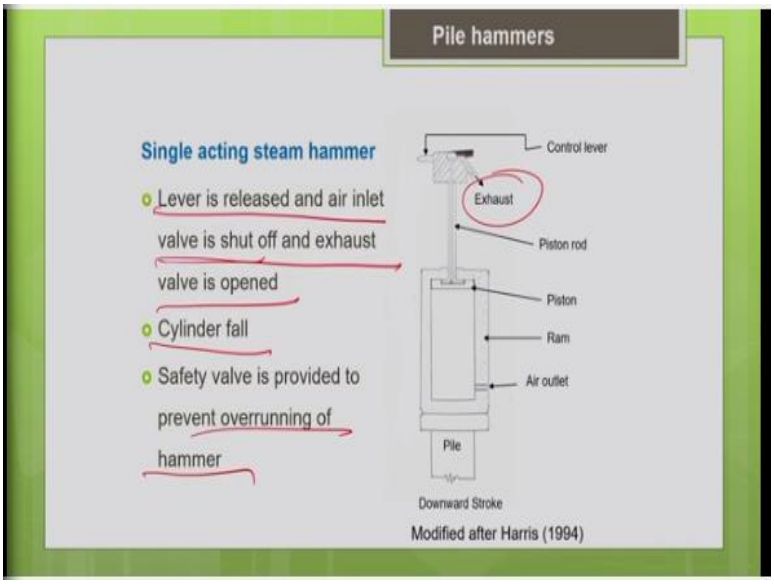
That means when you are lifting the hammer that is called as a upward stroke, only during the upward stroke I make use of the steam energy. So, the downward stroke that means when you allow the hammer to fall, it will fall freely by gravity, so that is why it is called a single acting steam hammer. So, the hammer is raised by steam or compressed air instead of winching, and you can see the setup.

So, this setup you can see you have a sliding cylinder which can move over the frame, this is a hollow piston rod, you can see the hollow piston rod and the piston. So, this is the control level which can control the air inlet and the air exhaust. So, first what you are supposed to do is, for the upward stroke, so you need to allow the entry of air into the piston rod. So, allow the air entry through the piston rod as the air fills the chamber, what happens?

Due to the pressure the ram is raised up, your cylinder is raised up, so due to the air pressure. So, to complete an upward stroke what you supposed to do is you allow the air entry into the chamber. Once the air enters into the chamber, you can say as the air starts filling the chamber, your hammer will be raised up due to the air pressure. So, now your upward stroke is complete. So, let me summarize.

So, the setup as a hollow piston rod and a sliding cylinder**,** this is a sliding cylinder it can move up and down. But the piston rod is fixed, only the cylinder can move up and down. Steam or the air is admitted into the piston rod through the valve, you can see the inlet valve. So, you can adjust the control lever, so that the air can enter through this inlet and into the piston rod. So, now as a air enters the chamber, the cylinder is raised up, so that is your upward stroke **y**our cylinder is raised due to the entry of air into the chamber due to the air pressure.

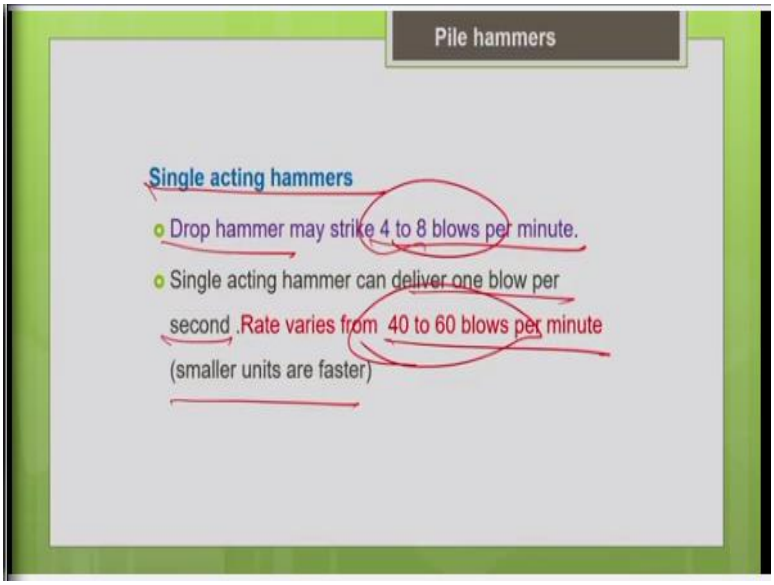
(Refer Slide Time: 12:14)



Now let us see how the downward stroke is done. Now what you do is you control the lever in such a way that the air inlet is shut off, you close the air inlet and all the air from the cylinder will be expelled out of the exhaust valve, so all the air now comes out of the exhaust. As the air is released out of the chamber, the hammer will fall down, so hammer falls down, so that is a downward stroke.

So, your lever is released and the air inlet valve is shut off, and the exhaust valve is opened. So, now you stop the entry of air into the inlet valve and you open exhaust valve, so all the air from the cylinder will go out. Now this will result in the fall of your cylinder, cylinder will fall down, that is a downward stroke. So, you are providing a safety valve also, mainly to prevent the overrunning of the hammer to prevent the excessive buildup of the air pressure. So, we have a safety valve to prevent overrunning of the hammer.

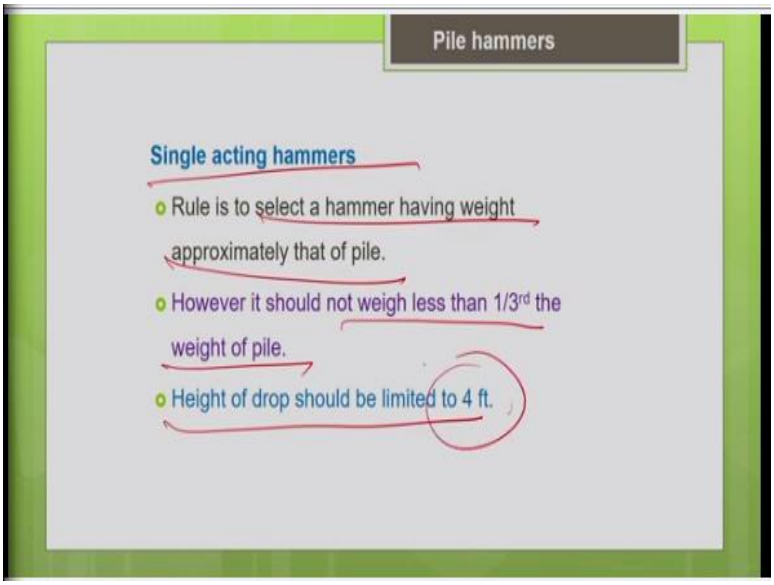
(Refer Slide Time: 13:10)



So, when you compare the productivity of your single acting hammer with the drop hammer, say earlier we discuss the blow rate of the drop hammer is 4 to 8 blows per minute. But your single acting hammer has a better productivity, it can go of a 1 blow per second. That means the blow rate is almost 40 to 60 blows per minute, even the smaller will more faster, when compared to the larger units.

So, when compared to the drop hammer you can see that the blow rate is significantly high. That is why when you are concerned about your productivity of your job, if you have a tight deadline, it is preferable to go for single acting hammer.

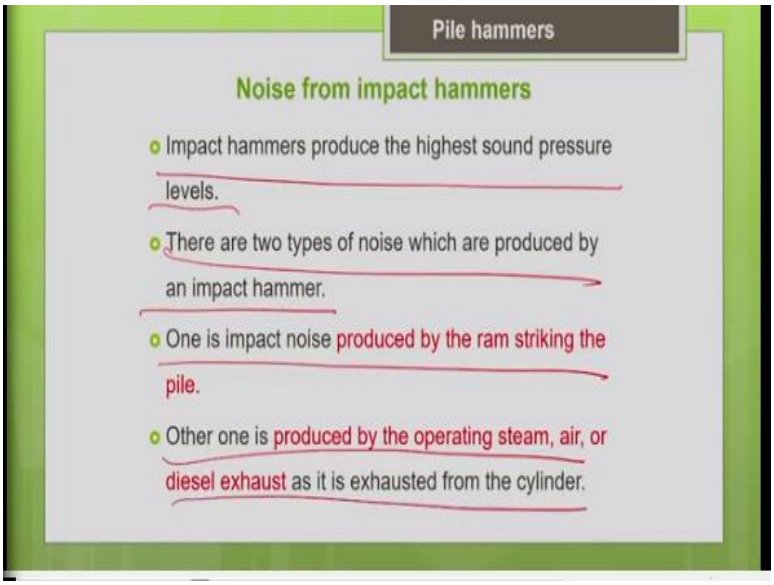
(Refer Slide Time: 13:48)



And again, the guidelines are given for single acting hammer. So, as I told you the basic rule is, select a hammer having a weight approximately equal to that of the pile. So, at least a hammer weight which should be equal to that of the pile. But sometimes certain concrete piles are too heavier, we do not have equivalent size hammer in the market. In the worst case, we should make sure that the hammer weight should not be less than one third of the weight of the pile.

So, that is a minimum requirement and the height of the drop should be limited to 4 feet. So, particularly for the concrete piles, we have to restrict the height for the single acting hammer it has mentioned there you should restrict it to 4 feet.

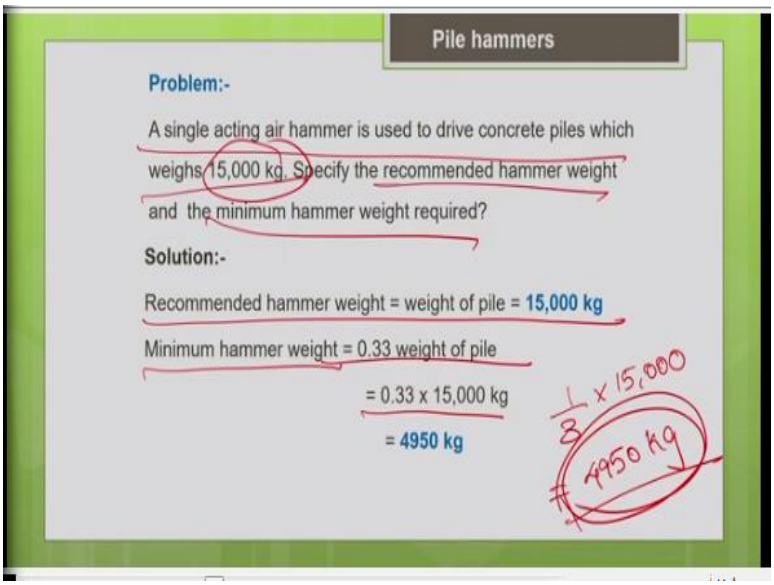
(Refer Slide Time: 14:26)



So, whatever hammers we discussed so far, a drop hammer, single acting hammer, all these impact hammers are noisy hammers, that means it results in lot of noise prediction during the driving operation. So, the impact hammers produce the highest sound pressure levels. So, there are different types of noises. One is because of the hammer the ramming against a pile head, that results in one type of noise.

The other type of noise is due to running of your air compressor or steam boiler, all these things also results in production of noise. So, there are basically 2 types of noise which are produced by impact hammer, one is your impact noise produced by the ram striking the pile, and other one is produced by the operating steam air, or the diesel exhaust as it is exhausted from the cylinder.

(Refer Slide Time: 15:21)



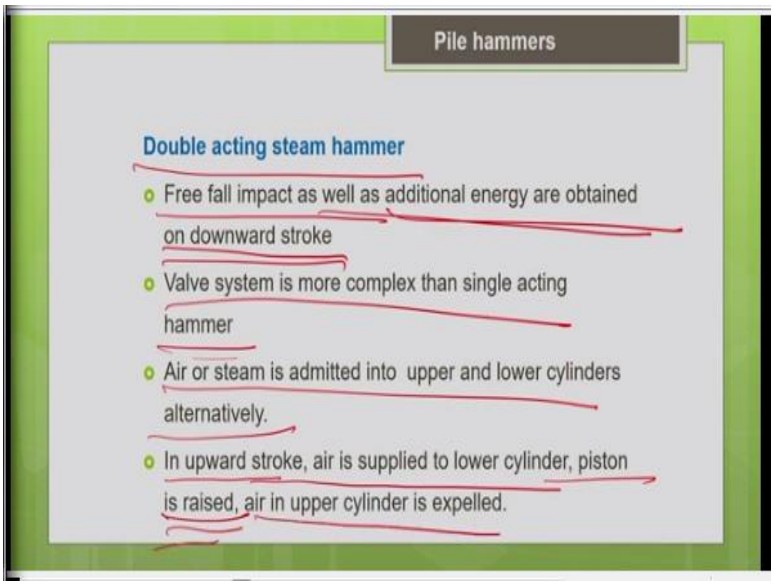
So, let us work out a simple problem on the hammer selection. A single acting hammer is used to drive concrete pile which weighs 15,000 kg, so the weight of the concrete pile is given as 15,000 kg, you are going to recommend the hammer weight needed, recommended hammer weight and the minimum hammer weight required. As I told you the basic rule for the single acting hammer is hammer weight should be equal to the weight of the pile.

So, the concrete weight pile is 15,000 kg, so recommended hammer weight is nothing but 15,000 kg. In the worst case, if 15,000 kgs of heavy hammer is not available in the market. In that case, the minimum requirement is you should never go below one third of the weight of your pile. That means minimum weight needed is

Minimum hammer weight = 0.33 × 15000kg = 4950kg

At least we should never go below this. So, this is the minimum requirement needed, you cannot go below this. So, this is a basic guideline that we should keep in mind.

(Refer Slide Time: 16:41)



So, we have discussed about the single acting hammer, now let us move onto double acting steam hammer. As the name indicates double acting, so you are going to use the steam energy for both the upward stroke as well as for the downward stroke. So, that means you are going to use the steam energy for rising of the hammer as well as for the falling of the hammer. So, the freefall impact as well as additional energy or obtained on the downward stroke.

That means you are using the steam energy for the downward stroke also. Here the valve system is little bit more complex than the single acting hammer. If you look into the setup I will show you in the next slide. Basically, there are 2 cylinders here, upper cylinder and the lower cylinder. Alternatively, you will be supplying to the upper cylinder and the lower cylinder to carry out the upward stroke and the downward stroke. So, air or steam is admitted into upper and lower cylinders alternatively.

(Refer Slide Time: 17:37)