Construction Methods and Equipment Management
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Lecture-16
Piles and Pile Driving Equipment (Part 1)

Hello everyone, I welcome you all to the lecture 16 of this course construction methods and equipment management. In today's lecture we are going to discuss about the piles and the pile driving equipment.

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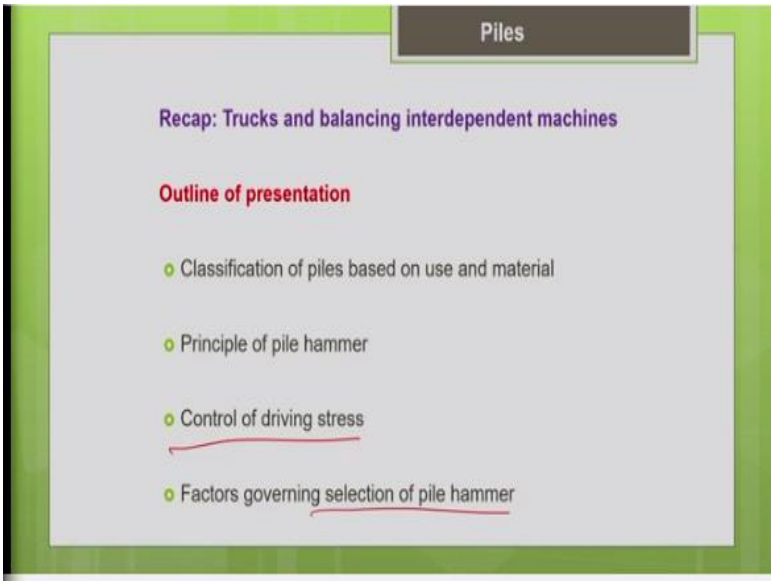

So, in the last lecture, we have discussed about the trucks, and how to balance the interdependent machine safe trucks and the loaders. How to balance them in terms of size and number, so that we can optimize the productivity, that is what we have discussed in the last lecture. Now let us look into the outline of today's presentation. In today's presentation, we are going to discuss about the different types of piles.

So, I will just give you a brief overview on what are all the different types of piles, because we can classify them based on the application, based upon the material type, based upon the method of fabrication, based upon the installation process. So, there are so many ways by which we can classify them. So, I will just give you an overview of how to classify and what are the merits and demerits of different types of piles**.**

So, then we will move on to what is the principle of the pile hammer. So, what is the principle of pile driving operation, and as you know that particularly the precast piles, they are subjected to more amount of driving stress. Say when you drive the pile into the ground, say we use a pile hammer, so for the driving mechanism, it is subjected to a huge amount of driving stress**.**

So, what are the methods to control the driving stress? That is what we are going to discuss. And also, I will give you a brief overview on what are all the factors which governs the selection of a pile hammer. So, based upon the type of the pile or based upon the size of your pile, so there are different factors which are govern in the selection of the pile driving hammer, so we are going to discuss about that in the upcoming slides.

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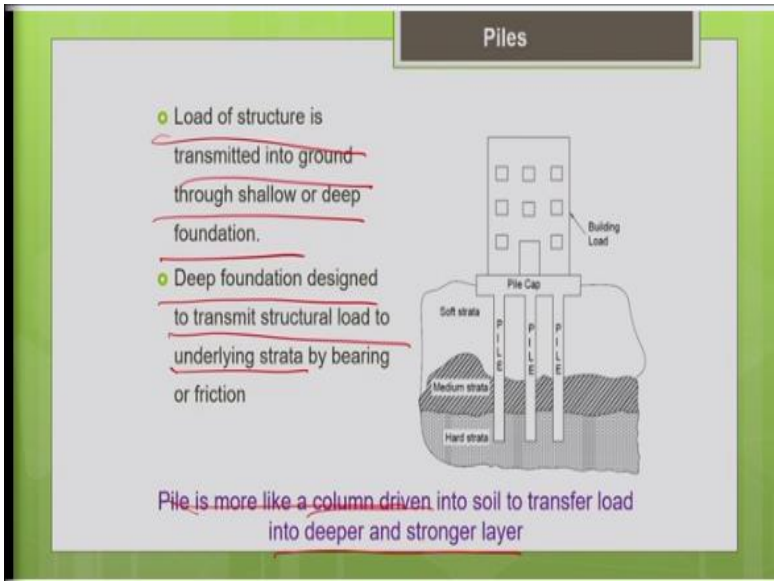

So, as everyone knows, the load of any structure is transferred to the ground to the foundation. So, this foundation can be a shallow foundation or deep foundation. Piles are deep foundation they are examples for deep foundation. So, they are capable of transferring the load from the structure through a weak stratum and it can carry till the depth where a hard bearing stratum is available.

So, the load of the structure is transmitted to the shallow or deep foundation as I discussed just now. The deep foundation that is a pile is designed to transmit the structural load to underlying strata. And the load transfer can be either on the basis of end bearing or basis of fiction, that we

are going to discuss in the upcoming slides. So, basically your pile foundation you consider it will act like a column, pile is like a column driven into the soil.

It transfers the load from the structure deep into the harder and stronger layer, which can bear the load. So, when do we go for the spell foundation? Basically, when we have weak soils or soil with poor bearing capacity, we need to transfer the load till we reach a depth where you confined a hard load bearing strata. So, till that depth we need to transfer the load, so for that we need a deep foundation like pile.

So, the other requirement maybe is a design load is very huge. Say for example you need to design a foundation for a skyscraper or a multi storey building, where the design load is very huge. In that case people commonly go for the pile foundation.

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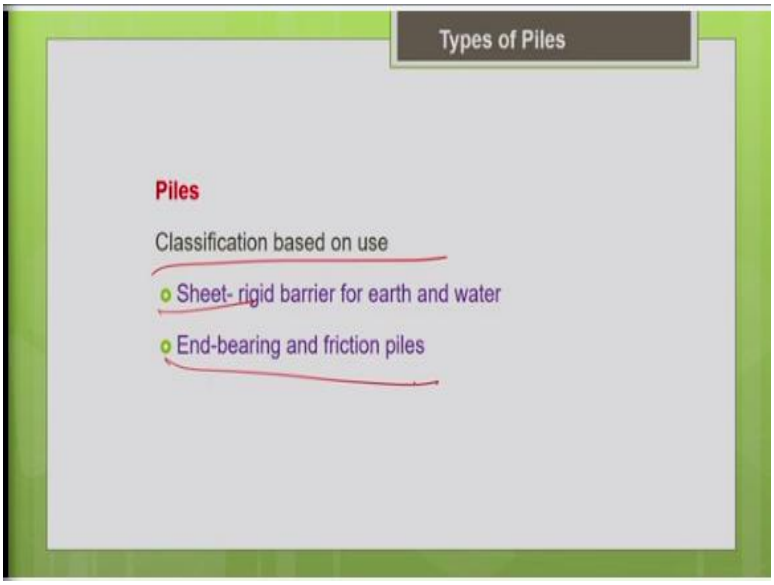

So, based on the application, so commonly, there are different types of uses of piles. So, I am just going to discuss few common applications, so one is a sheet pile and other one is your end bearing pile and friction pile.

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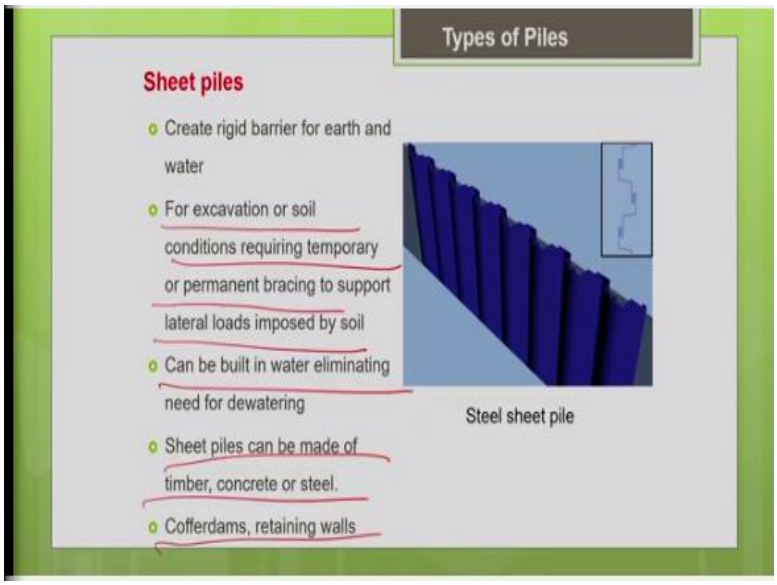

First let us see what are these sheet piles? The sheet piles so we might have seen this kind of steel sheet piles, so they are with interlocking joints, you can see that. So, they act like a rigid barrier for earth and water particularly during excavations or trenching. So, to protect the trench from the collapse, to prevent the trench from the collapse of soil, we go for this kind of sheet piles.

For excavation or the soil conditions requiring temporary or permanent bracing to support the lateral load imposed by the soil, we go for this kind of sheet piles. So, it acts like a rigid barrier supporting the lateral load from the soil, it can also be used in water, like a cofferdam. It helps to act like a barrier for the water it provides a dry working area or dry working environment, so eliminating the need for dewatering, it can also be built in the water.

So, you can use any type of material like you can go for timber sheet piles or steel sheet piles or concrete sheet piles, so it can be made out of different types of materials. So, commonly you can see applications and retaining walls and cofferdams as I discussed just now.

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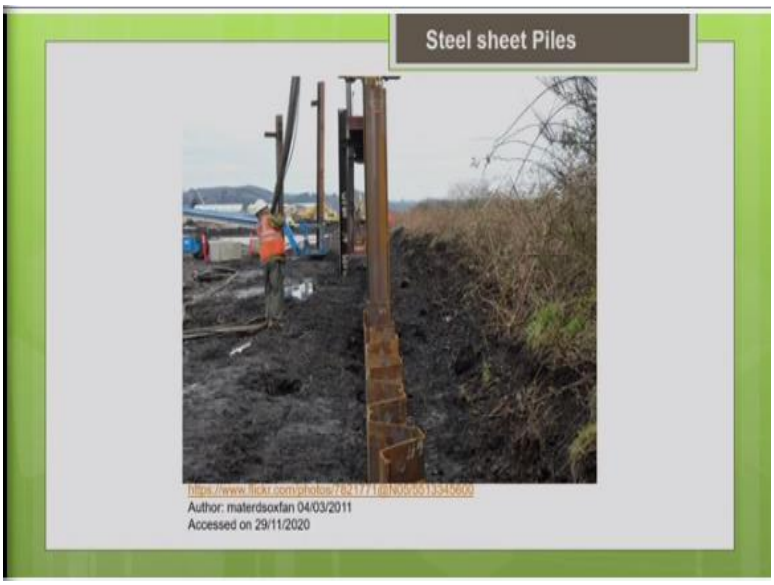

So, this is again a picture of the steel sheet pile, you can see the interlocking joints. So, this is mostly driven with the vibrating hammer, what is this vibrating hammer all these things? We will be discussing in the part 2 of this lecture, so where we will be discussing about different types of pile hammer. So, this helps to support a lateral load from the soil, helps as a barrier to the earth.

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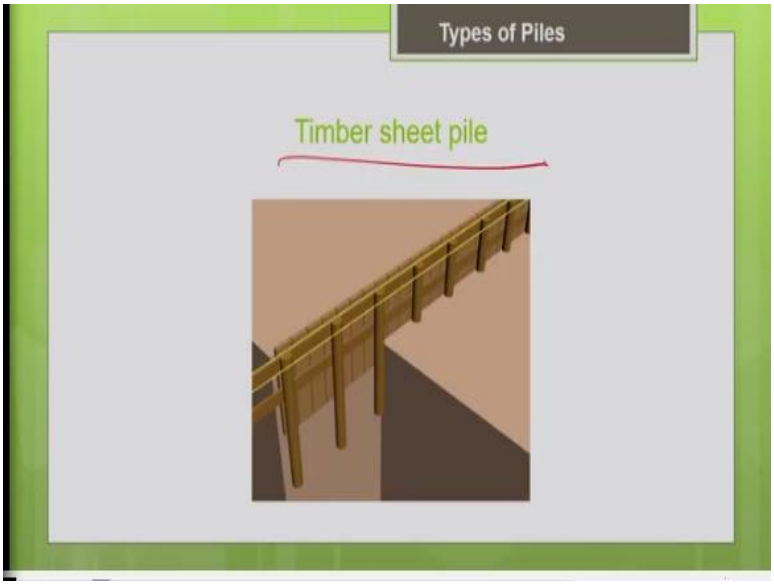

This is the picture of the timber sheet pile, as you know that timber is the oldest material. So, oldest building material we have been using this material for so many centuries, even now we use it wherever the timber is abundant.

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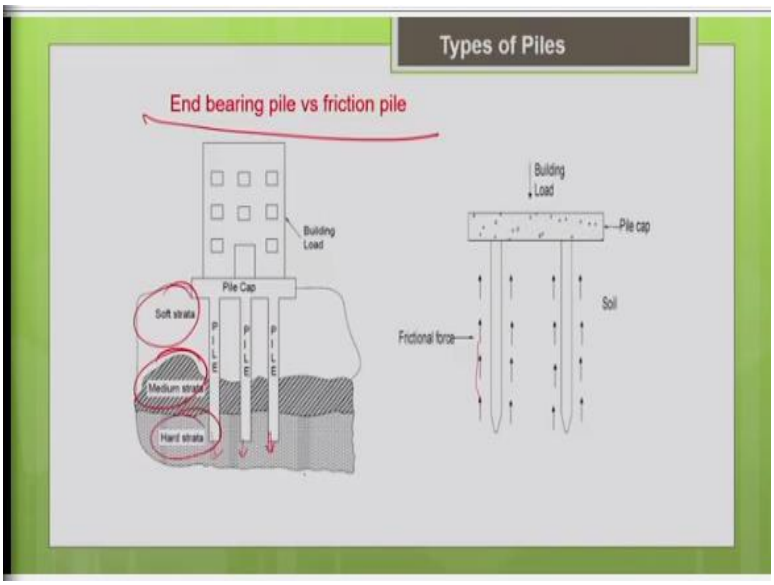

So, other types of applications are end bearing file and the friction pile, based on the mode of load transfer. So, particularly for the soil with poor bearing capacity and we go for this end bearing pile. So, the end bearing pile has to transfer the load through the weakest strata till it reaches it hard bearing strata which can carry the load. And the load is transferred through the end that is why it is called as the end bearing pile.

In the case of friction pile the load is transferred through the friction between the sides of the pile and the surrounding soil, so that is friction pile. So, if the end bearing strata the hard bearing strata is reachable it is within the reachable depth, then we can go for the end bearing pile otherwise we have to go for the friction pile only**.** If the hard bearing strata is at a very greater depth, it is not reachable, then we can design a friction pile.

The most of the piles you can see that they can transfer the load both through the friction mechanism as well as to the end bearing mechanism so that is also possible.

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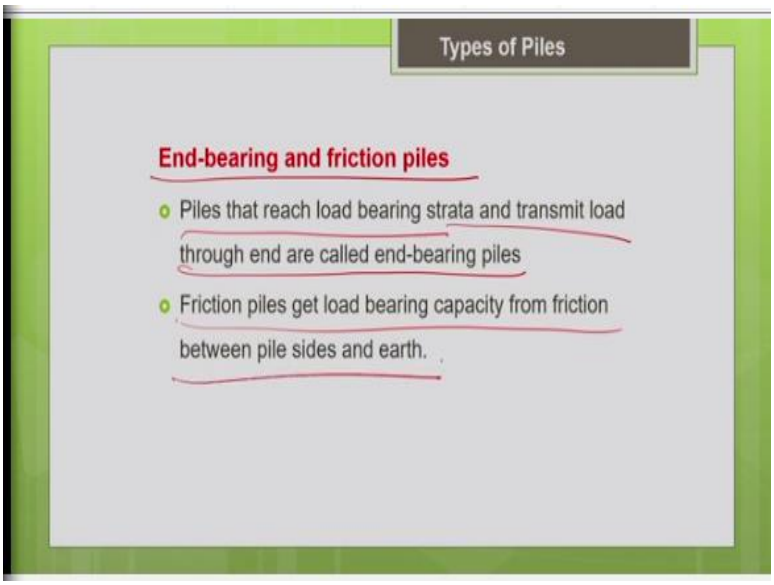

So, this is what we discussed just now. Piles that reached a load bearing strata and transmit the load through the end are called the end bearing piles. Friction piles get the load bearing capacity from the friction between the pile sides and the earth**.**

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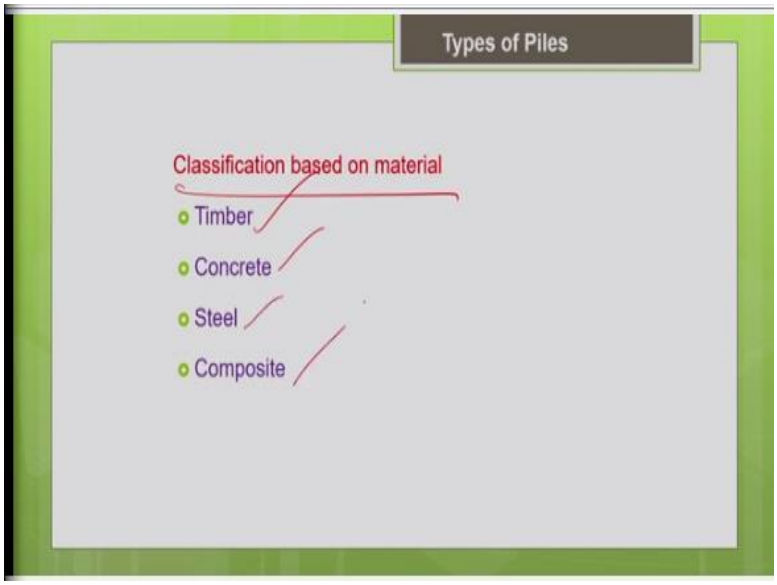

Now we have discussed the few types of piles based on the application or the use. Now let us see the classification based on the material type. So, we can classify it into timber, concrete steel and composite piles.

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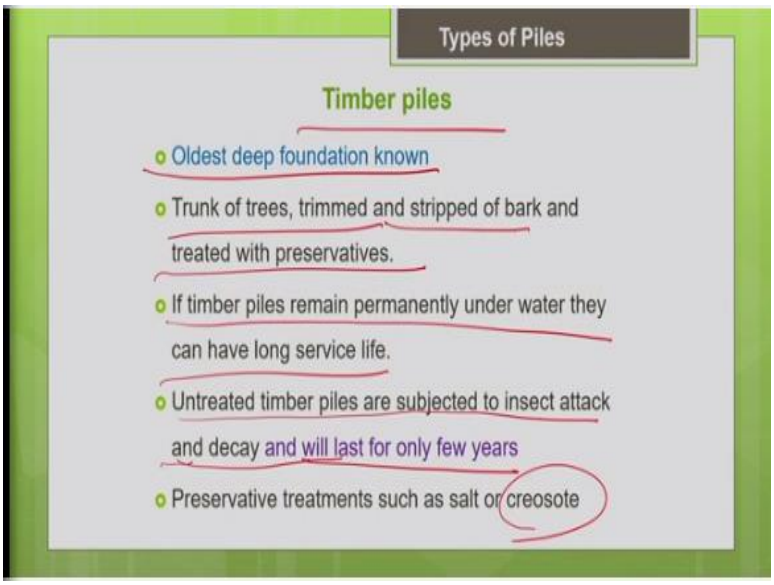

So, timber pile, as I told you this is the oldest material, I can say it is the oldest deep foundation known. So, it is very commonly used because easy to use, it is not expensive, easy to cut it and splice it, there are so many merits with it timber piles**.** How do you basically use it? You just use a trunk of the trees cut it, trim it and strip of the bark, why should we strip of the bark? When we use it as a friction pile there is possibility of slip between the bark and the trunk, so that is why we should strip of the bark.

And treat it with preservatives, that is very important because these piles are more susceptible to rotting and insect attack as everyone knows. So, particularly when the timber piles are subjected to fluctuating water table. So, you can see the issues of rotting and insect attack, this is because for the rotting mechanism, you need the presence of both water and the air. So, that is why timber piles which are permanently submerged in the water, they are not susceptible to rotting.

They are not susceptible to insect attack; there are so many structures with the timber piles, which are servicing for so many years without any damage, without any rotting or insect attack when they are submerged in the water**.** But the problem arises only when it is subjected to the fluctuating water table because you know that the presence of water and air is necessary for these mechanisms.

So, that is why in those cases where you know that it is going to be subjected to fluctuating water table, you should definitely go for the preservatives to prevent it from rotting**.** So, if timber piles

remain permanently in the water, they can have a long service life, that is what we discussed just now. And the untreated timber piles are subjected to insect attack and decay and they will last only for a few years.

So, both type of treatment we can offer to the timber piles to protect it from the insect attack and rotting. So basically, in the olden days used to soak the timber in the natural saltwater. So, the natural saltwater is best preservative, but nowadays we go for modern methods like this to creosote with pressure treatment. So that is found to be very effective for the treatment for insect attack and the rotting.

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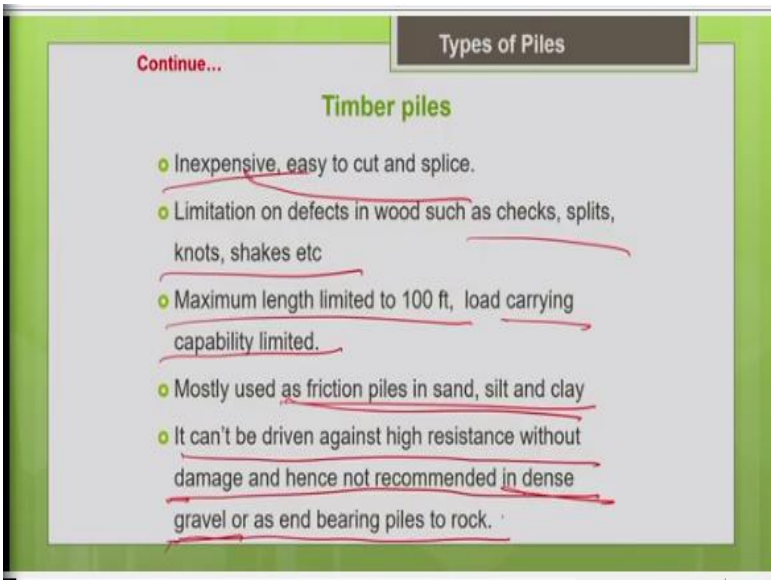

So, let us look into the merits and demerits of this timber piles. Basically, the merit is, it is inexpensive, easy to cut and splice, that is a major advantage. But the demerit is obviously we know that lot of defects was there, natural defect was there in the timber, let checks, splits, knots and shakes. So, we have to quantify the number of defects in the timber before assessing it is suitability for using it as a pile.

Where we have to quantify and whether the defects are within the permissible limit as given by the standards, we have to check before it is used as a pile. And also, there is a restriction on the maximum length and the load carrying capability is limited, you know that when compared to

concrete or the steel piles, it is load carrying capacity is limited. So, that is why mostly we use it as a friction pile in sand, silt and clay.

We do not use it as an end bearing pile or we do not use it in very tough soil conditions like dense gravel. Then timber pile is likely to get damaged easily when we drive it against high resistance. So, when we driving soils with high resistance, it is likely to easily get damaged, that is why we use it only as friction piles in sand, slit and clay. It cannot be driven against high resistance without damage and hence not recommended in dense gravel or as end bearing piles to rock.

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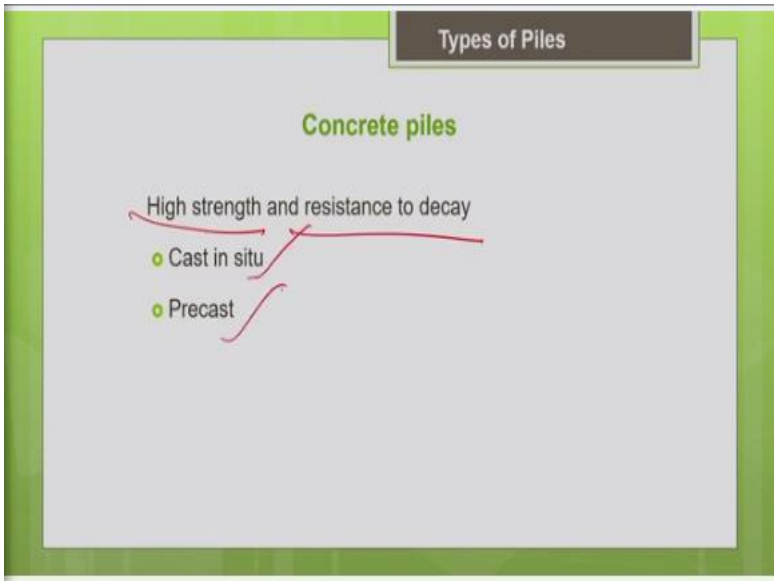

So, the next is about the concrete piles. Obviously, when it compared to the timber pile, it is load bearing capacity is high, there is a high strength and as good resistance to decay, there is no issues of decay. Now so there are based on the method of fabrication, you can either the casted at your project site or you can make it in the factory. So, accordingly you call it a cast in situ concrete piles or precast concrete piles.

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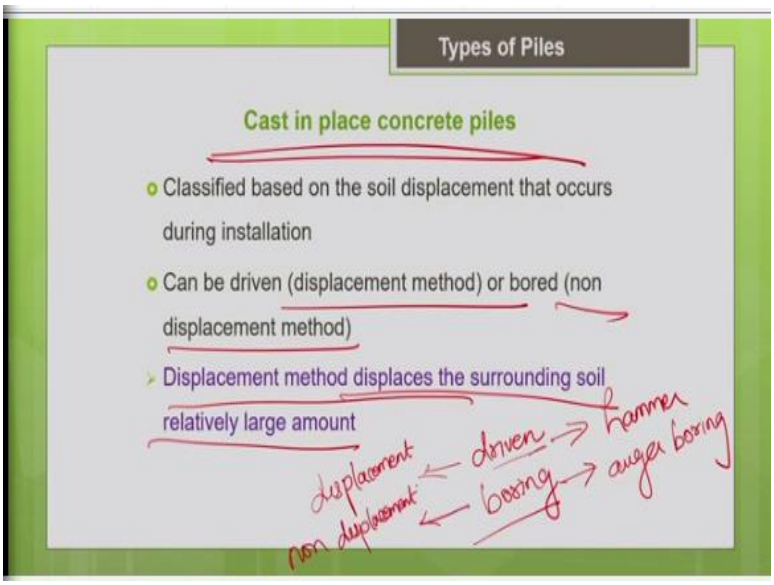

So, what is this cast in situ concrete piles, what are the methods of making cast in situ concrete piles? Here also based on the process of installation, you can classify it further into displacement method and non-displacement method. See, when you do the installation process, say if your installation process is going to disturb the surrounding soil to a greater extent, say if it is going to displace the surrounding soil to the greater extent, then it is called as displacement method.

So, if the disturbance to the surrounding soil is minimum, then it is called as non-displacement method. So, basically there are two types of methods**.** Displacement method means, it will displace the surrounding soil to a relatively larger amount. So, say for example, doing the driving, say in the case of cast in place concrete piles. So, you will be commonly driving your steel casing into the soil you have to drive the steel casing with a hammer.

So, what are the different types of hammer use? As I told you in the next lecture we will be discussing in detail. As of now what you need to know is we will be blowing a hammer on the top of the steel casing, so into the soil. When you do this driving operation, what happens is it will displace surrounding soil to a greater extent, say if it is going to be clay soil. So, due to the displacement you can see there will be huge buildup of pore water pressure in the clay surrounding the installation point.

That will result in the healing of the soil around the installed pile. So, this kind of the displacement may happen, so that is why we call them as a displacement method. So, there are two options to make the cast in place concrete pile, one is your driven method, driving, other one is a boring method. Driven means I am going to drive the casing here we are going to drive because it is cast in place concrete clay, will be driving the casing with the hammer, that is why it is called as the driven method.

Other one is boring method, so very commonly we use this auger boring method to make the hole into the ground. So, the first one the driving method is a displacement method, because it is going to displace the surrounding soil to a greater extent. But the boring method is the non-displacement method.

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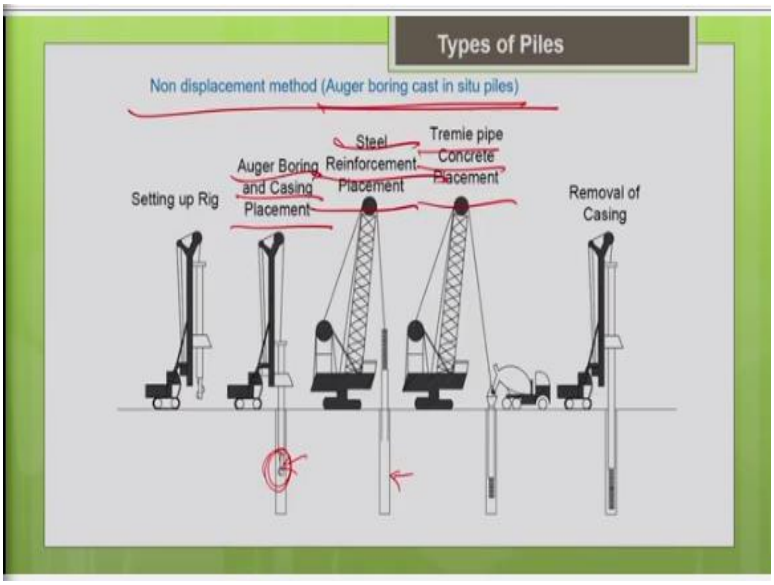

First let us discuss in detail about the non-displacement method. So, the commonly adopted mechanism or a methodology is the auger boring we are going to discuss about this in this lecture. This picture clearly shows you how the auger boring is done. First you set up the rig**,** then you can say this is the auger bore, it has a spiral or the helical the drilling bit at the bottom which can be rotated by the motor and it is usually accompanied by a casing.

So, when you provide the casing it helps to protect the soil also from the collapse and acts like a formwork to your concrete. So, this is the auger boring method, you can see this is the spiral or the

helical blade arrangement. So, this one can rotate with the help of the motor. So, based upon this rotary method, you can easily make a hole into the ground, this is the rotary boring method.

You make the hole into the ground and place the casing, so the placement of the casing and the boring is done together. Casing is nothing but a steel pipe, it will act like a formwork it will act like a formwork. So, that to prevent the collapse of the hole and also it acts like a formwork for a concrete placement. Then with the help of the supporting equipment like crane, as I told you for the pile driving mechanism we need loads of supporting equipment.

Like the crane to lift your casing, to lift reinforcement cage and to place the tremie pipe, for all these things we need the supporting equipment, so now what to do? Once a boring is done, the next step is placement of the reinforcement inside the borehole you place the reinforcement inside the borehole. Now, what we do is next step is the concrete placement. So, very commonly we go for this tremie pipe method of concrete placement.

Using the tremie pipe, you place a concrete to the greater depth. And now you can extract your casing, so that you can reuse the casing. So, this is what is it the commonly adopted method the boring method for making the case in situ concrete. So, let me summarize, first thing is you are going to use it auger for boring the hole into the ground and you remove the soil also.

While boring itself you place the steel casing which will act like a formwork**.** Then with the help of the crane place reinforcement followed by the placement of the concrete using the tremie pipe method. Then once the concrete is placed you can remove the casing, so then you can reuse the casing for the next piling.

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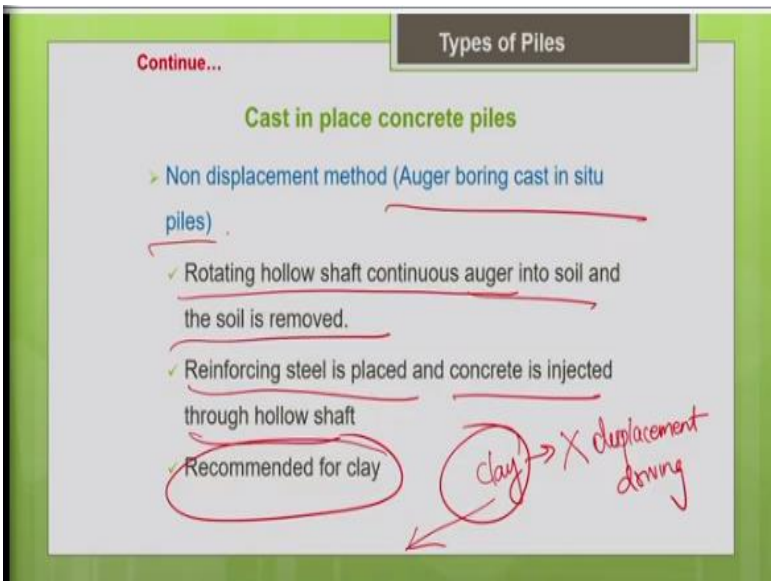

So, let me summarize, first you need to rotate the hollow shaft continuous auger into the soil is the rotary method as I told you. So, you have the rotating hollow shaft continuous auger. So, it has a spiral or helical auger as I showed you, which can easily bore the hole into the ground and it can remove the soil out of the hole. So, the soil is removed and the reinforcing steel is placed and the concrete is injected with the help of a tremie pipe.

So, this method we can recommend basically for the clay soil. So, basically for the clay we should not use displacement method the driving method cannot be used for the clay terrain. This is because when you try to drive the formwork as a steel casing into the clay. As I told you earlier it displaces the soil to the greater extent there will be huge buildup of the pore water pressure in the clay when compared to other type of the soil which results in healing.

So, that is why particularly for the clay you should go for a non-displacement method and auger boring is a best choice. Now let us see here the video clipping on how the auger boring method is done**. (Video Starts: 17:37)**, so in this video, you can see how the boring method is done first, so with the help of this boring method, you can make a hole into the ground and also you can extract the soil from the ground**.** You can see this casing which helps to remove the soil, you can see it clearly. **(Video Ends: 19:49)**

So, followed by that you can see how the reinforcement casing is placed with the help of the crane. So, after the reinforcement casing is placed, you can see how the concreting is done with the help of tremie pipe. So, this is how the bored cast in place concrete piles are done.

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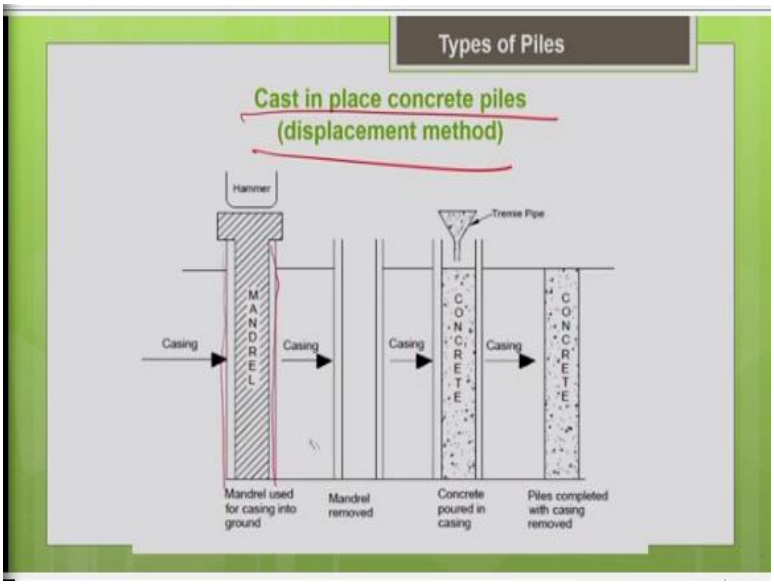

Next is we are going to discuss about the cast in place concrete piles using displacement method. So, first is we are going to drive the steel casing into the ground, steel casing is nothing but the steel pipe, it can be either open at the bottom or it can be closed at the bottom. So, drive the steel casing into the ground this is your casing, you can see that.

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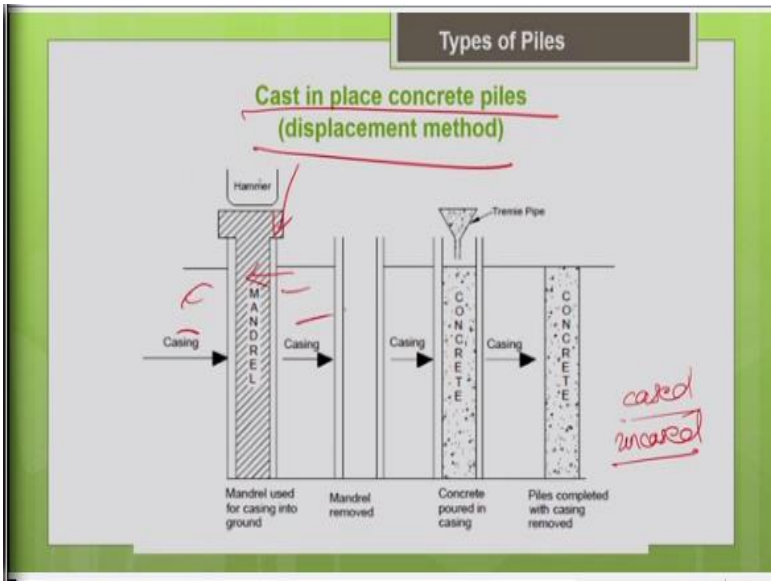

Now how do you drive it with the help of a hammer, you blow the hammer. Since there are chances are the casing may get damaged, and you have to reuse the casing for the further piling. So, that is why commonly you can see that inside the casing they put this mandrel this is the mandrel. So, then you can blow the hammer on the top of the mantel to avoid the damage to the casing.

So, now you blow the hammer on the top of the mandrel and the casing is driven into the ground. Once it is driven to the required depth, you remove the mandrel, now place your reinforcement follow by the tremie pipe concreting. So, mostly for the pile foundation as it is for the greater depth we prefer tremie pipe method, so you do the tremie pipe concreting. o, after that you can remove the casing if needed or in some cases they leave the casing permanent, so that it can act like an additional reinforcement to a pile.

So, if you leave the casing it is called as cased pile or if you remove the casing it is called as uncased pile. So, basically when the casing is closed with bottom, so it means that you are going to leave it permanent. So, the casing which is open at the bottom, we remove it and reuse it. So, this is a displacement method, because this driving mechanism will displace the surrounding soil.

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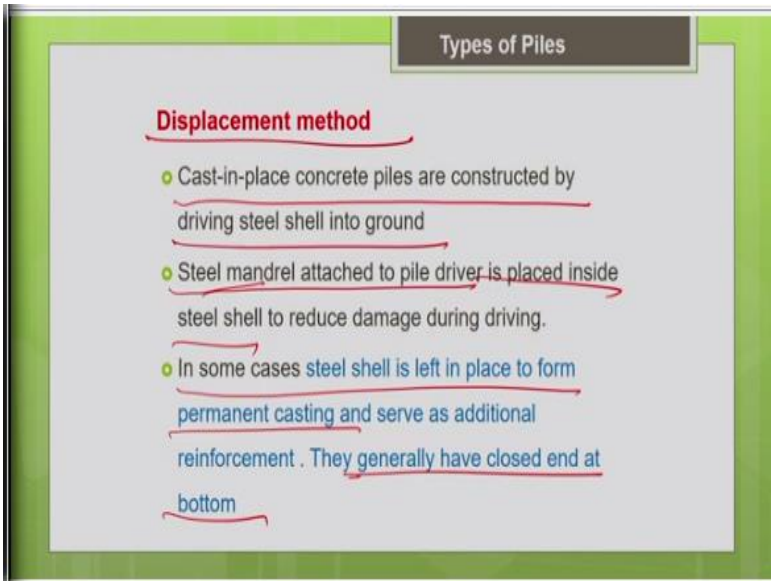

So, let me summarize what we discussed earlier on the displacement method. So, cast in place concrete piles are constructed by driving the steel shell into the ground, shell is your casing and the steel mandrel is attached to the pile driver is placed inside the steel shell. So, why the mandrel

is placed, so that you can reduce the damage to your casing, when you blow the hammer on top of it.

In some cases, steel shell is left in place, it can act like an additional reinforcement. So, they generally have closed end at the bottom if you are going to leave it permanent, they will have the casing will have the closed end at the bottom.

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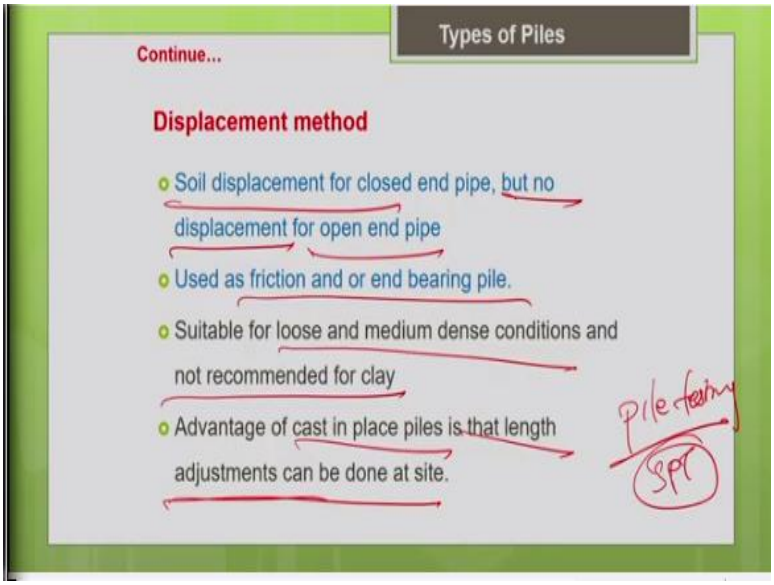

So, generally when we go for the closed end pipe, obviously there will be more soil displacement, surrounding it. But if you go for open end pipe, there would not be much displacement of the surrounding soil. So, mostly it can be used as either fiction pile or as end bearing pile because use it in both ways. You can use it for loose and medium dense conditions and not recommended for the clay.

As I told you, you never go for displacement method for the clay because it will result in huge buildup a pore water pressure in clay heaving. So, another advantage of all these cast in situ piles is that you can do some length adjustment of the pile at the site. Even if you are not able to predict the length requirement, if you are not able to predict the exact hard bearing strata, the location of the hard bearing strata.