Foundation Engineering
Prof. Kousik Deb
Department of Civil Engineering
Indian Institute of Technology, Kharagpur

Lecture – 28
Pile Foundation – II

In my last lecture, I have discussed about the various types of pile. So, in this lecture I will continue those classifications.

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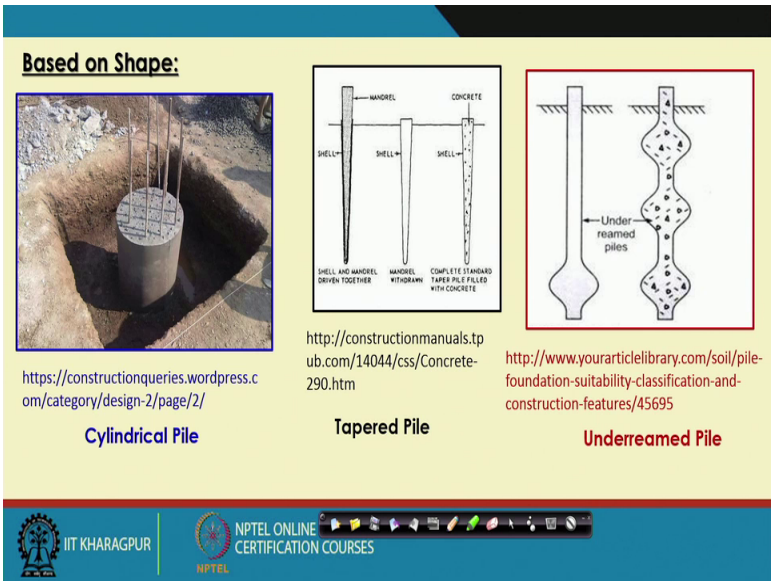

And so, based on the shape the pile can be classified as cylindrical pile tapered pile and the underreamed pile, ok.

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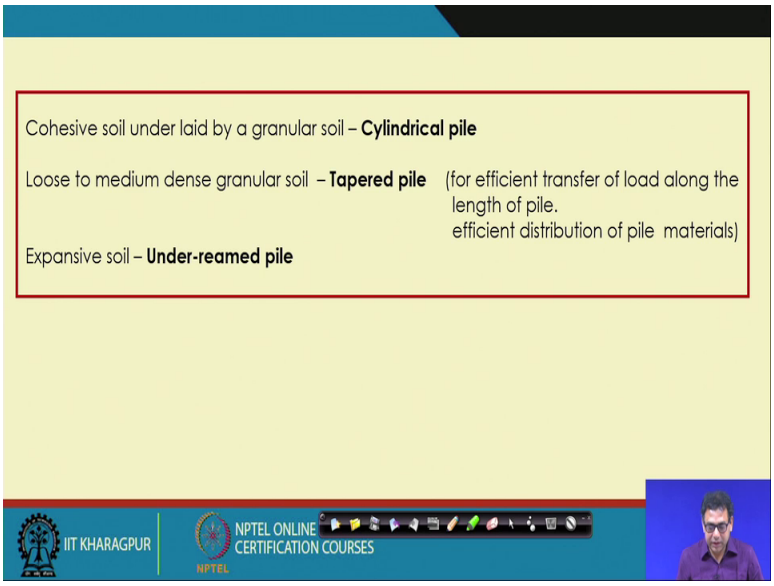

So, this under reamed pile is suitable for expansive soil, and if it is loose to medium granular soil, then tapered pile is suitable it will distribute the load and the material efficiently. And the cohesive soil under laid by granular soil cylindrical pile is suitable.

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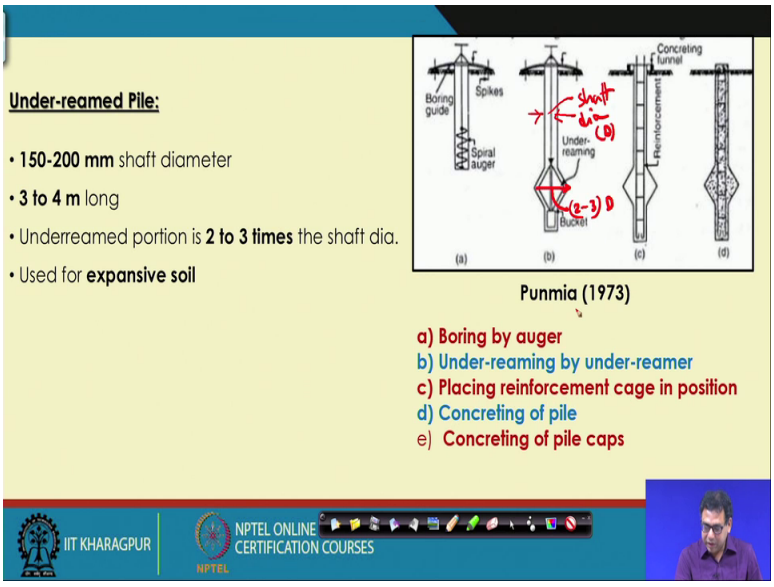

And then what is under reamed piles. So, under reamed pile is a pile which we are provided the bulb, ok.

So, it is generally 150 to 200 mm shaft diameter. So, shaft diameter is this diameter, this is the shaft diameter, ok. Then it is for 3 to 4-meter-long and underreamed portion is 2 to

3 times of the shaft diameter. So, this diameter if this is the shaft diameter 3 or D. So, this is 2 to 3 times of the D this is the bulb diameter, used for the expansive soil.

So, how it is been constructed first the boring is done for the with the use of auger, then underreaming is done by the under reamer. So, here this is the under reamer by which we can provide the under reamed pipe part. Then placement of reinforcement cage is placed, I mean in position placing of reinforcement cage in position that reinforcement cage is placed. Then the concreting is done into the soil and finally, the concreting of the pile cap.

So, that means, first it is boring is done. Then this under ream reaming is done by the by the under reamer, and then this casing is placed in the position then the concrete is in is done, and then the pile cap concreting is done. So, that is why it is suitable for expansive soil.

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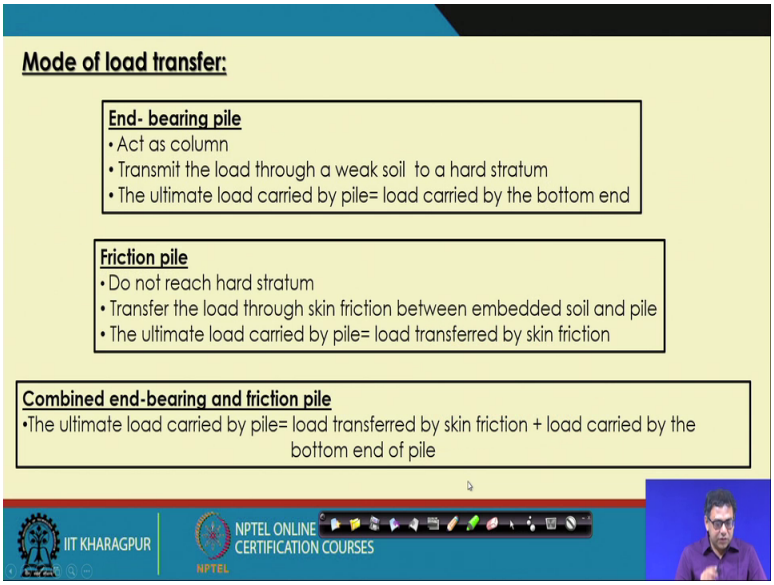

So, next one is the mode of load transfer. So, I in the previous class as I have discussed that can be the end bearing piles friction piles or combination of end bearing and the friction pile.

So, end bearing pile act as column transmit the load through a weak soil to a hard stratum, and the ultimate load carrying capacity of pile ideally it should be equal to the load carrying capacity by the bottom end. So, as I mentioned that pile load carrying

capacity is from the friction or the from the side soil, and the tip or the bearing ok. So now, if the all the loads are or the resistance pile are getting from the tip then it is called the end bearing pile.

So, that means, if the top soil is very loose are very soft then this pile is passing through this pile is passed through this soft soil, and it is rested on the hard soil or the hard stratum. In that case, the resistance coming from the friction parties very negligible compared to the bearing, because that is the hard stratum and the top portion is very soft or the loose, because that is why the friction resistance will be very less compared to the bearing resistance.

So, that type of pile is called bearing pile, ok. And friction pile it do not these pile do not reach hard stratum transferred the load through the friction between the soil the pile. And ultimate load carrying capacity or the capacity of the pile is due to the friction only, ok.

Theoretically but, that means, the majority of the bearing capacity of the pile is coming from the friction and it is not rested on the hard stratum it is on that soil is on the soil itself, and there it is getting the resistance and the tip resistant though it is getting some tip resistance, but that is not significant as compared to the friction resistance.

So, the majority of the contribution is from the friction resistance. So, that type of pile is called the friction pile. Now sometimes this pile can be combination of these 2 that mean the contribution is coming from the friction, as well as the bearing, and both the contribution is not negligible, ok. These are both the contributions of significant amount. So, that type of pile is called the combined end bearing and the friction pile.

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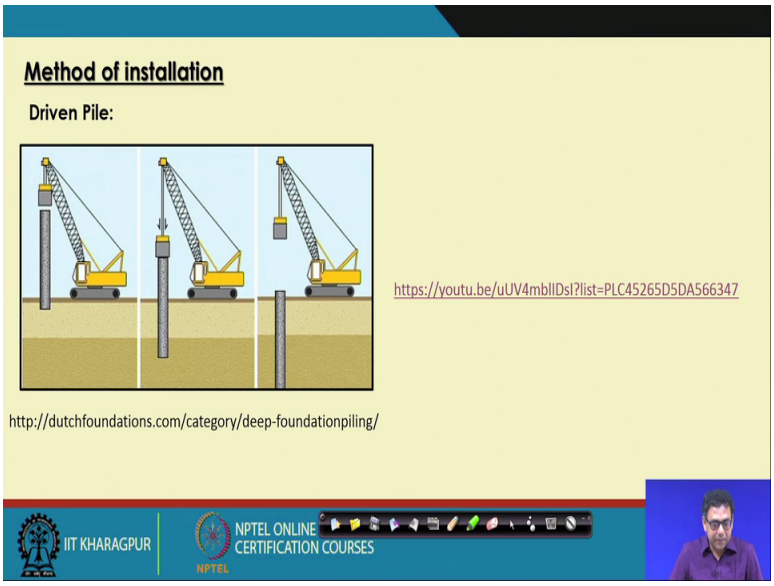

So, the method of installation the pile can be driven pile. So, this is the one example of the driven pile or I have given the photographs of the driven pile. So, first the pile is placed and it is hammer blow is applied over the pile, ok. So, that means, a driving force is applied, and it is installed into the ground. So, I have the one you tube video.

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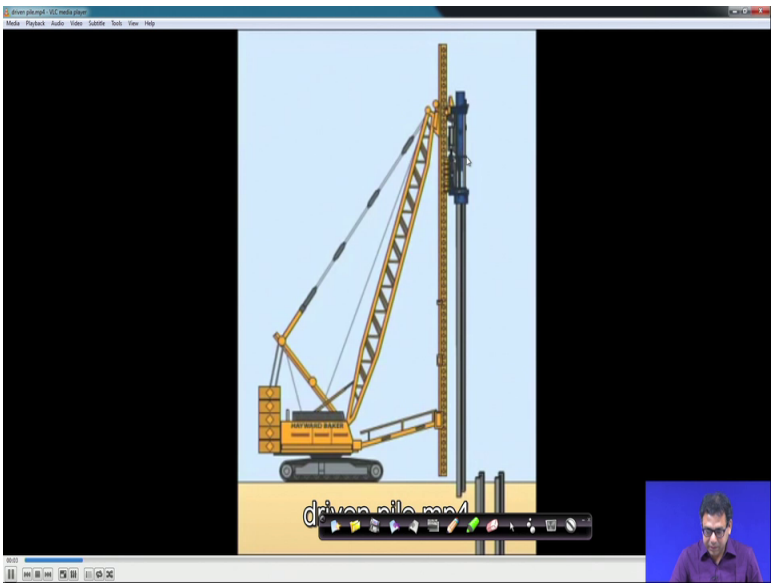

So, this is the pile where this driving this is the hammer, and this hammer has a weight, and this is the free fall, this height this is the free fall, and this is the hammer as we

applying the driving force. So, pile is driving into the soil. So, finally, this way it is been drived so, these are called the driven pile.

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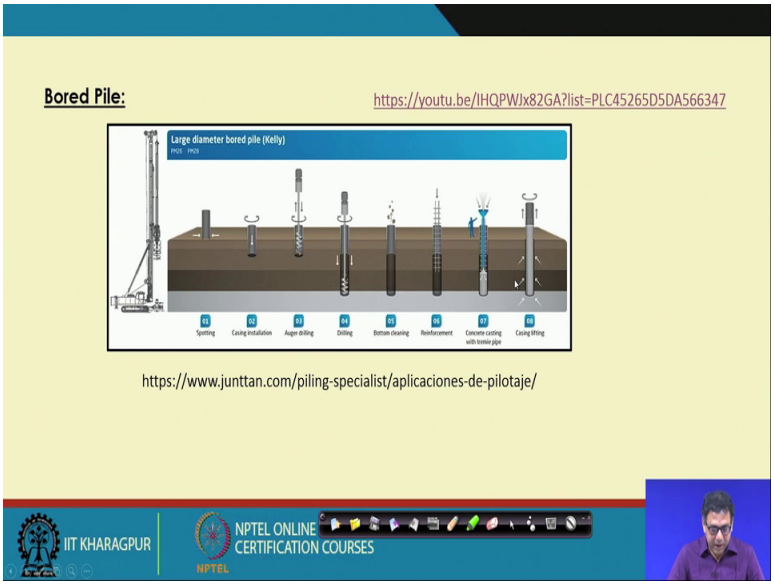

And the next type of pile is called the bored pile. So, where the first step is boring is done, and then the your reinforcement is placed and concreting is done. And finally, the casing if it is a casing is there. So, casing is lifted so, one example of this is the one photographs of the boring or the bored pile, and then I have one video, where also so, this is the boring is done.

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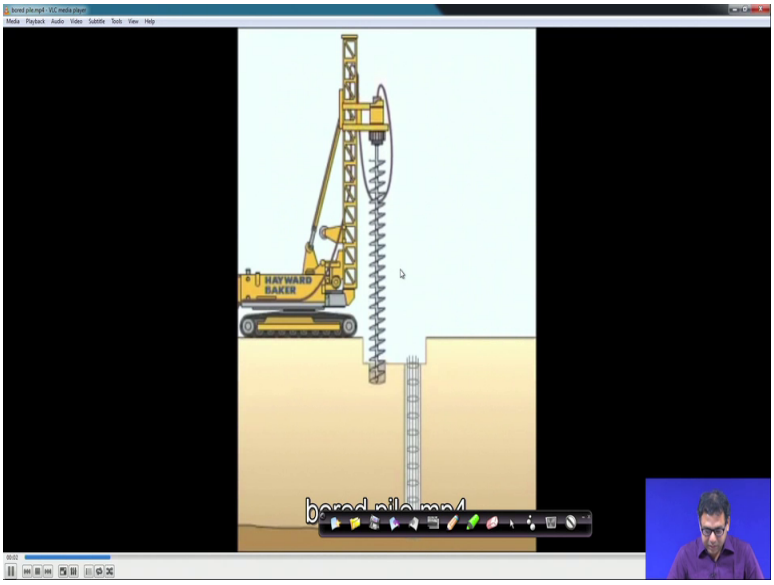

And then once the boring is done, this hole is created.

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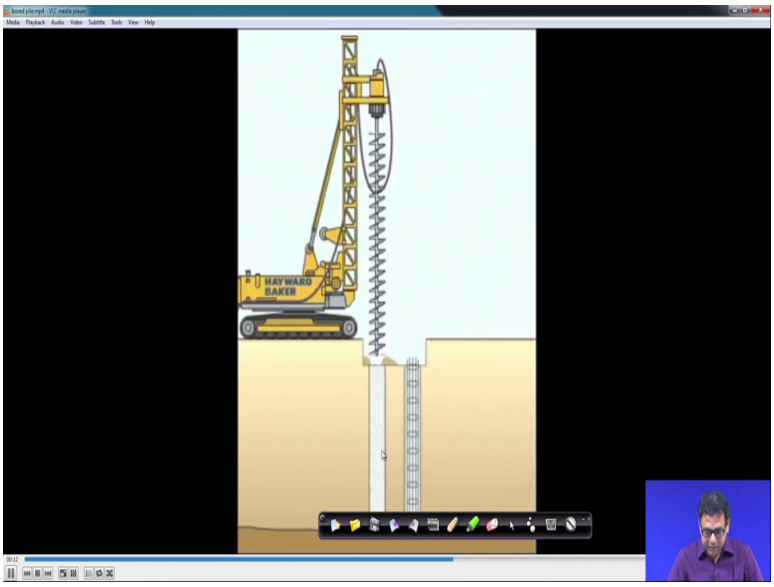

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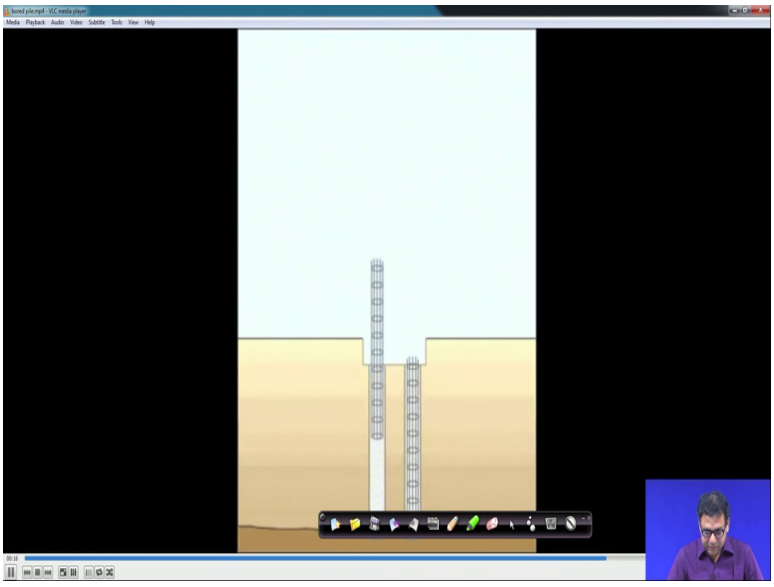

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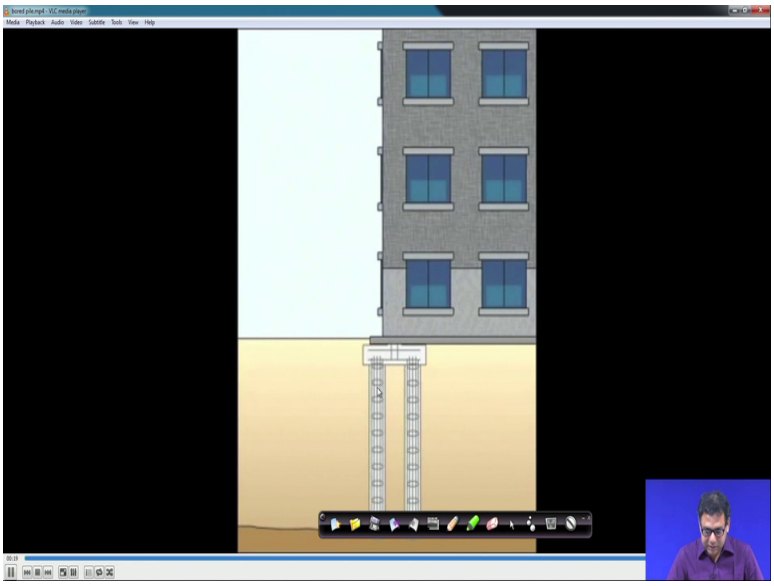

Then the reinforcement is this is the reinforcement cage is placed then the concreting is done, ok. So, this is the example of bored pile.

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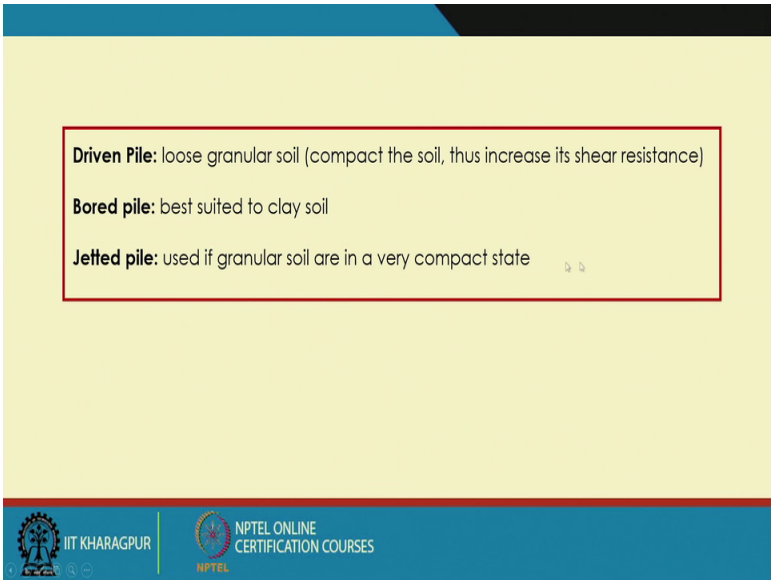

So, driven pile this is the, I mean soil where you can prefer the pile should be installed by driving. So, if the soil is granular loose granular soil, because then what will happen during the driving, because here the pile we are applying a hammer blow or driving force.

So, it is inserted into the soil so, because of this driving if the soil is loose then this soil will be compacted. So, it will increase the shear resistance so, pile load carrying capacity will increase. So, this is suitable if the soil is loose granular soil, then the driven pile is suitable. Then the bored pile best suited for clay soil, and jetted pile so, here a jet is applied or to loosen the soil. So, it is suitable if the soil is in compacted states where we apply a jet in form of water also. So, if we can apply jet so, which is suitable if the soil is in compacted state.

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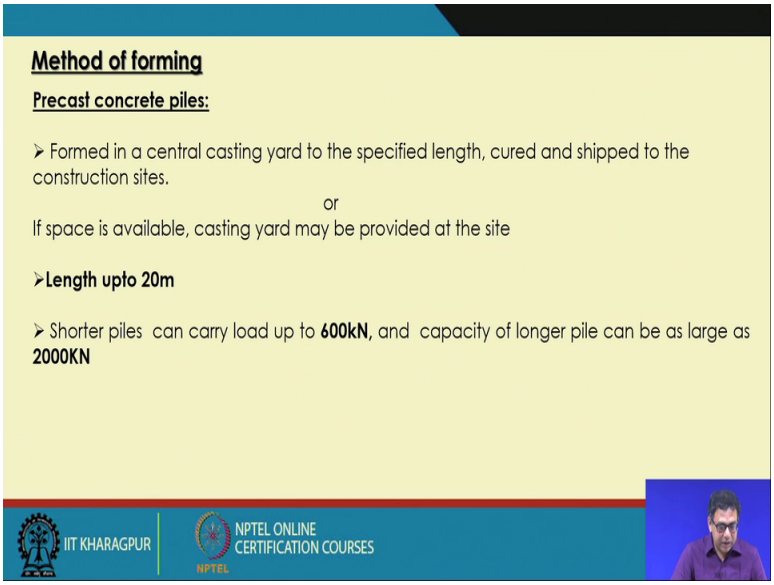

So, next one the method of forming so, pile can be precast concrete pile. So, the precast concrete pile mean this is the this pile is casted before and in a central casting yard. So, that been you can have a specific length, and you can cure that pile and then you can ship this pile to the construction site. So, that means it that is if there is a casting yard where the piled are casted, ok.

Then it is shifted to the site one option another that if inside the space is available then casting yard may be provided in the site. So, that means, this is casted then it is taken to the site. Then it is length can be go up to 20 m or shorter pile can take up to 600 kilonewton load, and for the longer pile it can go up to 2000 kilonewton capacity.

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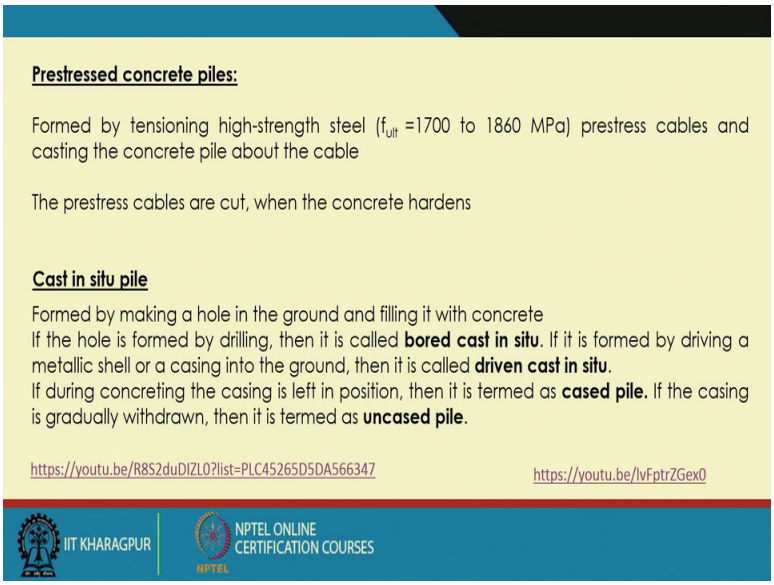

So, this is precast concrete piles, and then prestressed concrete pile, ok. This is formed by the tensioning high strength steel, that mean the prestress cable and then casting of concrete is done about the cable. That mean before the casting there is a high strength prestress cable is placed, and then concrete is done within that about that cables, and when the concrete is harden, then this prestress cables are cut, ok. So, that is why it can take more amount of load. And this and another is the cast in situ pile, ok. So, one is the precast one is the prestress another is the cast in situ pile. So,these piles are constructed or installed in the site itself, ok.

So, that means, this cast in situ piles are formed by making a hole in the ground and filling it with the concrete. So, that means, first the hole is done, then the casing is placed or if the it is a driven pile, so, that means, then the pile a casing is filled placed and the filling is done with the concrete. So, if the hole is formed by drilling, then it is called bored cast in situ pile, ok. So, that means, your once the this hole; that means, first the hole is created, then the concrete is done, ok. If this hole is created by boring, then this or this drilling if the hole is created by this drilling, then this type of pile is called the bored cast in situ pile.

If it is formed by driving a metallic shell or a casing into the ground, then it is called driven cast in situ pile. So, that means, the bore if it is done by boring or drilling then this

is called the bored cast in situ if the hole is done by drilling. And if the hole is done by driving a casing or metallic shell into the ground, then it is called driven cast in situ.

Now if during concreting the cast casing is lefted casing is left in position or casing is left in position, then it is termed cased pile and if the casing is gradually withdrawn during the concreting then it is called the uncased pile; that means, the hole concreting is done by keeping the casing into the hole, then it is called the cased pile, and if the casing is withdrawn then it is called the uncased pile, ok.

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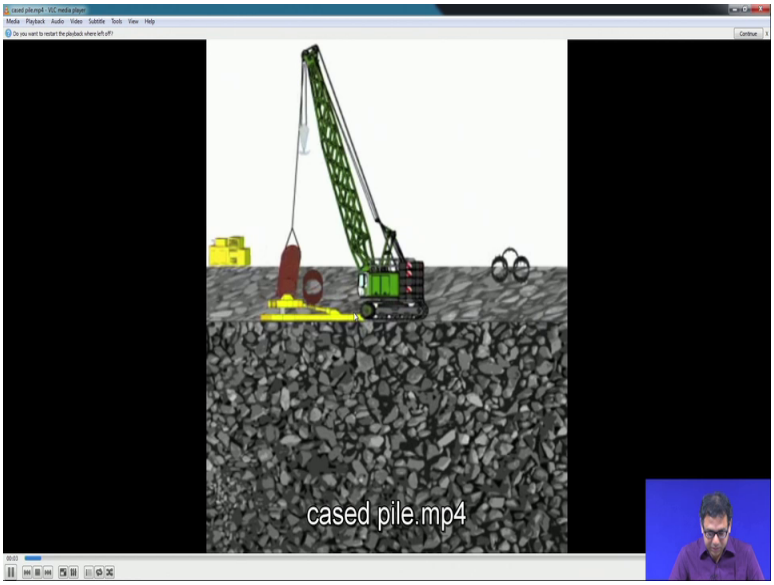

So, I have some video of this is the video of a uncased cased pile where you can see that this is the casing which is first inserted into the ground, ok.

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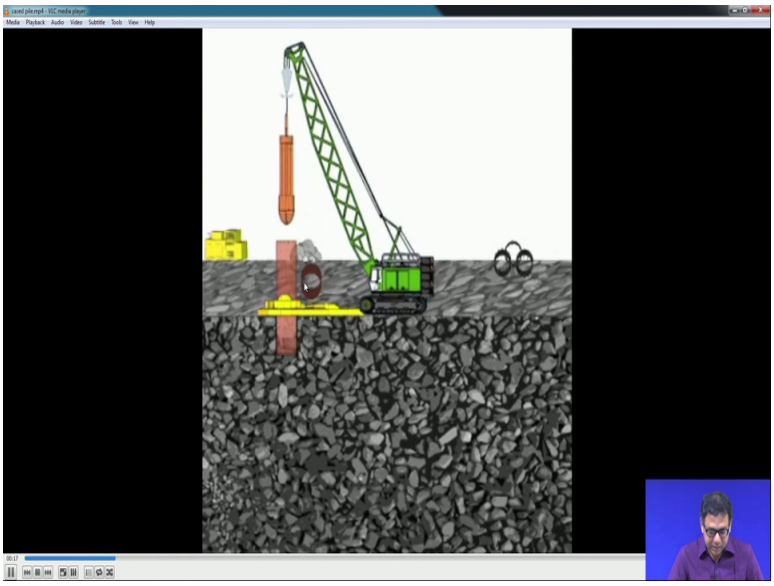

And then this bottom portion is cleaned, if there is any soil then again further it is inserted into the ground, then hole is created.

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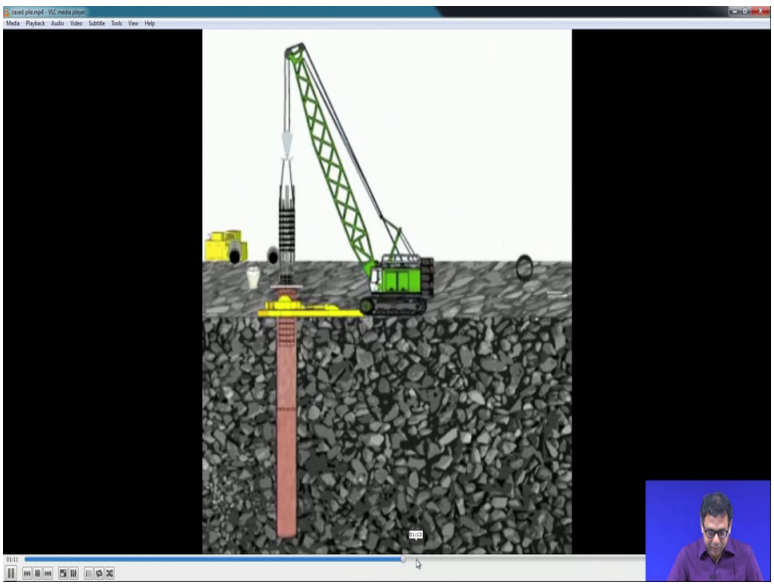

Then the reinforcement cage is placed into the hole, and then the concrete is is done by keeping the casing.

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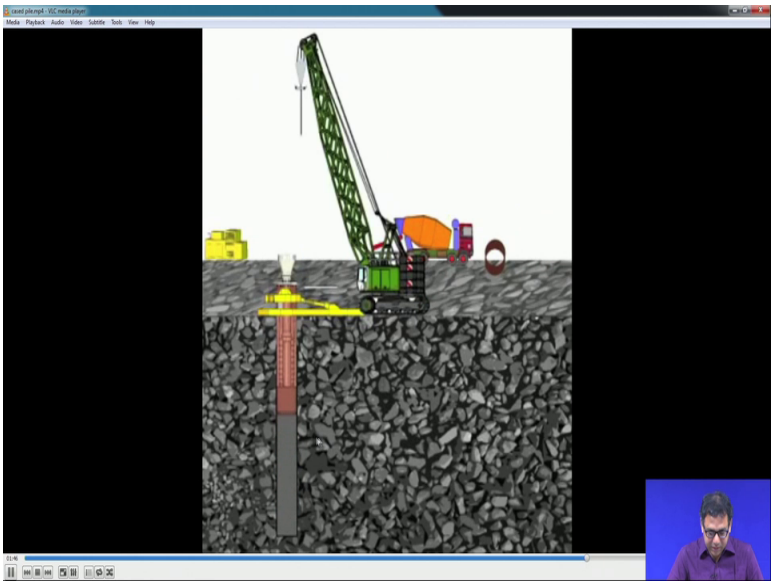

So, once the construction is done, then these casings are also removed. Sometimes piles can be enlarge base pile so, that is one example.

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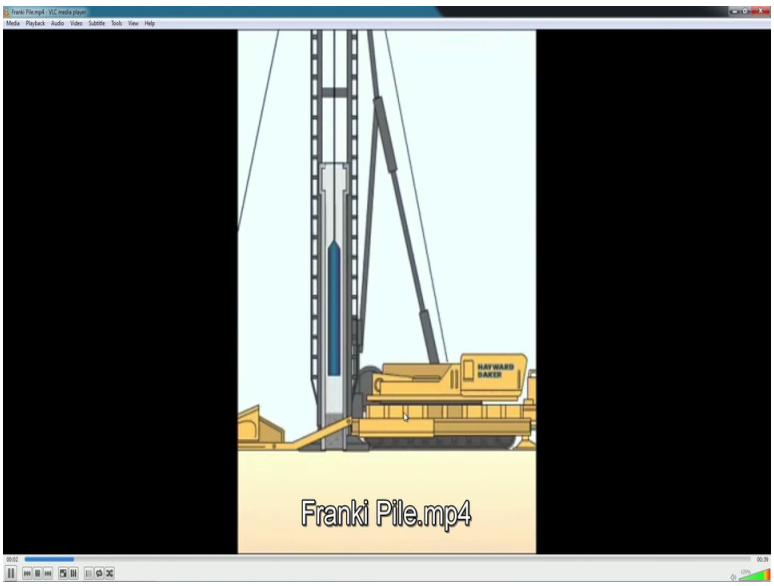

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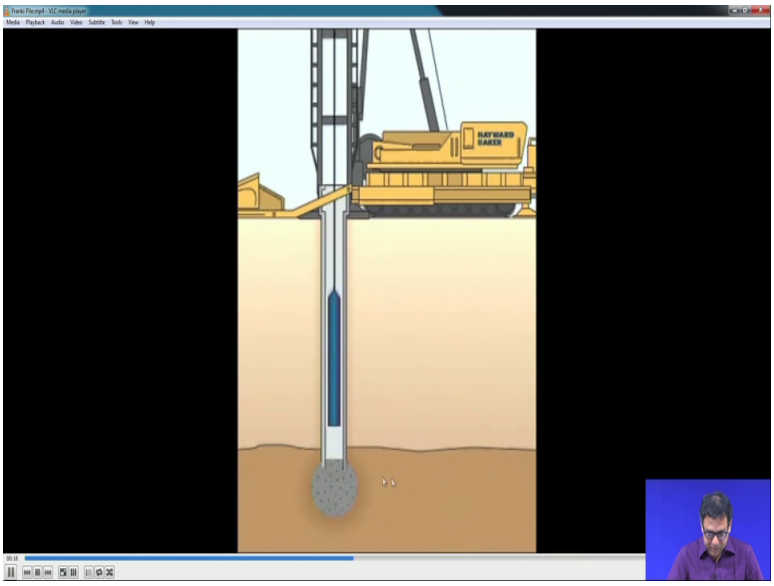

That here this is the hole is done by this driving force, then this is the enlarge base is done by this driving.

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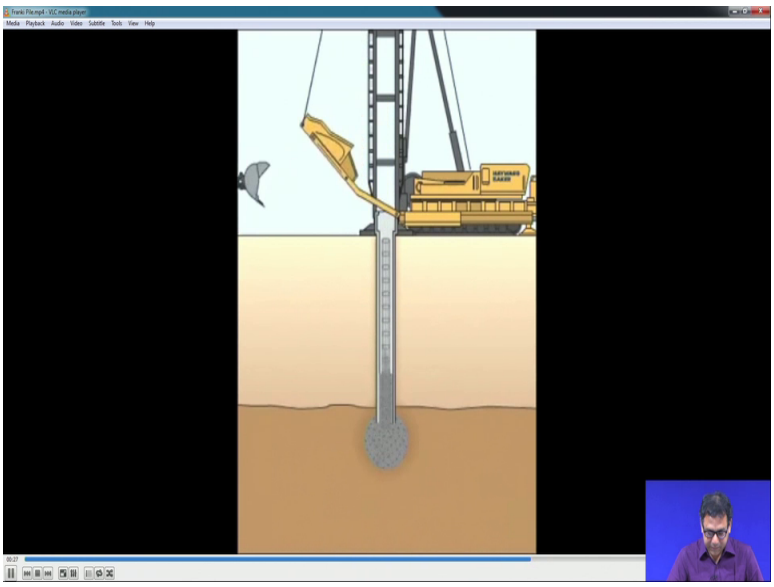

And then the casing is placed, then concrete is done, after that it is the casing is removed.

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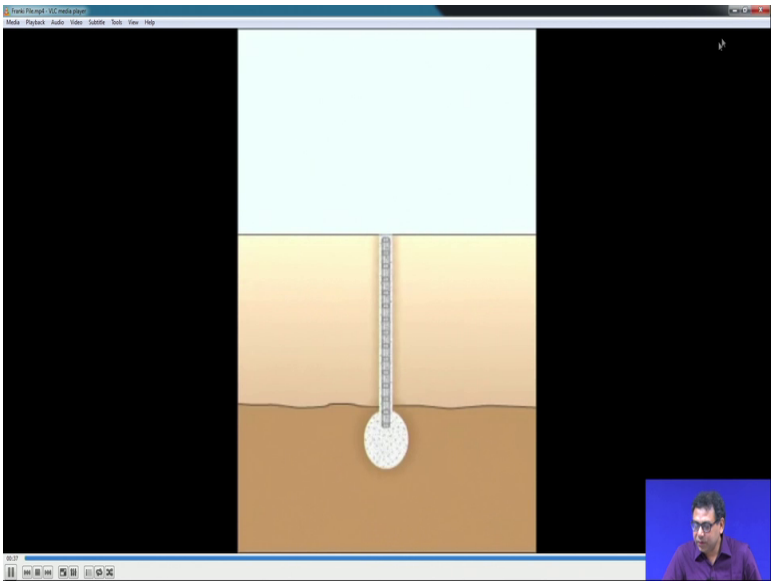

So, these are different types of piles.

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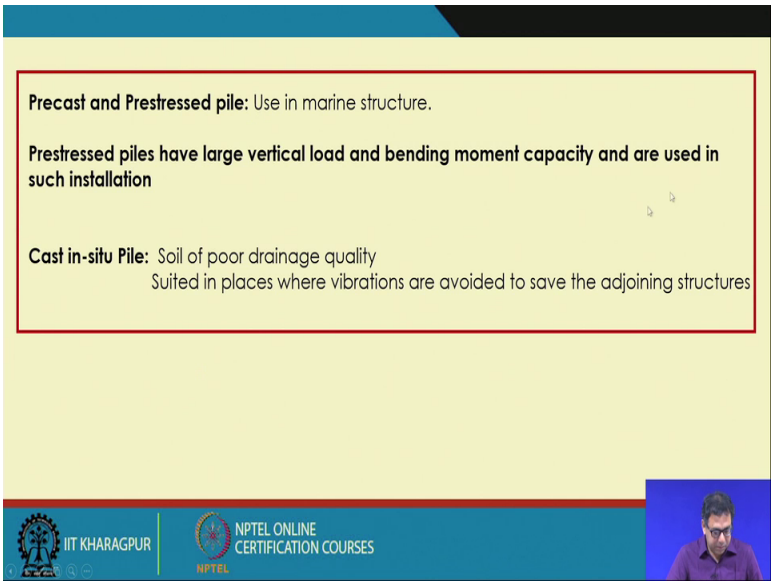

So now the precast prestressed piles are generally used for the marine structure, it is generally, is not the always, and the prestress pile have large vertical load and bending moment capacity, and which are used if this kind of requirements are there, ok.

So, because we it underprestress it can take large amount of the vertical load and then the bending moment. And cast in situ pile if the soil is in poor drainage quality, and because if the soil is (Refer Time: 15:05) soil has a poor drainage quality, then what will happen

during the driving the poor water pressure will developed, if soil has a poor drainage quality.

Now, this poor the pressure will reduce the effective stress, and that is why the strength of the soil will reduce. So, you will get a less amount of the bearing capacity of the pile. So, if the drainage quality is very poor, then cast in situ pile or is suitable driven pile or the precast piles are the driven pile because this precast pile, you have to drive into the soil so, that is not suitable. Now this is also suited when you have to avoid some vibration to save the adjacent structures. Because during the driving there will be lots of vibration. So, if you avoid those vibration or the, or noise then you have to go for the cast in situ piles, ok.

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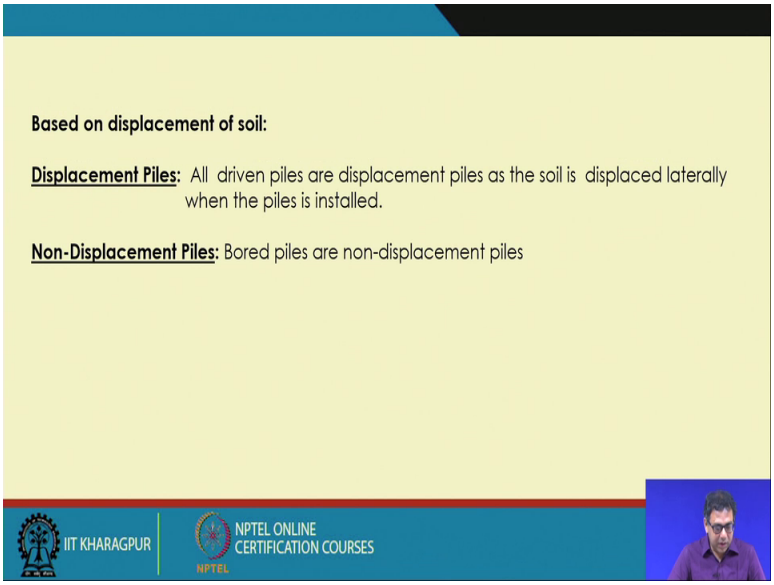

So now based on the displacement the pile has is 2 types one is the displacement piles one is the non-displacement piles. So, all driven piles are displacement piles, because as the pile is driven into the soil the soil is displaced, ok. Laterally when the pile installed, ok so that means, this soil is laterally displaced when you are installing this pile by driving. So, all the driven piles are displacement piles, and bored piles are non-displacement piles, because here you are not applying any driving so, that is why it is non displacement piles.

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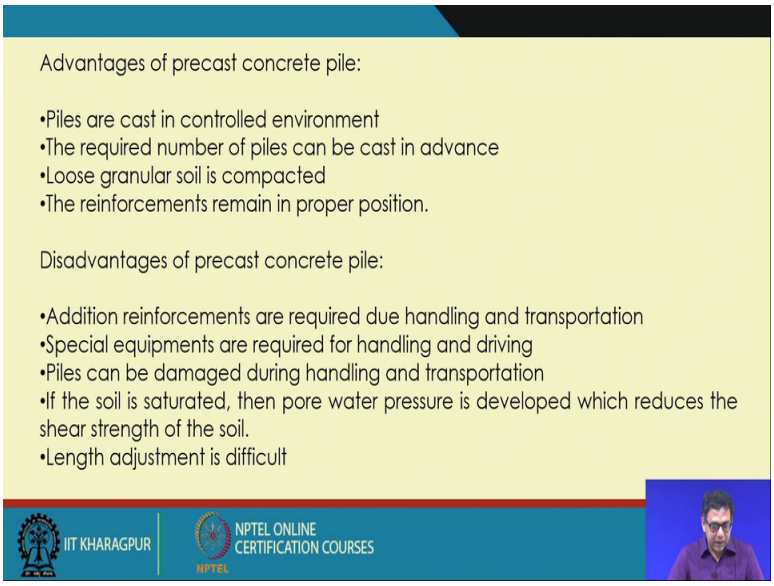

So, there is some advantages and the disadvantages of precast piles. So, has been mentioned that pile can precast prestressed and cast in situ to.

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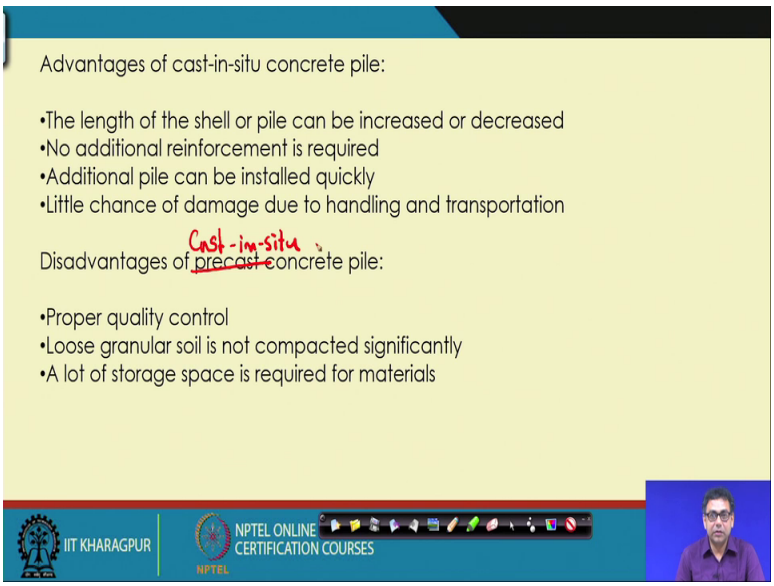

So, this is the advantages of precast concrete pile, what is the advantages? The piles are cast in controlled environment. So, you have a better quality control during the casting of the pile, and the required number of piles you can cast in advance, ok. And if the soil is loose, then driven pile if you apply the precast pile which is driven into the soil so, soil is

compacted. So, this strength of the soil increases so, you will get higher bearing capacity or load carrying capacity of the pile.

Now, reinforcement remained in proper position, because in the in the cast in situ piles, the problem is that you have to be very careful about the reinforcement, when you are doing the concreting the reinforcement position may shift. So, that problem will not be here, because it is in the controlled environment so, in the precast concrete the reinforcement remain in proper position. But the disadvantages of the precast concrete piles, that additional reinforcements are required due to the handling and transportation. What is that means that this piles are casted in the casting yard?

So, we have to transport this pile to the site. So, during the handling and the transportation a additional stress is developed in the pile, ok. Because we have to lift this piles through cranes so, we have to provide cables and then we have to lift because of the lift the additional force, or that will be induced in the reinforcement in the pile. So, additional stress is induced in the pile. So, we have to provide the additional reinforcement to take care those stresses, ok. And special requirements are required for handling and driving the piles.

Then piles can be damaged during the handling and transportation. So, during the handling and transportation there is a possibility, if you do not take the precaution is piles can be damage, and if the soil is saturated. So, as I mentioned then the all the drainage soil drainage is very poor, then the pore water pressure is developed with which reduces the shear strength of the soil ultimately the pile load capacity is reduced. So, if this type of soil is there then we will avoid this precast pile or the driven piles.

Then the length adjustment is difficult, that in the site if you found that if you found that this length of the pile is too short or to long based on your requirement, then that adjustment is very difficult, ok. So, that is these are the disadvantages of the precast concrete pile. So, this is the advantages and the disadvantages.

So, next one is the advantages of cast in situ concrete piles. Show so, that means, the length of the pile can be increased or decreased easily. So, that means, the length adjustment can be done easily, because you are casting this pile in the site, ok. So, no additional reinforcement is required because here you are not transporting this piles to the from the casting yard to the site. So, no additional reinforcement is required, because

this handling stress will not be will not be developed. So, that means, no additional reinforcement is required to take care those stresses.

Then if you found that you have to construct the additional pile, those can be done very quickly because we are casting in the site. And little chance of damage due to handling and transportation. Because as you are casting this pile in the site so, that is the little chance of damage and handling of this due to handling of this pile, ok. Then disadvantage of this is the cast in situ concrete pile. This is not the precast this is the disadvantage of cast in situ pile; this is cast in situ concrete piles.

What are the disadvantage is the because the precast piles are constructed in a controlled environment, but here that is why the quality control was very easy. But this cast in situ pile quality control is difficult. So, we have to take care to further quality control, then the you have to take care that whether during the concreting the reinforcement is properly placed or not whether there is a any shift of the reinforcement during the concreting. Or the concreting is properly compacted or not. So, those things you have to take care of this cast in situ piles.

Then if the soil is very loose, then the soil is not compacted or the compaction is not that significance as compared significant as compared to the driven pile or the precast pile. Then to provide the lots of storage space is required for the materials stored store purpose. So, these are the all advantages and disadvantages of the precast pile and the cast in situ piles.

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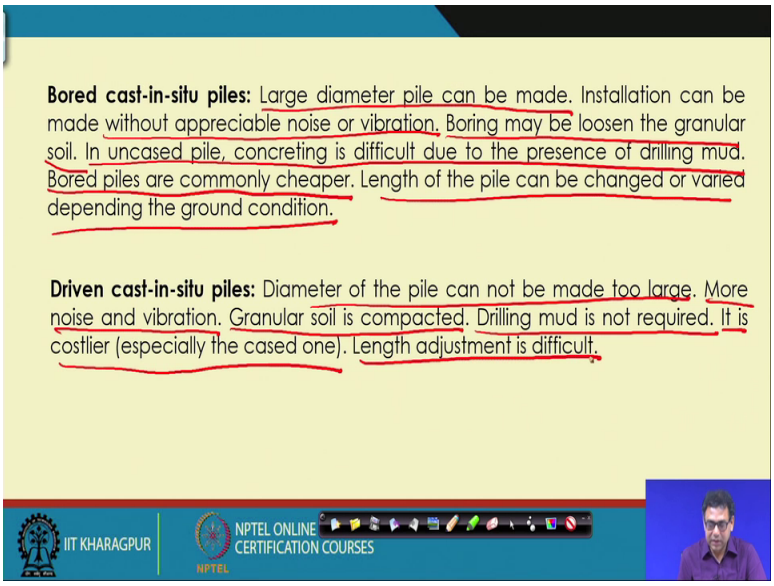

So, and then we have the even in the cast in situ pile, this can be bored or this can be driven. So, I have discussed already, so, that means, precast piles are mainly the driven piles, and the cast in situ piles can be also bored and driven cast in situ. So, what is the difference between 2 cases? That bored cast in situ piles the large diameter pile can be made, installation can be made without significant amount of noise and vibration, and boring maybe loosen the granular soil.

And for the uncased pile concreting is difficult due to the presence of drilling mud, and boring piles bored piles are commonly cheaper length of the pile can be changed or varied depending upon the ground. But on the other hand for the driven pile driven cast in situ piles the diameter of the pile cannot be made too large, but here it is large diameter is possible, but here diameter of the pile cannot be made too large.

So, this is one difference between 2 piles, then more noise and vibration are created, but here this is vibration and noise is very limited, then granular soil is compacted. So, if the soil is loose then it is been compacted, but the here the compaction is for the boring pile, the granular soil compaction is very rare. And the drilling mud is not required because it is in driven pile.

But here the drilling mud is required for uncased cast in situ pile. So, this is the differences, ok. Another one here granular of soil is compacted here the boring may be loosen the granular soil. So, here the granular soil is compact loosened here it is

compact. So, if the soil is granular soil loose granular soil is there, then the driven pile is more suitable or recommended.

Then it is costlier especially the cased one, but it is commonly cheaper, ok. And the length of the pile can be changed or varied depending upon the ground condition, but here length adjustment is very difficult, because it is already I mean driven cast in situ piles.

So, here the length so, I have also discussed for the precast piles also, that the length adjustment is very difficult. So, these are the differences between the bored cast in situ piles and driven cast in situ piles.

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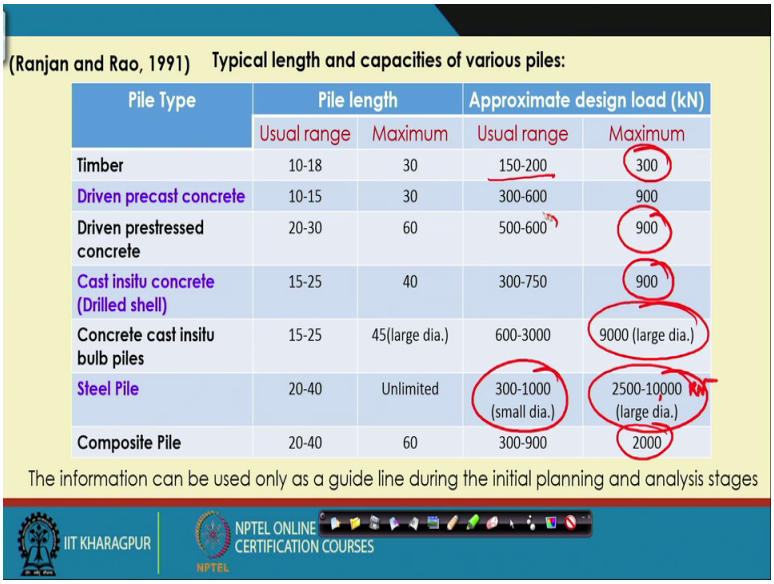

So, that is why so, I have given the all types of piles based on their shape then cross section method of installation then load sharing, then whether it is displaced or not it is not displaced, then displacement piles or non-displacement piles. Then so, I mean this is one summary. So, this is remember that this information are only for the guidelines during the initial planning, ok.

So, these are not a final value so, final value we have to calculate based on the available theories that we will discuss in the next class. So, these are timber pile so, usual range is 10 to 18 m maximum it can go to 30 m, and this is a usual range of the approximate design load and this is the maximum range of the design load. So, you can see the steel

pile, it can take higher load for the larger diameter a small diameter. So, it can take higher load up to it is can take 10 thousand kilonewton.

So, this is in kilonewton so, it can take up to 10000 kilonewton, where a timber pile can take a maximum as I mentioned, this is up to in this range 150 to 250 kilonewton, but you can take maximum 300 kilonewton. So, it is smaller further smaller load, and the composite pile also it can take up to 2000 kilonewton load, and if the concrete cast in bulb piles, bulb piles mean if the base is enlarged, then it can take for the large diameter 9000 kilonewton also.

And this is the cast in situ concrete pile. So, it is can take 900 kilonewton driven precast it also take maximum 900, kilonewton this is the probable range, ok. So, this is the driven precast pile, which is also maximum 900 and probable range is 300 to 600 km. So, this is the probable pile length, ok. So, what is the different length of the maximum length and this is the usual range that we use.

So, these are different pile driven precast driven prestressed cast in concrete and concrete cast in situ, ok. Cast in situ concrete and this is cast in situ bulb. So, here the diameter is or the base diameter is more compared to these ones. So, that means, here the uniform shift and here it is bulb, if the diameter base diameter more then will take the higher load.

So, these are the all summary of the different kinds of pile, and then as I mentioned depending upon the type of soil depending upon your site requirement you have to choose which type pile you will use, based on different maybe for different cross section for different loading. And then for the installation also which pile you will which methodology you will use during the installation. So, this is the all types of piles, I have discussed in the next class I have discuss I will discuss about the load carrying capacity of the piles, what are various methods available to determine the load carrying capacity of the pile.

Thank you.