Geotechnical Engineering II / Foundation Engineering
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Lecture - 37
Pile foundation

Good morning. Welcome again now today, I will just start a new topic that is Pile foundation. In fact, pile foundation, there will be several aspects actually. First of all how to choose first of all, we need to know when actually use we have already discussed shallow foundation where actually we can make a square, rectangle, stiff, different types of footing, we have discussed, how to design the type of foundation we have discussed and they are actually basically want to 2 meter depth. So, because of that, it is called shallow foundation.

But there is a new type of foundation we are starting now, that is pile foundation. Pile foundation is what actually this a quite long at go quite deep inside the soil. Why, actually first of all you need to know why? Because it is a expensive one connected compared to shallow foundation.

First of all, you need to know where actually need to, you will go for pile foundation, first thing. Second thing, what are the different types of pile foundation available and how to choose them and after doing that again finally, you have to design actually. How many piles are required and what would be the length what would be the diameter; that means, there is a design aspect and for that you need soil properties. And once you know the soil properties and then based on that, how to design the foundation pile foundation; that means, what is the diameter, length, etcetera that to be designed. And of course, there is a structural design part also. So, that is not very complicated.

And then, after so, that design aspect I will come later on, but initial part actually interaction type, what is pile foundation. Then, how to select and what are the situation where actually pile foundation essential, what are the differentials of types of pile foundation, all those things I will discuss first and then design aspect I will go later on.

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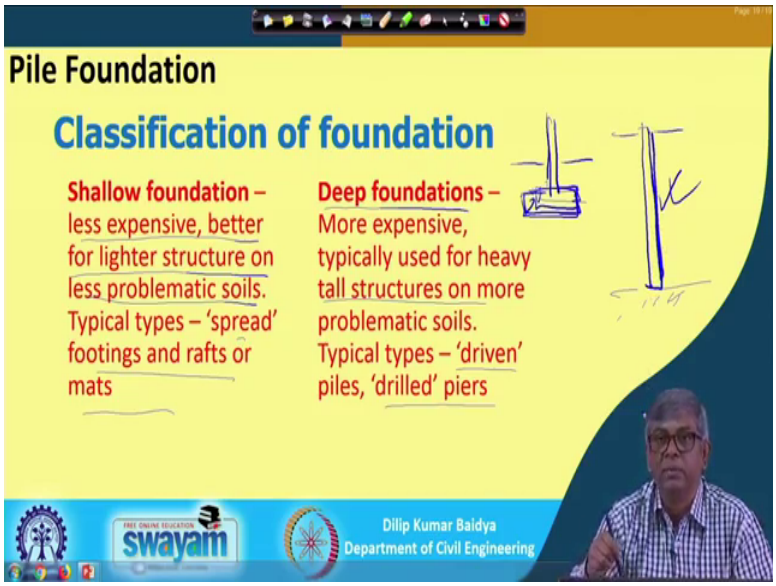

And so, first slide actually, you can see that this is the thing at the beginning also, I have done the classification of foundation. And it is divided into that is shallow sorry. And so this is actually shallow foundation is and deep foundation and that is actually you can see that shallow foundation is less expensive as I have mentioned and it is used for lighter structure and less problematic soil.

So, an typically spread footings raft, mat and all those things we have discussed before. And deep foundation is more expensive and typical used for heavy and tall structure and more problematic soil. Problematic soil means when if you build something or construct something either it will be settling too much or it fails by shear. So, they are the type of soil called problematic soil. And sometime some of the soils at the still behaviour is not completely understood and so that type of soil actually the called problematic soil.

So, deep foundation will be used mostly heavy structure and that too problematic soil. And typical pile foundation is driven pile, drilled piers and all those things that what is driven piles and drilled piers some details. We will discuss later on for the time being, we say this is actually. Shallow foundation means it will be at shallow at depth and deep foundation, suppose shallow foundation example is something like a it is like that there is a column, column is coming like this and then you will be go inside the soil and then will be spreading and the rectangular or square base. So, this is a typical shallow foundation whereas, deep foundation is it is a column like structure will go deep enough to the soil.

And either it will be resting on a very stiff or rock or sometimes without that also can be done. In that case, how to find out length etcetera, we will see later on. So, this is deep foundation. This will go quite deep inside the soil.

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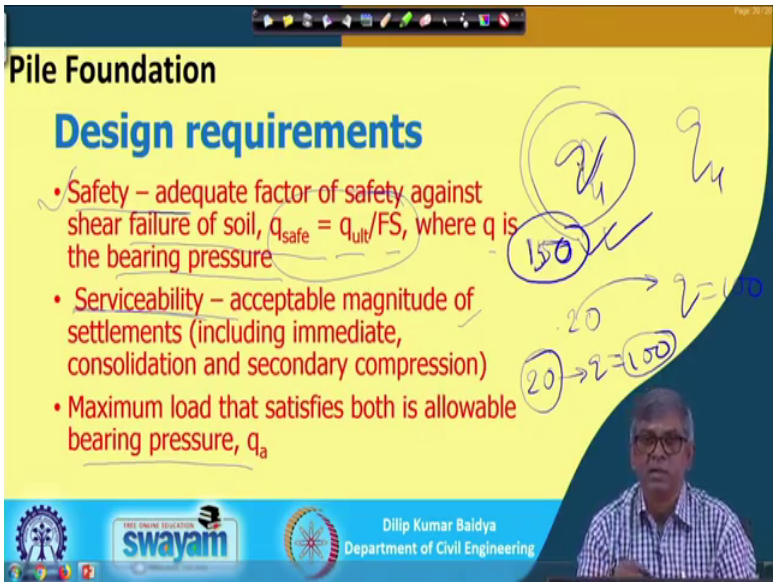

Next to let me go to the next slide and design requirement. So, design requirements actually safety is the most important part adequate factor of safety against shear failure is required. So, q ultimate required free factor of safety where q is the bearing pressure. So, in the normal soil, when you if you try with shallow foundation, if it is not able to satisfy by this, then you have to go for actually the this one. And this is actually one that is safety requirement and serviceability requirement that is means acceptable magnitude of settlements. Suppose if you built a or construct a foundation and under that if the entire structure settled too much, that is not desirable.

So that means, serviceability requirement means when you make a foundation and over that you build a structure, it settlement should be within a particular limits. So, that is the serviceability requirement and settlement actually occurs why actually we have discussed. Already, there will be compression of soil because as elastic material or sometimes consideration of the soil. So, that is the one that that is serviceability requirement and maximum load that satisfy both is allowable bearing pressure.

So, that means, so based on bearing failure, you may get some value some q based on bearing failure of criteria. You get some q value and based on settlement criteria, you

may get another value of q. And these two, I have to see smaller on will be we has to be used. If we use suppose based on settlement criteria. So, settlement limited settlement is suppose 20 millimeter, corresponding to you are getting a pressure q suppose 100 and based on shear criteria, suppose you have got 150.

So, then what we have to what we have to allow for this design? You have to use only for q equal to corresponding to q settlement criteria you got q equal to 100 and based on shear, you are getting 150. So, you have to allow only 100. Why it is so? Because, if I now put 125, then under that pressure whatever settlement will occur that will exceed this 20, so that is the reason out of the two criteria settlement and bearing failure satisfying both you have to take the, you may while satisfying, you will be getting two values and then you have to use the lesser one.

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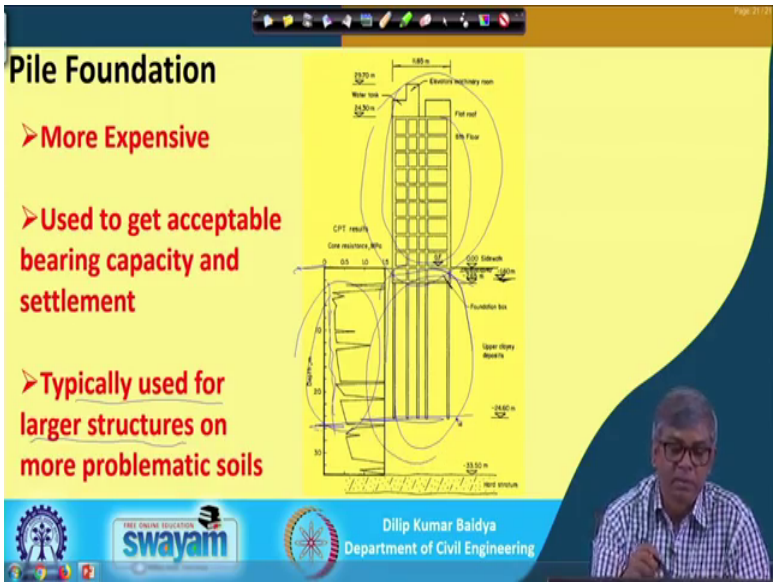

So, this is the design requirement.

Next, you can see already, I have shown perhaps that the deep foundations it is shown here you can see this is the building and this is the this is the foundation actually. And you can see it is going below 25 meter of the ground surface from the ground it is below 25 meter depth whereas; most of the shallow foundation will be within 2 meter. So, it is more because of that it will be more expensive and used to get acceptable bearing capacity and settlement. So, when by shallow foundation, we are not able to satisfy that bearing capacity and settlement.

Then, we are using this to satisfy that and it will be typically used for larger structure. You can see the huge structure, this is the multi storage. And more problematic soil may be you can see here the soil profile is shown somewhere, most of the time the soil value the properties are quite small. That strength properties is quite small. So, that means, this tall this deep foundation will be using two thing actually; one is tall and heavily loaded structure and same thing and same sometime, when the soil is problematic.

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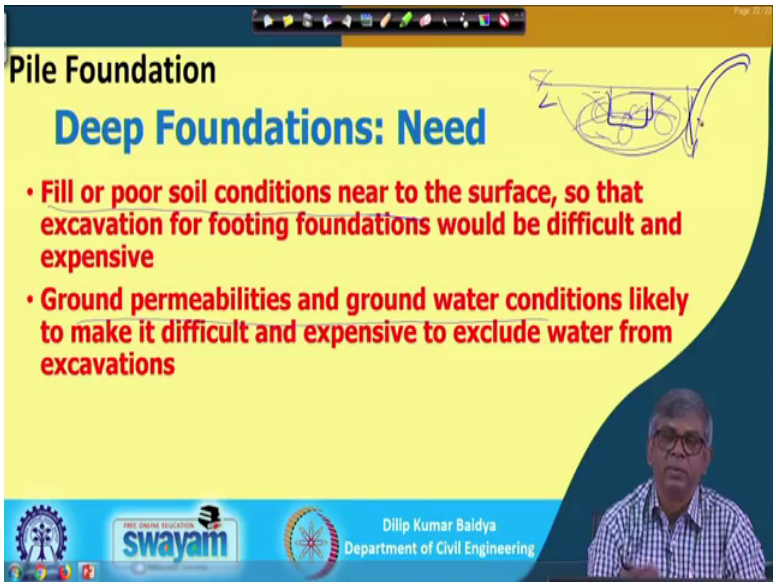

Now, deep foundation need mentioned that I will try to you have to first know why and when you need to use deep foundation. You can see one by one it is listed first point first point is here fill or poor soil condition near to the surface; that means, if there is a if this area is filled up. So, by loose soil is loose. And if you try to build anything here; that means, this soil will not be good. So; that means, fill of poor soil condition near the surface. So, the discussion for footing foundation would be difficult. So, if this is a very loose soil, if you try to excavate here, you will not get the same sometimes it will collapse and it will become say like this. So, that is the first point the soil should be stiffener and we can make excavation for shallow foundation and if you cannot do that. Then; obviously, you have to go for deep foundation that is first point.

So that means, near surface if the soil is poor loose and you cannot make proper excavation. And second part is ground permeabilities and ground water condition; that means, if the groundwater table suppose is the surface, then if you excavate here

immediately water will enter. And every time, what you have to either you have to remove water or you have to do some permanent watering system to lower the water table to make suitable for excavation. If that is the situation also, you may not use shallow foundation instead of that, you may use deep foundation. So, these are the second point.

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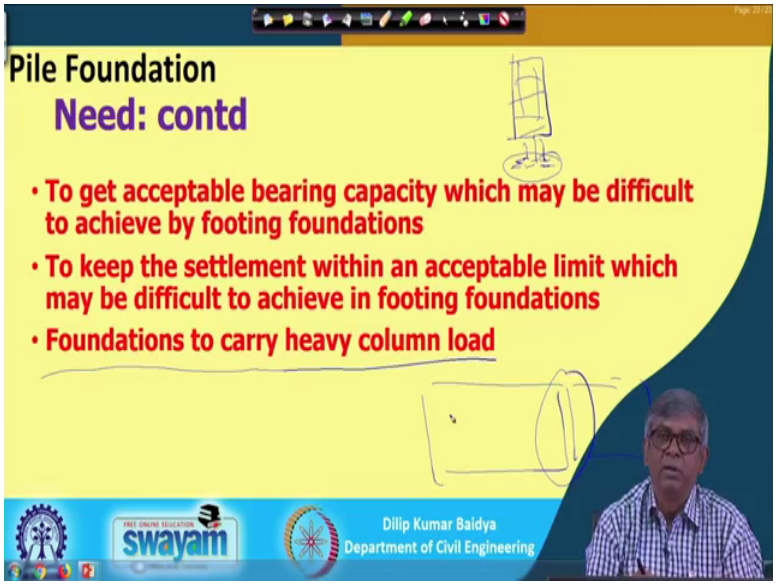

Next point is gate to get acceptable bearing capacity which may be difficult to achieve by footing foundation. Suppose as I have mentioned that for heavily or heavily loaded structure that will be very large building and suppose is the very large building and if you draw if you do some isolated footing and whatever pressure it is giving that pressure may be much bigger than the high level bearing pressure.

So that means, to acceptable bearing capacity it is, may be difficult to achieve by footing foundation; that means, this is the if this is the structure and by footing foundation will may not be able to keep the pressure within the permissible limit. In that case, you have to go for deep foundation that is already mentioned that why we use deep foundation for heavily loaded structure.

Similarly, to keep the settlement within acceptable limits, so, when suppose this is a moderately high structure and we can by using your shallow foundation still we are getting acceptable bearing capacity suppose. But if I apply that much of pressure, you may see that the settlement will be more. In that case, you will not able to apply that

much of pressure. So, the if that situation happens, then sometimes you will not be able to manage or satisfy by shallow foundation and in that case and in that case you have to go for deep foundation.

Similarly, this is a very obvious point when foundation carry heavy column load that is obvious that when heavy column load, then automatically if I use shallow foundation then footing size will be too large. And it will become so large, you may see that one footing overlaps other or there may be very close footing meniscus two footing become very close that excavation will be also will be difficult. So that means, when foundation to carry heavy column load that situation also, you have to go for deep foundation.

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Further, we can see that foundation required to take large uplift force, when there is a if there is a tall structure particularly and if there is a tall structure and if you have shallow foundation like this, during earthquake and all that this there will be some uplift. So, that means, foundation required to take large uplift forces when tension pile may be a cheaper than the providing necessary footing size with the mass to resist the uplift, so that means, in the situation where there will uplift and if there is a shallow foundation if you have to make some arrangement to resist that uplift. So, that will be sometime will be expensive instead of that filter. If you put the pile deep, then the uplift force can be very easily taken.

Similarly, foundation required to be stiffer than can be achieved with footing foundation;

that means, stiffer means whatever I have mentioned already the settlement. If the settlement is more; that means, less stiff a settlement less means it will be stiffer. So that means, shallow by shallow foundation whatever stiffness we can achieve, if you require more than that then also you have to go for deep foundation.

And then, last point perhaps the poor soil conidian when ground improvement techniques may prove, more expensive than the piles. As I have mentioned that not necessarily that when the ground conidian close the surface is poor and you have to go immediately for deep foundation what is the we have another alternative also. That is we can use there is a techniques by which actually you can improve the soil properties strength and other property comprehensibly you can reduce strength can be improves improved by there are several ground improvement techniques, we can apply them and by that we can improve it. But sometimes if it is show for or you need improvement up to such a great depth, then the ground improvement may not be beneficial. Instead of that, if we use pile foundation may be beneficial. So, that is another point actually why we need deep foundation.

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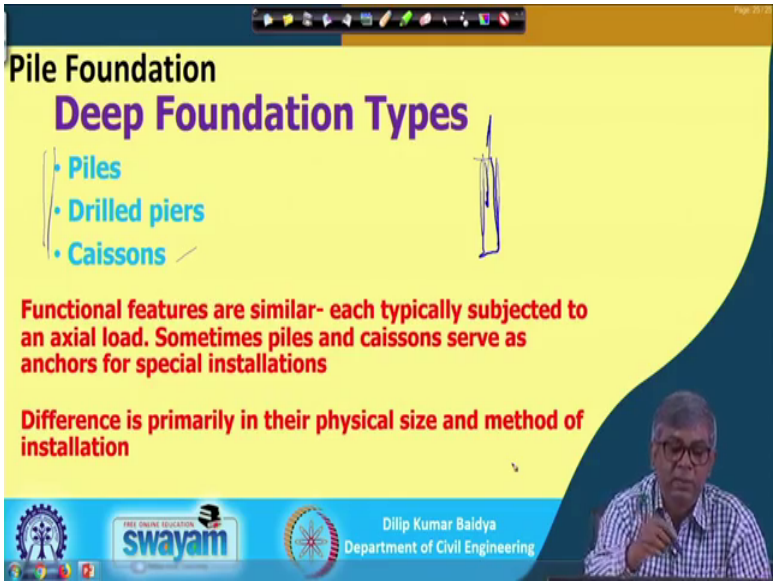

So, these are all different points we have discussed. Now, once if you know that that is only option that you have to go for deep foundation, then you have to look for what are the different types of deep foundation foundations are available. So, for that you can see that deep foundation class can be classified as pile piles, drilled piers and caissons. And

they are almost similar only by some way they are little different and sometime the some are larger diameter, some are smaller diameter like that and caissons is totally different generally it is a large diameter like a short column, actually it works. So, we will see that what are the difference functionally.

The functionally functional features are similar for each of the whether it is pile or drilled piers or caisson. Most of the time that take compressive load and each typically subjected to an axial load that may not necessarily tension may be uplift also. So, there will be axial load. Most of the time, will be axial load. So, if this is a pile. So, either it will be this way or it will be this way sometimes piles and caissons serves as anchors for special installations. So, not only a compressive load and sometime, it can be taken tension as I have mentioned and difference is primarily in their typical size and method of installation how we install. That is the only difference, otherwise the functionally they are similar.

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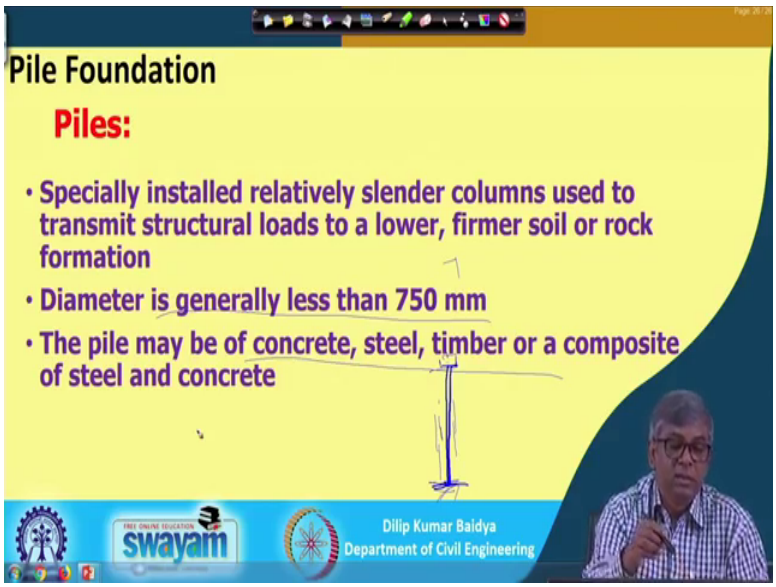

And so pile is especially installed vertically, relatively especially installed relatively slender columns used to transmit structural load to a lower former soil or rock foundation; that means, when you think about a pile, it will be compared to the lateral dimension length will be quite long L by D is very high. That is one thing, slender column like and second thing it transmit structural load. That means, the over the pile, there will be foundation and this foundation the load from the structure will come to this

and then through this load, through this pile it will be transfer to this deeper soil so; that means, that is transfer the load to a lower firmer soil or rock. So, some time it will be here sometime throughout the depth also, transfer the load. So, that I will discuss when we will talk in pile, again different types of pile there is a friction pile or protein pile or end bearing pile that I will discuss.

So, in general that structural load you have to transfer through the pile to a deeper and stiffer and firmer layer. That is one thing and diameter is generally within 750 millimeter and the pile may be of concrete steel there are based on material, it can be concrete pile, it can be steel pile, it can be timber pile or it can be mixer of one or two materials or two or more material that is composites are materials. So, this is about pile.

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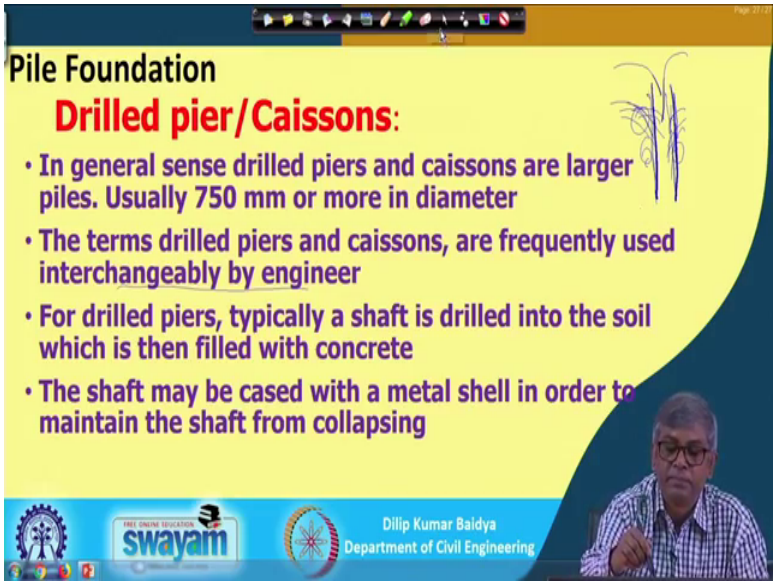

And drilled piers and caissons, they are almost similar. Actually, you can see in general drilled piers and caissons are larger piles large diameter piles and usually 750 millimeter or more in diameter. They can be called the pile also. Functionally, almost similar, sometime we will classify that as a drilled piers because pile most of the time. Sometime different types of piles are there you can directly by hammering when penetrate we can make a drill and in situ contraction we can do. So, there are different ways.

But drilled piers means, it will always you have to drill the holes initially and then you have to install the pile. So, that is the thing. Otherwise, they are almost similar and this is when it is a pile, it can be either drilled or it can be driven. Whereas, when it is a drilled

piers and large that is one condition is large diameter and second condition it has to be drilled first and then pile will be constructed.

So, in general and the terms drilled piers and caissons are frequently interchangeably by used by engineer; that means drilled pier and caisson almost similar. For drilled piers, typically a shaft is drilled into the soil which is then filled with concrete and soft may be cased and uncase; that means, when you make a drill here drill at the at the are the in that inside soil, depending upon of soil type sometime you have to make a casing.

What is the purpose of casing? Actually when you put the concrete through these it will be giving you proper shape one thing. And another thing is while make drill hole sometime the wall will be collapsing. When it collapsed, the wall then sometime will not get the desired diameter of the pile. So, to prevent that we have to casing we have to use particularly close to the surface up to some depth you have to use the casing and the shaft may be cased with a metal shell in order to maintain the shaft from a collapsing. That is the what I have mentioned already that the when you make a drill hole that soil if it is not a good soil then immediately making the bore well soil may come inside the hole and it fill it up. So, to prevent that, you can make the casing.

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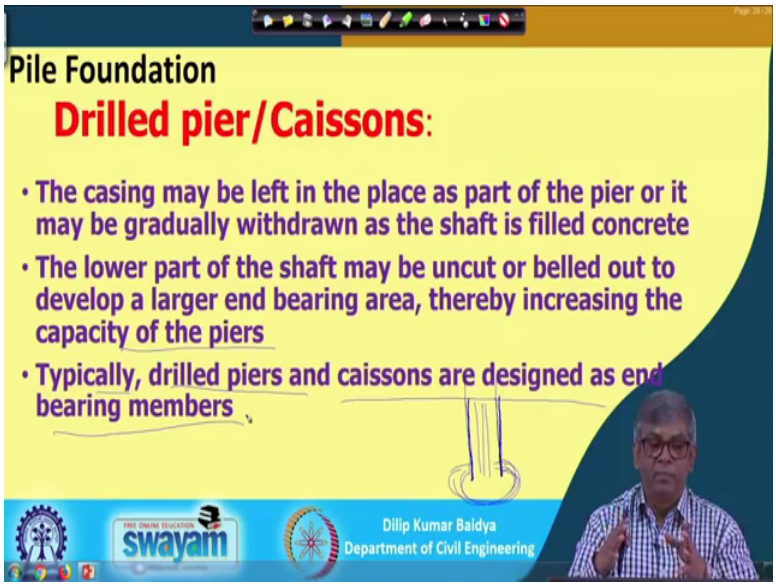

And the casing may be left in the place also as part of the pier are sorry and it may be it may be gradually withdrawn as the shaft is filled with concrete.

So, as I have mentioned that when you make a this is the casing and when you fill the concrete, sometime it can be kept as it is or sometime when after pouring the concrete, it can be lifted. That is the one and the lower part of the shaft may be uncut or build out to develop larger in bearing area. So, this drilled pier and caisson, most of the time this at the bottom may be enlarge. If you have the enlarge you will have more bearing capacity actually, thereby increasing the capacity of the piles typically drilled piers and caissons are designed as end bearing.

So, as I have mentioned drilled piers, caisson and pile they are almost similar but drilled piers and caisson they are generally large diameter and again and both the cases you have to first make the hole and then you have to make the structure are the piers. And while making this one, you can make uncased or cased and again after completing the construction you can remove the casing or sometimes you can lip the casing as it is. And also, while doing this construction at end can be sometime enlarged also, different shape of the bottom can be made to increase the capacity. So, that is and most of the times this drilled pier and caisson will be used as a end bearing.

Whereas, a pile normally it can be end bearing but it can friction, it can be combination of both friction and end bearing that details, I will discuss later on.

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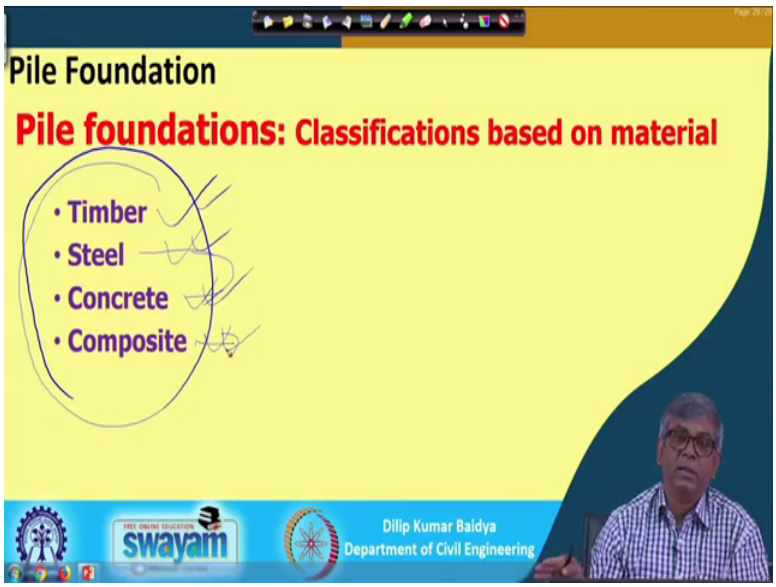

And once, if you know that based on your structural condition, what type of pile you require whether you required piers and caisson that is actually generally required for the

bridge foundation. Whereas, pile most of the time it is required for a buildings and once you know that that whether it is requirement is pile or caisson or piers, then after knowing that, again we can go for design. But pier and caisson, we will not discuss much. Actually, we will discuss in detail about the pile.

Now, pile foundation, again once you decide that you have to go for pile foundation, then you have to see what are the different types of pile. That pile classification can be based on material first and if you classify the based on material that you will had it can be mentioned as a timber pile, it can be mentioned as a steel pile, it can be mentioned as a concrete pile, it can be mentioned as a composite pile. And again, since we have different types where you will use timber pile, where you will use steel pile, where you will use concrete pile, where you will composite pile, there will be some criteria to be so known. And so, to choose that, you need to know that timber pile what should be the diameter, what should be the length. So, that sometime give you the limitations that you cannot use particular area.

Similarly, steel pile if it is a steel pile, then what should be the length, what should be the diameter or what should be the cross section, what is the length, length is the most important actually, how much length we can go for with particular material. So, based on that, sometime some material will be limited to some length. So, similarly concrete, what is similarly composite, what are different? So, some material again you have to where you are constructing the pile that you have to know and again maybe if there is a particular area where timber may not be suitable. Because of some environmental condition, that timber will be spoiled quickly. Similarly, that may be some environment where steel may be corroded quickly. So, we will not able to use that. Like that, several things are there, what based on materials we would need to know what would be the length, maximum length you can achieve by different materials.

Then, you have to know the environmental condition, based on that you have to some material may not be suitable some material may be suitable. So, accordingly, so out of these different material though available in your choice, then you have to finally, decide an particular material. And most of the time, actually in a large construction either steel or concrete most of the time will be uses and sometime timber are used for a small work. And sometime composite also will be used in some application. So, like that based material, I have given the classification. Similarly, based on installation process, based

on function, there are what function it is carrying out the particular pile; based on that also, you can classify. So, those classification again, I will do in the may be subsequent lecture. So, today I will stop here with this I will today.

Thank you.