Lecture - 41
Pile foundation (Contd.)

Let me continue with Pile foundation once again and this is now we have discussed about various aspect of pile foundation and then how to find out the pile capacity of a single pile and either it is driven in sand or clay. And then of course, I could have taken few numerical problem, but I will take maybe after one or two classes some problem related to estimation of capacity pile capacity both in sand and clay I will take two problems.

It will be clarify your if there is any doubt further. And now we have shown that we have calculated or you have shown the process or method for estimating the capacity of the single pile. But if you see of course, in a problem and the field actually it will be not a single pile most of the times it will be in a group and so, how to find out the group capacity that I will also this discuss later on.

Before going to that I will take another topic that is actually pile load test. Because when you are estimating a capacity of a pile and group also, they are also dependent on the capacity of single pile. So, single pile to group pile when I will go that actually I can find out some I can discuss some method and I can show you later on.

But when I will assess or estimate the single pile capacity based on some theory that is whatever we have discussed actually that is based on theory. And that whatever value of theory, we have got based on theory whether that to be used or not whether is it is different from that actually has to be tested in the field. So, because of that most of the time in any project few at least one pile load test will be carried out.

So; that means, that pile load test means it is actually a test pile is what actually test pile. Most of the time when you carry out some test that is for testing purpose only, but here actually one pile actually in any pile it is very much expensive. Construction a pile actually quite expensive because of that only for test we never do.

Most out I what we will do. One of the designed pile itself would try to test and confirm whether whatever we have done analysis we have whether it is correct or not. So, for that we do pile load test and the test we on which we carry out the test that is called test pile. And as I have mentioned that for testing purpose most of the time we do separate, but the test pile here is one of the designed pile itself ok.

So, this is not a separate one after test it will be lying there and that it will be used for the actual construction also. So, that testing procedure etcetera and how to calculate, how to estimate the ultimate capacity etcetera that actually I will try to discuss through this module.

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So, let me see whatever I have some of the information I have given you for you one and sometime more than one for bigger project as I have mentioned here of the design piles on which load test are carried out. Normally piles are design designed initially by analytic or other methods based on estimated load and soil characteristics.
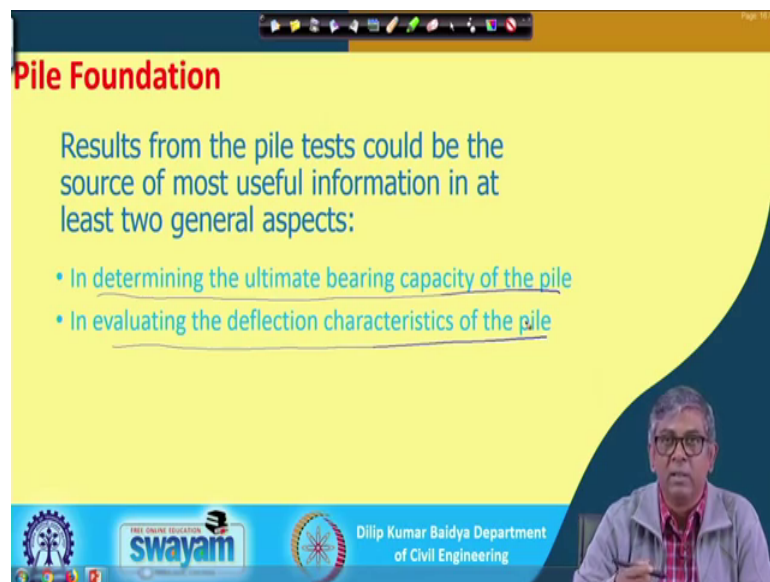
So, pile load test are performed on a test pile during the design stage to check the design capacity. As I have told you that we have we are carrying out the soil test and base based on that we estimate we take a typical soil value and then assume some diameter assume some length. And based on that we calculate the capacity of the pile and then based on the loading in the building how many piles required etcetera we design. But while doing

that to check we generally one or two piles, we will crust actually in the designated process.

Suppose I have a area suppose here and these are the pile location like this number of pile locations are like this. So, like this suppose there are number of piles located so, this is the actual location of pile. So, we will initially drive a one or more than one somebody if it is required suppose these are actual location and that pile to be tested. And if you find that during testing if you find whatever estimated capacity you have taken and it is coming less, then what you have to do?

What you have to re design actually you have to this test value to be taken as a granted not the design value analytical value. So, and if it is if the capacity comes much higher than that whatever you have taken that time also one can if they you; if they decide they can also reduce the size or length to make it economic, so, both way. So, and if it comes of course, more capacity comes more generally good it will be safe, but it comes less; obviously, you have to redesign there is no other alternative.

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So, next slide let me go to. So, results from the pile load test could be the source of most useful information into at least two general aspect. So, when you do the pile load test we get two important things, other than that many other things we get which will be I will discuss. You can see fast what is the thing, we get the ultimate bearing capacity we get

and we get deflection characteristic of the pile how much it will deflect. So, that is also this two things important thing we get from the pile load test.

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And then in addition to that as I just with regard to the ultimate bearing capacity on expected settlement, one may reflect on several additional and tangential benefits. So, while doing this suppose a pile estimated deflection is much small, but when you are testing that deflecting is too much. That means, we will get some indication about the site condition. So, that is the thing, so, some additional some additional and tangential benefits we get while doing these test.

For example, if the capacity of the pile is different r settlement is excessive from that desired the pile length diameter and details of installation can be adjusted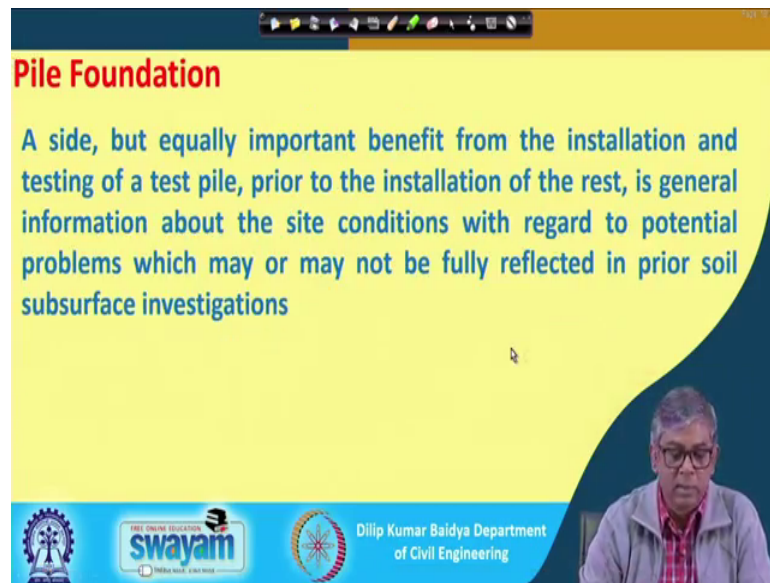 prior to the installation of the rest of the piles. So, that means, while doing test if I see this is the obvious for example it is given by see then; obviously, either we have to change the diameter or you have to change the length or have to change the installation method. So, these are the things you have to modify in the design stage design and construction stages.

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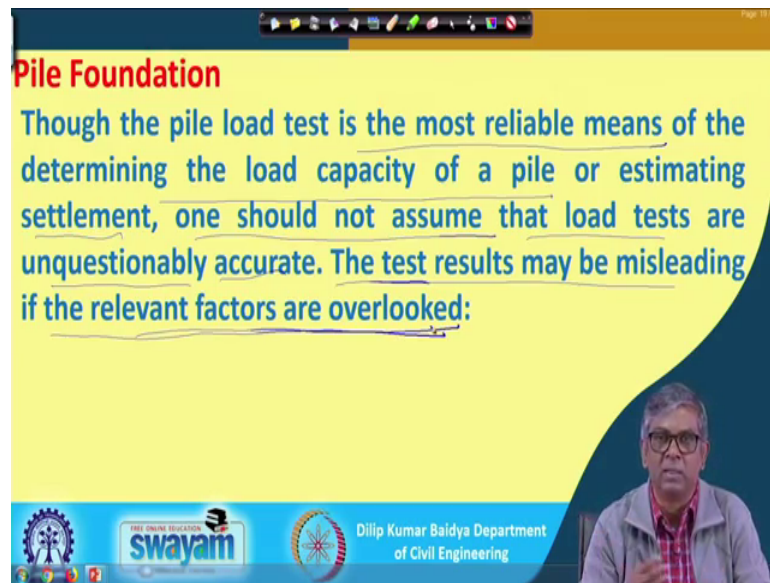Then and a site a; that means, some tangential benefit what are the important tangential benefit we get. Important benefit from the installation and testing of test pile prior to the installation of the rest is general information about the site condition with regard to the potential problem which may or may not be fully reflected in the prior soil surface subsurface investigation. So; that means, while driving the pile or while constructing the pile, you will get again that stratification and if you use when driven pile then how some depth actually going very easily some depth is going very difficult with great difficulty.

So, from those things actually we will get some additional information and you have to see that information whether is matching with the subsurface investigation report. If it is not matched, then you have to see carefully and if necessary you have to re examine or re investigate the site to get the proper site condition.

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And another thing is we as I have mentioned that I have to give most imp more importance to the pile load test. I have I get some value from the analytical method, I get some value from the test and I have told that test value to be relied most.

But most of sometime this value should not be taken granted until unless you follow certain things; that means, here without questioning this value to be not should not be taken that is what it is I have given a statement you can see that though the pile load test is the most reliable means of the determining the load capacity of a pile or estimating settlement. One should not assume that the load test are unquestionably accurate; that means, this is only when it will be accurate only when you follow certain condition see the rest test results may be misleading if the relevant factors are overlook.

What are those relevant factors ok? So, those relevant factors I will discuss one by one. That means if you follow standard procedure and then some relevant factors if you take care and based on that if you estimate the capacity or settlement, then only it will be taken granted. Otherwise if there is a mismatch actual condition and test condition, then it cannot be taken only for guidance you may use, but that cannot be used as a designed value. So, what are those factors to be seen?

Let me give you one by one slide. For example, first thing is time lapse should be provided between the time of installation and time of test loading; that means, when we uninstall and immediately. If you test what during installations pile will be disturbed and all those things will happen and because of that you will not get the correct picture.

So, for see here actually it is mentioned that the time lengths is important and what is the minimum 3 to 4 days for granular stratum and about a month for clay soil; that means, in the clay soil if you derive a pile you have to test after at least 1 month, because the clay should regained the quotation with the pile. This is the time normally required for respective soils to re gain the strength lost during the driving operation ok.

And in the case of concrete piles, minimum time is also required to develop material strength that if it is a concert pile is used, then at least 28 days again you have to wait because to get the full strength of the concrete. So, these are the things; that means, you drive a pile and immediately testing it is totally misleading because depending upon soil type if the sand at least it required 3 4 days to get the full strength whatever it was there and whatever used in the analysis.

Similarly, it will require almost 1 month to regain the strength for clay whatever you have used in the design and what if it is disturbed during the driven driving.

So, that the disturbance of soil that point actually you need to wait 3-4 days for sand and 1 month for clay where as if you use a concrete pile again another condition that you require 28 days for to get the strength of the structural members; that means, concrete pile.

So, these are the one thing and that is most important the time lapse. That is important if you do not give then that results is no use and then specific location for the installation and subsequent testing of the pile must be representative of oral site if the test results are to be represented if of the rest of the piles.

That means, I have a big area and then if I use a very strong point area what point where which actually soil condition is very strong. And then based on that whatever you value you are getting and if you use that one is this design that is not correct because you are using higher value than many other places having less instead of that what we can do comparatively we cause put area to be selected there actually pile has to be tested and that value whatever we in get minimum value and many sides in many places will be having capacity more than that.

So, if we use that it will be safer. So, that is why it is common practice on the part of the engineering engineers to select the most unfavorable condition of the soil. That means, when it is a big site outer the big site, you have to choose one site where actually most unfavorable that mean shop or maybe there is a wires or something we have observed in the during the site investigation that site should be selected and if you get the value reasonable value that value to be used for the rest of the pile. Then that is the instead of that if you select a site where the soil is very strong and then if you test it and then value that value if you compare that is not correct. So, that has to be kept in mind.

Similarly, the pile characteristics that such as length, diameter, installation method installation method most closely resemble those of the piles to be installed. That means, I have designed a cast in place bored cast in pile, but I have while testing I have done a driven pile tested a driven pile, it is not correct. So, that is why diameter whatever diameter you have used same diameter has to be there whatever diameter used in the design that same whatever length is used same length has to be there, then construction method should be same. And then if you test whatever result will get that should be represented in to the rest of the one.

So, like for example, as I have mentioned that you have you have entire project you have used somewhat driven pile, but you are doing a pile test on a board cast in there are cast in pile that is not represented in. So, this three these are the points to we remember let us let us see next.

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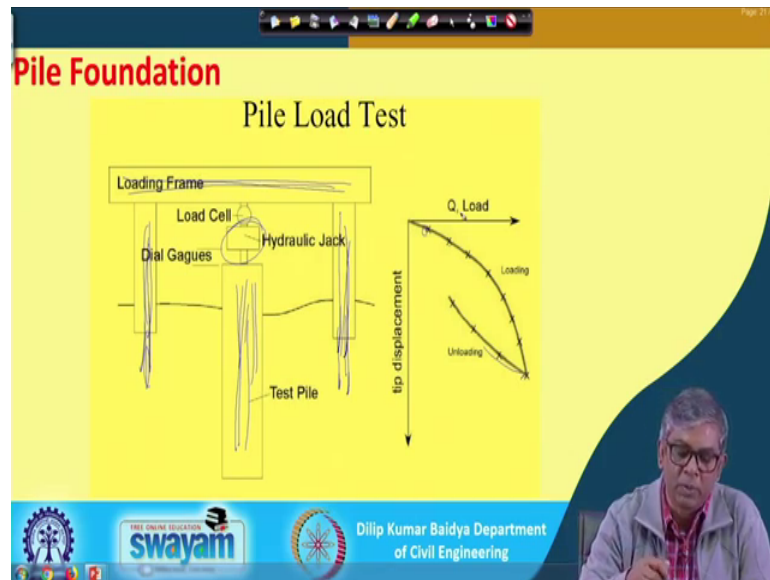
So, how to do the pile load test? There are two different ways pile load test can be done you can see here. There will be initially two anchors will be made in the ground initially and then there will be loading frame will be there and pile will be here and from here hydraulic jack. This is actually inside the ground its anchor and through hydraulic jack this loading frame ready rosy loading frame and through that load will be applied.

And because of this loading so, this thing will be will settle and then load settlement. So, you have to use if the ultimate value of the 25 percent or even less in the steps of 25 percent of the designed load to be applied and double the design load up to double the designed load pile has to be tested of different code. Of course, different way it is explained. So, I have at least you have to go beyond the design load ok. So, they like that and whatever designed load it has to be divided into whatever a test ultimate value that has to be divided 8 parts and that means, 25 percent each.

So, one point actually here like that you will go after the full loading then after full loading actually you have to unload it and you have to see how it is going to get the actually net settlement. That is there will be so, unload is the rebound will be there and if

you subtract the rebound, then will get the net settlement. And net settlement is the indication of the characteristics of the pile and capacity of the pile.

So, this is one way; that means, two anchor pile will be made number of anchor pile and then over that there will be loading frame and below from the pile at the loading frame that hydraulic jack will be there through that load will be applied. And after load applied, you have to keep settlement grace actually dial gauge and from where actually you have to keep more than 100000 dial gauge actually may be around 3 to 4.

And average of those to be taken as a actual deformation and then load versus tip displacement to be plotted and from there are different ways we can find out the ultimate capacity that I will discuss later on. So, this is one way of load to load test.

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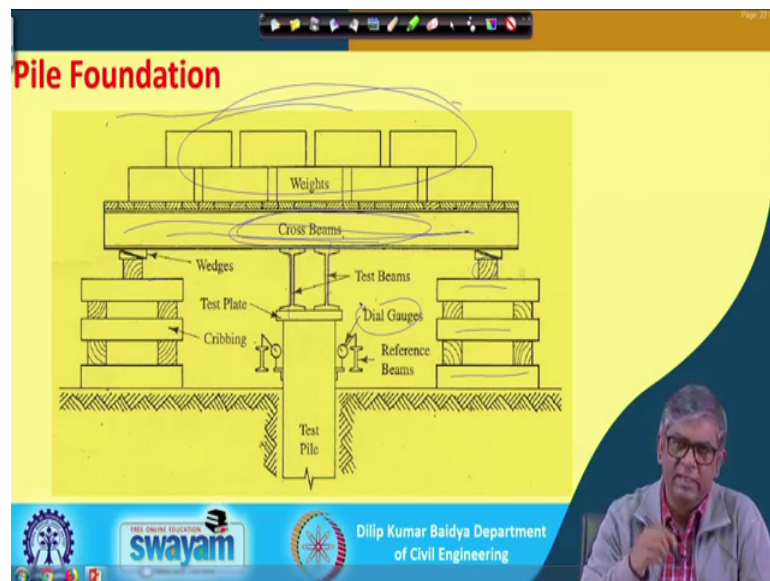
Second way of load testing second method of it is something like this. You can see this is the pile and on that pile there will be number of beams and cross beams will be there it will be reaches up to this. And then there will be some again there will be beam and on that cross beam will be applied here and between this there will be loading will be applied to and it will be supported by this.

And that means, load should not come on this actually this two. So, it will be supported; it will be supported by this two by this beam. And now on this above this; above this that you can add load by at the form of some sand bag and other things. And this load will be

suppose 25 percent load will be applied, then 50 percent, 75 percent, 100 percent, 125 percent, 150 percent like that. In stages there are by sand bag or by other mechanism load will be applied over this and then corresponding settlement through this gauge dial gauges.

The dial gauges are there all around and from there actually deformation to be observed. So, finally, load settlement curve will be plotted and from there one can find out the net settlement and from there one can find out the capacity of pile.

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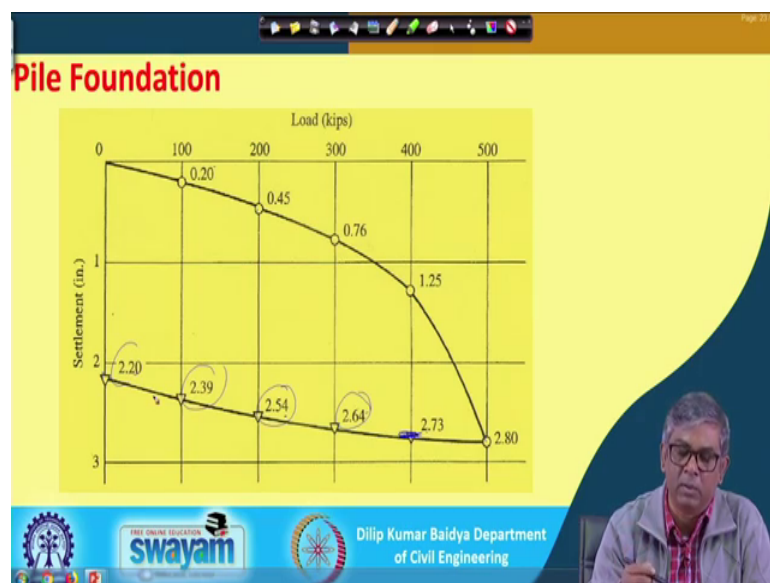
 And you can see typical load settlement curve and rebound very properly conducted test it will be like this. Actually you can see here load is applied actually 100 kips actually 100 kips you have to 1000 pounds actually. And then this is this one 200 thermo 2000 3000 so, like that pounds load are applied and just gone up to this and then load is applied removed. That means, it has gone up to 500 and then it is reduced 400. The way load is increased a similar way in step as load will be reduced and then you will get another smooth curve.

And then you can see at this level actually you can how you can find out the rebound? This was the actual. So, re actually after reloading at 400 this is 2.73 there and if I re there is no load it is this value 2.20. So, rebound actually 2.73 minus 2.20 for 400 load. Similarly 300 load rebound is 2.64 minus 2.0.

So, 200 load rebound is 2.2 2.54 minus 2.2 and 100 actually what is the rebound 2.39 minus 2.20. So, like that we can find out the rebound and from there actually we can find out the net settlement and then different recommendation given in the different code based on that net settlement versus your load ultimate load can be estimated.

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And you can see I will go to the next slide and you can show you in the tabular form and you can see here. If I go back to that I already I have shown and you can see this is hundred kips and if you turn if you think, then it is 50 ton actually. And you can see gross settlement was a 0.2 if I look at the curve initial curve. So, it was like this. So, gross was corresponded to 0.2 and rebound actually what actually when it is coming back from here from coming from here; coming back from here difference between this and this actually is a rebound.

(Refer Time: 21:40) So, it was 2.39 here, it has 2.2 2.3 minus 2. So, rebound is 0.19 and gross was 0.2 rebound was 0.19. So, actually what is the net settlement? So, net settlement is even rebound means that was elastic, but overall because of the loading how much pile is settling that is actually 0.2 minus rebound that is 0.19 0.01 and that is a range. Similarly when is a 50 100 ton load, then actually gross settlement was when it 100 gross settlement was 0.45.

If I go back to previous one and at this stage was actually 2.54 and here it was 2.2. So, 2.54 minus 2.2 that is rebound was 0.34. So, actually net settlement is 0.45 minus 0.3 4,

so, it will be 0.11. Similarly if it is 150 so, suppose here and that was a loading. So, there was gross was 0.76 and at this point when a rebound we are going on, here actually it was 2.64. So, net was net settlements 2.64 minus 2.20. See the 0.4 4. So, net settlement was 0.76 minus 0.4 4 that is a 0.32. So, like that we can find out that different places different net settlement and in the code actually is recommended that the load corresponding to maximum net settlement allowed is suppose 0.75 inch or 0.5 inch like that it is mentioned and you can see every where it is less than that.

So, if it is mentioned suppose a 0.75 is the limiting. So, 0.75 inch is your limiting settlement net settlement and you can see at this loading, it is less than 0.75 whereas, that this loading it is more than 0.75. So; that means, we cannot take this as a design load and it is very close to this so and even less. So, because of that I can consider 200 as ultimate load.

So, ultimate load Q ultimate will be taken as 200. So, Q allowable will be taken as 200 divided by 2; that means, 100 kilometer. If it is mentioned that your ultimate net settlement or net settlement is suppose 0.5 inch. And you can look at this table actually this when you in that case this loading also will be more than the producing more settlement than the recommended.

So, if you go to next one you can see 0.32 net settlement is 0.32 and corresponding load is 150. So, if the restricted settlement or net settlement is recommend is 0.5 is the minimum, then corresponding so, you can see from this test the minimum one here actually its 46 producing 0.32 inch settlement corresponding to 150 ton load. So, I can say Q ultimate approximately I can take 150 and Q allowable will be equal to 150 divided by 75 kilometer.

So, different code will have different recommendation accordingly net settlement calculation process I have shown. Now based on given value you have to compare and we will be what about the limiting value lesser than that of course, they are also less. So, will not consider, it has to be close to that and based on that I can find out the ultimate or allowable load. Now sometime or sometime actually that is another method load versus settlement curve also will be drawn like this or like this and then they drawn double tangent initial tangent and final tangent and from there, it will be produced here and then

it will go back here that point actually consider also as a ultimate load. So, that become ultimate load.

So, if you divide by 2, then it will become allowable load. So, like that in the code actually you have different methods or that is called double tangent which I am not discussed, but this is another method that is net settlement. How to estimate the net settlement I have shown and then what is the recommended value of net settlement permitted and you have to see the net settlement option for different loading which is the close to that actual loading that can be taken as ultimate load and divided by the desired factor of safety, you can find out the allowable load ok.

So, this is the way and sometime in some code it is mentioned double tangent method the load settlement curve if you plot something like that if you plot then it will be something like that. So, initial portion of the curve you have to draw e another tangent on tangent, final portion of the curve we draw another tangent and produce it to the first tangent and they will intersect somewhere and that point actually produce vertically in the axis. The loading axis that load will be Q ultimate and Q ultimate divided by factor of safety that gives you Q allowable design Q design.

So, this is also; that means, how to do carry out part pile load test, what is the importance of pile load test, during pile load test what are the additional information we get and then how to utilize the pile load test to estimate the capacity or design capacity of the pile all those things are discussed through this.

With this I will stop here.

Thank you.