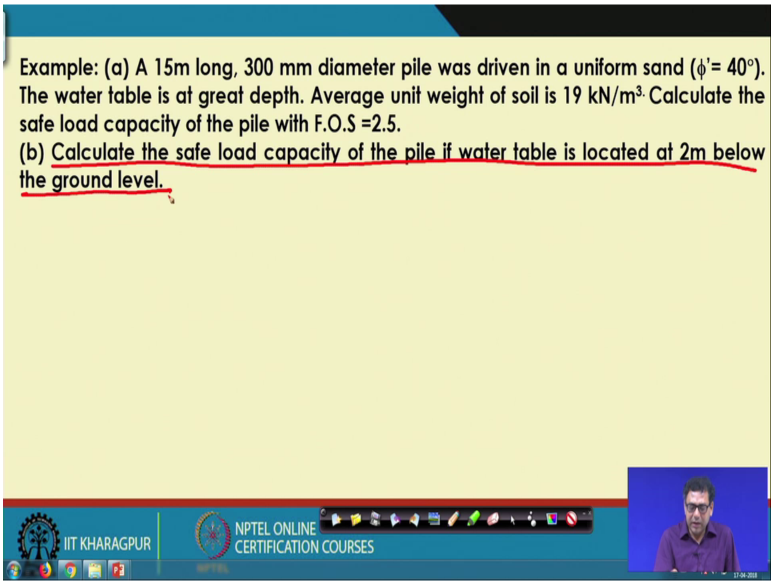
Foundation Engineering
Prof. Kousik Deb
Department of Civil Engineering
Indian Institute of Technology, Kharagpur

Lecture - 31
Pile Foundation - V

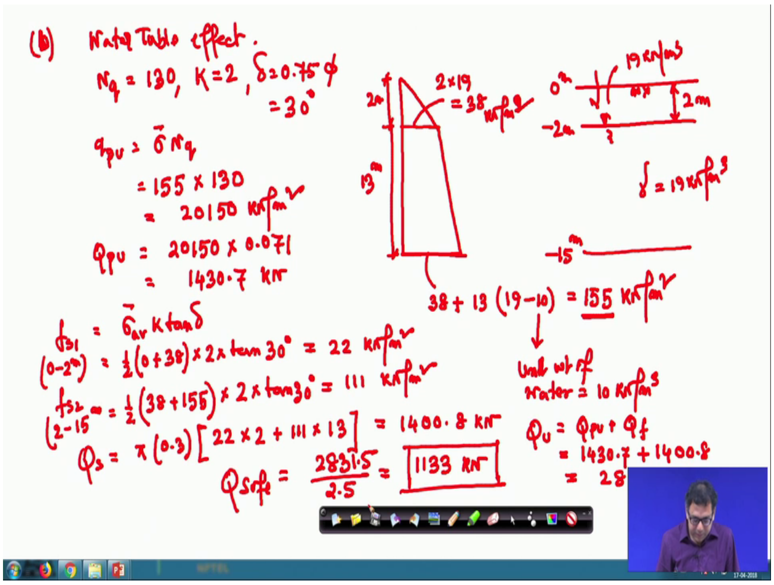
So, in the last class, I have solve one problem on pile in homogeneous sign, and then I calculated the load carrying capacity up to pile, without considering the critical length concept, ok. I consider the total effective overburden pressure at the tip as well as the along the length of the pile. Now the same problem I will consider, and then I will introduce the critical length concept in that problem. And then, I will calculate the new load carrying capacity of the pile.

(Refer Slide Time: 00:53)



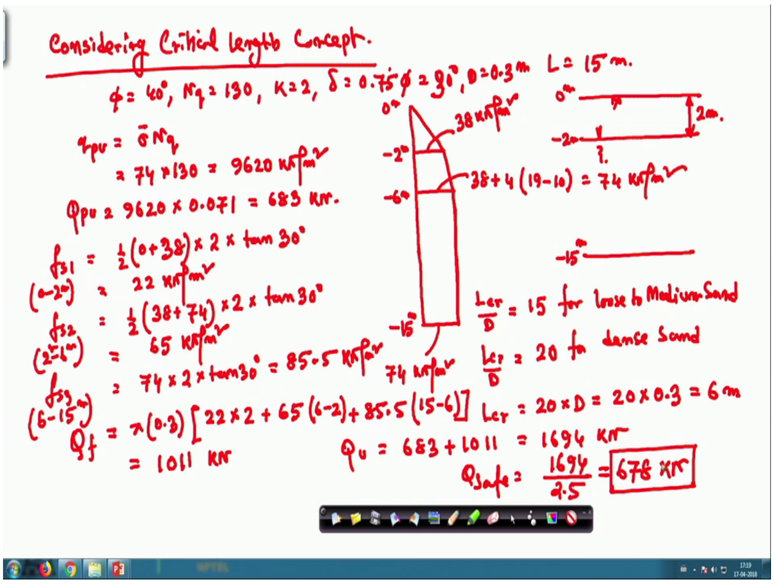
So, this is the problem and so, the here I will take this example part b, and then here I will introduce the critical length concept. Similar way you can introduce these things on part a also, but I will do on the part b only.

(Refer Slide Time: 01:15)



So, last class in the part b, without considering what a critical length concept, the loading was 1133 kilo Newton.

(Refer Slide Time: 01:36)



And so now, here I will consider the; so, if I considered the critical length, then what will happen? That the same this is the ground surface, this is the water table position, and water table position is 2 meter, and this is the pile is 15 meter. So, this is 2 meter, this is 0 meter and this is 15 meter, minus 15 meter; where the pile is rest in.

But here the phi value is 40 degree same as the previous case. N q value is also 130, and k value is 2, and delta is 0.75 phi. So, that is 40 degree, sorry 30 degree and D value is 0.3 meter, and length of the pile L is 15 meter so, all the data's are same; so now, as I am considering the critical length concept.

So, first let us see so, what is the critical length of this type of problem? So, the critical length if you see that last I mean last to last class note, then we will find that critical length by D is equal to 15 for loose to medium sand. And critical length by D is taken 20 for dense sand. So, here the phi value is 20 40 degrees.

So, it is in dense sand so, will consider that our critical depth is 20 times of D. So, it is 20 into D is 0.3 so, it is 6 meter, ok. So, the critical length is 6 meter, from the ground surface. So, the distribution is up to 2 meter, the again this value will be 38 kilo Newton per meter square. Because that is the value that I have got in the last class, ok. Now, in the up to 6 meter.

So, this is up to 2 meter, minus 2, this is 0 meter, this is 6 meter. So, up to 6 meter these value is 38 plus 4, this difference is 4 meter into 19 minus 10. So, that that value is 74 kilo Newton per meter square. So, this is 74 kilo Newton per meter square, and then up to 15 meter from the 6 meter the stress will not change, ok. So, that will remain same, because that is the concept of critical length theory.

So, that means, here also this is 74 kilo Newton per meter square. So now, at the tip also you are considered in 74 kilo Newton per meter square. So, my q p u is equal to sigma bar N q and sigma bar is here at the tip 74 N q is 130. So, this value is equal to 9620 kilo Newton per meter square.

So, as I mentioned in the last class that, this value is less than 11,000 kilo Newton per meter square, but some researchers are considering or suggested that that if this is 9, this value is greater than 11,000 kilo Newton per meter square. So, you can take it 11,000 kilo Newton per meter square, but I would consider the value actual value that is coming from the calculation. Because that is the value and few researcher I have suggested that you take the total values that is coming.

So, that is why I will consented on the total value whether it is a critic to the considered in critical length or not I will consider the total values that is coming. So, here it is 9620 ok, so, an even if it is greater than 11,000 kilo Newton per meter square that I will still consider that higher value that, that that method I prefer to consider.

So, and then I will find that f s, this is the, or q p u is equal to again this is 9620 and area is point this 0.07 1.071. So, that will be equal to 683 kilo Newton. So, that is considering the critical length concept, now the friction part f s 1 that is from 0 to 2 meter. So again, if you look at this diagram; so this will be the average value will be 0 plus 38 into 2 k is to and tan 30 degree. So, this is equal to 22 kilo Newton per meter square.

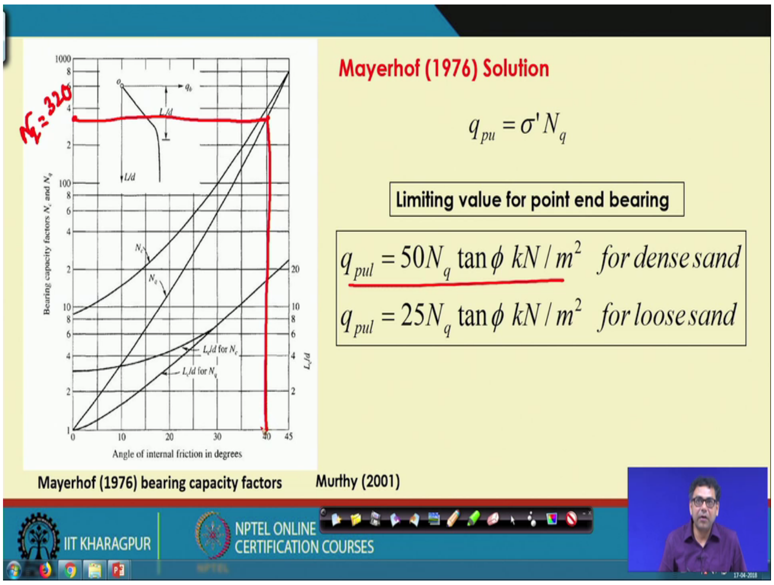
And f s 2 that is 2 meter to 6 meter, this one. So, this will be again average, here it is 38, and here it is 74, then 2 k value is 2, and tan 30 degree so, that is equal to 65 kilo Newton per meter square. Then f s 3 which is 6 meter to 15 meter so, that is equal to because there is the uniform pressure.

So, this pressure is uniform so, I will consider only 74, then k value is 2, and this is tan 30 degree. So, that is equal to 85.5 kilo Newton per meter square. So, the total frictional force is equal to pi into D is 0.3, then first part f s 1 is 22 and the length is 2 meter, this is the length is 2-meter f s 1 is 0 to 2 meter. So, 2 then f s 2 is 65 length is 4 minus 2 or 6 minus 2, this is the length plus this is equal to 85.5, and the length is 15 minus 6. So, that will be equal to 1011 kilo Newton, ok. So, this is 6 minus 2 and this is 15 minus 6.

So, my total q is equal to 683 plus 1011 that is equal to 1694 kilo Newton. And so, q safe is equal to 1694 divided by 2.5 so that is equal to 678 kilo Newton. So, if you look at the previous problem so, this is 1133 is without considering the critical length. And which is further reduce and it is 678 kilo Newton if I consider the critical length concept by then the same method. We have done considering full effective overburden pressure one problem, another problem we have done considering critical length concept.

So now the both the methods people are using, so now, one thing it is the designers decision which one they will choose, but I will show you both the methods and then in layer soil also, how will take care the problems considering critical length and without considering the critical length, ok. So, the next problem the same problem I will solve by using the Meyerhof’s method, ok.

(Refer Slide Time: 11:29)



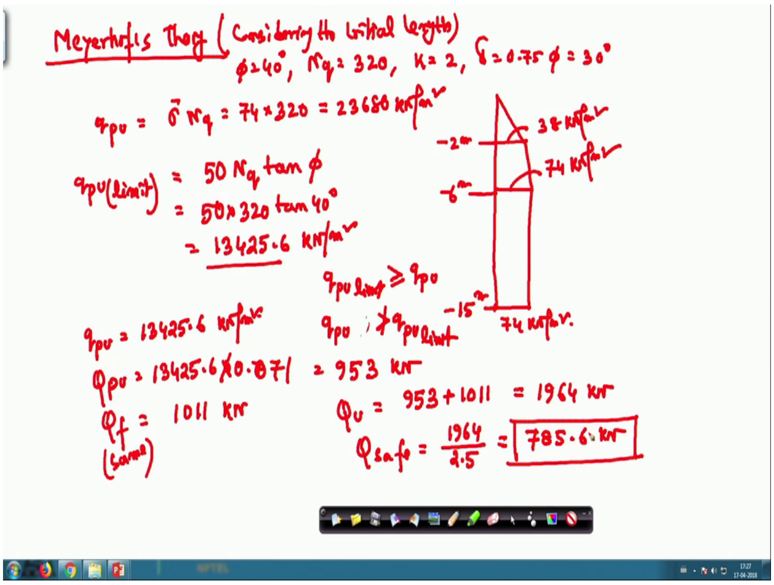
So, the same problem I will solve considering the Meyerhof method this is the Meyerhof methods, and here also Meyerhof methods as suggested you have to consider critical length.

So, that means, the critical length concept we will use in the Meyerhof method, and then also in the limiting value of bearing capacity also we will consider, ok. And here in the chart you see that in the chart it is 40 degree and the value of N q that we are getting is here. So, that value we are getting is this is the N q curve, and this value is here.

So, these value is around N q Nq is equal to 320. So, the N q value is 320 as per Meyerhof method and you can see the Meyerhof method this is the critical length concept is used. So, Mayer and they have suggest some limiting tip resistance also for the dense soil. So, our case it is the dense soil, we will consider this limiting tip resistance concept. And the N q value corresponding to 40-degree phi is 320.

So, the same problem if I solve with Meyerhof methods.

(Refer Slide Time: 13:05)



So, by using the Meyerhof theory so, you will calculate that the same phi equal to 40 degree, N q value is coming out to be 320, then our k value again you are taking 2, and delta value is 0.75 phi, that is 30 degree and you are using the critical length concept, ok. So, this is the same water table is here then 6 meter, then it is uniform, ok.

So, this is 74 kilo Newton per meter square, and this value is 38 kilo Newton per meter square, and this is also 74 kilo Newton per meter square. And this is minus 6 meter, this is minus 2 meter, and this is minus 15 meter. So, these are the total state distribution.

So, your q p u is equal to sigma bar into Nq, sigma bar is 74 that is at the base. And then it is 320 so, that value is equal to 23680 kilo Newton per meter square. Now Meyerhof x suggested that q p u limit there is a limiting value, and for the dense sand that limiting value is 50 N q into tan phi, ok.

So, that means, your q p u should not be greater than q p u limit. So, that is 50 into N q is 320 and tan 40 degree, ok. So, that value is coming out to the 13425.6 that is kilo Newton per meter square.

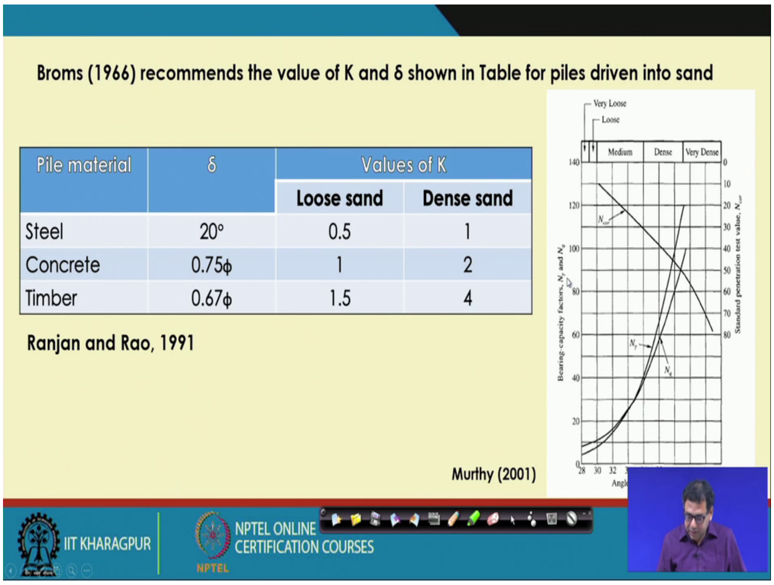
So, this is the limit a near value is 2 3 so, it is greater so, we cannot considered these value. So, we have to consider this value. So, that that is why the q p u limit is greater than equal to q p u. Or in other word you can say that q p u, cannot be greater than cannot be greater than q p u limit, ok.

So this would, cannot be greater than q p u limit. So, that is why you have to consider our q p u is equal to 13425.6 kilo Newton per meter square. So, my q p u the area is same 13425.6 into 0.071.

So that is equal to 953 kilo Newton. And but the friction resistance part will remain same, because I have not changed the friction resistance part. So, that is the same value, that you are considered last time so, that is 1011 kilo Newton. So, the q ultimate is 953 plus 1011 that is equal to 1964 kilo Newton. So, q safe is equal to 1964 divided by 2.5, that is equal to 785.6 kilo Newton, ok. So, my previous problem this value was 678 kilo Newton without considering critical depth using the first method.

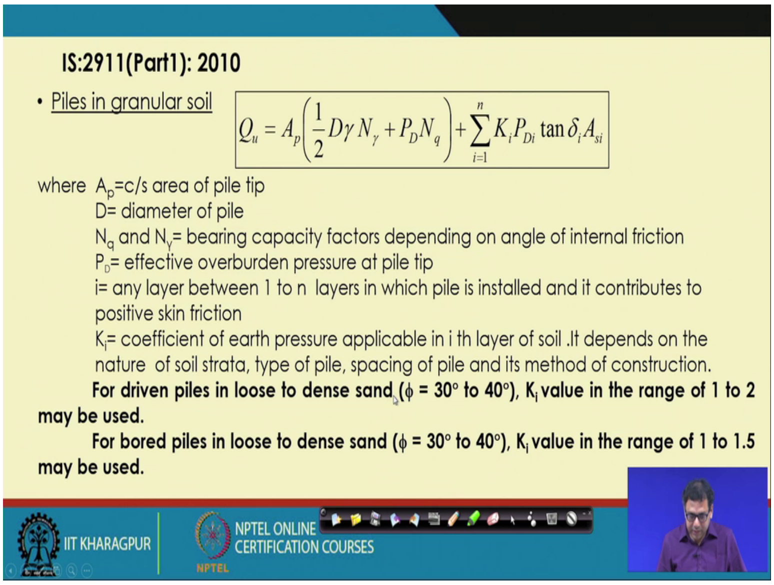
And now with considering this is with considering the critical depth, considering the critical depth by using the first method, and now by using the Meyerhof method, considering the critical depth critical depth or critical length. So, that me remember that when you are using the Meyerhof methods, you have to consider the critical length concept, so, that is 785.6 kilo Newton. Now the same problem I will do it considering the IS code ok. So, let us see how I can do it. So now, this is the Meyerhof's method, I have discuss this is the limiting value and these are the values I have taken.

(Refer Slide Time: 18:24)



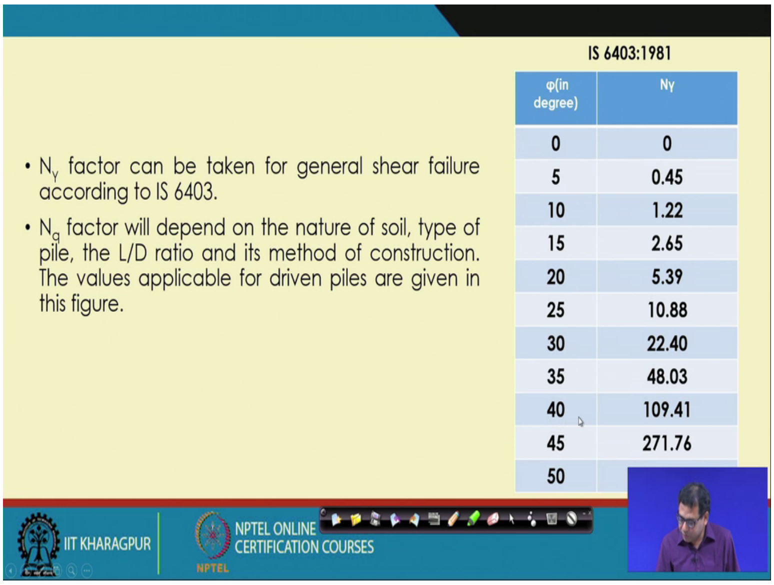
Now I will go to the IS code part.

(Refer Slide Time: 18:57)



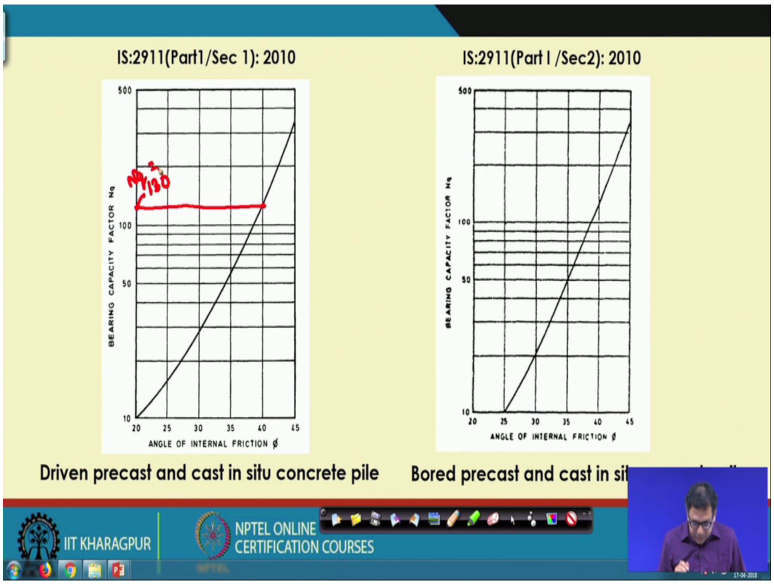
So, it is a homogeneous soil it is it is for the layer soil also, but it is the homogeneous case. So, here I will go for the IS code part. So, difference is that that here that it is the driven pile; so the 40 degree. So, I will take k value is 2 as recommended by the IS code. So, it is 2 I will take for the 40 degree.

(Refer Slide Time: 18:33)



And then for N N gamma value because IS code you have to consider the N gamma N gamma corresponding to 40 is 100, 109.41, that is the N gamma corresponding to 40.

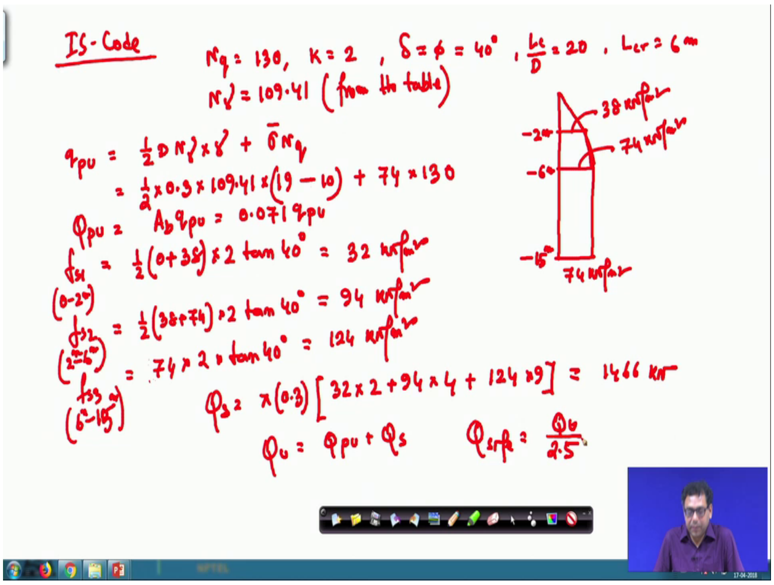
(Refer Slide Time: 20:09)



And the N q value and here the yes N q value is you have to consider N q value here. N q value corresponding to so, this is the driven precast or cast in situ concrete pile. So, this is the driven pile so, for the driven pile have to use this chart. So, for both pile up to use this chart.

So, for the driven pile corresponding to 540 degree; so this is the value so, that value is coming out to be again 130; so, N q is equal to 130, ok. So now, I will use the IS code method. So, if you so, this is the IS code method, and area of the base half into diameter into gamma into Nq, ok, N gamma plus p D into N q p, D is the effective overburden pressure at tip of the pile. So now, if I write the IS code method if I consider the IS code method the same problem.

(Refer Slide Time: 21:25)



If I considered the IS code, now my N q value is coming out to be 130, k I am taking is 2, but IS code recommended that you take delta is equal to phi. Because where I mention about the IS code, I mention that that there recommended that or the delta may be taken as a phi. So, I am also taking delta is equal to phi is 40 degree for the concrete pile. And another thing is that about the IS code, IS code has mention that if your length of the pile is more than 15 D, 220 D then you consider the effective overburden pressure corresponding to 15 D to 20 D case, when which is similar to the critical depth concept.

So, for the IS code also you have to consider the critical depth concept because as per my understanding that that form 15 to 20 degrees part the stress will not change. So, in that case so, as per the IS code here the dense soil. So, their mention for 30 degree through I mean loose sand it is 15 D and dense sand it is 20 D so, here it is dense sand.

So, we are considering critical L critical to D is 20. So, that means, L critical is again 6 meter. So, the same things will use this is up to 2 then 6, then it will uniform, ok. So, this will be the 74 kilo Newton per meter square, this is the 6 meter, this is the 2 meter, minus 2 meter, minus 6 meter, minus 15 meter.

So, this is 38 kilo Newton per meter square, and this is the value which is 74 kilo Newton per meter square ok, but IS code N q part is also their N gamma part, N q is 130 N gamma part is also there N gamma is 109.41 that from the table that have shown, ok. So now, let us will start so, we will start q p u, that is equal to half into D into the N gamma into gamma, gamma is the unit weight of the pile, and then plus that sigma bar into Nq. So, if I put this value half into diameter of the pile is 3 meter 0.3 meter, N q is 109.41 into gamma is 19 kilo Newton per meter, ok. So, this gamma is consider 19 kilo Newton per meter minus 10, because it is under the submerge condition.

So, then plus n bar is 70 sigma bar is 74 into 130. So, these will be the for the q p u and the friction part f s 1 0 to 2 meter is equal to the same average into 0, 0 plus 38 k is equal to 2, but tan delta will be tan 40, ok. So, that is equal to 32 kilo Newton per meter square. Similarly, f s 2 2 meter to 6 meter, that is equal to a same only difference is sand delta will be the tan 40, this is 38 plus 74 into 2 into tan 40 degree.

So, that is equal to 94 kilo Newton per meter square, and f s 3, that 6 meter to 15 meter. So, that is equal to half, sorry is because which is uniform so, these half is not require. So, that you will be equal to 74 into 2 into tan 40 degree. So, that is equal to 124 kilo Newton per meter square.

So, my q s is equal to point pi D into 32 into 2 meter plus 94 into 4 meter, plus 124 into 9 meter. So, that is equal to 1466 kilo Newton, ok. So finally, we have to add this 2 value and q p u that a b into q p u so, a b is 0.071 into q p u. Finally, you add this 2, then you will get the q p u plus q s and the q safe is equal to q u divided by 2.5.

So, you add this 2 and you will get the value of safe load carrying capacity based on the IS code. So, in summary I have discussed 3 methods. So, first methods have discuss considering the full effective overburden pressure; that means, without considering the critical length concept as well as considering the critical length concept, ok.

And second method I have discuss the Meyerhof method where the critical length concept is used, and in the IS code method also critical length concept is used. Because IS code is recommended that you cannot take the effective burden overburden pressure, more than corresponding to the effective overburden pressure at 15 to 20 D depending upon the type of soil. So, in the three methods: so, we have discuss, so and one more thing in the first method that in the second method Meyerhof's method that the limiting tip resistance value is given.

So, we have check that condition IS method is not suggested in that kind of check. But in the first method as I have suggested that here you can consider a limiting value of tip resistance that 11,000 kilo Newton per meter square, and in the friction resistance also you can limit with 100 kilo Newton per meter square.

But I would prefer to consider that total stress or the load that is coming considering the full effective overburden pressure as well as the critical length concept. And here the question is that I have solve the problems by considering critical length and without considering critical length. Now both the methods people use, and now you have to judge your own judgment and then you will decide which one you will consider.

So, in the next class I will discuss about the bearing capacity of pile in layers soil how will calculate the bearing capacity if it is the layer soil sand. And then later on we will discuss about the clay and then sand clay both.

Thank you.