Foundation Engineering
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Lecture -30
Pile Foundation – IV

So, last class I have discussed about the load carrying capacity of pile. I have discussed mainly the load carrying capacity of piles in granular soil. Now today I will solve few problems related to load carrying capacity of pile in granular soil, a homogenous as well as the layer soil. So, and I have also discuss that in terms of material the piles can be timber piles, steel piles and the concrete pile and the concrete piles which is a frequently used and that is why all are problems that I have I will solve I will concentrate only on concrete pile.

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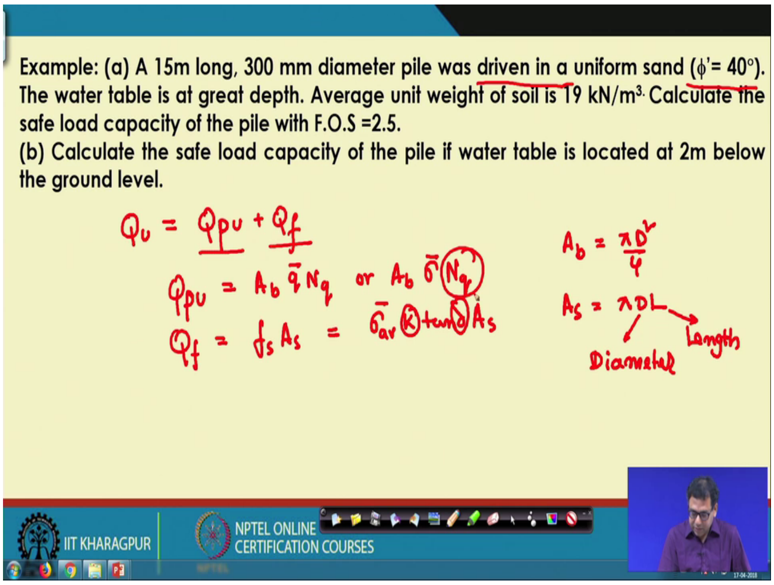

So, and the solution of the problems can be on driven piles or the bored piles and so, first problem that I have taken is the a one 15 meter long, 300 millimeter diameter pile was driven so it is a driven pile. So, pile was driven in a uniform sand the water table is at great depth so that is why water table effect will not be considered in first case. The average unit weight of the soil is 19 kilo Newton per meter cube, calculate the safe load or allowable load carrying capacity of the pile with factor of safety 2.5 as I mentioned factor of safety can vary from 2.5 to 3 and the load carrying capacity means the compressive load carrying capacity because I will concentrate only the compressive load carrying capacity of the pile.

So, here the phi value or the phi dash is given 40 degree. Now let us see what are the values we have to consider. So, as you know that for this type of problem that first the equation of Q u ultimate load carrying capacity is Q p u plus Q f this is the bearing or the tip resistance part this is the friction resistance part this thing I have discussed.

Now, Q p u is equal to A b and Q bar N q or A b you can write sigma bar N q now sigma bar is the effective overburden pressure at the tip of the pile N q is the bearing capacity factor and A b is the area of the base of the pile and Q f is equal to f s into A s, f s is the friction resistance A s is the area of the pile surrounding area of the pile. So, f s we can take that sigma average bar into k into tan delta and this is the A s. So, this is the all the expressions so A b is pi D square by 4 and A s is pi D L where D is the diameter of the pile and L is the length of the pile ok. So, now, k is the coefficient of lateral earth pressure delta is the friction angle between the pile and the soil.

So, these things I have discussed in the last class now so; that means, we solve it. Now what are the things we should know? So, we should know the N q k and delta. So, these are the things we should know before we start this problem and I have given you the chart or the table from where I will get this value, but in few cases this value will be given in the problem itself. So, first let us see what would be the N q value and the other values.

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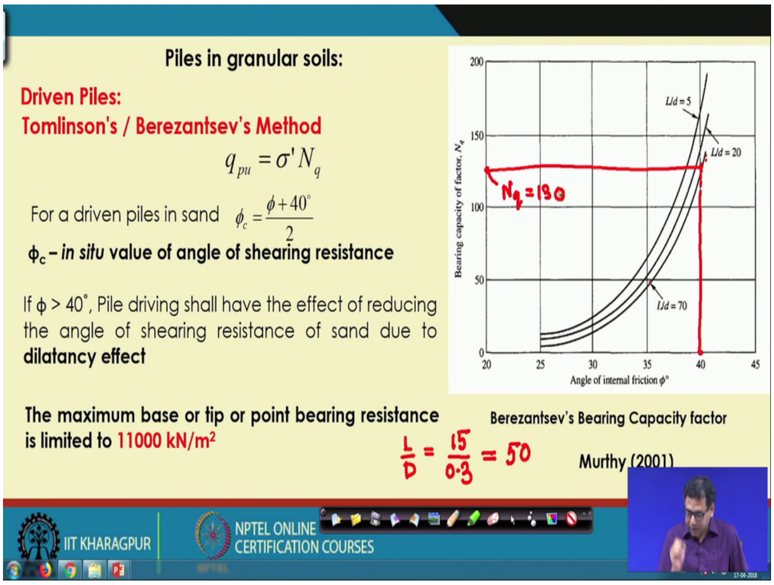

So, if I take the first method and I am doing this for the driven pile so I am using the first method which is the Tomlinson's method or Berezantsev's methods. So, this is the Berezantsev tips method so this method either this 2 these are the same methods. So, we will use this phi value is our case is 40 degree. So, this is 40 degree is the phi value and the a length of the pile and diameter of the pile so the length of the pile is equal to 15 meter and diameter of the pile is 0.3 meter. So, it is the value that we are getting is 50 um. So, this is your 50.

So, L by D is 50 here also this is L by D is 50. So, this chart is for 70 L by D this is for 20 this is for 5. So, 350 will be somewhere here. So, this is the 40 degree and 50 is here. So, this is the 40 degree and 50 so this is the value. So, corresponding N q value is coming out to be 130. So, N q value is coming out to be 130 from this method this chart ok so N q value is 130. So, now, we have to go for the delta and k value.

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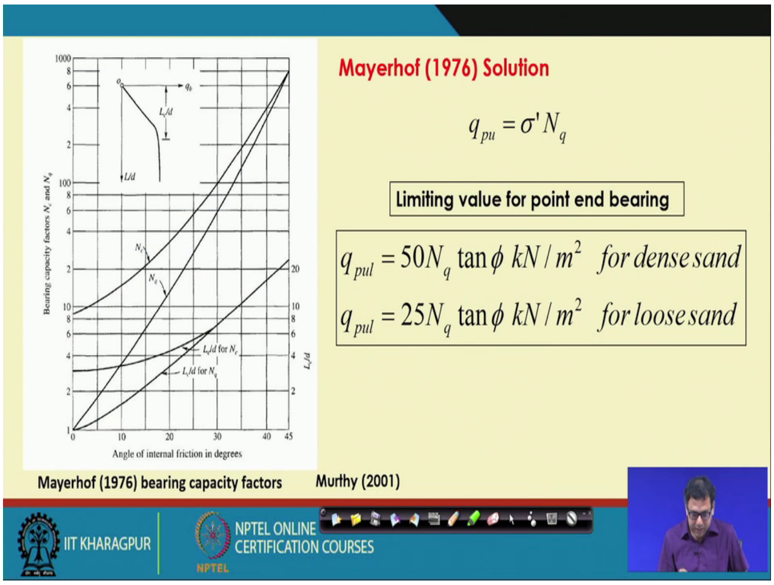

So, later on I will use this chart when I will discuss about the Meyerhof solution.

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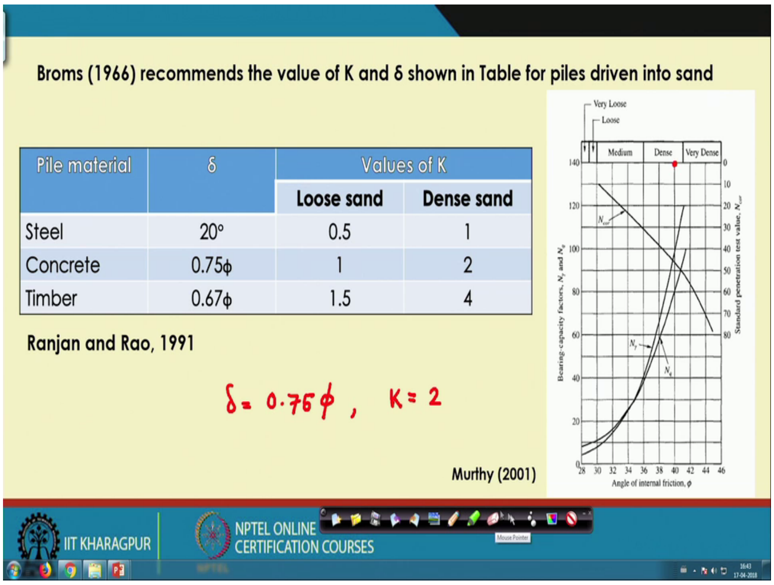

So, now to take for this chart and this chart will help me to get the type of the soil because it is a 40 degree. So, the 40 degrees; that means, is the dense soil. So, it is 40 degree so it is the dense soil it is in the dense range so dense soil. So, dense soil it is a concrete pile you are using as I mention I will concentrate only on the concrete pile so, in the concrete pile so my delta value is equal to 0.75 phi and as it is a dense soil concrete pile. So, k I will take is equal to 2 ok. So, that is why we will get these 2 value, now let us start the solution.

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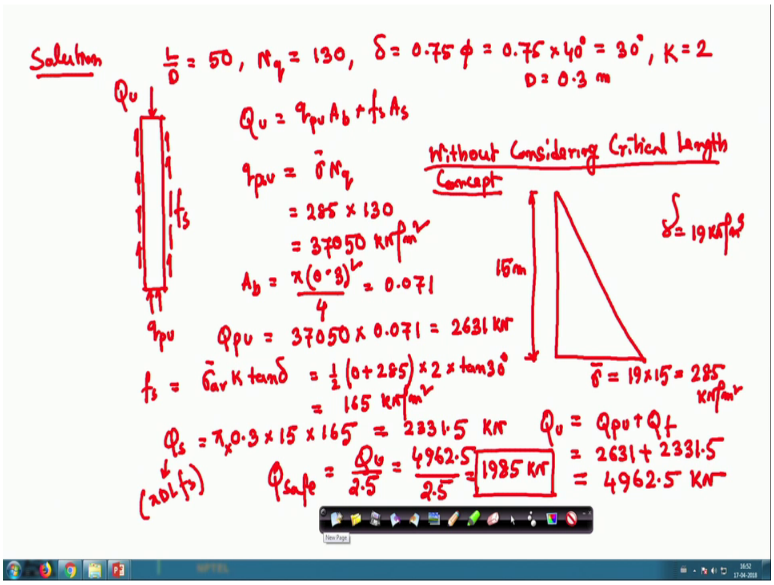

So, the first solution is I have taken that your L by D is equal to 50. So, N q value is equal to 130 delta we are using 0.75 phi, so that is 0.75 phi is 40 degree. So, it will be equal to this is 30 degree and k value is taken as a 2 ok. So, this is the pile and it is in the homogenous soil and so this is the q p u and these are the frictional resistance f s ok. So, now, we will solve the, that is the Q u that is acting on the pile. So, now, you know that Q u is equal to q p u A b plus f s A s. So, now, q p u is equal to sigma bar N q.

Now, there is a question. So, I have mentioned about the critical depth concept or the critical length concept because in the researchers have observed that that the effective overburden pressure along the length of the pile does not increase linearly up to a depth after a depth. So, that depth is equal to critical depth. So, up to that depth it increases linearly and beyond that depth the overburden pressure is uniform ok. So, that is the critical length concept, but later on researchers have also observed that critical depth concept is may not work in the pile because it underestimate the pile load carrying capacity.

So, in few researchers they have suggested to use the full overburden pressure during the load carrying capacity of the pile. So, now, both the methods can be used because few researchers they suggested to use the critical length concept and some researchers have suggested to use the full overburden pressure along the length of the pile ok. So, here what I will do I will solve both the methods one is without considering the critical length concept considering full overburden pressure along the length of the pile and the second one I will consider the critical length concept and then you will see how the things will change.

So, the first one I will taking that without considering critical length concept. So, the if it is without critical length concept; that means, it is linearly increases so the length of the pile is 15 meter unit weight is 19 kilo Newton per meter cube. So, the pressure vertical pressure sigma bar here bar is equal to sigma because water table effect we have not considered. So, that will be equal to 19 into 15 ok.

So, that is equal to 285 kilo Newton per meter square ok. So, we have taken the full effective overburden pressure because you are we are not considering that critical length concept. So, now, my sigma b bar at the tip is 285. So, this is 285 into the N q is 130 so this is 285 and N q value is 130. So, this value is coming out to be 37050 kilo Newton per meter square and the A b is equal to pi D square by 4 your D value is equal to 0.3 meter because diameter of the pile is 0.3.

So, it is equal to 0.071. So, my Q p u is equal to 37050 into 0.071 that is equal to 2631 kilo Newton. So, now, I will calculate the f s, f s is equal to sigma v average and k into tan delta. So, sigma v average here it is 0 here it is 285 so average will be 0 plus 285 and k is equal to 2 and tan delta is equal to tan 30 degree. So, we are taking that is equal to 165 kilo Newton per meter square ok.

So, my f s is area of the outside surface of the pile is pi D pi into D, D is 0.3 into L. L is 15 into f s is 165 so that is because this is pi D L into f s. So, pi D is this is cross pi 0.3 into 15 into 165, this is 2331.5 kilo Newton. So, the Q ultimate is equal to Q p u plus Q f. So, this is equal to 2631 plus 2331.5 that is equal to 4962.5 kilo Newton ok.

So, now if I apply the Q safe, so, apply the factor of safety Q u by 2.5 factor of safety you have taking so 4962.5 divided by 2.5 so that is equal to 1985 kilo Newton. So, the load is coming out to be 1985 kilo Newton in the.

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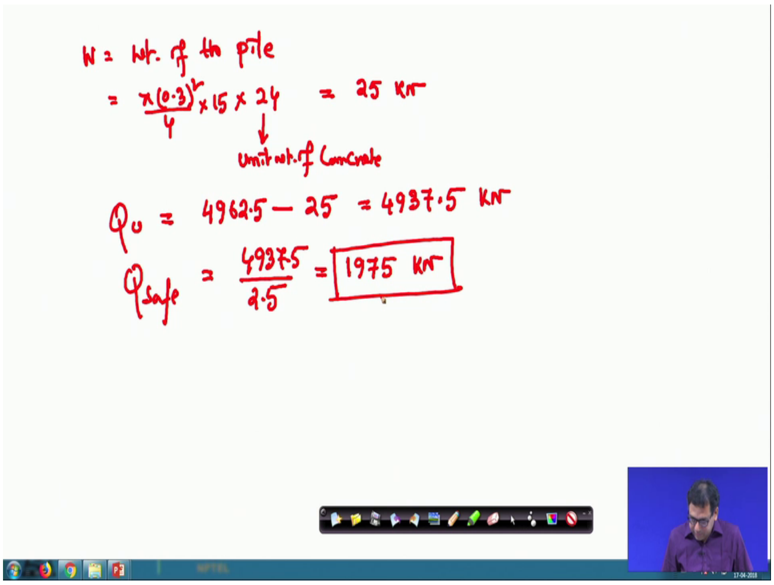

Now if we consider the weight of the pile then the W is equal to weight of the pile then W is equal to pi D square by 4 area into 15 that is the volume of the concrete and if I take unit weight of the concrete is 24 kilo Newton per meter cube this is the unit weight of concrete then his value is equal to 25 kilo Newton. So, you can see compared to the pile load carrying capacity this weight is very small still if I consider that one then my Q u will be equal to 4962.5 minus 25 ok. So, that will be equal to 4937.5. So, the Q safe is equal to 4937.5 divided by 2.5 so that will be equal to one 975 kilo Newton ok. So, this is also kilo Newton.

So, now if you see this previous value is 1985 kilo Newton and if I consider the weight of the piles is 1975 kilo Newton so the difference is very negligible. So, in that case that is why in the next problem so I will not considered the weight of the pile, but if you want to calculate the accurate value then you can consider the weight of the pile also But generally the weight of the pile I will not consider in this in the next problems because we will consider the resistance from the tip and the from the friction as the ultimate load carrying capacity of the pile.

So, now if you see this here that we have not considered the water table effect now if I consider the water table effect then what will be the change.

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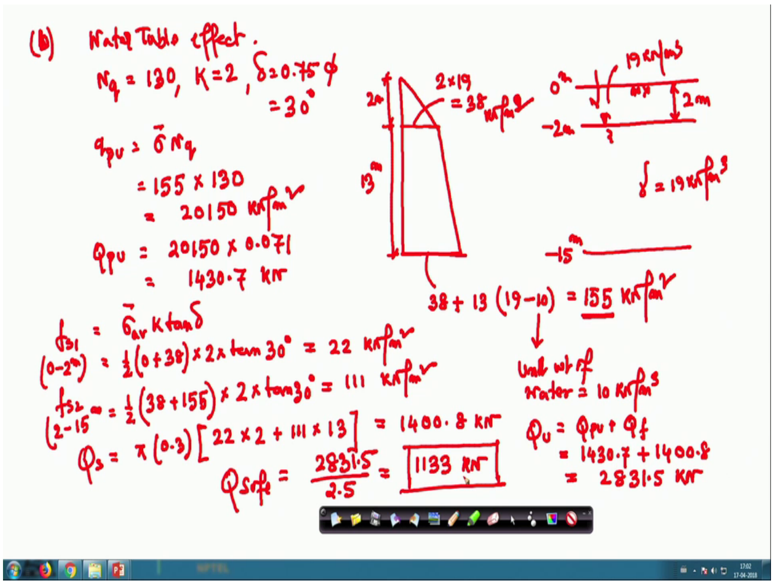

So, now, the water table effect is considered because the that is the our second problem that water table is at 2 meter below the ground surface. So, we are talking about the water table effect ok. So, now, this is the ground surface water table at 2 meter below the ground surface this is the 2 meter and this is the 15 meter, this is 0 meter minus 2 meter and this 15 meter below the ground surface the length of the pile and remember that here the same unit weight is given that is the unit weight is 19 kilo Newton per meter cube.

So, the saturated you will consider this is now as a saturated unit weight and the sub margin unit weight will be 19 minus 10 9 kilo Newton per meter cube 10 is the unit weight of the water. Now if in water table case there maybe some different unit weight can be given. So, you have to consider that unit weight, but here the same unit weight we are using for the dry soil and the saturated soil. So, now, the 19 kilo Newton meter cube will be the saturated unit weight, but that can be different also, but that will be mentioned in the problem. So, now, a so; that means, nothing is mentioned you will consider both as a same unit weight. So, now, my earth pressure or the vertical pressure distribution will be so it is up to 2 meter.

So, this is the value so this value is 2 into 19 that is equal to 38 kilo Newton per meter cube because now the saturated unit weight as well as the unit weight of the soil above the water surface are considered same ok. So, that is why unit weight of this soil is also

19 kilo Newton per meter cube. So, both are consider same. So, that is why it is 19 kilo Newton per meter cube into 2, now after that it will change ok.

So, now this value is 38 plus because this is 2 meter and this one is 13 meter because total length of the pile is 15 meter. So, this will be 13 into 19 minus 10 this is the unit weight of water which is taken as 10 kilo Newton per meter cube you can take as 9.81 kilo Newton per meter cube also, but I have taken 10.10 kilo Newton per meter cube. So, that is equal to 155 kilo Newton per meter square sorry this is meter square ok.

So, now our bearing capacity part will also change now the N q will remain same that will be 130 k value will remain same 2 and delta is equal to 0.75 75 phi that will also be equal to 30 degree because phi is here also 40 degree. So, now, the value of Q p u is sigma bar into N q sigma bar is 155 because that is the effective overburden stress at the tip of the pile this is the base of the pile. So, you have to consider the effective overburden pressure at this point.

So, this is 155 so this will be 155 into 130. So, this value is equal to 20150 kilo Newton per meter square ok. So, my Q p u the same area so it will be 20150 and area of the base is 0.07 1that are used in the previous part of this problem. So, this will be the 1430.7 kilo Newton. So, now, the friction part so now, the friction part f s 1 that I am calculating from 0 to up to 2 meter so this part I am calculating. So, here that again it is sigma bar average k into tan delta. So, sigma bar average is half 0 and in this level it is 38.

So, this is 38 average k is 2 into tan 30 degree ok. So, this will be equal to 22 kilo Newton per meter square, now f s 2 I am calculating from 2 meter to 15 meter because this is the 0, this is 2 meter 250 meter this 30 meter the average is half here it is 38 degree and at the base it is 155 into 2 into tan 30 degree ok. So, this is a sigma average sigma bar average. So, this value is 111 kilo Newton per meter square. So, the total friction resistance Q s is pi D pi D is 0.3 then the f s 1 into L is 2 meter. So, f s 1 is 22 into length is 2 meter 2 plus f s 2 is 111 and length is 13 meter.

So, this will be equal to 13 ok. So, this will be equal to 1400.8 kilo Newton. So, the total Q u will be the Q p u plus Q s ok. So, the Q p u value is 1430.7 plus 1400.8. So, that is equal to 2831.5 kilo Newton. So, the Q safe is equal to 2831.5 divided by 2.5. So, this value is 1133 kilo Newton ok. So, this is the total load carrying capacity of a pile the water table effect is considered. So, you can see that initially without considering water table effect it is 1985 kilo Newton. Now it is become 1133 kilo Newton if I consider the water table effect.

So, next one that I will do that the same problem I will solve considering the critical depth concept ok. So, and one more thing I want to mention that in when I discuss about the this first method there I mention that the limiting value of point bearing resistance is 1100 kilo Newton per meter square so, but our case this value is greater than that. So, this according to this method that this is the limiting value; that means, your tip resistance cannot be greater than this ok, but some researchers I have suggested that you should consider the full tip resistance that you are getting by considering the full effective overburden pressure.

So, that is why I will not put in a limit here. So, the value that I am getting that will be treated as a load carrying capacity of the pile ok, but few cases people have suggested that you limit your point resistance is 1100 kilo Newton per meter square ok.

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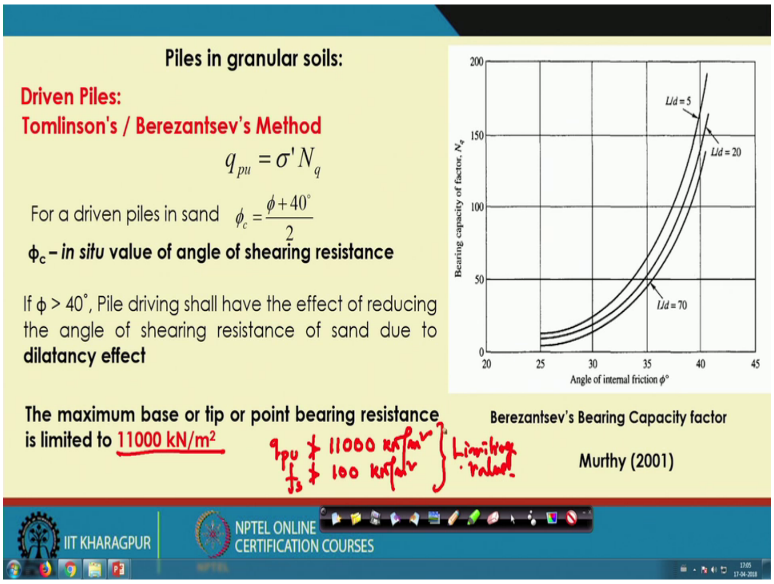

So; that means, your limit value of q p u should not be greater than 11000 kilo Newton per meter square, if this value is greater than that you consider this value and similarly the friction value also they have suggested that friction value should not be greater than 100 kilo Newton per meter square ok. So, this is the limiting value so, but our case both the values are greater than that. So, I will keep those values because this limiting values where people are use some peoples are using this value some are not.

So, that is why I will not keep any limit. So, what are the values I am getting from the calculation that will be treated as a load carrying capacity of the pile. So, in the next class I will discuss about the same problem by considering the critical length concept and then will see what will be the changes in the calculation part.

Thank you.