Foundation Design
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Lecture – 18D
Deep Foundation – Part 3

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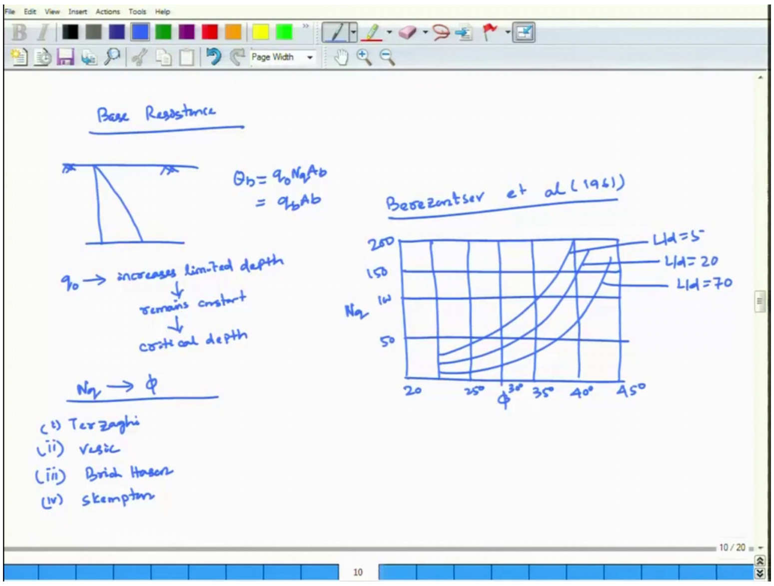

Now, the base resistance if you look at the base resistance, so base resistance Q b is equal to q 0 N q A b which is equal to q b into A b. So, q 0 it increases with a limited depth it increases limited depth beyond which it remains constant; for pile up to a certain depth q 0 increases, so beyond which it remains constant. So, it has nothing to do with your embedment depth of the pile, so that is called your critical depth that is called your critical depth. So, bearing capacity factor at base particularly N q it depends upon your value of your phi.

For this there are many theories has been given; first one is your Tera zaghi, second one is your vesic, third one is your Brid Hason, fourth one is your Skempton. So, one author that is your Berezontser et al 1961, he gave based on your field data. What he has given he has given the value of N q; and this is your phi 20 degree, then this is your 25 degree, 30 degree, 35 degree, 40 degree, 45 degree. Here it is 50, 100, here it is a 50, 100 150, 200.

So, this value they have given for different L by d is ratios first one is your L by d is equal to 5, second is your L by d is equal to 20, third is your L by d is equal to 70. You can utilize the theory of the Terzaghi, you can utilize the theory of Vesic you can also utilize theory of Br id Hasens also Skempton. However, Berezontser et al 1961 they have given the values of N q based on the field data of the phi for L by d 20 and 70 different values. This charts you can collect it in a book then this can be utilized to find it out your base resistance.

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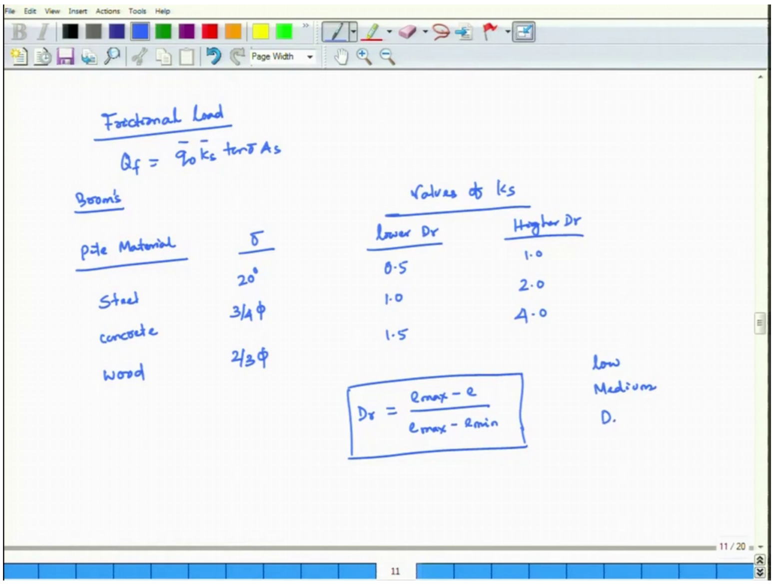

Come to your frictional load, frictional load if you look at the frictional load in frictional load Q f is equal to q 0 K s tan delta into surface area. So, Brom's has given the values Brom's has given the values for different pile materials. This is my pile material with delta, delta is your friction between pile material and soil and values of E s, it is your lower D r, then this is your higher D r. And this is your steel, then concrete, last one is your wood, delta generalize steel is your 20 degree; concrete, it is your three-forth phi; wood is your two-third phi. Then for lower D r value of your K s, the K s value is lateral earth pressure coefficient and Brom's has given the value of the K s. Lower D r means it is a loose conditions or medium dense condition; higher D r means that is your dense conditions. So, this will be 0.5 and this will be 1.0 then this will be 1.5, and this will be 1.0, 2.0 and this will be 4.0.

So, D r you can calculate D r relative density you can calculate e max minus e by e max minus e minimum which is equal to gamma d minimum by gamma d into gamma d minus gamma d minimum by gamma d maximum minus gamma d minimum. So, form here you can find it out based on your ins it to word ratio, if you know e maximum and e minimum I am remaining this one this will be better for knowing. If you know e maximum and e minimum and if you know what it of instead word ratio e then, you can very easily find it out whether, it is this relative density is very low or medium or dense. For lower medium lower D r this values has been given; for high D r, these are the values has been given.

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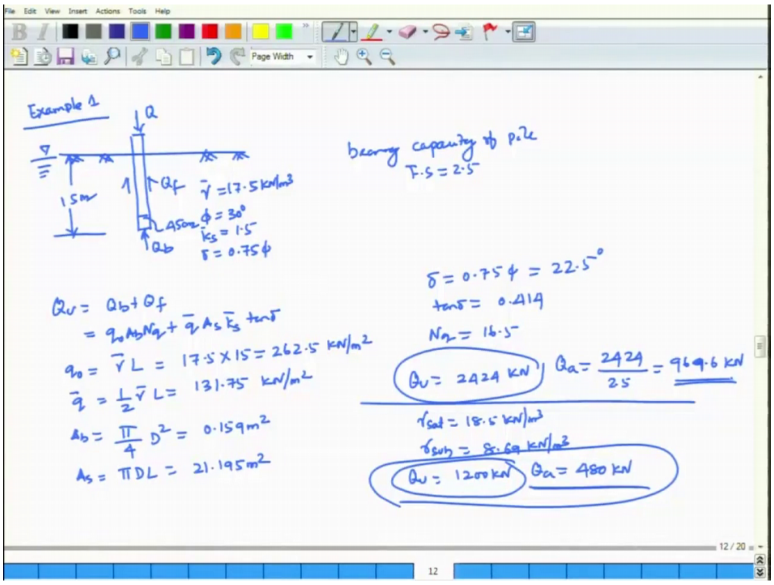

Now, we will solve one example. Example 1, this is the K s has been given look at here. Let me draw the pile. Pile is here then, this is there is water table is here, then here it is 1.5 meter, this is your Q f, this is your Q b, this is your Q. So, gamma is given 17.5 kilo Newton per meter cube, phi is equal to 30 degree, K s is equal to 1.5, delta is equal to 0.75 phi. So, question is calculate ultimate bearing capacity of pile, bearing capacity of pile right considering factor of safety is equal to 2.5 and water table is at ground surface.

So, let us start ultimate bearing capacity Q u is equal to Q b plus Q f, so which is equal to q 0 A b N q plus q bar A s K s bar tan delta. So, q 0 is equal to gamma L which is equal to 17.5 into sorry it is not 1.5, rather it is 15 meter, into 15 which comes out to be 262.5 kilo Newton per meter square. And q bar is equal to half gamma prime L which is equal to 131.75 kilo Newton per meter square. A b is equal to pi by 4 into D square base. Base is your D square. So, diameter is given this diameter is your 45 centimeter. So, this will be comes out to be 0.159 meter square; A s is equal to pi D into L which comes out to be 21.195 meter square, then delta is equal to delta is 0.75 phi from there you can calculate 22 degree 0.5. So, tan delta is equal to 0.414. So, N q is coming out to be 16.5.

So, water a table if I do not consider the water table without the water table then this is my Q u, Q u is equal to Q b into Q f which is equal to q 0 A b into N q and q bar A s K s bar into tan delta. q 0 is equal to gamma bar L q bar is equal to half gamma bar L A b is equal to pi by 4 D square that is area of your base A s is your pi D L. Delta is equal to 22.5 degree; tan delta is equal to 0.414. N q is equal to 16.5; N q is equal to 16.5. Based on that the Q u comes out to be 2424 kilo Newton you can calculate then Q a is equal to 2424 by your factors of safety 2.5 which is equal to 969.6 kilo Newton.

So, now, mater is there if water table is at the ground surface, what will happen then water table is at ground surface then gamma saturated is your that is given that is your 18.5 kilo Newton per meter cube. To gamma some most you can calculate which is your 8.69 kilo Newton per meter cube then you calculate Q u. So, Q u comes out to be or approximately that is your 1200 kilo Newton, and Q a is equal to 480 kilo Newton almost more than 50 percent half of this value has been reduced ultimate bearing capacity without water table that is your 2424 kilo Newton with water table it comes out to be 1200 kilo Newton. So, Q allowable is comes out to be 480 kilo Newton here Q allowable is comes out to be 969.6 kilo Newton.

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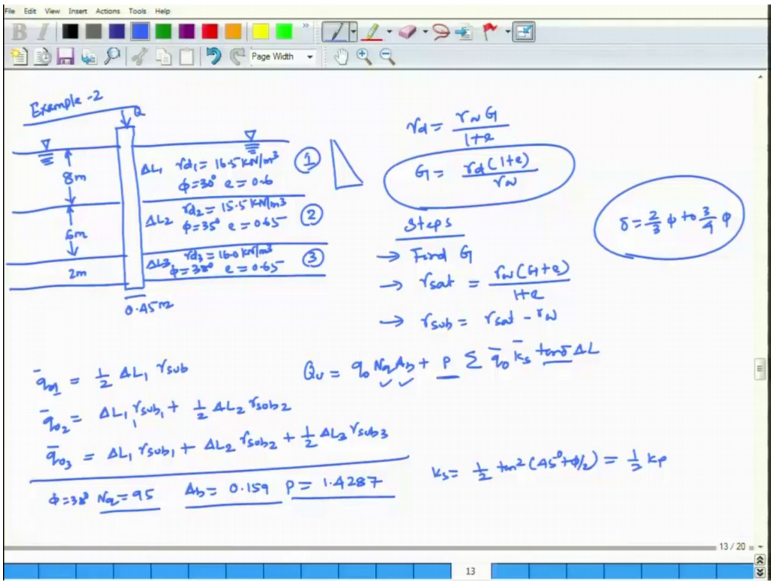

One more example let us considered one is your layer soil. Then you can calculate for layer soil how it looks like. Example 2, there is a pile here. This is your 8 meter, 6 meter, 2 meter. So, dia is your 0.45 meter, gamma d 1 is your 16.5 kilo Newton per meter cube, phi is equal to 30 degree, e is equal to 0.6. Gamma d 2 is equal to 15.5 kilo Newton per meter cube, phi is equal to 35 degree e is equal to 0.65. Then gamma d 3 is equal to 16.0 kilo Newton per meter cube, phi is equal to 38 degree, e is equal to 0.65. So, gamma d 1, gamma d 2, gamma d 3 is given if I write it in the formula gamma d is equal to gamma w G by 1 plus e, then G is equal to gamma d into 1 plus e by gamma w.

So, what are these steps? The steps you have to follow calculate G, find G. Once you find G then find it out gamma saturated which is equal to gamma w G plus e by 1 plus e then you can calculate gamma submerge which is equal to gamma saturated minus gamma w. Then you can find it out then you can find it out that is your K s Q u is equal to q 0 N q A b plus P summation of q 0 bar K s tan delta delta L. Then I am writing the procedures you can try it q 0 bar 1, q 0 bar 1 that means, this is layer one, this is your layer two, this is your layer three. This is at the base, so which is equal to half delta L 1 gamma submerged q 0 2 is equal to delta L 1 gamma submerged plus half delta L 2 gamma submerged 2.

If I put it this is my delta L 1 this is my delta L 2 this is my delta L 3. Similarly, q 0 3 these at the average value I will come back let me write it first this is your delta L 1 gamma submerged 1 plus delta L 2 gamma submerged 2 plus half delta L 3 gamma submerged 3. So, then perimeter you can find it out at the base considering this is my base layer phi is equal to 38 degree, N q is equal to 95. Area of the base you can find it out 0.159 pi by 4 into d square 0.45. Perimeter, you can find it out because a cross sectional throughout is same. So, perimeter is equal to 1.4287, then K s you can find it out K s is equal to half tan square 45 degree plus phi by 2 which is equal to half K p.

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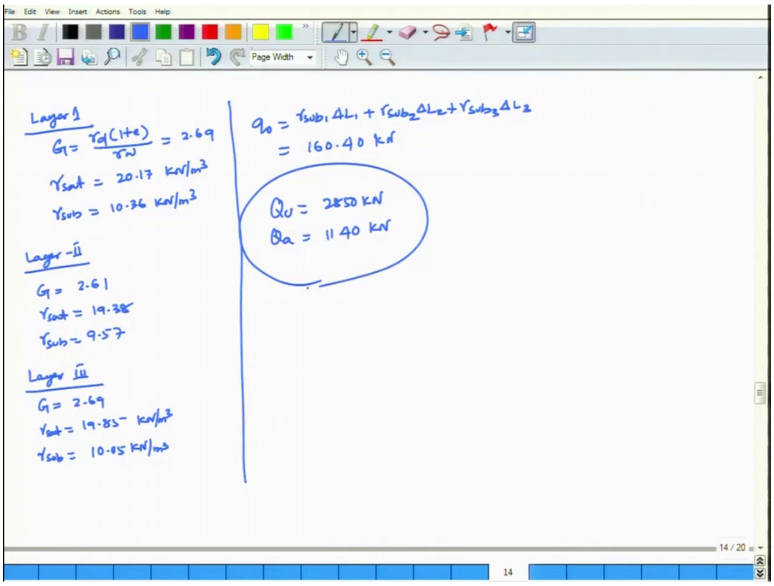

Let me start with this for each cases let me find it out for layer 1. Layer 1 G is equal to gamma d into 1 plus e by gamma w which is equal to 2.69, then gamma saturated is equal to 20.17 kilo Newton per meter cube, gamma submerged is equal to 10.36 kilo Newton per meter cube. Similarly, layer 2 G is equal to 2.61, gamma saturated is equal to 19.38, gamma submerged is equal to 9.57. Layer 3, G is equal to 2.69, gamma saturated is equal to 19.85, gamma submerged is equal to 10.05 kilo Newton per meter cube.

Now, q 0 based on that q 0 you can calculate gamma submerged 1 delta L 1 gamma submerged 2 delta L 2 plus gamma submerged 3 delta L 3 which is equal to 160.40. If you come back here, so example 2, there is a layer case. In the layer case, earlier I have said for layer soil Q u is equal to q 0 N q A b plus P summation of q 0 bar K s bar tan delta delta L. Now, if you look at here, there are three layers - layer one, layer two, layer three. What are the parameters I have been given dry density has been given, phi has been given 30 degree, then e has been given. So, what is missing water table is at the ground surface that means, you need to have to have your gamma saturated you need weight. To get gamma saturated, you need weight you have to calculate your specific gravity G. So, gamma d is equal to gamma w G by 1 plus e.

So, from there you can calculate G, then once you calculate the G then you calculate gamma saturated is equal to gamma w into G plus e by 1 plus e. Then gamma submerged is equal to gamma saturated minus gamma w. Then Q u is equal to q 0 N q A b plus P, P is your perimeter summation of q 0 bar K s bar tan delta delta L. Tan delta we have calculated every case delta is given delta whether you can take it or you can find it out from there. So, delta you can take it in to take into consideration of delta between because here nothing has been given. You can take this value, it is a still delta you can shake it 20 degree or you can consider delta value is your delta is equal to if it is not given two-third phi to three-forth phi.

This value you consider. So, then what are the parameters to be calculated N q, A b, q 0, phi is equal to 38 degree, N q got it 95, area of base is your 0.159, perimeter is your 1.428. So, K s is equal to half K p. So, q 0 1 average value of q 0 1, if it is a summation half delta L 1 gamma submerged per layer 1. q 0 2 delta L 1 gamma submerged 1 plus half delta L 2 gamma submerged 2. q 0 3 delta L 1 gamma submerged 1 plus delta L 2 gamma submerged 2 plus half delta l 3 gamma submerged 3, this average value. For layer one, this is what your half has been taken delta L and gamma submerged. For layer two layer one into gamma submerged that is K s plus particularly for layer two this is your half; for layer three this is half and this has been added.

Then for each layer we calculate G gamma saturated gamma submerged. Then once you knowing then you can calculate q 0 q 0 is gamma submerged 1 delta L 1 gamma submerged 2 delta L 2 gamma submerged 3 delta L 3. This value is comes out to be 160.40 that is your kilo Newton. Then then you once you get it find it out value of your Q u and Q a. You can check Q u comes out to be 2850 kilo Newton; Q a comes out to be 1140 kilo Newton. This is what up to the piles in cohesion less soil, granular soil.

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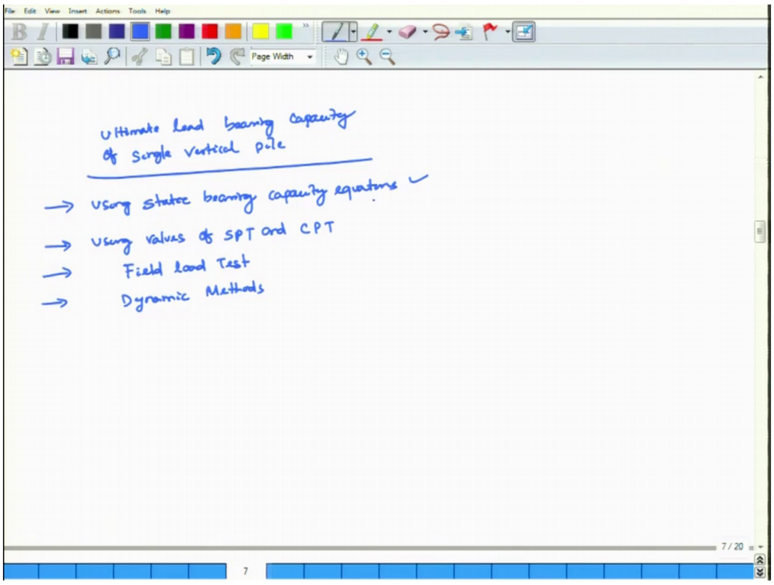

Considering using static bearing capacity equations, next class I will start piles driven into cohesive soils one-by-one we will go it. So, I will stop it here.

Thank you.