Geotechnical Engineering II / Foundation Engineering
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Lecture - 46
Pile foundation (Contd.)

Good morning once again and I will just continue with pile settlement. In fact, in the last lecture I have discussed about various aspects how to model or calculating the settlement, how to model the group of pile embedded in different soil and calculate the settlement. And now, I will take two examples to explain that computation procedure and so that depending outside type we will also model how to model actually whether two-third depth or pile tip and then, various component how to calculate one by one; that I will try to show through these two problems.

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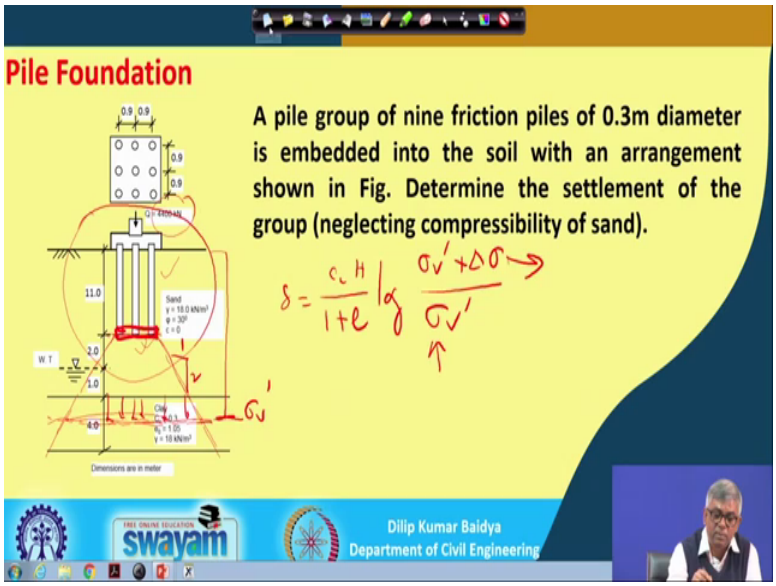

So, first problem let me take; actually this is a problem actually you can see here the given a pile group of 9 friction piles of 0.3 meter diameter is embedded into the soil with an arrangement shown in figure. You can see in this figure and determine the settlement of the group neglecting compressibility of the sand. You can see here as I have told you the model actually see the; this is the zone, this is uniform zone. The soil is embedded in sand and also resting on sand.

So, that means I can I can imagine equivalent raft at the pile tip. That is one thing, first thing to be there and you have to find out you can see that there is a compressible layer just slightly away from the pile tip. So, 3 meter away from the pile tip and thickness of the clay layer is 4 meter. So, because of if this q that pile pile group carries actually 4400 kilo Newton of load and when I will transfer here same load I will be transferring and then, this load will be dispersed like this, ok.

So, it will be the equivalent raft will be somewhere it will be here, equivalent raft will be here and through that raft pile pressure will be dispersed like this. So, what I have to do to point out the constant centimetre of this layer, I have to apply the formula, log formula in the middle of the clay layer. So, this middle of the clay layer if you want to apply, then what I have to do; first of all I have to find out the sigma b dash at this point before applying load.

So, sigma b dash is what actually weight of the soil up to this and when there is a water table, of course I will be taking submerging unit otherwise total unit to it that is one thing I will be doing and second part will be I have to find out what is the delta sigma here. That means delta sigma here because of this foundation loading or how to find out that? With this dispersion, that means, one horizontal two vertical like that this dispersion generally we take.

Based upon that I will find out what is the length and width of the footing and then, at this step and based on that what is the pressure. So, that pressure will be the additional pressure coming because of this loading and so, using that finally I will be using delta equal to equal to C into h by 1 plus e log 10 base sigma C dash plus delta sigma divided by sigma b dash; this formula is to be used. So, delta sigma calculation actually we have to find out width here and sigma p dash actually to be calculated by using the weight of soil up to this soil this layer.

So, this is the way I have told and in fact, I have discussed two different modules and you can say this is the first module; that means, second module actually what I have shown that is actually equivalent half to be considered at the pile t. This is the one we can consider and if you do that, then what are the different components let me erase this one.

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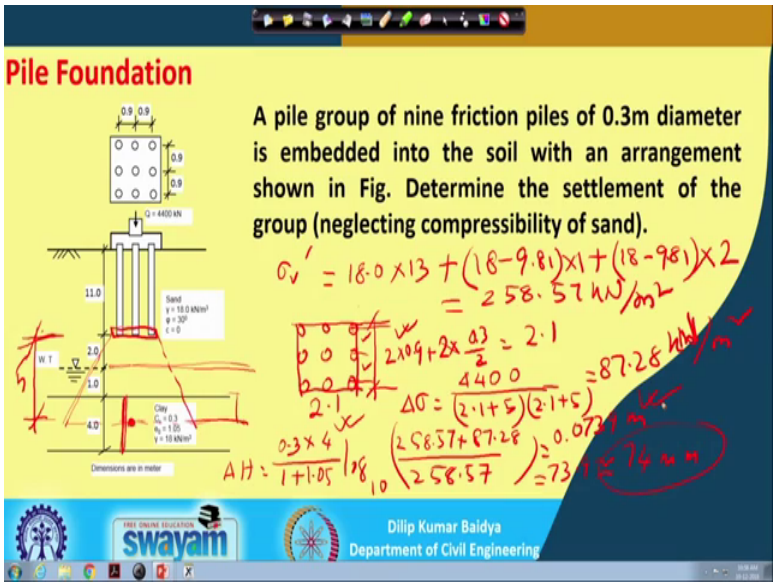

And once again I will do you can see here delta sigma. First of all suppose I want to find out sigma b dash and since I will find out settlement at the middle of the clay layer, so I will be considering unit weight of the soil up to this. So, sigma b dash will be you can see up to this dry unit weight of sand will be used and what is the length actually or height.

So, this actually 18 is the unit weight of the sand, length actually 11 plus 2 is 13, plus I am taking dry unit weight and moist unit weight also sand since it is not given here. So, I will take and, but it is below water table. So, the total unit weight minus unit weight of water that gives you the submerged unit weight multiplied by actually this distance thing is 1 plus this one will be taking.

So, here actually submerged unit weight is 18 again minus unit weight of water 9.81 multiplied by actually up to 2 meter middle of the three layer I will take. So, it will be 3. See we calculate this, then you will get a value equal to sigma b dash at 258.57 kilo Newton per meter square. Now, I want to find out delta sigma and if I consider pile raft here, then if it is going like this if it is going like this, then and this width of the width of the block first of all you have to find out you can see here like this they are there.

So, if I draw tangent from here, if I draw tangent from here, if I draw tangent from here, then what is this actually this length? This will be equal to 2 times of 0.9 plus twice 0.3 by 2. 0.3 by 2 that mean your centre to centre distance is spacing. So, this is one spacing

twice two spacing I have taken already and then, at this side from the centre to end actually d by 2 here also centre to d by 2; so, d by 2 multiplied by twice which is at this side and this side.

So, it becomes 2 in 2 multiplied by 0.9 1.8 plus 3; so it become 2.1. So, that means the block size is 2.1 by 2.1. So, here enlarge and from here to here depth is how much? From here to here middle of the clay layer this depth actually will be equal to this depth equal to how much? 2 plus 1 plus 3 plus 2. That means, 5 5 meter up to this upto middle of the from the pile tip, the middle of the clay layer it is 5 meter. So, you will have enlarge delta sigma will be equal to q design actually 4400 divided by your b is 2.1 plus 5 and w also 2.1 plus 5 since it is square 1.

So, this delta sigma if you calculate it gives you a value equal to 87.28 87.28 kilo Newton per kilo Newton per meter square. Now, your delta h will be equal to C c layer of this how much? 0.3 multiplied by thickness of layer is 4 and 1 plus e value is 1.05 log 10 base sigma dash actually 258.57 plus this 87.28 divided by 258.57 this one. So, if you calculate this one by calculator you will get a value equal to 0.0739 meter because everything is expressed in meter. So, this is also should be in meter because these are all non-dimensional, but unity is because of this 4 meter thickness I have taken in meter.

So, this result will be in meter. So, if I convert in millimetre, so it will become 73.9 or equal or you can say 74 millimetre settlement. So, for this pile when the pile is embedded grouped like this and embedded in sand where actually at some depth there is a compressible layer, then ignoring the compression of the soil itself, the elastic compression will be there that I have ignored. Even that ignoring that because of this presence of this sub compressible layer, the pile entire pile group will settle by 74 millimeter. It is almost like 3 inches that has to be carefully see that how important settlement calculation you can imagine.

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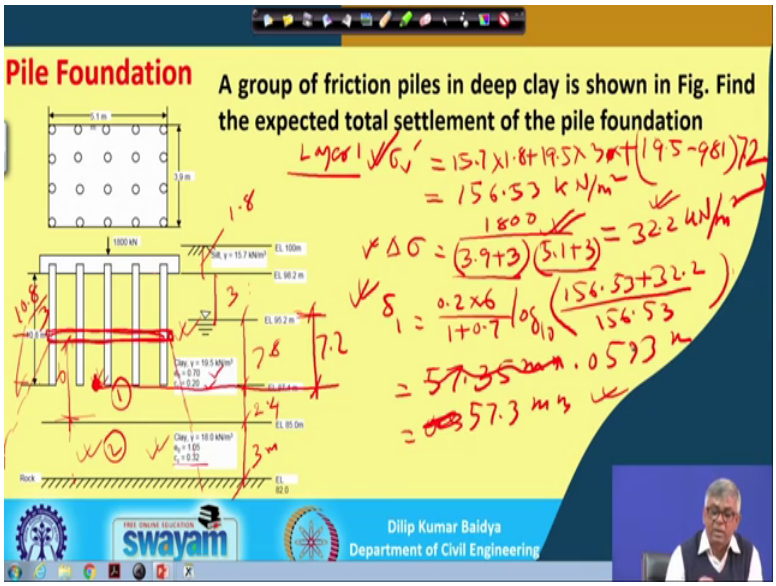

Next one next problem is like this actually you can see here. This is actually you can see the model which I have explained in the first one and you can see here there are there is a very large group of 5 by 4. The total 20 pile where there and the length of the length of the pile is 10.8 metre and different elevations are here; it is given based on this elevation, I can find out the thickness. Actually we can see this is this thickness this thickness of this layer is 1.8 meter, this is 1.8 and this is actually your 3 meter and from here to here actually this is actually your 7.8 meter and from here to here actually this is 2.4 meter and here to here it is 3 meter.

So, these are there and now you can see that this is clay, this is also clay. So, we can see here this clay is having 0.7 and cc is 0.2 and here actually you can see it is less and compressibility is also less and whereas, in this problem you can see clay is quite high above 1 and cc obviously is little high 0.32. So, that means when the pile is embedded in uniform soil, then that too compressible clay soil then what is the model actually? Our model is actually 2 2 equal raft to be considered at two-third height, ok.

So, this is the one you have to consider the equivalent raft at this depth and this will be nothing, but and this will be actually from here to here, it will be 10.8 by 3 because this side two-third, this will be one-third. So, now if I equivalent raft is here, this is compressible, this is also compressible. So, two layers are their compressible layer, but they have different compressibility. So, I cannot use the formula at a time. So, I have to

apply formula twice. So, for this pile once and for this pile once and then, what I have to do then I have to consider the dispersion like this, dispersion like this and from here to here from here to here this distance comes actually 6 meter.

So, that means somewhere here in between I have to find out the width with this dispersion what is the width and then, at this depth what was the sigma I have to find out. So, I will calculate in two parts that I consider this one layer 1 actually one part and layer 2 is second part. Part 1 and part 2 calculation I will do and then sum it up, to get the total.

So, when I will calculate layer 1 when I will calculate layer 1 ok. So, I have shown the position of equivalent raft and based on that when I will do layer 1, then you will be having delta sigma dash or sigma b dash. Sigma b dash will be equal to 15.7 multiplied by 1.8 that means, weight of this layer this is actually entire this zone since it is this above water table unit weight of sand is not given, unit weight of clay is not given, I will take the same value. So, 19.5 multiplied by 3; 19.5 multiplied by 3.

So, this is 19.5, this depth and then from up to water table is 7.8 meter. So, sorry this is plus plus actually 19.5. So, this is 7.8 meter, but if I come up to middle of the clay layer, this gives you 7.2. So, this gives you, that means from the from here to here this gives you 7.2.

So, it is 19.5 minus 9.81 multiplied by 7.2. So, that means for layer 1 what was the sigma b dash before application of the load? If I calculate this, this comes actually 156.53 Newton per meter square and what will be the width of the 14 at the middle of the clay layer. Actually this dimension is given 3.9 by 5.1. So, delta sigma b for layer 1 will be equal to q 18000 kilo Newton divided by 3.9 plus 3 because it was total 6.

So, it will be 23 meter and this is 5.1 plus 3, so that gives you a value equal to 32.2 kilo Newton per meter square. Now that use the delta suppose delta 1 if I took, then C c actually 0.2 multiplied by 6 meter is the thickness 1 plus the (Refer Time: 16:26) ratio is 0.7 log 10 base 156.53 plus delta sigma is 32.2 divided by sigma beta as 156.53. So, if I calculate this one you get delta 1 will be equal to 57.35 millimetre.

So, initially it will be equal to initially it will come in metre of course 0.0573 metre. So, finally it will be; this will come 57.3 millimeter. So, this is the these actually what I have

calculated because of the this the pile is driven through uniform friction pile that (Refer Time: 17:29) pile.

So, in that case our model is that pile raft will be an equivalent raft will be considered at two-third depth two-third from here, two-third from here; so one-third from here. So, if it is one-third, so here then I can find out this from here to here one clay layer from here to here another clay layer. So, from here to here this clay layer thickness is 6 meter; so that means 6 meter.

So, middle of the clay layer I have to find out what is the delta sigma b dash? That means because of the soil weight before application of the foundation pressure what was the pressure that is circulated here. And then, I have to find out after application of the load; what is the additional friction is coming that how I will find out? By just by dispersion two vertical one horizontal and at a depth of 3 metre from the raft and that if you do, this is just the formula to use that is enlarging the width that 3 metre depth that is 3.9 plus 3 and 5 plus 1.3: then if you do this, this will come 32.2 kilo Newton per metre square, then I can apply the (Refer Time: 18:41) log formula to find out the compression of this layer that is coming 57.3 metre millimetre.

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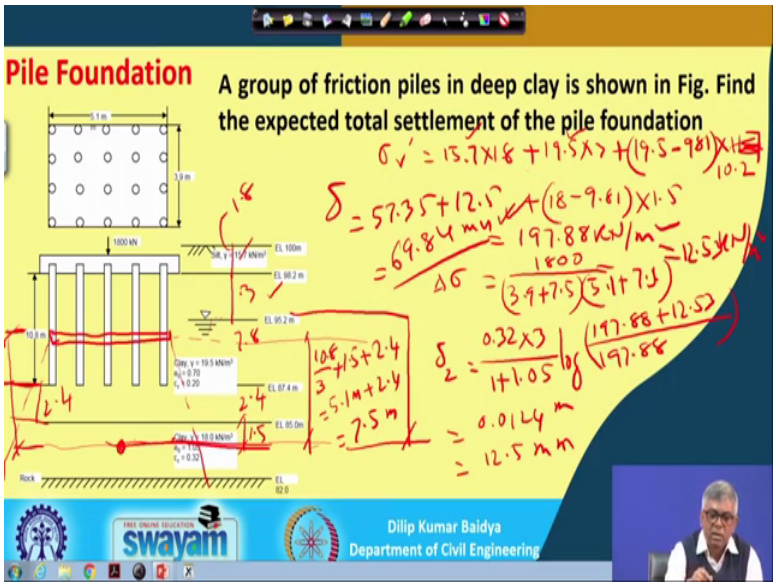

Now, I will take the second part let me second part for second part again same I will do equivalent raft here and I will do this one. So, I have to find out at this middle of this layer. So, I have to this is actually 1.8 and this is 7 I think, sorry this is 3, this is 7.8 and

this is 2.4 and this is actually 1.5 and from here to here from here to here what is the height? This will be equal to or I can show this height also. This height will be equal to 10.8 by 3 plus 1.5, ok.

So, this will be equal to will see that 10.5 10.8 by 3 plus 1.5 plus 1.5 that gives you 5.1 metre, ok. So, if this is 5.1 meter oh no sorry this will be plus 10.8 by 3 plus 2.4 plus 2.4 actually. So, 5 plus 2.4; so that gives you it will be 7.5 actually. So, from here to here from here to here, so this is 10.5 by 3, then 2.4 plus 1.5; so this is 7.5 meter.

So, I just find out delta or sigma b dash; sigma b dash will be equal to your sigma b dash equal to 15.7; 15.7 minus multiplied by 1.8 plus 19.5 multiplied by 3, 19.5 multiplied by 3 plus 19.5 minus 9.81 multiplied by it will come this will be 7.8; ao 7.8 by 10.8, so that will be 11. 7.

So, it will be 11.7; so because I have to find out from here to here, so it will be added. So, it will be total 11.7 7.8. This is 7.8 plus 2.4 7.8 plus 2.4 7.8 plus 2.4 plus 1.5. So, that gives 11.7, so that means I have to take weight of soil up to this.

So, this is the weight of this first part; second part weight of the second part and from here to here soil is same the unit weight is same. Oh sorry that could have been taken differently. This will not be correct 19.5 minus 9.81 multiplied by 7.8 plus 2.4; 7.8 plus 2.4 7.8 plus 2.4 that gives you 10.2 and plus 19.18. This is actually 18; so 18 minus 9.81 multiplied by 1.5. So, that gives you 197.88

Let me find out that 18.9 0.81 18.0 minus 9.81 multiplied by 1.5 plus 19.5 minus 9.81 multiplied by 10.2 plus 19.5 multiplied by 3 plus 15.7 multiplied by 1.8; that gives you 197.88.

Now, delta sigma will be equal to delta sigma will be eqaul to your total weight is 1800 divided by 3.9 plus 3.9 plus 7.5 multiplied by 5.1 5.1 plus 7.5. So, that gives you the pressure equal to 12.53 kilo Newton per metre square. This is also kilo Newton per metre square, then layer 2 settlement I can find out delta 2, then Cc actually here actually 0.32, thickness is 3 metre divided by 1 plus e is 1.05 log 10 base.

So, 197.88 plus 12.53 divided by 197.88. So, this if I calculate, then it will be 197.88 plus 12.53 divided by 197.88. This I can take log multiplied by 3 multiplied by 0.32

divided by 2.05. So, this gives you 0.012 4 metre or multiplied by 1000 that gives you 12.5 12.5 millimetre.

So, delta 1 plus delta 2, now the total settlement delta will be equal to that means initially there one delta 1 was 57.35 plus 12.5 that will be 12.5 plus 57.35; these two together 69.84 millimetre. So, that means for this foundation when this is loaded with 1800 kilo Newton load, then total settlement for this compressed layer ignoring the elastic compression only consolidation settlement if I consider, then you have 69 millimetre settlement, then 70 approximately 70 close to 3 inches.

So, this is actually two method two models I have discussed. One is actually at two-third length depth and at pile depth and both the problem I have both type of model I have taken in the numerical example. And only thing you have to know where actually you have to model how and rest of that rest of the calculation whatever we have learnt. So, it is same thing only ok; with this I will stop here.

Thank you.