Soil Structure Interaction
Prof. Kousik Deb
Department of Civil Engineering
Indian Institute of Technology – Kharagpur

Lecture - 7
Design of Shallow Foundation (Continued)

So last class, I have discussed how to determine the safe bearing capacity or allowable load carrying capacity of foundations isolated footing in sand. So, I determined the net safe bearing capacity based on the bearing criteria and I will continue from there.

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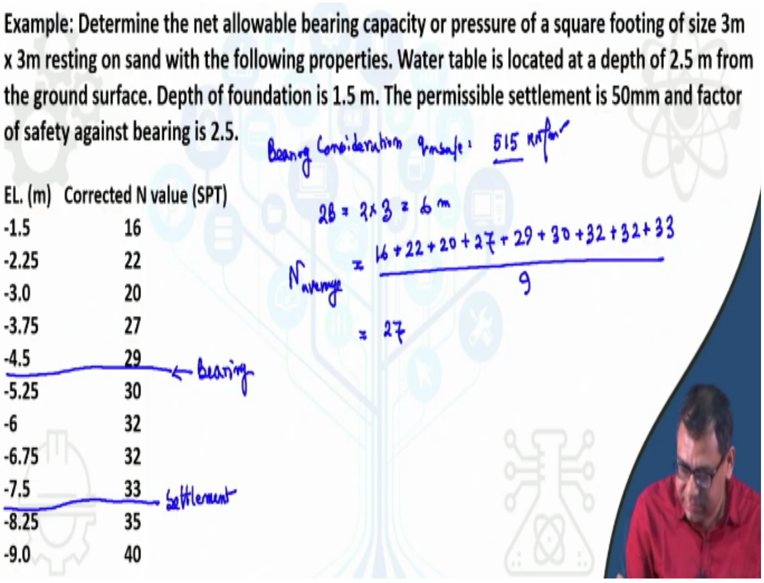

So, the same equation or same problem I am taking. So here from the bearing consideration, you can see your value was, q net safe was 515 kilonewton per meter square. Now we will consider the settlement consideration and then I will go for the allowable bearing capacity consideration. So when we are talking about the settlement consideration, then our influence zone will be 2B. So the influence zone will be 2B, 2 into your B is equal to 3, that means 6 meter okay. So now the influence zone will be from the base of the foundation it is 7.5 meter okay.

So, the influence zone will be 7.5 meters. So 4.5 meter from base of the foundation was for the bearing and for the settlement it is 7.5. So now the N average value will be that is

$$= \frac{(16 + 22 + 20 + 27 + 29 + 30 + 32 + 32 + 33)}{9} = 27$$ So average N value is 27. So now these average N value we will use for settlement consideration okay. So let us go for the settlement consideration.

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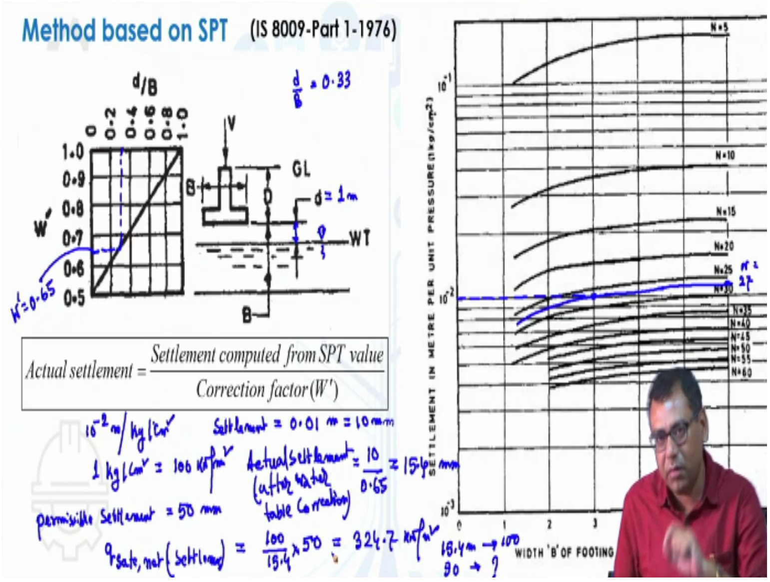

So, this I have already used. So now settlement consideration, I will use the method based on SPT because we have SPT data available, and plate load test settlement I have already discussed, so you can use that value also if plate load data is available. If SCPT data is available, you can use for SCPT data also, but here SPT is available, so I will use these based on SPT. So, from your N average value is 27. Now for the chart, your N value is 27, you can go, this is the N value, this N value is 20.

This N value is 30, this is 25, so 27 will be somehow here okay and your B value width of the foundation is 3 meters. So, this is the twenty seven 27, curve will be around this okay. So, from the 3, this is your value, so corresponding value is this one. This is the blue one is the N value 27, chart curve okay. So this is the 10 to the power 2, so kg per centimetre square. What is written in the y axis? The settlement in meter per unit pressure in kg per centimetre square.

So that means, it is given that this is 10 to the power minus 2 meter okay is your settlement**,** it is per kg per centimetres square okay. So if your load is 1 kg per centimetre square, then your settlement is 10 to the power minus 2 meter. So I can write that our settlement value is 0.01

meter that is equal to 10 meters okay. So I can write that here for the 10 meters settlement is we will get for 1 kN/cm^2 okay. So that means here I can write that 1 kN/cm^2 is equal to 100 kN/m^2

So, 1 kN/cm^2 just I have converted the unit only, 1 kN/cm^2 is 100 k kN/m^2 okay and here the settlement is 10 millimetres sorry, settlement is 10 millimetre, here we have not considered the water table effect. So, we have to consider the water table effect and then I will get the actual settlement okay. So, because in previous case also when I considered the bearing consideration, we considered the water table. Here, we have not considered the water table.

So now we have to consider the water table. Now, if we consider the water table, then here what would be the water table correction factor because now my water table is here okay. So, water table is here, your d by B, this is the small d, that small d value is 1 meter okay. So, again the d, small d by B is 0.33. So, this is 0.33, will be somewhere here. So the same correction table I am using here. So the W dash will be 0.65, the same correction factor that I have used for the bearding consideration, but here, as I mentioned, for the bearing I multiply that, but here I have to divide it.

So my actual settlement will be after correction is equal to 10 divided by 0.65. So that value is equal to 15.4 okay. So, actual settlement is coming out to be 15.4 millimetre, and as I mentioned in the problem, it is giving the permissible settlement is your main value was equal to 50 millimetre. So, it is like that that for 15.4 millimetre settlement you will get corresponding to 100 kN/m^2, then 50 millimetre settlement, you will get corresponding to which stress okay and that stress value will be your permissible stress or safe bearing capacity okay.

So, that means I can write now my q safe or net or net safe in terms of settlement criteria will be equal to, that means your 15.4 millimetre corresponding to 100, then 50 millimeter will be corresponding to what okay. So that means it will be $= \frac{100 \times 50}{15.4}$. So, that will be equal to 324.7 kN/m^2, clear. So, in terms of settlement consideration, it is 3247 kN/m^2 square. In terms of bearing consideration, it was 515 kN/m^2. Now, I will use one more equation or one more method and then check which one is giving the lowest value.

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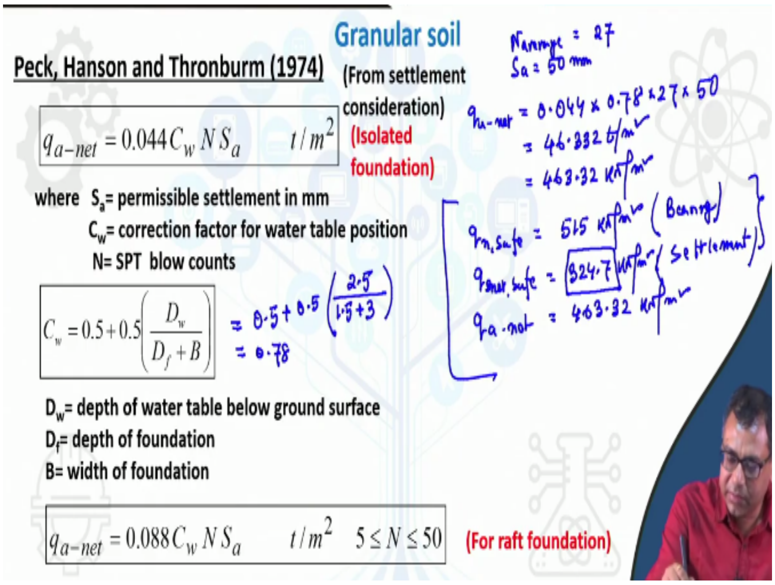

So, one more method that I will use is the method which is given by Peck, Hanson and Thornburm. So here also I will get the allowable bearing capacity considering both, settlement as well as the bearing. So, let us see. So again as we are considering settlement here, permissible settlement, so our N average value we will get 27 okay and then here permissible settlement means Sa is 50 millimetre okay. Now equation that we are using, so we put here $q_{(a\text{-}net)}$ and this is for isolated foundation.

Now your settlement factor is 0.5 + 0.5 and your D_f, D_f now that is the depth water table below ground surface, so depth of water table below ground surface is 2.5 meter. Then D_f depth of foundation is 1.5 and with the foundation is 3. So this value is 0.78. Here, a different correction factor is coming because we are using a different methodology or different equation. So, now we are putting these values here, 0.044, C_w is 0.78, then N value is 27, and permissible settlement is 50.

So, this value is 46.332 ton per meter square, in terms of kN/m^2, it will be 463.32 kN/m^2 okay. So, now we have 3 values okay. Now, I am writing those 3 values. In summary, I am writing those 3 values. So directly for the bearing consideration net safe is equal to 515 kN/m^2 for this is bearing consideration. Now $q_{(a\text{-}net)}$ is equal to 324.7 kN/m^2 settlement consideration and then q allowable net that we are getting here 463.32 kN/m^2 okay, so considering both.

So, as I mentioned that ideally, lower of these two will give you the allowable load bearing capacity, here I have considered third one also to re check it, so but the lowest value among these three is this one. So, your allowable load carrying capacity or SBC safe bearing capacity will be 324.7 kN/m^2 corresponding to these conditions. That means, these conditions that means your foundation width is 3 meter, it is a square footing and your depth of foundation is 1.5 meter and position of water table is 2.5 meter from the ground surface, then only this SBC value is 324.7 kN/m^2.

If this condition changes, this value will also change. So, it is not a unique value remember that, it is a function of depth of foundation, width of foundation and position of the water table, even if your N value will remain say okay, and definitely if your width of foundation changing, then automatically influence zone will also change and your N average value may change also okay. So, you consider these things when you design okay. So that means among these three, the lowest value will give safe bearing capacity or allowing bearing capacity okay.

So the next one that I will discuss, I have discussed on the sand part and then I have discussed thus how to calculate the settlement and then how to design or determine the safe bearing capacity for a shallow isolated foundation on sand. Now, the next one that I will discuss is I will design raft foundation on clay okay. So, I will discuss raft foundation on clay and because I have discussed only one foundation design on sand, now I will discuss on clay, how to design a foundation on clay and this is a raft foundation, keep the problem okay.

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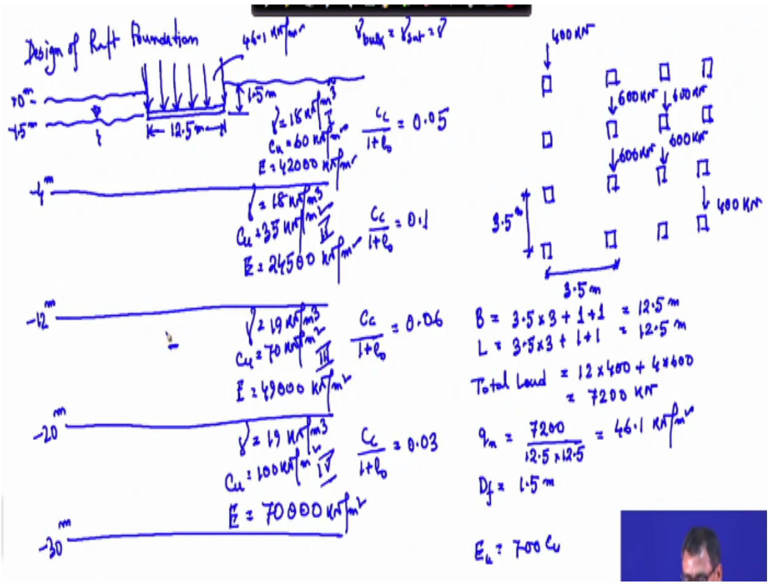

So design of raft foundation. Because last problem I have solved for the isolated footing, now I will solve a problem for the raft foundation. Suppose this is your building column position okay. So there are say 4 columns. This is also 4 by 4 column position for a building where I will put the raft because initially we have to check the individual foundation for individual column. Now it has been checked and it is observed that the foundations are overlapping each other by dimension, so we are going for the raft foundation or sometimes in settlement criteria also or differential settlement criteria also you can go for the raft foundation also.

Here, we will go for the raft foundation and the loading is coming for the periphery columns. The load is coming 400 for each column. So, all the 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, all the 11, 12, the load from the structure is coming 400 kilo newton as the periphery, where the internal columns load are coming 600 kilo newton for each, all the 4 columns, load is 600 kilo newton okay, that is 600 kilo newton. The centre to centre distance for each column is 3.5 meter okay and here also centre to centre for each column is 3.5 meter.

As we consider the raft foundation, so what would be the dimension? First we have to choose the dimensions. So we are choosing the dimension B and here as it is B and L will be same because the spacing and the number of column in each direction are same. So B will be, there is a three spacing, so 3.5 into 3 plus for the first trial what I am doing, I am taking 1 meter extra from the centre of last column for both the sides. So 1 meter extra from left side and 1 meter extra from the right side for the first trial, let us see whether it is satisfying or not.

So the dimension will be 12.5 meter that is the width. Similarly, length will be 3.5 into 3 plus again I am taking 1 meter each side, so that will be 12.5 meter okay. Now, how much total load is coming? Total load is coming on the raft is, there are 12 columns those are carrying 400 kilo newton each, so 12 into 400 okay; 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12. Then 4 columns were carrying six hundred 600 kilo newton each, so 4 into 600. So, this total load is 7200 kilo newton okay, that is the total load coming on this raft okay.

So, now the net load that is acting on this raft okay, we are taking the raft load we are neglecting and considering that external load is much much more compared to the weight of the raft. So, the total load that may stress or you can say that is 7200 or that is 12.5 into 12.5. So, that is equal to 46.1 kN/m^2. So, we have converted these loads and that amount of uniformly distributed load is acting on the raft okay, and for the first trial, we are also assuming depth of foundation is 1.5 meter okay.

So, this is the geometrical point of view or the loading point of view. Now, come to the soil strata or soil point of view. So, suppose this is the ground level and we are considering this is our raft okay. We are placing our raft here. So, this is the raft where the load of stresses is coming and that is 46.1 kilo newton per meter square okay, and this is the ground level and raft position is 1.5 meter below the ground level because Df for the first trial you have considered 1.5 meters.

For the first trial, you have taken the width of the foundation is or the raft is 12.5 meter, here width and length both are same okay. The position of water table is also at 1.5 meters below ground level okay. So if you say this is plus 0 meter, this will be 1.5 meter position of the water table okay. Now there is the layer, different layer is there, this is layer 1 okay. So, there is another layer, layer 2. This is another layer, layer 3, and this is another layer, layer 4. So, there are total four layers within the influence zone and let us see which is within the influence zone or not.

So, the soil strata, we will get the soil strata from the soil investigation and these are the properties and first trail we are placing a raft depth of raft is 1.5 meter below ground level and the length of the raft is 12.5 meter and loading intensity is 46.1 kN/m^2 square okay. So now, this is minus 4 meter from the level, this strata is minus 12 meter from the ground level, this strata is minus 20 meter from the ground level, this is minus 30 meter from the ground level okay.

The properties are given for the strata one, unit weight is given 18 kilo newton per meter cube and here it is assumed the unit weight above water table that means bulk and below water table that means saturated is equal to same okay. So, I have discussed already it can be different, it can be same, most of the cases it is different okay. Saturated unit weight is more than the bulk unit weight, but here it is assumed more or less same okay. So the properties are given, unit weight is kilo newton per meter cube 18 cu and then cohesion is taking 60 kilo newton per meter square.

Then E value is taken or it is given is 42000 kN/m^2 and C_c one plus E_0 directly is given 0.05, and if you say this E value is 42000 and C_u value is 60, so the relationship is coming you can say E_u is 700 C_u okay, but that that means, this soil is normally consolidated clay okay. So soil is given normally consolidated clay and E_u is 700 C_u, but the range I have given is 750 to 1200 C_u, but here it is given 700 as this value is given. If it not given, you can choose any value from the range okay.

So, now the second layer, your unit weight is given again 18 kN/m^3, C_u value is equal to 35 kilo newton per meter square, E value is equal to 24500 kN/m^2, and C_c divided by $(1 + E_0)$ zero is 0.1. Again, it is all the case Eu is 700 C_u. For the third layer, unit weight is 19 kN/m^3, Cu is your 70 , and E is 49000 kN/m^2 okay. Again Cc $1+E_0$ is equal 0.06 okay.

For the fourth layer, your unit weight is 19 kN/m^3, Cu is given 100 kN/m^2, E or Eu is 70,000 kN/m^2 and Cc $1+E_0$ is equal to 0.03 okay. So, this is the strata and these are the first trial we are taking the dimension. So, now first we will calculate the bearing capacity, then we will calculate the settlement and we will check whether both are within permissible limit or not. So, the bearing capacity as I mentioned for the bearing capacity influence zone will be B.

So here B value is 12.5, so influence zone will be 12.5 from the base of the foundation. So, the influence zone up to 12.5, so from the surface it is (12.5 + 1.5) , so it is 14 meter okay. So, influence zone will be 14 meter up to here say for the bearing capacity calculation. This is the influence zone, so 14 meter. That means here the influence zone for the first layer will be 2.5 meter, second layer 12 meter full, sorry 8 meter full because second layer is 8 meter, 2.5, then another 2 okay.

So, for the bearing capacity influence zone of first layer is 2.5, second layer is 8 meter, and third layer is 2 meter okay. So, in the next class, I will discuss that how I will calculate the bearing capacity and then how we will calculate the settlement for these conditions. Thank you.