Foundation Engineering
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Lecture – 20
Shallow Foundation - Settlement V

So, last class I have discuss about the calculation of settlement of foundation on clay. Now this class I will discuss how will calculate settlement of a foundation resting on sand and what are the methods that will used to determine the settlement.

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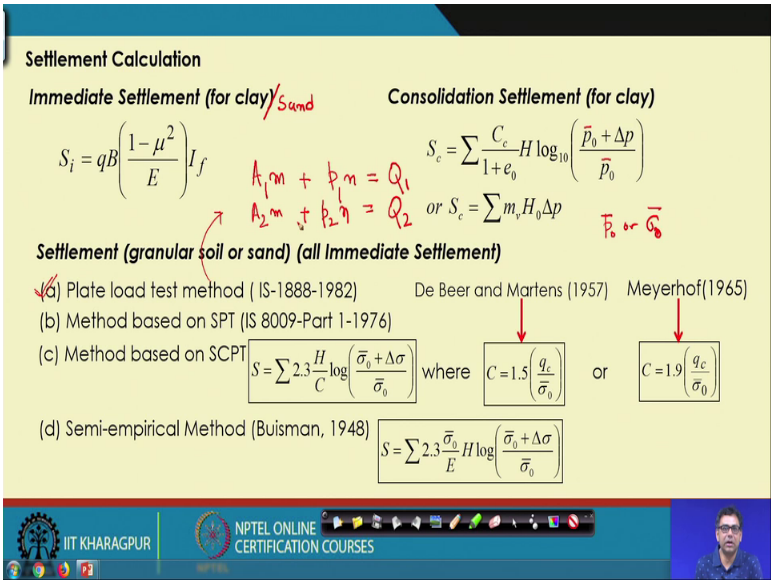

So, these are the summary of the all the methods that I have discuss to calculate the immediate and the consolidation settlement of clay and the calculate or the settlement of foundation on sand and in case of sand or granular material this settlement all are immediate settlement.

So, one thing I want to mention that so this is p 0 bar this is effective this is also effective. So, here you if you see that here p 0 bar is using and here sigma 0 bar is using. So, both are same so both are effective overburden pressure. So, either you or we can be used as a p 0 bar or sigma 0 bar both are effective overburden pressure. So, keep it mind and another one is that so when you are talking about the immediate settlement.

So, for the immediate settlement calculation of clay we are using this expression only because this is the expression for the clay immediate settlement calculation or this is based on the elastic theory and this is the consolidation expression settlement expression. And for the granular soil so as I mention so we will using these 4 methods, but you can use this expression also the this immediate settlement calculation expression for which we are using for clay.

Sometimes we can use these expression also, but I would prefer to use these expressions which are mentioned in the immediate settlement calculation because in the case of sand we can do the in situ test. So, these expressions are these methods are based on in situ test like plate load test, SPT SCPT except the fourth one which is based on the semi empirical methods so, but if we do not have these any of these methods available then we can use this expression also. So, sometimes we can so that mean this is applicable clay or sand also, but again mentioning that I would prefer to use any of these in situ test based method for sand settlement calculation. So, in your assignment or the exam also it will be mentioned if it will be either it will be mentioned that which method you have to adopt or based on the given values of soil parameters either it is SPT or SCPT or plate load test you have to select any of them which is listed here.

So, either you can go for this all in situ base test method or sometimes we can use the sand the this expression elastic the based on the elastic theory which we have used for the clay. So, keep in mind and another one that today I will discuss about the settlement calculation of the sand and I have already discuss about this plate load test part because here how the settlement can be calculated based on the plate load test data or how we locate the allowable load bearing capacity of a foundation based on the plate load test data. So, this things been discuss.

So, and one thing I want to mention in the plate load test with the problem that I have solved in the plate load test case. So, here I have introduced the water table effect also keep in mind that you will only introduced the water table effect if the plate load test is done above your natural water table I mean; that means, during your test of the test on the side your water table was for a below from the influence zone of the plate. So, in that case only if the water table raise is happened then only you have to introduce the water table effect.

If the water table is always there within the influence zone during the test then that thing you would need to consider, but and all the problems that I solve that they are the water table was not there during the test condition and that is why we introduced the water table effect. This is one thing, another thing in plate load test sometimes using of 1 single plate where using 2 plates also.

So, how it will help? So, it will help suppose you have you are using so this is a plate load test. So, if you are using 2 plates of say one is perimeter or area A 1 for 1 plate and perimeter p 1 for another plate. So, we can use this expression A 1 m plus p 1 n is the Q 1. So, what is that? That A 1 is the area of first plate p 1 is the perimeter of the first plate and Q 1 is the load carrying capacity of the plate and then if you do another test A 2 m plus p 2 n is equal to Q 2 ok.

So; that means, the Q 2 is the load carrying capacity of the second plate where A 2 is the area of the second plate and p 2 is the perimeter of the second plate. So, if we have these 2 expression from there we can calculate the m and n now based on these m n we can now determine the load which any plate or any foundation can carry. So, this is the another way we can do it and, but most of the cases we follow that single plate expressions also by which also we can determine the load carrying capacity that I have explain.

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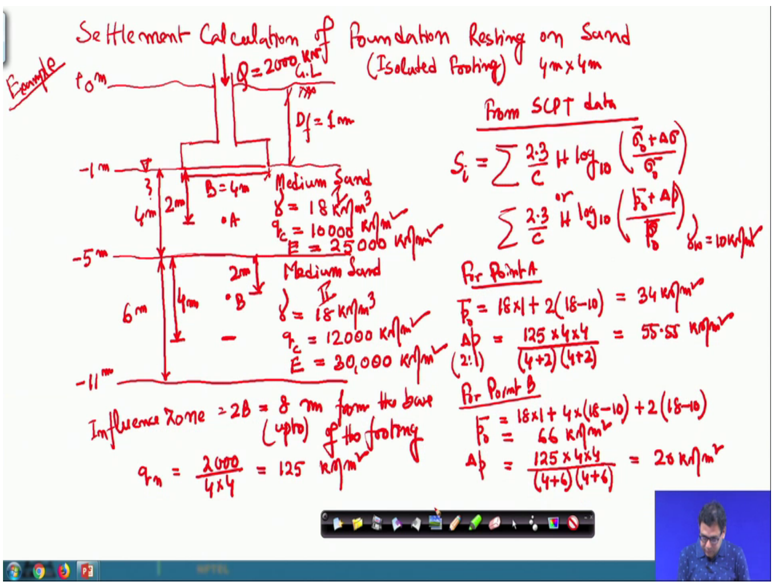

So, but today I will discuss about the methods which are based on so first I am taking 1 problem the example problem that I am taking. So, settlement calculation of foundation resting on sand. So, last class calculated the settlement of foundation resting on clay today calculate the settlement of foundation resting on sand and was on the problem that example problem that I am taking. So, this is the ground surface and here we have a foundation. So, this is the G L ground level and water table is at the base of the foundation in the problem on clay I have taken of raft foundation here I will take a isolated footing.

So, it is I am taking isolated footing. So, this is the water table location. So, this is plus 0 meter. So, water table is at minus 1 meter so an it is the 2 layer soil system. So, this is the layer 1 up to this is layer I. So, this is layer 1 this is layer 2 layer 1 is minus 5 meter and the layers II is extended up to minus 11 meter. So, this is the problem an isolated footing and the soil so the layer 1 which is medium sand medium sand and the layer 2 also medium sand, but which different properties. So, properties that are taken the unit weight of the soil is 18 kilo Newton per meter cube form first layer q c cone resistance is 10000 kilo Newton per meter square and the E value elastic modulus of the soil is elastic modulus of the soil is 25000 kilo Newton per meter square.

So, this is for the layer 1 and similarly layer 2 unit weight is again 18 kilo Newton per meter cube q c cone resistance is 12000 kilo Newton per meter cube meter square E value is 30000 kilo Newton per meter square and the dimension of the footing. So, it is a square isolated footing of dimension 4 cross 4 meter. So, the width of the footing B is 4 meter and the depth of foundation or D f is 1 meter.

So, now which of the methods we can we can use here. So, as I mentioned if the any of the particular methods is mentioned then we can use that method, but here you know particular methods I mean. So, you have to check that what are the methods we can use. So, the first method that we can use that we can use the method based on the CPT SCPT because this SCPT data is given. So, E value is also given. So, that so we can you use the method 4 also d that is semi empirical methods, but you cannot use the n value methods here because that n value is not given here. So, it is only q c value is given. So, and the plate load test is not done so plate load test also not given here.

So, we can use method 3 and 4 and in addition to that as I mention some we can use the elastic theory also to calculate the immediate settlement that I have used for the clay immediate settlement calculation. So, that method also we can use, but I would prefer that I will use these 2 methods which are available q c is available then we can use that method only, but here I will show all the 3 methods that we can use in this case.

So, and the thickness of these first layer is 4 meter and the thickness of the second layer is 6 meter and as we are doing the settlement; so, the influence zone is to 2B. So, the influence zone influence zone is twice B, So, up to 8 meter ok. So, it is up to 8 meter, but this thickness of this layer is 4 meter from the base of the footing. So, 6 meter this is up to meter from the base of the footing. So, here up to 8 means suppose your influence zone is up to here. So, first, so, influence zone the second layer thickness up to the influence zone is 4 meter ok.

So, now the methods that we are talking about, so, first method that will do it is based on the SCPT. So, from SCPT data and the expression is given for the SCPT value that is immediate settlement S i is the summation of 2.3 by C; H is the thickness of the layer log 10 sigma 0 or p 0 bar or del sigma or sometimes we can write summation of 2.3 as I mention H log 10 p 0 bar plus del p divided by p 0 bar.

So, again we have to calculate the p 0 the middle point of each layer. So, this is the middle point of this layer and middle point is 2 meter from the base of the footing and here it is not the middle point of this layer because it here the total layer is second layer is not within the influence zone. So, it will be the middle portion of the thickness of the layer which is influenced by the foundation. So, the influence zone thickness for the second layer is 4 meter. So, we have to take the point B which is again 2 meter from the top of the second layer or bottom of the first layer.

So, I can for point A so, you have to calculate that what are the what are the stresses coming in the point A. So point A p 0 bar is equal to the top as I mention there is only 1 unit weight given. So, that will use for the unit weight above the water table and for the saturated both. So, if there is 2 different unit weight’s are given so, you have to use both depending upon which unit weight’s are given; here only one is given. So, that is why you will use the 1 only. So, the p 0 bar for the thickness above the ground base is 18 into 1 that is the overburden pressure plus for this one is 2 meter. So, 2 into 18 minus 10 because 10 is the unit weight of water which is taken as so, 10 is the unit weight of the water is taken 10 kilo Newton per meter square.

So, this value is 34 kilo Newton per meter square and del p as we are taking it is 1 is to or 2 is to 1 distribution. So, as I mentioned; so, del p will be. So, the total load which is coming on the foundation Q is given 2000 kilo Newton ok. So, total load is 2000 kilo Newton. So, the q net which is including the load Q is including the weight of the footing. So, the q net which is coming as 2000 kilo Newton divided by the 4 cross 4; 16, so, the net intensity that is coming out to be 125 kilo Newton per meter square. So, that is the load which is acting on the base of the footing.

So, this is the net load net stress which is acting on the footing is 125; this stress is due to the application of external load. So, this is load including the load coming from the super structure plus the foundation weight. So, that mean del p will be 125 into 4 cross 4 divided by 4 plus 2 and in the other side 4 plus 2. So, this 2 is to 1 method I have discussed in the last problem when the settlement of foundation resting on clay that was calculated. So, we are using the same methods were following and you are getting the del p at point A is 55.55 kilo Newton per meter square.

So, similarly for point B, the p 0 bar is equal to 18 into 1 plus now the 4 meter 4 into 18 minus 10 plus this 2 meter, this 2 meter that at B so, plus 2 again 18 minus 10 because here also unit weight is 18 kilo Newton per meter cube. So, it is coming out to be p 0 bar is 66 kilo Newton per meter square. Similarly, del p at point B is 125 cross 4 cross 4 divided by 4 then 4 meter plus this 2 meter 6 meter, so, plus 6 again 4 plus 6 ok. So, this will give 20 kilo Newton per meter square. So, these are the things are given.

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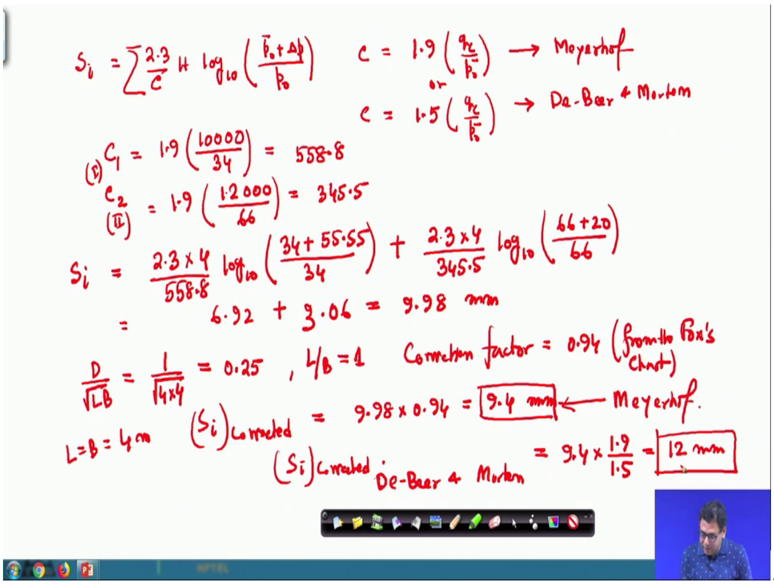

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So, now in the next one is that; so, as I mention that now the our immediate settlement S i is equal to 2.3 divided by C into H log 10 p 0 bar plus del p divided by p 0 bar so, this is summation. Now the C value we can calculate based on 2 methods, this C value is equal to 1.9 into q c divided by p 0 bar. So, this is suggested by Meyerhof or I can use C is equal to 1.5 into q c divided by p 0 bar this is given by De-Beer and Morton ok.

So, if I use the Meyerhof expression, so, if I use the Meyerhof expression then the C 1 for the first layer will be 1.9 and q c value for the first layer is the q c value for the first layer is given 10000 kilo Newton per meter square and q c value for the second layer is 12000 kilo Newton per meter square. So, I can write this is 10000 divided by p 0 bar. So, p 0 bar for the first layer is 34 and p 0 bar for the second layer is 66. So, this will be the 34. So, this value is 558.8.

Similarly, C vale for the second layer, layer 2 this is for layer 1 is 1.9 this is 20000 12000 divided by 66. So, this is coming out to be 345.5. So, finally, if I write the immediate settlement we can write this is equal to 2.3 and the thickness of first layer is 4 meter and second layer is 6 meter not so, 4 meter not 6 meter because 4 meter is only up to the influence zone. So, remember that thickness of first layer is 4 meter and the thickness of second layer is 4 meter also because you have to consider up to the influence zone only.

So, that mean this is 2.3 for the first layer into 4 divided by C, C for the first layer is 55 8.8 then this is log 10 p 0 bar is 34 then del p is 55.55 then divided by 34 then plus for the second layer 2.3 again thickness is 4 meter C is 345.5 then log 10 p 0 is 66 del p is 20 p 0 bar is 66. So, we can write this value is 6.92 plus 9 plus 3.06. So, total settlement is 9.98 millimeter.

So, next one is that now if I use from this settlement. So, you have to apply the correction factor. So, what are the correction factor you have to apply that as I mention for the immediate settlement you have to correction apply the correction factor for the rigidity correction factor and the depth correction factor, but as this foundation is the isolated footing. So, it is not a rigid foundation. So, we will apply only the depth factor correction. So, depth factor corrections. So, you know that d is d root over L B. So, here d value is 1 meter and L B is root over 4 cross 4 and because your L is equal to B is equal to 4 meter. So, this correction this value is 0.25 and L by B is equal to 1.

So, correction factor is equal to 0.94 from the Fox's chart. So, this Fox's chart are given. So, S i corrected will be equal to 9.98 into 0.94. So, that is equal to 9.4 meter millimeter. So, as for the this is as for the Meyerhof.

Now, if I want to calculate the settlement S i corrected as for the De-Beer and Marten then this value is because if you see here this things are. So, this is the Meyerhof or De Beer by Marten divided by Meyerhof if I say this is the De-Beer if I say this is the C for the Meyerhof and C for the De-Beer by Marten. So, that will be equal to 1.9 divided by 1.5. So, because this is 1 value so; that means, the we can write the corrected value for the De-Beer and Marten. So, instead of this is 1.9 we have to use this is 1.5. So, all the C i value will change, so, all the C i value will change.

As the C i value is we are dividing this C value. So, what will happen? So, for this case De-Beer and Marten case, C value is lower than the C value as propose by Meyerhof because it is 1.9 it is 1.5. So, C value that you are getting by using De-Beer and Marten will be lower than the C value that you are getting by Meyerhof. So, now, if I divide that lower value in the final expression, so, our settlement that you will get by using De-Beer and Martin will be higher than the settlement that will get by using the Meyerhof ok.

So, the De-Beer Martin settlement will be because Meyerhof settlement we have and higher means this will be 1.9 divided by 1.5 because this is a factor 1.9 1.5 because thus Meyerhof value will give lower compared to the value that will get by using De-Beer Martin. So, this will be you this value will be 12 millimeter. So, this is the another value that we are getting. So, this is the settlement we are getting. So, next one that if we use the next approach.

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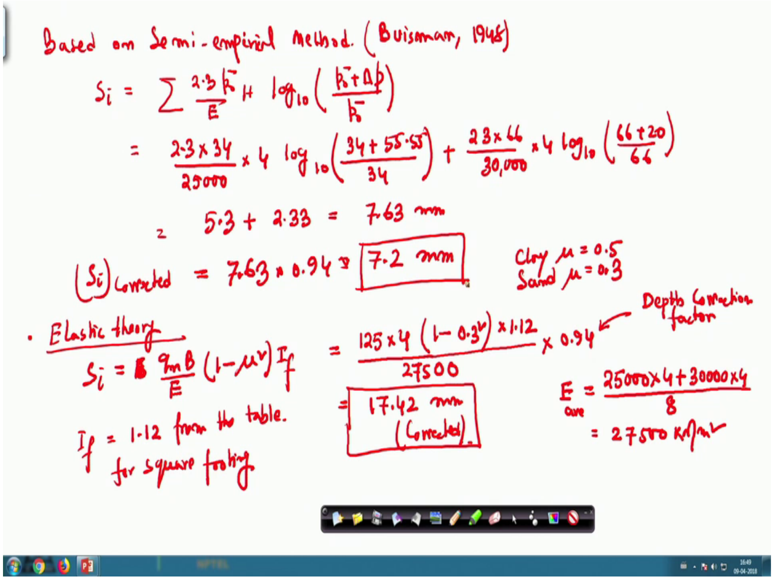

So, the next approach is based on semi empirical method. So, the settlement that you are getting based on semi-empirical method, so, which is propose by Buisman 1948. So, which is also similar to that S i is the summation of 2.3 p 0 bar divided by E into H log 10 p 0 bar plus del p and p 0 bar. So, all the values are calculated for the p 0 bar at the center for same procedure have to follow, but only instead of C you have to use the E and this is the p 0 bar you have to also used here.

So, now if I use that semi-empirical methods so then for the semi empirical methods; so, our E for this first layer is 25000 kilo Newton per meter square second layer is 30000 kilo Newton per meter square. So, finally, I will use this is 2.3 and p 0 bar for the first layer is 34 divided by 25000 into thickness again 4 meter this is log 10 p 0 bar is 34 plus 55.55 divided by 34 then plus 2.3 into 66 divided by 30000 into again H is 4 meter then log 10 this is 66 plus 20 divided by 66. So, this will be 5.3 plus 2.33. So, this will be 7.63 millimeter. So, again the S i corrected will be 7.63 into 0.94, so, that is equal to 7.2 millimeter. So, this is the values that we are using here.

So, the next thing is the elastic theory. So, this as I mention we can use this one also for the sand immediate settlement calculation, but though of not listed it in the list that are given sum in the summary list, but this is mainly used for the clay. But I would prefer that if you have the other values the like SPT, SCPT of then we should use those value and those methods to determine the settlement immediate settlement, but this method also you can use, but and that mean this method is you know that immediate settlement S i is equal to your q n B divided E 1 minus mu square into I f ok.

So, q n value is here q n is 125. So, q n is 125, B value is 4 and 1 minus 0.3 square. So, remember that for the clay generally mu value we take 0.5, but for the sand the mu value take 0.3 and the I f value we are taking it is equal to 1.12 from the table because this is for the square footing, I f value for square footing, it is and it is flexible foundation. So, at the center on the table we are taking I f value is 1.12, but the E value as it is the 2 layers. So, again you have to take the weighted average. So, A value average we are taking is equal to 25000 into 4 plus 30000 into 4 divided by 8. So, this will be the 27500 kilo Newton per meter square. So, we can divided by 27500.

So, final value that is coming 125 into 4 1 minus 0.3 square and 2700 so, and then we have to apply the correction factor 0.94 because this is the depth correction factor. So, the value will be 17.42 millimeter and that is corrected. So, we have basically 3 methods we have used because the data those are given we can use for the 3 methods for other 2 methods like SPT and the plate load test that we can use cannot use here because those that are not given. So, based on that we got settlement value 17.42 for one method another method the corrected value is 7.2 millimeter and then other two is 9.4 millimeter and 12 millimeter.

So, here it is around 9 and 12 and this value is around 7.2, so, from 7.2 and this is 17.42. So, we can see that here this elastic theory is given very high value or higher value of the settlement compared to the other methods that we have used and then this semi empirical methods is given are lower value among these three and this is given in between them. So, again I recommend that if the SPT or SCPT data's are given you all those theories or method determine the settlement value, but in the exam or in your assignment if any method is mentioned then you have to use that method only otherwise depending upon your available soil parameters you can use respective settlement calculation methods.

Because I have because I have discuss the plate load test I have discuss the elastic theory or discuss the semi empirical methods or discuss the SCPT based settlement calculation or for all discuss and only SPT ways settlement calculation is remaining that I will discuss in the next classes when I will I will design the foundation on sand.

Thank you.