Foundation Design
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Lecture – 12A
Examples Based on Bearing Capacity and Settlement

So we have finished bearing capacity Meyerhof's terzaghis theory, Meyerhof analyses. I have also bearing capacity for modified bearing capacity for in case of strip footing as well as gone to modified value for square rectangular, settlement analyses immediate and consolidation settlement analyses. Stress below a point load, line load, strip load, rectangular loaded area, circular load. Then last part I have finished any shape vertical stress of uniformly loaded area of any other shape other than point strip circular or rectangular.

Now, before I go to the design of this foundations let us solve few problems.

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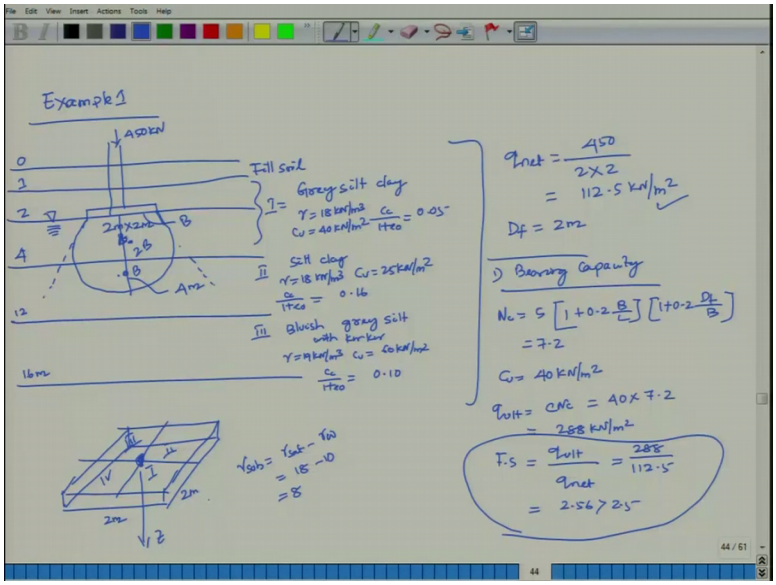

So, example one. This is the case, this a 0, this is one meter. This is a 2, this is a 4, 12 meter subsoil investigation is up to 16 meter. Though I have not started the design, it has been from the design it has been said the foundation is resting at a depth 2 meter below the ground surface waters water table is located at 2 meter.

So, this size of this foundation is your 2 meter by 2 meter. Loading density is coming 450 kilo newton. And 0 to 1 meter is your filling or fill soil between 1 to 4 meter, 1 to 4 meter, this is soil one having grey silt clay gamma is equal to 18 kilo newton per meter cube, Cu is equal to 40 kilo newton per meter square. Cc by 1 plus E 0 is equal to 0.05, then lab 2 it silt clay. Gamma is equal to 18 kilo newton per meter cube Cu is equal to 25 kilo newton per meter square. Cc by 1 plus E 0 which is equal to 0.16 lab 3. It is again bluish grey silt, with kon kor. Gamma is equal to 19 kilo newton per meter cube. Cu is equal to 60 kilo newton per meter square Cc by 1 plus E 0 which is equal to 0 point one 0.

So, from here let us find it out q net q net is equal to 450, 450 divided by 2 by 2, which is equal to 112.5 kilo newton per meter square. And the depth of the foundations is equal to 2 meter. So, bearing capacity first one is your bearing capacity, bearing capacity you have to find it of Nc, Nc is equal to 5 into 1 plus 0.2 B by l into 1 plus 0.2, Df by B this things earlier we have I have discussed with you. So, it comes out to be 7.2. So, what happen it is 2 meter by 2 meter, if I put it if this is my B if I put it my failure envelope up to 2 times of B 2 into 2, 4 meter. So, here it is 2 meter here it is 2 meter total will be this will be your 4 meter.

So, in that case. So, as most of the if you look at here, either you can take it vetted average of Cu 1 and Cu 2 because both this cases it is lying layer one as well as layer 2. In this case I am considering Cu is equal to 40 kilo newton per meter square. Generally, if half part will there other half part will be there here. Then it will be vetted average generally taken now q ultimate q ultimate is equal to CNC. So, which is equal to 40 into 7.2 which is equal to 288 kilo newton per meter square. So, factor of safety is equal to, factor of safety is your q net is your 112 and q ultimate, q ultimate by q net which is equal to 288 by 112.5, which is equal to 2.56 greater than 2.5 which is ok.

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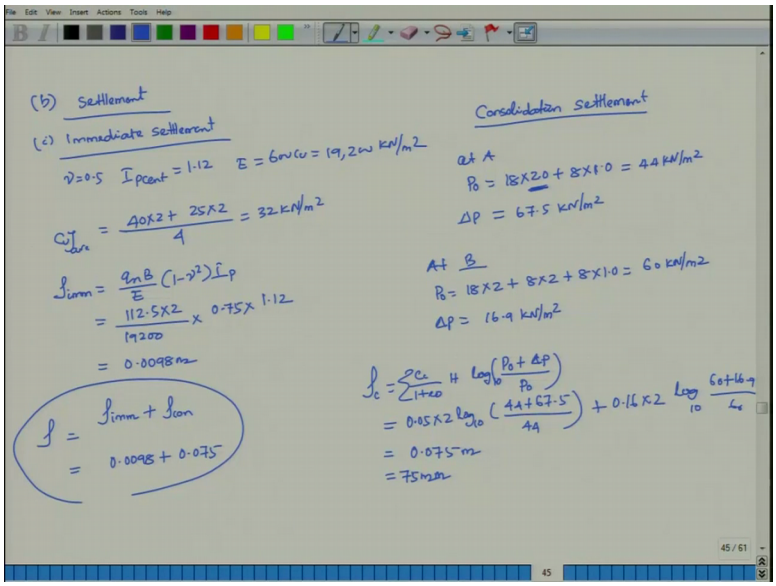

Now, come to your settlement calculations, in settlement first one is your immediate settlement. In immediate settlement what are the things given mu is equal to 0.5 Ip center is equal to 1.12 E is equal to 600 Cu which is equal to 1 9 2 0 0 kilo newton per meter square. So, Cu average which is equal to 40 into 2 plus 25 into 2 by 4. 40 into 2 this 40 it is your 2 meter then 25 this is your 2 meter. So, that is why this average has been taken this average is your 32 kilo newton per meter square.

Now, immediate settlement immediate which is equal to qnB by E into 1 minus nu square to Ip which is equal to 112.5 into 2 by 19200 into 0.75 into ips 1.12 which is equal to 0.0098 meter. This is your immediate settlement. Now come to your consolidation settlement consolidation settlement. So, you have to find it out p 0 and delta p. So, at a, because consolidation settlement you have to find it out a different point at this point at this point because up to these it is effective. So, consolidation settlement at point a p 0 is equal 18 into 2.0 plus 8 into 1.0. Why? 18 into 2.0, if you look at here your complete soil.

So, this soil having including this fill soil gamma is 18. So, water table is a 2, meter if I come up to this, then what will happen up to 2. 2 into this your up to water table below 18 is your gamma then 8 into 1.08 into 1.0 after 2, then add the middle. So, it will be 2 meter. So, at the middle one meter. So, it will be 8, 8 because gamma sumurge submerge is equal to gamma sumurge is equal to gamma saturated minus gamma w. So,

approximately I put it 18 minus 10 which is equal to 8. So, this will be a 8 into 1. And that gives the value of 44 kilo newton per meter square.

Now, delta p, there are 2 ways either you can measure it by means of 2 is to one distribution or you can measure because this is a square. This is a square, this shape is there. So, this is a square. So, here it is a 2 meter, here it is 2 meter. So, what will happen at the center. Then in that case you make it into 4 parts as I have discussed earlier increase in stress at a depth below the footing one meter what is your increasing in stress. The delta p comes out to be 67.5 kilo newton per meter square. At point B, at point B; that means, here if I put it a this is a, this will be B. At point B p 0 is equal to 18 into 2, plus 8 into 2 plus 8 into 1.0, which is equal to 60 kilo newton per meter square.8 into 2 up to here because water table is here gamma is 18, 18 into 2 plus 8 into here it is 2 meter, 8 is a sumurge unit weight into 2 here it will be up to 2 meter 10, 1 meter will be there at the center again it is 18. So, 18 minus 10, then it will be 8 into 8 into 1.

So, similarly you can find it out delta p which is equal to 16.9 kilo newton per meter square. So, consolidation settlement is equal to Cc by 1 plus E 0 h, log 10 p 0 plus delta p by p 0 because. There are tool 2 terms. So, it will be 0.05 into 2, 2 (Refer Time: 13:20) this. Then log 10 44 plus 67.5 by 44 plus 0.16 into 2 log 10 60 plus 16.9 divide by 60 which is equal to 0.075.

Now, total settlement which is equal to immediate plus consolidations, which is equal to 0.0098 plus 0.075. This is your final settlement. So, in this case let me repeat, what I have done? This is your subsoil profile is there and foundation size has been already decided this will come from our design, it will be continuing after this examples are over. The foundation size are 2 meter by 2 meter. And it rested below a ground surface of 2 meter below the ground surface acted upon by load intensity of 450 kilo newton, there are 3 layers layer one having grey silt clay gamma is given Cu is given. And Cc by 1 plus E 0 also given, second layer is your silty clay third layer also grey silt. In this case what happen once foundation is putting there generally effective see it if this is my B. So, the effect will be 2 B. So, if once it is 2 meter it will be extended up to 4 meter so; that means, this is your 2 meter and this is your 2 meter.

So, load intensity has been calculated load divided by area of the foundation, this is your load intensity and bearing capacity also calculated from there factor safety also I

calculated factor safety q ultimate by q net then immediate settlement as well as consolidation settlement has been calculated for immediate settlement. Cu average has been consider because 2 layers are there 40 in 2 plus 25 into 2 divided by total is a 4. So, that is your 32 kilo newton per meter square as per consolidation settlement 2 points has been consider at the center. This layer at the center A, this layer at the center B up to this height then then increase in stress because this is a square. So, this is a square and it is at the middle below this z depth this is a z then what will happen if this is my depth below this z what will happen below this at the center. So, how I have calculated make into approximately square.

So, then this is 1, this is 2, this is 3, and this will be 4. This will be exactly at the corner then increase in stress has been calculated as 67.5 per case 1. Case 2 it is 16.9 kilo newton per meter square. So, consolidation settlement comes out to be 0.075 meter which is your 75 mm here it is your 9.8 mm. So, add it 84 point something mm is your consolidation settlement, this is the calculation of your bearing capacity.

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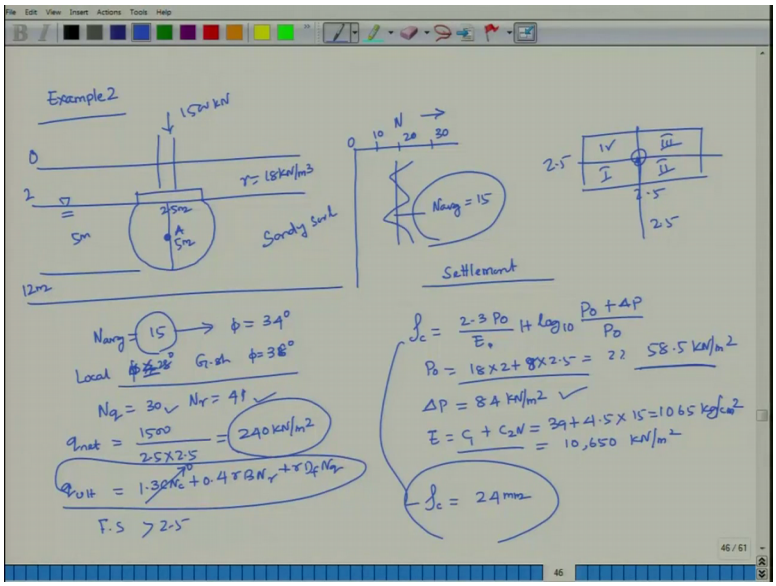

Next example, example 2 this is what given this is a 0. This is 2 this is your 12 meter and there is a footing here. This is a 2.5 meter gamma is your 18 kilo newton per meter cube. And this profile is given n value profile is given SPTN, 0 10 20 and this is your 30 SPTN. So, it comes out to be n average which is equal to your 15.

Now, once it is a 2.5 meter. So, what will happen pressure intensity will be up to a depth of 5 meter, up to a depth of 5 meter. So, this is where at a depth 2.5, where interested to find it out so; that means, if this is your 5 meter. So, 2 meter is there then it will be 70 meter below there. So, what is given here n average is your 15. Once you know the n average value then from the n average your suppose to get the value of phi is equal to 34 degree. Once phi is equal to 34 degree, what does it mean basically it is neither general share failure. So, local share failure phi is greater than equal to 28 degree general share failure phi is 28 degree to phi is equal to 36 degree.

So, you have to do the interpolations by do will, I have explained also this interpolation earlier by doing this interpolations. You will find it out phi is equal to 34 degree Ng is equal to 30 degree, n gamma is equal to 41 sorry, it is not degree Ng is equal to 30 n gamma is equal to 41. Then your q net is equal to q net is equal to how much is a load intensity load intensity is coming out to be it comes 1500 kilo meter. So, net load intensity will be 1500 divided by 2.5 by 2.5, which is equal to your 240 kilo newton per meter square.

So, what is your ultimate bearing capacity, ultimate bearing capacity q ultimate because it is rectangular. 1.3 CNC plus 0.4 gamma B n gamma sorry, it is a square 1.3 CNC, B gamma plus gamma Df, Ng. You can calculate from here. Then you can calculate your factor safety which is greater than 2.5. Then you go for your settlement. Because this is a sandy soil. For sandy soil what is your settlement consolidation settlement 2.3 p 0 by E h log 10, p 0 plus delta p by p 0. So, p 0 will be 18 into 2 plus 9 into 2.5. 18 into 2 here is also water table 18 into 2 and below this. So, it will be 8 or 9 depending upon 18 into minus 9.81 depending upon that. So, you are calculating your p 0.

Now, calculate your delta p. So, delta p again same thing you can calculate. This is 2.5 and this is your 2.5 at the center. So, put it. So, it become a corner at a depth of your 2.5 depth of these your also 2.5, you can very easily calculate your delta p. So, delta p comes out to be 84 kilo newton per meter square. Here it is your 58.5 kilo newton per meter square. So, based on this n value E can be calculated c 1 plus c 2 n c 1 is your 39 plus c 2 is your 4.5 into n average is your 15 which is equal to 1065 kg per cm square, which is equal to 1065 kilo newton per meter square.

So, based on this rho c calculated 24 mm. So, if you look at this example 2, now there is a subsoil profile water table is located at 2 meter depth and foundation size is 2.5 meter by 2.5 meter, resting on sandy soil below a depth of 2 meter below the ground surface gamma is given. And other parameters have not been given only parameter is given n values up to different depth from there you can calculate what is the n average n average is coming out to be 15. Once you know the n average from n average you calculate the value of f phi.

Now, it is neither general share failure or local share failure. So, sorry it is less than equal to 28 degree. Neither it is general share failure or local share failure it is in between. So, interpolation has to be done and has been carried out. Based on that based on the value of phi is equal to 34 degree Ng is equal to 30 n gamma is equal to 41. So, qnet is equal to 240 kilo newton per meter square. So, based on that you calculate your q ultimate value 1.3 CNC 0.4 gamma bn gamma plus gamma Df Ng nq. And n gamma is there because there is no term of c this can be 0 then you can calculate factor safety it is it should be come out greater than 2.5. Then find it out settlement, settlement is your 2.3 p 0 by E h log 10 p 0 plus delta p by p 0. So, p 0 is 18 into 2 here is a water table. So, 8 18 minus 10 that is your 8 up to you have to find it out up to here center. So, this will below 2.5.

So, this comes out to be 58.5 kilo newton per meter square. And delta p how you have calculated this is are a square set 2.5 by 2.5 at the middle I divided into 4 parts one 2 3 and 41234 and at the corner rectangular loaded area at the corner add it. So, delta p is your 84 kilo newton per meter square. You have to calculate E, c 1 plus c 2 n c 1 is your 39 c 2 is equal to 4.5 kg per cm square. So, it comes out to be one 0 6 5 kg per cm square E is equal to 1065 kilo newton per meter square from there we calculate rho c is equal to 24 mm. I will solve 2 more examples may be next class, I will keep it here.

Thank you.