Foundation Design
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Lecture - 8A
Settlement Analysis - Part 1

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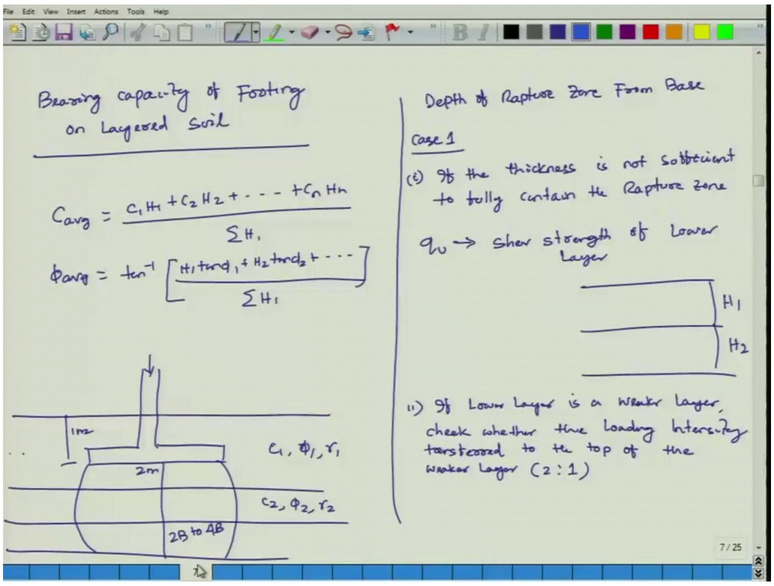

So last class, I have covered bearing capacity of footings on layer soils and different cases case one case 2 case 3 I have disused then solved a problem best on your data and from plate load test how to calculate bearing capacity of a putting.

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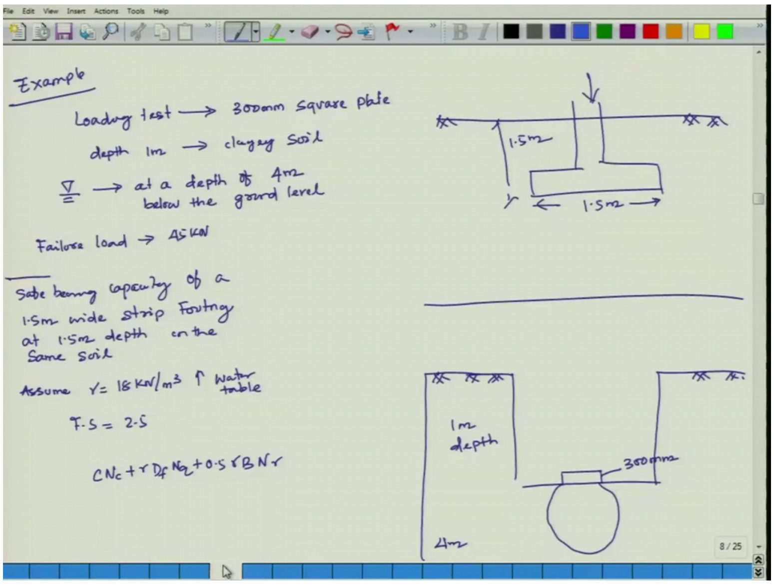

Then will start new one that is your settlement analysis before your deign of the foundations.

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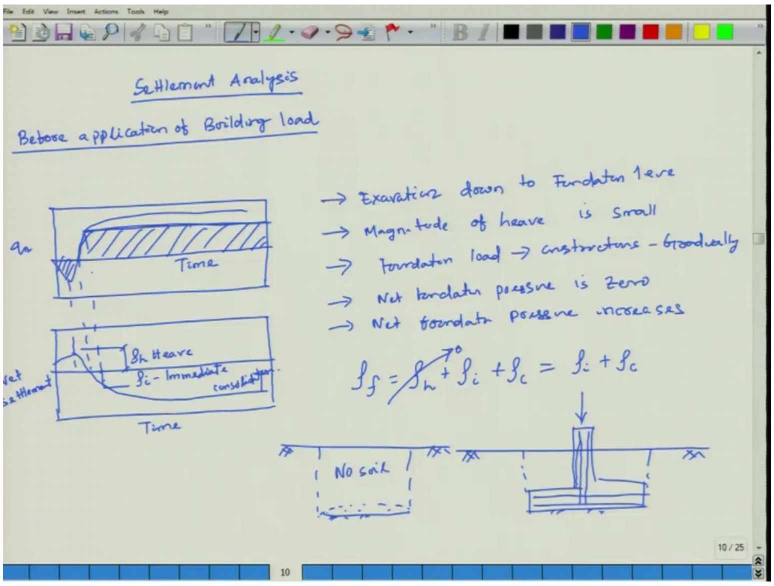

Their requirement is your bearing capacity second part is your settlement analysis before I go for your settlement analysis. So, what happened before application of building load building load. So, look at this 2 graphs this is your q n one part is your net load intensity versus time second part is your net settlement versus time this part is your rho h general it is called heave and second part is your this is your rho I immediate and this part is your consolidation.

So, there is a usually in building what will happen usually there is a excavation prior to your foundation level there is an excavation down to foundation level and because of the excavations. So, the magnitude of heave magnitude of heave is small look at here there is a ground surface here and suppose you want to construct a strip putting or may be isolated putting then what will happen below the ground surface you do the excavations take out the soil. Once you take out the soil then what will happen once you make the excavation. So, this is your excavation is they are means no soil. So, because of that there will be some heave at the bottom this heave is small if you leave this heave for a long time if there is a deep caught it may be a larger magnitude the heave may be larger magnitude.

So, once after this excavations then you laid the foundations; that means, foundation load has been applied or constructions gradually you to this excavation construct then construct lay the your enforcement caging. So, particularly put your enforcement caging base of your then do the concreting. So, then what happen these construction has been done gradually. So, what will happen then foundation load has come into picture are this level here are this level foundation load will come into picture. So, what will happen once there is heave pressure if you look at here there is heave pressure net intensity. So, once you apply the foundation pressure this will become 0 and it will counter somewhere else it will counter. So, that net settlement or become 0 or net foundation pressure net foundation pressure is 0.

Then after words further increase in load by means of how the further increase in load once this construction is over this is your foundation after foundation there is a column it will be connected with your column has to be constructed then beam then slab. So, slowly foundation loading on the foundation is coming in gradually. So, further increase in load net foundation pressure increases net foundation pressure increases.

So, what will happen then this settlement if I put it my total settlement final settlement is because of your one is your heave other is your immediate settlement other is your consolidation settlement generally heave settlement is very negligible hence it become immediate plus your consolidation settlement before I start it I thought to a explain this is because what will happen net foundation pressure it decreases because of your heave because of your heave net foundation pressure decreases by application of load on the foundations it again start increasing and it become 0. That means, net foundation pressure is 0; that means heave has to be settle down this heave has to be settle down against your foundation pressure.

Then once you increase and it increase up to a certain level then it remains constant or may be it kind of it is a kind of it may be go in this way or it may be in this way. So, this part is called elastic this part is called plastic. So, basically behavior is elastoplastic after your heave has been settle down similarly if you compare with your net foundation pressure with time then net settlement with your time this is your heave then it comes to 0 then there is a immediate settlement then there is a consolidation settlement if there is a deep caught and you will leave it for a longer period of time definitely there will be a heave settlement in the opposite directions in the opposite directions it will be heave it will reduce your net foundation pressure.

So, total settlement will be your settlement because of your heave plus immediate settlement plus your consolidation settlement because magnitude of heave is very small that is why it has been neglected. So, total settlement is equal to immediate settlement plus your consolidation settlement.

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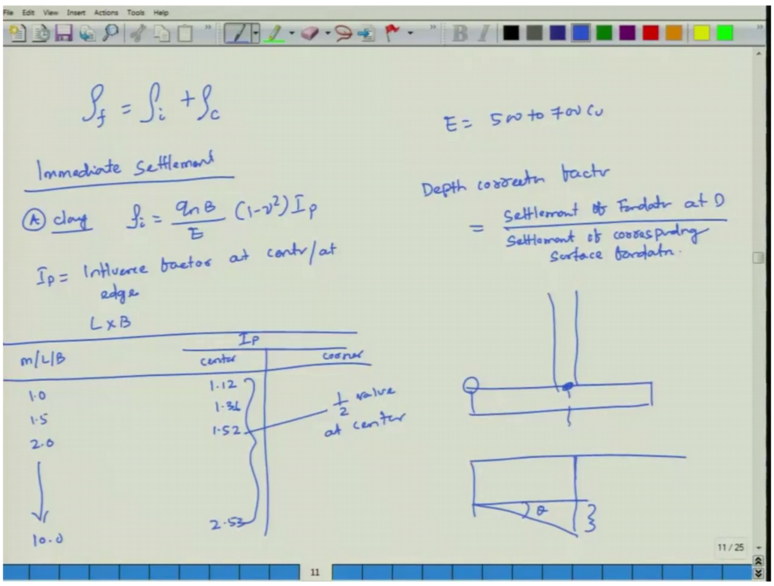

Then start with your part of your if I write it rho f rho f final settlement is equal to immediate settlement rho c is your consolidation settlement now start with your immediate settlement then immediate settlement there are 2 cases one is your clay soils other is your sand or cohesionless soils is your clay.

In that case immediate settlement is equal to QnB by E 1 minus mu square into IIPQN is your net foundation pressure B is equal to is your width E is your Young's modular of a soil mu is your poison ratio I P is your influence factor I P is your influence factor at centre as well as at edge from where you will get the influence factor either this influence factor will be given or you can go for a plate load test. I have explained earlier also you can find it out what is your influence factor at this centre as well at the your at the age of the foundation why this influence factor has been used in incase of your immediate settlement from their you can find it out deferential settlement of a foundations of a putting.

So, that it can be said the differential settlement is within permissible limit or not now if you look at different value is of your influence factor has been given particularly for a rectangular foundation L by B; L by B values has been given. So, m is equal to L by B and I P influence factor then here it is at this centre here it is at the corner or edge. So, I am just writing you can get it from book all books they are provided. So, just I am writing it 10.0. So, it will be 1.12 then 1.5; it will be 1.36, 2.0 it will be 1.52 then 10, it is 2.53 and this value at the center at the corner half of half the value are center has been taken suppose this is 1.12 then at the corner 1.12 by 2 has to be taken into considerations.

So, is your modules of elasticity for clay generally E is wearing from 500 to 700 c u c u is your undent cohesion; undent cohesions the E value has been given all year I could not give this entire table how to calculate E other E also you can get it this is one is 500 to 700 c u 500 to 700 to c u other value of E particularly in case of sand also you can find it out by means of E is equal to C 1 plus c to n will discuss then there are 2 correction factors one is your depth correction factor depth correction factor. So, depth correction factor is your settlement of foundation at depth D at depth D then settlement of corresponding surface foundation settlement of corresponding surface foundation; that means, as if foundation is lying in this surface.

So, this is your corrections another correction is your pore water pressure corrections I will discuss later in this particularly settlement analysis later part pore water pressure corrections it will be applicable only in case of consolidation settlement not in case of immediate settlement. So, that is why I remove it right now; we are discussing about your immediate settlement for clay. So, rho I immediate settlement is q n into B by E 1 minus mu square into IPQN is your net foundation pressure B is your width of your footing is your modulus of elasticity mu is equal to poison ratio I P is your influence factor at this center or at the corner once you know I P at this centre and at the corner then you can find out if there is a putting here what is your immediate settlement at the corner what is your immediate settlement at the center best on that immediate settlement at the corner and at the centre you can very easily find it out deferential settlement deferential settlement.

And correction factor depth correction factor has to be determined; that means, settlement of a foundation at depth D and settlement corresponding to surface foundation as you taking in to there is no depth of the foundation; foundation has been placed at this surface.

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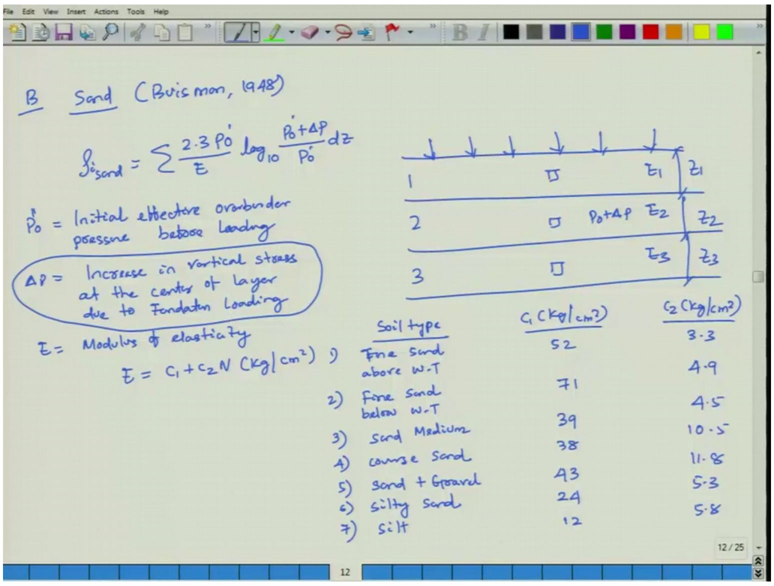

So, depth correction factor you calculate then part B sand immediate settlement in case off sand it has been given by Buisman 1948 for sand immediate settlement for sand it is summation of 2.3 P 0 by E log 10 P 0 plus delta P by P 0 into D z. So, P 0 is your initially effective over burden pressure before loading in different books it is P 0 it is sigma 0. So, initial over burden effective over burden pressure it may be P 0 or P 0 prime I am taking about effective over burden pressure may be you can write it P 0 prime P 0 prime P 0 prime. So, it is initially effective over burden pressure before loading then dealt P increase in vertical stress vertical stress at the center of layer due to foundation loading E is equal to modules of elasticity.

Now, so, there is a case here layer by layer if I put it here I can put it only four layers 3 layers. So, here it is pressure intensity because of your foundation I write it like this. So, layer one 2 and 3; here is your z 1, here is your z 2, here is your z 3, and this is your E one E 2 and E 3 then this will be your P 0 plus delta P you have to consider layer by layer and each layer you find it out what it though P 0 and delta P and P 0 plus delta P p 0 is your initial effective over burden pressure before loading delta P is your increase in vertical stress at the center of the layer due to foundation loading this part stress in solve mass Buisman theory and as well as at the center of your circular loaded rectangular loaded point load this will be discuss after this settlement analysis.

Then from there you can find it out delta P increase in your vertical stress and modules of elasticity E for sand E for sand has been E has been given E is equal to C 1 plus C 2 n which is your kg per c m square. So, for different soil type it has been given the values soil type this is your C 1 kg per c m square C 2 kg per c m square soil type first one is your fine sand above water table second one is your fine sand below water table. So, this will be 52 and this will be 3.3 and this is 71 and this will be 4.9 sand medium size sand then course. Aand then sand plus gravel then silty sand then is your silt why I am writing many books may not be providing this value E is equal to C 1 plus C 2 you can get it N SPT N value from the field or may be 0 technical investigation ones you take out the value of n and best one your what is the type of your soil from where you can take the value of this C 1 to C 2 that is why I have written here for medium sand it is 39 here it is 4.5 course sand it is 38 here it is 10.5 and sand plus gravel it is 43 here it is 11.8 then silty sand it is 24 and it is your 5.3 silt 12 and 5.8.

So, this is one case these are in empirical in nature immediate settlement they have proposed. So, it is your Buisman 1948 he has given immediate settlement per sand it is summation of layer by layer 2.3 P 0 prime E log 10 P 0 prime. So, plus delta P by P 0 prime in to D z P 0 prime or P 0 sometimes P 0 prime or P 0 it is your initially effective over burden pressure before loading delta P is your increase in vertical stress at the center of layer due to foundation loading is your mod less of elasticity and he has given E is equal to C 1 plus C 2 n for different soilties C 1 and C 2 has been given you can pick it what is the soil type best one your s P t n value and C 1 C 2 you can calculate for sand what is the value of your E

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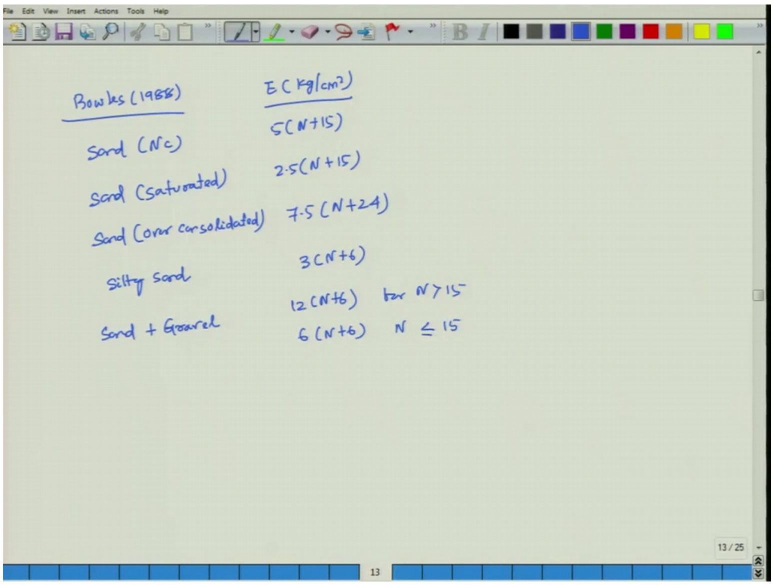

Then there are other correlations also given by bowels 1988 you can look at that book foundation design in analysis by bowels.

So, E is kg per centimeter square sand normally consolidated sand saturated sand over consolidated then silty sand per sand it is 5 into n plus 15 per saturated sand it is 2.5 into n plus 15 sand. That means, over consolidated sand it is 7.5 into n plus 24 then sand with gravel or silty sand it is 3 into n plus 6 then sand plus gravel it is 12 n plus 6 for n greater than 15 then this is your 6 n plus 6 n less than equal to 15 this is what given by your Bowel’s 1988, another relationship has been given by Schmertmann and Hartman 1978.

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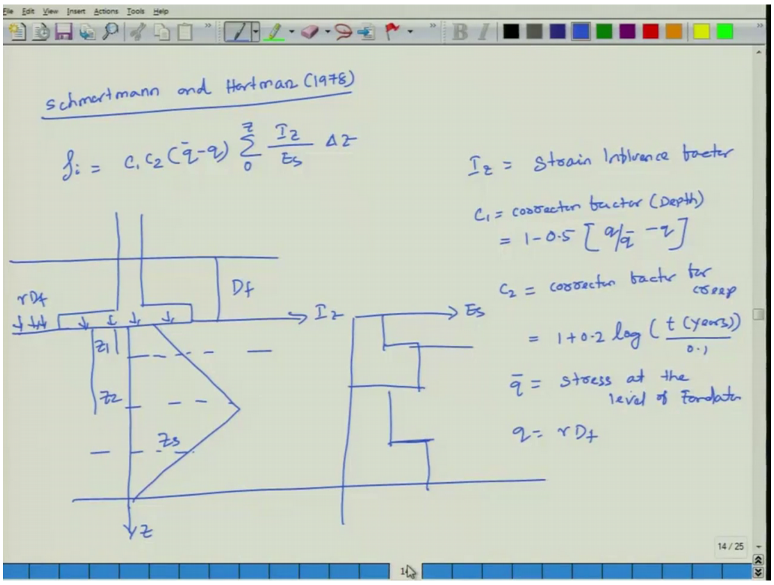

So, they have given immediate settlement for sand C 1 C 2 into q prime minus q summation of 0 2 z of entire depth I z by E s into delta z. So, what they have done let us consider this is a footing isolated footing. And this is a variation of your I z this is your depth of the foundation this is your gamma D f and this is your footing load intensity. Then if you look at here this is your z and this value this value is your E s and for different depth.

Suppose, this is your z 1 this is your z 2 this is your z 3 up to this depth then the value is comes out to be here then here then. So, this value is your variation of modulus of elasticity E s over depth z what is I z? I z is your strain influence factor; factor and C 1 is your correction factor for depth of the foundation C 1 is correction factor for depth of your foundation and his comes out to be 1 minus 0.5 into q by q bar minus q and C 2 is your correction factor for creep it is your correction factor for creep and this is 1 plus 0.2 2 log t in years by 0.1.

So, q prime or q this is your stress at the level of foundation stress at the level of foundation and q is equal to gamma D f will solve problems once your foundation analysis over. So, basically there are 2 methods 2 empirical has been used based on empirical correlations one is your by means of Buisman 1948 and other is your by means of Schmertmann and Hartman 1978, these are a 2 methods widely used proposed relationship to find it out your immediate settlement in sand for immediate settlement in clay it is very clear q and be E into 1 minus mu square into I p.

I will stop it here next class, I will start this consolidation settlement.

Thank you.