Application Of Soil Mechanics
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Lecture # 11

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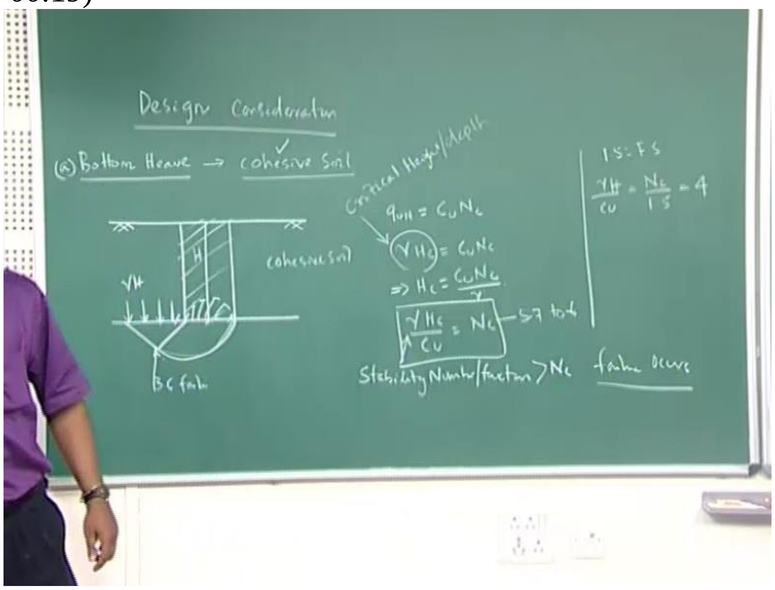

As we discussed last class about the design consideration of braced exavation. First one is your bottom heave formation or bottom heave. It occurs generally in cohesive soil. Let us say, this is a cohesive soil and this part is your ground surface, and this is your height H of the excavation of height H and this is overburden gamma H, and this you can say that bearing capacity failure. Then this comes as a heave. For homogenous soil, clay q ultimate, for clay q ultimate is equal to C u N c, C is your (( )) cohesion. And for critical depth, gamma H c is equal to C u N c – this is your critical depth, that means H c is equal to C u N c by gamma. And you can write it down like this gamma H c by C u which is equal to N c, generally the value of N c is 5.7 to 6. So gamma H c by C u, it is called stability number. If stability number or stability factor, greater than N c then failure occurs.

For a factor of safety of say, 1.5, factor of safety of 1.5, you can write out gamma H by C u which is equal to N c by 1.5 which is equal to 4. Now what is it mean, if we look at they are, if you remember well last class we discussed about the one of the design criteria or design consideration is about your bottom heave. This bottom heave generally occurs in what kind of soils, generally it occurs in case of cohesive soil. How the bottom heave has been formed, as you go more the deep, more depth you cut vertical cut means below the ground surface then what happen this overburden pressure will pressure. Because of this increasing overburden pressure, below the cut what will happen this soil will fail by means of bearing capacity. Once this soil will fail, then nearby soil will be pushed, so that there will be a heave or meson, in the exavations. So this is your exavations.

This shaded area is your completely exavations; and in this exavations, once there is a heave formation, heave means the soil from the bottom will come insight your underground exavations. Once this thing has been occurred, what will happen, whatever the structure constructed here like Metrorail underground, so it will also fails. So to start with this, understand this phenomena, let us say for this cohesive soil, this is a cohesive soil, what is the bearing capacity? For cohesive soil bearing capacity is, purely cohesive soil, there is no pile C N c or C u N c. C is your (( )) cohesion. Then this C u N c is nothing, you have to equate it to critical height. So that means, it is not in a kind of critical height, if you equate it into this will be your gamma H c, critical depth or critical height. So this C u N c depends upon your critical depth.

Now from there critical height is coming H c is equal to C u N c by gamma. If I take this all the terms gamma H c by C u, this is called stability factor. Gamma is C by C u, this is called stability factor, which is called to N c that means this N c value is generally for ah bearing capacity factor for cohesion value for purely cohesive soil, it is 5.7 to 6. That means gamma H c by C u is your stability number or stability factor, which is if it is this stability number or stability factor, if it is greater than N c, that means failure occurs for cohesive soil. Failure occurs means, what will happen, there will be a bottom heave formation, that means this is the condition the stability number or factor, it should be less equal to N c. It should not greater than your bearing capacity factor for cohesive soil.

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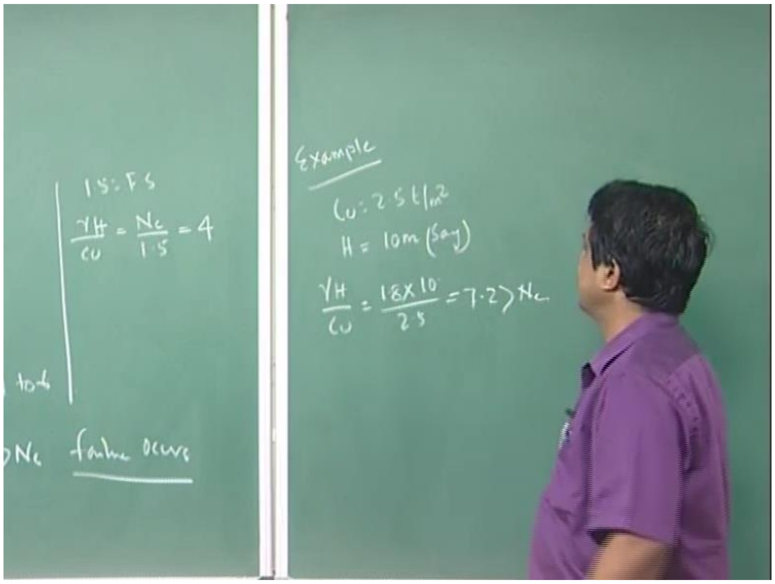

Now for example, in (( )) soil C u is equal to 2.5 ton per meter square. And H generally cot, typical example I'm taking Calcutta metro H is equal to ten meter say height of cot exavation. So gamma H by C u which is equal to gamma is equal to 1.8 into H is equal to 10 by 2.5, which is equal to 7.2 greater than N c. That means, if there is your underground construction, underground construction in Calcutta soil, there is a chance that bottom heave will be formed, bottom heave formation will be there. So this is your first criteria for design consideration that is your bottom heave. Then another example, this is you can say that this is a uniform soil, suppose this soil is purely uniform there is no layer soil that means say constant value of C u is there. This is your calculation.

Now if I go for second example, so how do you prevent before I solve this second example, how do prevent? The prevent will be, you have to deep water, you have to deep water from the cohesive soil, so that water depth will go below your for below this depth, so that it will become harder slightly harder, so that bearing capacity failure may be avoided.

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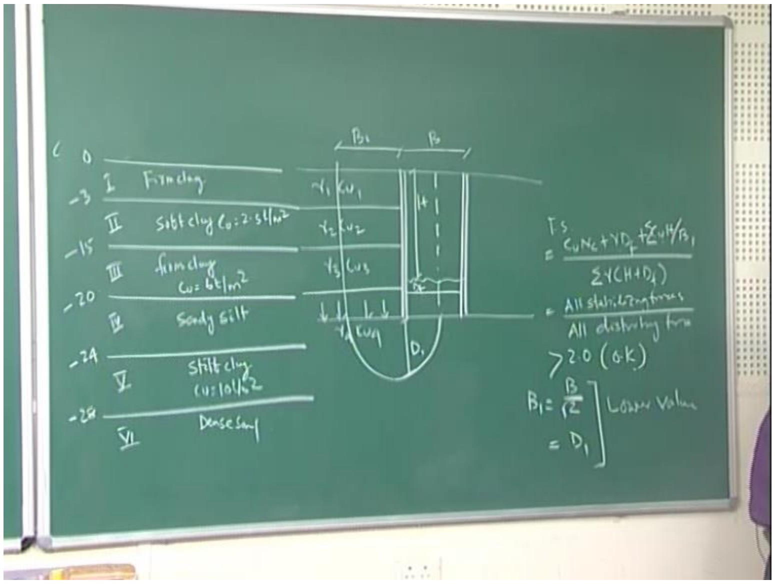

So example two, there are six layers of soil. As I said, this is not a uniform soil layer. So layer one is your firm clay. Layer two is your soft clay, C u is equal to 2.5 ton per meter square. Layer three again it is firm clay, C u is equal to six ton per meter square. Then layer 4 is your sandy silt; and layer 5 is your stiff clay, C u is equal to ten ton per meter square. And layer six is equal to your dense sand. Now there is a chance that there is a cut off to sand silt that means vertical cut off, you do the vertical ground exavation, you go for if these are your all your soft soil at what depth you can go for your vertical exavation, where you are getting a kind of hard stratum. This is sandy silt or dense sand, you can go here.

So if I draw with this there is a vertical cut in exavation up to sandy silt. Let us say with this sandy silt say, this is your D f and this is your kind of you can write H and let us we put it layer by layer, layer 1, layer 2, layer 3. Layer one is equal to gamma 1, C u 1; gamma 2, C u 2; gamma 3, C u three then from they are it is starts like this. Then let us say this is my case of D one, then this is gamma 4 and C u four. Then if it is coming in this way up to the middle, the bearing capacity failure, I am showing up to this middle like this. So let us say the failure envelope from here, you can extend up to B 1, and here it will be completely B. Now factor of safety is equal to C u N c plus gamma D f plus C u H by B 1 by gamma H plus D f. So that means this is your all stabilizing forces divided by all disturbing forces. Then what will happen, the factor of safety greater than 2.0, it will be ok.

If the factor of safety is coming out to be for against your bottom heave, if it is greater than two point zero then it is ok. So what we are basically doing, we are taking a influence line, influence of failure envelope here up to a distance B one; and this is B, here it is extend B one. How do calculate B one, so B one is equal to B by root two and D one, from there it is your lower value. If we look at here, first with check your stability number and factor, it should be greater than N c, so that if it is greater than N c then failure will occur, based on that you can calculate your factor of safety. For finding out factor of safety, let us say this is an exavation, there are one, two, three, four, five, six number of layers and at two positions or fourth number of layer this is sandy silt. And sixth position is your dense sand, so that means your exavation, you can extend from here to here or exavation you extend from here to here. That means the base of your exavation till exavation where you are doing up to that depth it should be ensure that up to that depth at that depth, there is a hard stratum line, that means this is your hard stratum line – sandy silt or dense sand.

So what happen, I'm taking a this is my involvement D one is your influence area based on your bearing capacity, so once your are getting then there will be a depth of foundation, this will be also given, height also given, B also given, only you have to find it out B one and D one. So D one will be come, it will come based on your bearing capacity calculation. Then once you get D one then you can check your factor of safety. Your factor safety is equal to there are 5 layer; 1, 2, 3, 4, 4 layers, that means C u 1N c 1, C u 2 N c 2 all for you calculate plus gamma D f – gamma into depth of foundation, depth of these depth gamma D f plus C u H by B 1. This C u N c, this one is your C u N c, and C u H by B 1 - this summation of C u H by B 1 by gamma H plus D f divided by gamma H plus D f.

If you look at here, all stabilizing forces dividing by all disturbing forces, from there you have to find it out your factor of safety is equal to 2.0. And B 1 you are going to calculate, B one is equal to B by root 2 or D 1. B 1 is equal to as it is given B and D, so B by root two or D one that means which is lower. Lower value of B one, you are supposed to take it. This is for design consideration of bottom heave. Then next part is your clay brusting. How to calculate factor of safety for your bottom heave, this has been done.

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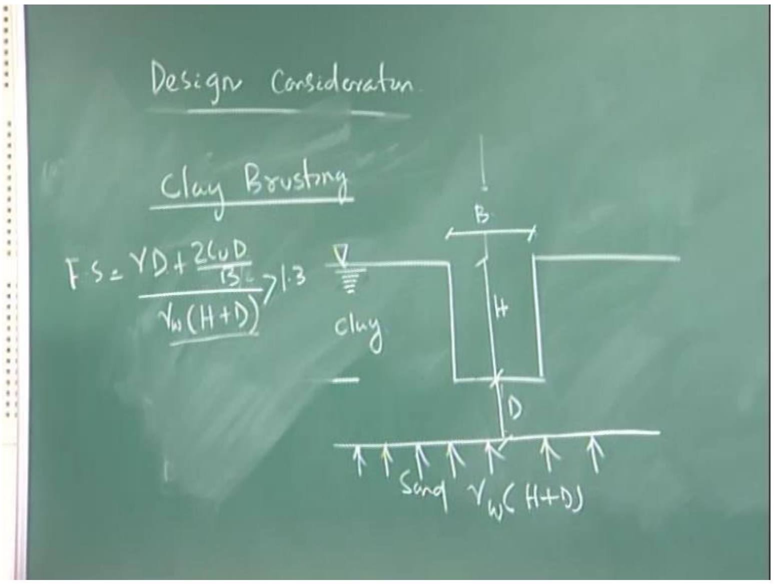

Then for clay brusting, what is the condition for clay brusting. Clay brusting means clay soil sample will come out along with the water. If there is a clay layer of shallow depth, then there is a water table, then water table is a ground surface, then below the shallow depth of clay if there is a kind of sandy soil, sand or sandy soil or sand then there is chance of clay brusting. In these case, the factor of safety, how comes the clay brusting will come, the sand will give upward movement. If we look at here, this is your clay of a shallow depth of the clay layer is there, then here there is a sand layer, so once you start exavation that means you completely exavate, exavate and small part above your sand you are there, you stopping there. What will happen this along with this water, it will make upward force, so what will happen mixture of sand and clay, it will come up in the exavation. So you have to stop the clay brusting. Clay brust means it will brust out and puncture and the clay will come out from the exavation, that is the meaning.

So what is the factor of safety you should take it, factor of safety is equal to gamma D plus two C u D by B divided by gamma w H plus D which is equal to greater than one point three. Gamma D, gamma times into D – gamma times into depth of D plus two C u D, two times C u D into B, it is nothing but C u D by B by two. So this B by two, this two, because this half of the part will be taken into consideration. So once this half of part is taken into consideration, so B by two that means these two ((Refer Time: 19:58)) there. So two C u D (Refer Time: 20:00) by B then for upward thrust, this is your upward thrust, upward thrust will be gamma w into H plus D. Gamma w is your unit weight of water and H plus D is your this height up to this height, it is applying your upward thrust. So this factor of safety would be greater than one point three for design consideration of clay brusting, that means each case we have to check this whether this factor of safety is satisfying or not. If it is not satisfying, then this design has to be changed that means the depth has to be changed or other criteria the thrust has to be provided very close to each other.