Foundation Engineering

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Lecture – 58
Sheet Piles and Braced Excavation

So, in this lecture first I will discuss about an example on Cantilever Sheet Pile in cohesive soil and then I will discuss about the Braced Excavation. So, first I am giving an example on cantilever sheet pile in cohesive soil ok.

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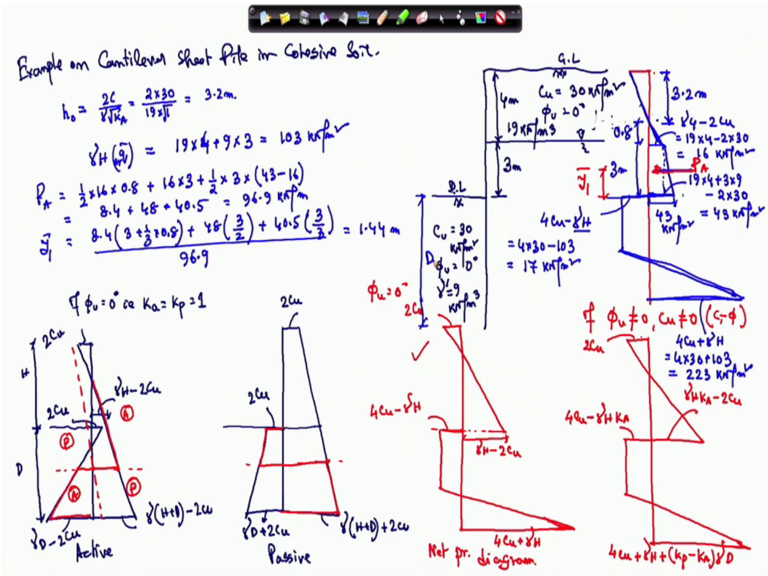

I have solve one example problem on cantilever sheet pile in granular soil and anchor sheet pile in granular soil. Now, this class first I will solve one example problem on cantilever sheet pile in cohesive soil ok. So, I am taking the similar kind of example problem that I have solved during the granular soil. So, this is the dredge level, this is dredge level and this one is the ground level ok.

And the water table is here which is 4 meter below the ground level. This height is 3 meter ok and the C u here is 30 kilo Newton per meter square, phi u is 0 and unit weight I am taking the same unit weight 9 kilo Newton per meter cube below the water table. And above the water table again I am considering same C u value above and below the water table. So, this is also 30 kilo Newton per meter square, phi u is 0 degree and above water table unit weight is 19 kilo Newton per meter cube ok.

So, this is the problem that I am taking. So, I am writing this value here because I have to draw the diagram in this side. So, this is 19 kilo Newton per meter cube ok. So now, first I will draw the diagram for different cases. So, as I am mentioned that if I draw the diagram for the cantilever sheet pile wall in cohesive soil, so, if this is the dredge level. So, this is the active earth pressure distribution and this is also active earth pressure distribution ok. So, it is not in proper scale, so, actually this side will be more this value.

So, right hand side this value should be more, but I am writing this is C u, this is the active earth pressure. And I am writing this is 2 C u and this value is this one is gamma H minus 2 C u and this diagram is valid if phi 0 phi u is equal to 0 that is K A equal to K p equal to 1 ok. Then only this diagram is valid. And this value is gamma H plus D minus 2 C u and this value gamma D minus 2 C u. This is active condition.

So, what is H? H is this one and this is D. And this value is again this small one 2 C u. So, this is the active diagram, similarly the passive diagram will be same way I can draw. This is the passive pressure diagram ok. So, this is 2 C u, these value will be gamma H plus D plus 2 C u. This value is 2 C u, this one gamma D plus 2 C u, these value. So, this is the passive condition.

So and as I mentioned there are 4 zones. So, suppose it is moving with respect to this height. So, the here it is active. So, this is the net diagram, here it is active, then it will go this side and then this is the active diagram ok. This is the diagram; diagram I am taking the only positive one. And about this point this is rotating, see this wall is sheet pile is rotating about this point.

Similarly, these so that means, this side is active this side is passive, again this one active this one passive ok. So, this side is passive so, I can draw this is also passive. So, my here diagram is this zone, this is the passive pressure diagram. So, my net pressure diagram will be the net pressure diagram will be this one. Then I have explained in the last class, it will shift here, then it will continue and then it will again come this side because here this portion is passive, so, it is more. So, the net pressure diagram will shift from this side to this side, again or right to left, again this right side in the bottom this is the passive which is more compared to active.

So, again it will shift from left side to right side. So, the values are 2 C u and then this value is gamma H minus 2 C u ok. So, this is the active gamma H minus 2 C u and this value is 4 C u minus gamma H. And this value you have to add this thing. So, it will come out 4 C u plus gamma H ok. So, this is the net pressure diagram ok. So, this is the active case this is the cantilever sheet pile in cohesive soil.

But remember that this diagram is only valid if it is your phi u is equal to 0 ok. Now, if phi u is not equal to 0 and C u is also not equal to 0. So, it is a C phi soil then this diagram would be the similar pattern only the value will change ok. So, this diagram would be in similar pattern. So, the values will be changed. So, in that case I have to draw like this ok. So, this will again will be 2 C u because your K a value in terms of q and q is 0 here.

And instead of this is gamma H minus 4 C u. So, we have to write this is gamma H K A minus 2 C u. So, depending upon the position of this water table it can be gamma dash also ok minus 2 C u and this one again will be 4 C u minus gamma H K A ok. Again K p part this is starting point. So, this will not K p will not be there, because here in passive one the q value is 0. At because you have a passive this q starts from here. And here your value would be this point is 4 C u plus gamma H plus K p minus K a into gamma D ok.

So, here if it is your K p equal to K a equal to 1, then this part will 0 because that is the case. In case of here where the phi value is equal to 0 4 C u plus gamma H, here 4 C u plus gamma H plus K p minus K a into gamma D because here this part will exist ok. So, this is the diagram. So, depending upon whether it C soil or C phi soil you have to use this diagram. So now, what I am taking for our case, I am drawing the diagram and our case it is your phi value is 0. So, you have to consider this diagram ok.

So, now our case first we will draw this diagram. So and first we calculate that what is the value of H 0, H 0 means the no stress condition. So, what is the value of H 0? So that mean the no tension crack depth. So, no tension crack depth H 0 is 2 C by gamma root K A ok. Now, 2 C is 30 gamma because here above the water table because your H 0 will be the above a water table. So, it is 19 and K p this is root 1. So, this value is 3.2 meter.

So, your H 0 is 3.2 meter. So, I can draw this line and this is 3.2 meter ok. This is the H 0 no tension depth. So, this is 3.2 meter and here at 4 meter I can write that this is your gamma into 4 minus 2 C u. So, gamma is 19 into 4 minus 2 C u is 30. So, this value is equal to 16 kilo Newton per meter square, because at 4 meter it is this is the 4 meter, gamma is 19 degree into 4 K A is equal to 1 and minus 2 C u, C u is 30 ok.

Now, at dredge level, so now, this will be another value due to the actually this line will change the direction, because it is not linear you know. So, because here water table effect is there that is why it will give you a smaller value ok, remember that. So, that is why the total one here is the total value at this point is 19 into 4 plus 3 into 9 minus 2 C u into 30. So, this is equal to 43 kilo Newton per meter square ok. So, this is 43, this is the total one is the 43. So, this is the total one is 43 kilo Newton per meter square.

Now, it will shift this direction then up to this then it will go this side ok. So, here this is 4 C u minus gamma H. Now, here this gamma H value is I can write this gamma H or q bar which is equal to gamma H will be 19 into 3 4 plus 9 into 3 ok. So, this value is 103 kilo Newton per meter square. Because this gamma H we will use here ok or this is or. So, that is this value is 4 into 30 minus 103. So, this is equal to 17 kilo Newton per meter square.

Similarly, here this value is 4 C u this value is 4 C u plus gamma h. So, 4 C u is 4 into 30 plus gamma H calculated 103 ok, this is 4 C u plus gamma h. So, this value is equal to 223 kilo Newton per meter square. So, this is the total diagram, now I will solve ok. So now, I will solve this value, first I will calculate the P A ok. So, P A I am considering only this portion and this portion is 3.2. So, this height is 0.8, because up to this it is 4 meter and this portion is 3 meter ok.

So, I am considering this portion as the P A ok. So, I am taking this is the P A value and this value is this P A is y 1 bar from base of the dredge level ok, from the dredge level. So, P A I am calculating, because there is 3 part this upper triangle, this lower rectangle and lower triangle ok. So, P A is upper triangle half into 16 in 16 this is 16 into 0.8 ok, this is the upper triangle, then lower rectangle 16 into 3, then the lower triangle half into 3 and this total is 43 and this rectangular dimension is 16 so, this is 43 minus 16. So, this 3 part will be 8.4 plus 48 plus 40.5.

So, this is equal to 96.9 kilo Newton per meter ok. And the y 1 bar I am calculating from this dredge level and this is first at upper triangle is 8.4, liver arm is 3 meter plus 1 third of 0.8. This is 3 meter plus 1 third of 0.8, then that lower rectangle 48 that is 3 divided by 2, then that lower triangle which is 40.5 into 3 divided by 3 that total is 96.9. So, this is 1.44 meter. So, y 1 bar is 1.44 meter from the dredge level ok. So now, I will solve the expression.

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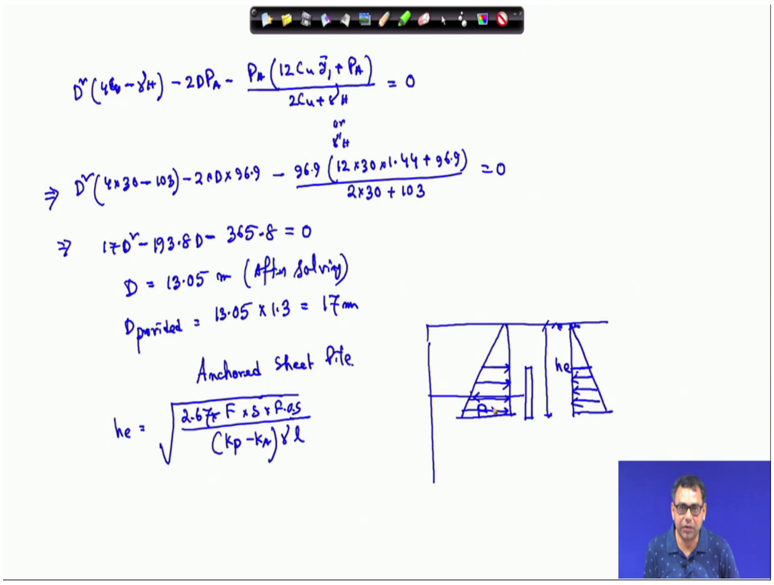

So, expression the final expression was given for this type of problem was D square where D is your this dimension. This dimension is this is the D ok. So, the final expression we have D square into 4 C u minus gamma H minus 2 D P A minus P A 12 C u y 1 bar plus P A divided by 2 C u plus gamma H, or gamma dash H gamma H, or sometime I can use gamma dash ok. So, that is equal to 0 this expression, I have derived already in the previous class.

So, the value I am writing the D is unknown. So, D square 4 into 30 gamma H or gamma dash H are calculated as 103, ok. So, this is gamma dash H or gamma H or q bar is 103. So, this is 103 minus 2 into D P A is 90 P A is 96.9 kilo Newton per meter. So, this is 96.9 kilo Newton per meter minus 96.9 into 12 into 30 y 1 bar is 1.44 plus 96.9 divided by 2 into 30 plus again gamma dash or gamma dash H or gamma H is 103, that is equal to 3 0.

So, after simplifying we will get 17 D square minus 193.8 D minus 365.80. So, after solving we will get D is equal to 13.05 meter and D provided is equal to 13.05 into 1.3 which is around 17 meter ok. So, after so, you can see that same similar problem you have taken. And you have taken for granular soil is giving cantilever in granular soil, it is giving 9.5 meter. Then cantilever in cohesive soil it is given 17 meter and the anchored sheet pile in granular soil it is given 3.5 meter.

So, here also 17 meter is very, very high value. So, you can reduce to reduce this value we can provide the anchored sheet pile or this soil is C value is very small, 30 or kilo Newton per meter square, if higher C value is there. So, automatically for the higher C value this 4 C u minus gamma H. So, this part will increase so, the required depth will reduce ok.

So now, there are one there are few points. So, first point is that, if there may be some possibility that this depending upon the C u this upper portion of the dredge level, the total stress can be negative ok; that means the C u H 0 value if C c u value is very high. If C u value is very high, so, H 0 can be greater than 7 meter also.

So, if H 0 value is greater than 7 meter. So, upper portion we do not need to consider any stress, because we will not consider the negative one. So, this is one point, another point is there may be one possibility that this 4 C u minus gamma h. So, gamma H is very high, C u values will release. So, it can go in this side also negative ok. So, in that case you may not use this sheet pile in that type of soil ok. So, you keep these things in mind before you solve this type of problem when you designing the sheet pile.

So, this is one thing and the another thing is that when during the calculation of H g that of the anchor. So, I have use, so, for the anchor design anchored sheet pile. So, when I design the anchor so, this is the anchor length and this is the ground surface. So, I as this is the H value he value and I give the expression he is equal to root over 2.67 into F which is the anchor force F and into S is the spacing into factor of safety and then divided by K p minus K A into gamma into l. So, these meaning of this all these notations are already we explained.

So, in sometimes you may find that people are using the H instead of 2.67 they are using 2 so, but I would recommend you use that 2.67, why they are using 2? Because people are considering you, sometimes people consider this is the total active and the total passive force. So, that is why this is total one from the ground surface to the base, but I would recommend that you consider only this portion ok. Not the total one, because that is the stress is acting on this anchor plate.

So, if you consider the total one from the ground surface to the base of the anchor plate, then you have to instead of 2.67 it will be 2. But I would recommend you use the 2.67 ok. So, that will increase the he value. So, so you will get the more resistance. So, these are the points that I want to share with you. So, the next topic that I will start about the brace excavation, ok.

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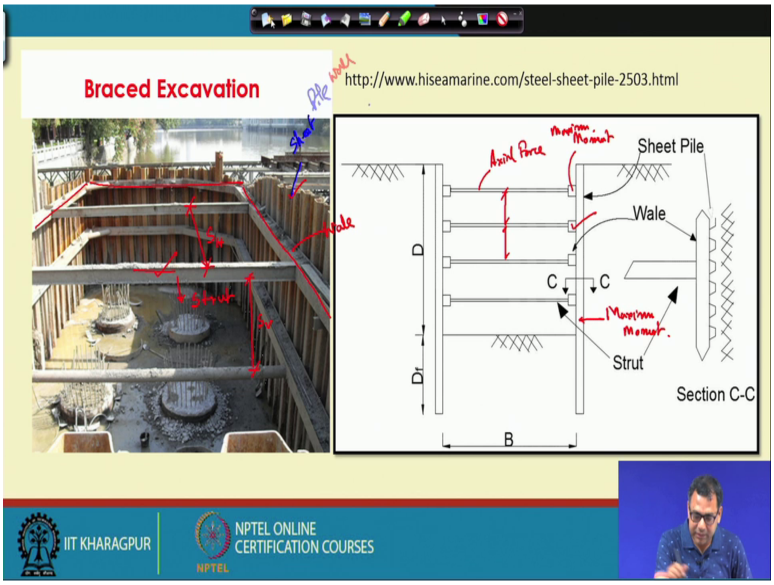

So, what is the brace excavation? So, brace excavation is that as you have observe the sometimes these the depth of the sheet pile will increase if your height of the sheet pile is more.

So, that means, these sheet piles are used for the temporary construction like the excavation. So, this is one particular excavation size site. Now if your height of the excavation is very high or large, then only sheet pile is not sufficient ok. So, here also this figure, you can see that this is the sheet pile. So and if this height is very large, then only sheet pile is not sufficient, then the required depth of the sheet pile will also increase. So, to reduce that depth and this for that type of problem one bracing system is provided. So, that is called the brace excavation. What is the bracing system?

This is the sheet pile in addition to that we will provide a beam ok. So, this is called the Euler beam or the wale ok. So, this is the Euler beam, you see this is this is the beam, this one is the beam which is connected with the sheet pile wall. This is sheet pile wall and then we provide some lateral support. So, this is the lateral support, these are called the Strut, this is called Strut ok.

So, here you I have the section, this is the sheet pile wall, this is the sheet pile wall. Then this is the Euler beam, because this is the section of the Euler beam ok. And this is the strut so, this is the strut. So, you can see the strut has 2 spacing, one is vertically. So, there is one spacing, this is in terms of vertical ok. So, this is vertical another one is the horizontal ok. So, this is the SV, this is the SH or the horizontal spacing. So, that means, when you design this thing you will find we will use this SH and we can provide the AV also.

So, there can be the one level strut, 2 level strut, here there is a 4 strut ok and there is the spacing between the respective struts. So, what are the things when you design? So, we have to design what are the force is acting on this on this strut because here the wall will deform and this side also deforms. So, will be axial force will be developed in the strut. So, the strut will carry the axial force that we have to determine. So, this beam what is these beams are carrying what is the moment coming on this beam or the maximum moment. So, that also we will calculate and what is the maximum moment is coming on the wall. So, these 3 things we will determine, so, during the design fine.

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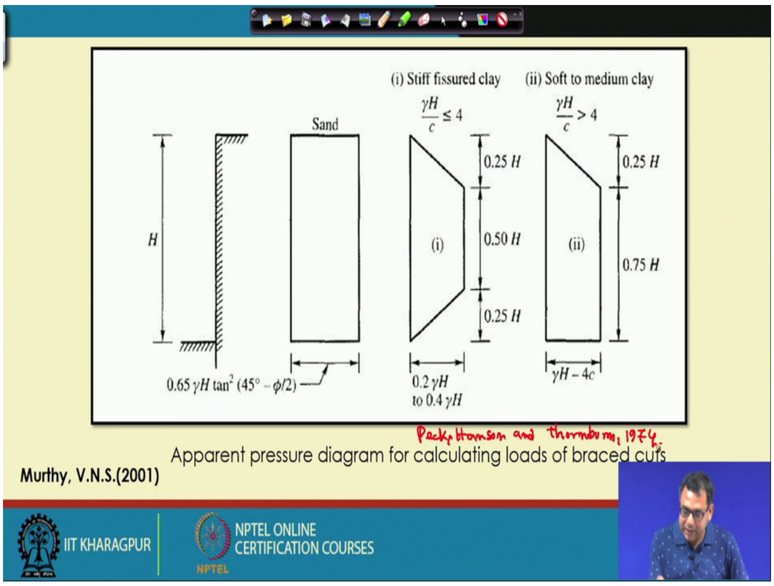

So now, to determine these things, so, determine these values, some guidelines are suggested ok. So, here the earth pressure equation earth pressure equation or the distribution pattern is suggested by Peck Hanson and Thornburn ok, 1974. So, what they are suggested? Because here that distribution depends on many factors ok, what are those factors? Because here, this is not a wall in between thus that the axial support or the strut there.

So, that depends on the spacing between the struts. So, that depends the construction time ok. So, rate of construction depending upon all these things or keeping all these things in mind based on the observation, they have proposed this type of distribution for different types of soil. So, if it is sandy soil so, this is the distribution or this is the value of the p a ok.

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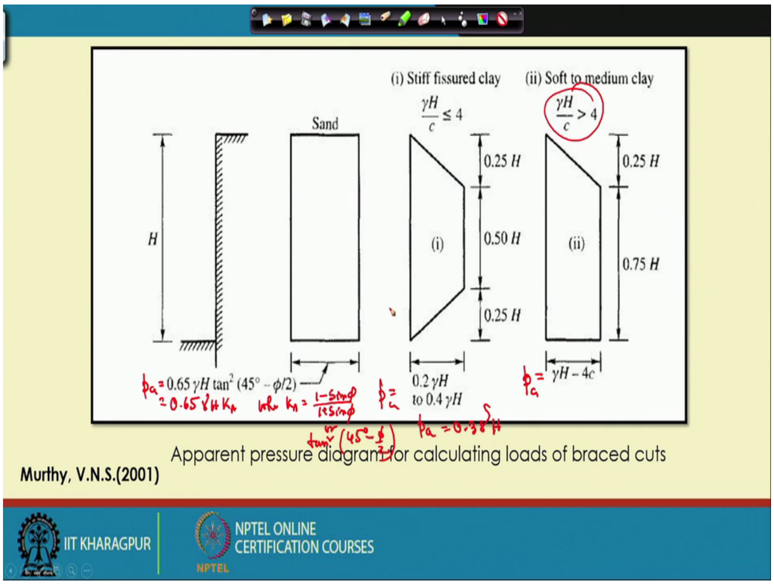

So, this is the p a value of the p a or it is equal to 0.65 gamma H into K A or where K A is equal to 1 minus sin phi divided 1 plus sin phi or this is tan square 45 degree minus phi by 2.

So, this if this is a sandy soil. If it is a stiff clay when stiff clay if this value is gamma into H minus c is c u is less than equal to 4, then you will use this distribution. So, this distribution is 0.2 gamma H to 0.4 gamma H ok. So, this is the value and if this is the soft to medium clay, this value is gamma H divided by c is greater than 4 then we will use this distribution. So, this is the p a value is gamma H minus 4 c u, this is the p a value ok, 0.42, sorry, 2 gamma H to 0.4 gamma H or we can take average value p a is equal to 0.3 gamma H, because the this is the average value.

So, these distribution will help us to design the strut force or to calculate the strut force, bending moment coming on the wall and the bending moment coming on the beam ok. So, based on this is the simplified approximate method by which we can determine those things ok. So, I will discuss this value with a problem and in the next class that how we will determine the axial force and a bending moment of a brace excavation which is constructed in either clay or sand.

Thank you.