Foundation Engineering
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Lecture – 56
Sheet Piles – V

So, last class I have shown that how I will get the net pressure diagram from the sheet pile which is install in cohesive soil, and there are 4 zones and like the cohesionless soil and then we got the net pressure distribution diagram. Now today I will show you that from that net pressure distribution diagram, how I will got the D value expression. So, this was the expression that we got in the last class ok.

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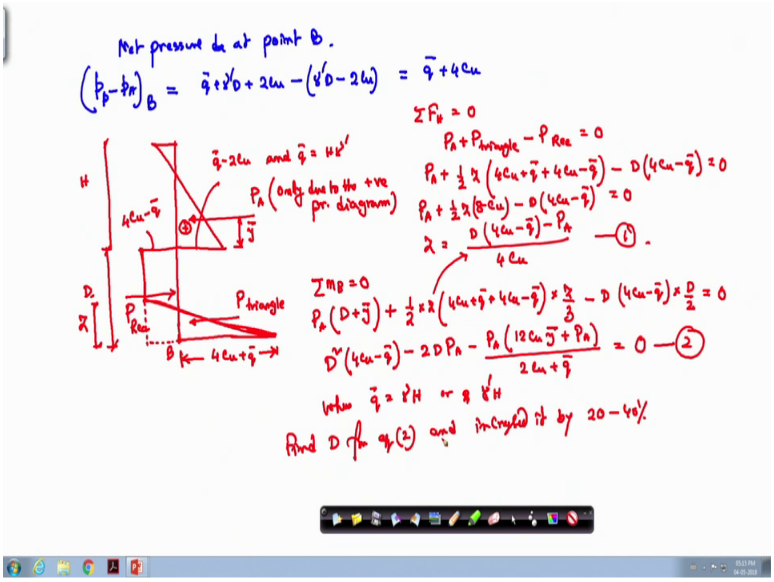

Now from this expression so, I will get the expression of from this diagram I will get the expression of D. So, this is I am taking thus summation of all horizontal force is 0. So, what are the forces are coming? So, what I am doing again here also I am taking this construction line I am drawing. So, what I am doing that I am taking the horizontal forces.

So, one horizontal force will act is this P A, another forces are this is the force P due to this triangle if I say this is this triangle ok. This is the triangle and here this is the P this is P rectangle. So, I am getting that forces means P A plus P due to this triangle minus P due to this rectangle that will be 0.

So, what I am doing I am considering this triangle and then I am taking this rectangle also, and both opposite site. So, this portion I have taken twice this dotted portion, I have taken twice 1 I have added and in the triangular are added this portion and in the rectangle I have also added that portion. So, when both the forces are acting in opposite direction. So, this portion is automatically cancelled.

So, that is why I have taken this 2 portion, but forces are in both the opposite direction. So, this portion will automatically cancel. So, now, the P A as I mentioned P A is the only positive part that you have to consider; now the P A plus this triangle portion if I say this is the z value z value is the height of this triangle from this point this is z. So, I can write that half into z height plus the base is this is 4 C u plus q bar this 1 4 C u minus q bar. So, I can write 4 C u plus q bar plus 4 C u minus q bar this is for the triangle then the rectangle it is a rectangle and this side is 4 C u minus q bar. So, I can write this is D 4 C u minus q bar that is equal to 0.

So, finally, if I further simplify this thing this is P A plus half z 8 C u 8 C u minus D 4 C u minus q bar. So, this is 0. So, z value I will get from this expression is D 4 C u minus q bar minus P A and this will be the 4 C u. So, this is equation number 1.

Similarly, I will take this is the B point summation of all a moment taking fromB point is 0. So, again there are 3 forces. So, I am writing that this is P A the lever arm will be the capital this lever arm that will be your D plus y bar. So, this is the total is D. So, this will be D plus y bar is the lever arm because from this point, this is the D plus y bar and then plus this portion you triangle because of this triangular force, this is half into z into 4 C u plus q bar plus 4 C u minus q bar; then into it will act as a height of z by 3 then minus will be that this is the rectangle which is D 4 C u minus q bar in to this will be D by 2 that is equal to 0.

So, if I finally, simplify this expression, I can write D square 4 C u minus q bar minus 2 D P A minus P A 12 C u y bar plus P A divided by 2 C u plus q bar is equal to 0; I have replace this z value with this expression. So, z is replaced by this expression 1. So, this the z is replace with this expression ok.

So, finally, I will get this equation and we have remembered that where q bar is equal to gamma H or gamma bar H depending upon the position of the water table. So, when you solve this D from this equation, then you increase it find D from equation 2 and increase it by 20 to 30 or 40 percent. So, this is the equation to determine the depth of a cantilever sheet pile in cohesive soil.

So, and the a solution process same that the problem I have solve for the granular soil case, because here you have to you have if you these 2 expression and P A you will get from this triangle and, but remember that there may be some c phi soil also in this top portion. So, depending upon your soil you will get a at pressure distribution diagram.

So, you take the positive part of that diagram only and get the P A value and calculate the y bar, that I have also shown how to calculate the y bar and then you will get this z expression put those values now that z expression you put here you will get this total expression.

So, this q bar you did determine depending upon if this is total soil is below the water table, then you have to consider gamma sub into H, but some portion of the soil maybe above the water table some portion maybe below the water table. So, above the water table you have to consider gamma into H and below the water table you have to consider gamma dash or gamma sub into that H 1 or H 2 whatever the height ok.

So, remember that that q you have to consider depending upon the water table if it is some portion of the soil is above water table considered the gamma, if some portion of the soil is below water table considered the gamma dash or gamma sub ok. And I have solved the similar problem in the granular soil case. So, in the next part that I will start is the, your anchored sheet pile and I will consider the anchored sheet pile, both for c and phi soil. So, this is the Anchored sheet pile.

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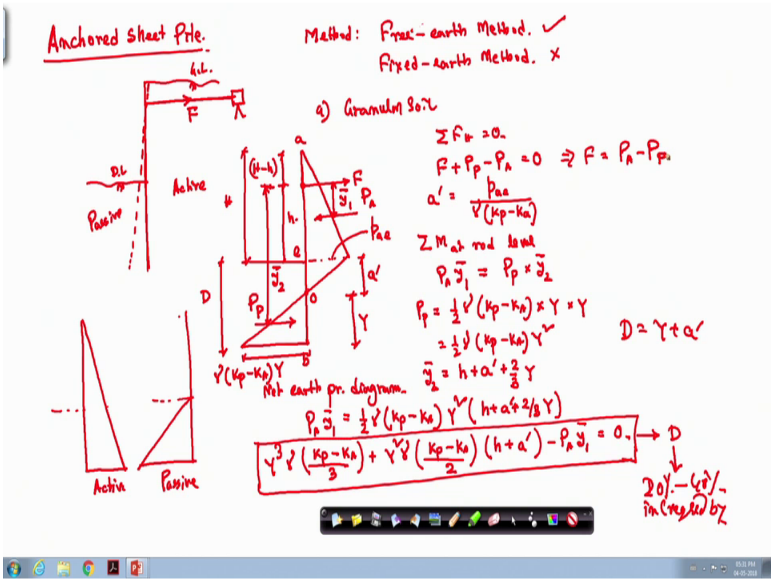

So, these Anchored sheets pile. So, as I have shown instead of in the cantilever sheet pile, this is the gradge level and this is the ground level. So, here we are putting anchorage and apply some tension. So, that when this is the anchorage a rod where a plate can be attached which will be inst inserted into the soil; so, that will give anchorage

So the, what is the advantage? Here r force F is acting that mean F force you are applying on the sheet pile. So, that automatically you are get giving some resistance F in the sheet file. The advantage of these things that it will reduce the required depth of the sheet pile and if your height of H is very large, then also you can provide the anchorage. So, then you can reduce the depth of the sheet pile.

So, here your deformation shape is considered as if it is. So, this is the 2 methods generally we considered. So, one is Free earth method another is Fixed earth method. So, in this course I will only concentrate in the free earth method I will discuss only the free earth method; fixed earth method I will not discuss in this course.

So, first the distribution that I am talking about this is the free earth method that as I mentioned I will discuss only the free earth method. So, we have 2 cases one is in the granular soil all is in the c soil. So, first I will discuss about the granular soil part, then I will discuss about the cohesive soil part ok.

So, in the free earth method, it is say assume that your wall is rotating like this ok. This is the wall that is it is free earth means this base is a free it is not fixed; fixed mean it will be fixed. So, suppose if your depth of the sheet pile is relatively less, then you can consider the free earth method, but if it is very high then the lower portion will also be will not rotate so, that is the fixed condition. So, that will not discuss here I will discuss the free earth method where your base is rotating. So, and it is rotating about the anchor rod position.

So, and. So, that means here also now you have this is the portion is active this portion is passive, but there is a small portion above the anchor rod. So, this is the anchor position above the anchor position there is a small portion where you also you can say this portion is passive, but as it is a very small portion. So, that is why you are neglecting that condition and you are assuming that this right side is total active and this left side is total passive. So, this is our active and this is the passive condition.

So, if it is a granular soil, then as it is total active and passive condition. So, this portion is passive this portion is active. So, if we can draw that this is my earth pressure distribution, this is the active condition; now from here up to this is only active now below the dredge level this side is active, this side is passive; left side is active right side is a passive and definitely your passive force will be greater than the active force. So, what will happen? Your diagram will shift from right side to left side ok.

So, this will be the diagram of these cases and there will be a force F fine this is the anchorage force. So, this is the earth pressure distribution diagram. So, I can write this is p a and this is the e.

So, this is I can write pae; this is point this is the b point or o point at which the net earth pressure is 0. So, this is the net earth pressure diagram. So, you can draw the again the separately the active and passive pressure diagram. So, this is the total active and this side will be total passive ok. So, passive will be here.

But in the cantilever sheet pile case, it was active passive active passive 4 zones, but here only the right side is total active and left side is total passive. So, up to here the net earth pressure diagram this will be the active, then it will shift from this side to other side because I had the passive is more. So, it will shift ok.

Now quickly I will give you that how I will determine these values; this is the D and these values say capital Y and this one is a or a dash because in case of previous problem I considered this is a dash and this is the force which is acting P A.

So, what I will do, I will consider this P A considering this above the o point and then there is a 4 set P because of this triangle. So, I can write that the F force is the anchor force and your unit weight is gamma or gamma dash depending upon the water table condition.

So, the summation of all horizontal forces is 0. So, F H is 0. So, what are the horizontal forces? The horizontal forces are F this is the anchor force plus P plus P P minus P A, that is equal to 0 ok. And now from the you know the, a dash value I will get from the previous granular soil anti lever sheet pile in granular soil, I get that this is pae divided by gamma or gamma dash into kp minus ka ok.

So, that is the dash I will get; then next one that I will take the moment at rod level ok. So, I will take it moment with this point at rod level it is 0.

So, I am taking the value that this is the P A and y dash and I am taking that P A is at a distance of y 1 bar; and this one is this is say h small h this 1 capital H and the this height is say capital H minus small h and from here to the P P is y 2 bar.

So, the lever arm of P A is y 1 bar from the F that will be equal to the P P and lever arm is y 2 bar ok. And P P value I can write that you know here net earth pressure is 0 at o point net earth pressure is 0 then it will increase this value.

So, the net earth pressure, this P P or this value will be kp minus kA into capital Y. So, that it is the same thing I did in the last problem of cantilever sheet pile in granular soil. So, this value is kp minus k into y because this is net earth pressure into y, y is the capital Y Y. So, I can write that P P is if will be half and this will be the gamma also this is gamma into kp minus kA into capital Y.

So, this will be the half gamma k p minus k a this is this due to this triangle this is the base into y ok. This is the your k p into another y because this is the base is gamma k p minus kA into Y then into another y this will be the P P. So, P P value is half into gamma into kp minus kA into capital Y square ok. And y 2 bar is equal to y 2 bar will be small h this is small h plus a dash plus two third of y because this is from base it is one third of y and this is the triangle. So, this will be two third of capital Y.

So, finally, if I write this expression, then I will get that P A into y 1 bar that will be equal to half that will be equal to half gamma k p minus ka into capital Y square into h plus a dash plus two third of capital Y. So, after simplifying I will get capital Y cube gamma k p minus kA divided by 3 plus capital Y square gamma kp minus ka divided by 2 into h small h plus a dash minus P A y 1 bar is equal to 0.

So, you have this final expression, now from this expression you find D then increase it by 20 to 40 percent we increase it. So, this is the total solution now in this case we have a anchor also. So, how to design this anchor. So, that is also important. So, I will solve that first I will discuss that how will design this anchor, because here that you have a anchor and then from that solution.

So, if you look at this solution that from this solution you will get capital Y, now your D value is capital Y plus a dash a dash you will get from this expression you have the capital Y. So, you will get the D and you know the h. So, the you total h plus D you know ok.

Now, once you get the D now you put this capital Y you then put you capital Y here you will get the P P P A you will get from this diagram remember that this diagram from o P P value you will get the values from o 2 a; this total 1 is P P (Refer Time: 23:35) P A ok. So, P a is that the distribution the force due to this portion of this diagram form o 2 a and once you get the P A P P, then you will get the F value.

So, a from this expression F will be equal to your P A minus P P. So, that will give you the F value final a value. So, that a value once you get this F value now I have to design the anchor.

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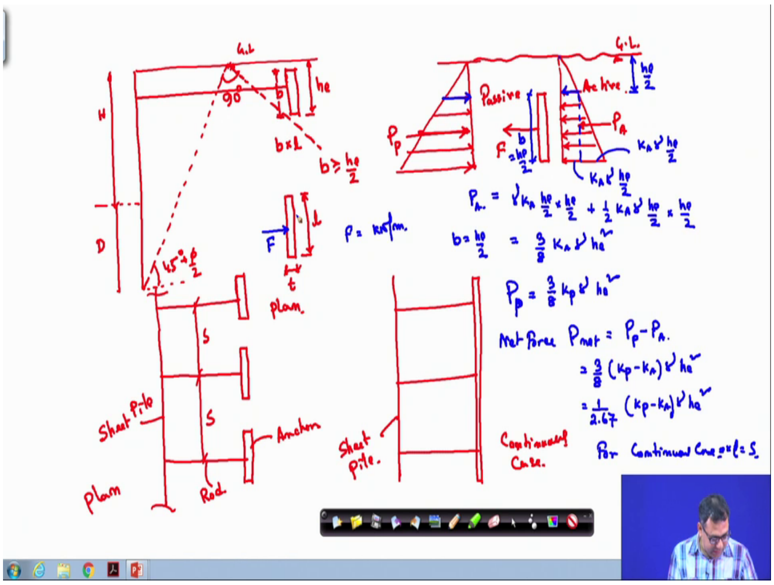

So, now if this is the retaining or the sheet pile wall; so, now, I know the D value and the H value is known. So, this is the D value. Now, the sheet pile it assumed that there will be a line. So, this is the ground surface GL ok. So, I will draw a line which is 45 degree plus phi by 2 because this is active site. So, this may be the , this will be del failure zone or failure surface. So, you cannot put the anchor in this zone. So, and then you draw a 90 degree line here this is 90 degree. So, your anchor that you will place this is the anchor sheet that should be above this line. You cannot put anchor in this zone this anchored should be above this line above these dotted lines. So, this is the anchor position in terms of horizontally.

Now, the vertically what would be the depth of this h e say is the say depth of the anchor and b is the, this width of the anchor. So, what I can say that this is the anchor. So, this is the anchor b into L L means in the length y. So, now, if I draw the plan this is the section the plan will be maybe this is the plan ok.

So, this is the length l and this is the thickness say t. So, this is the plan is it the length and so, you can put anchors like these also in terms of plan if I draw. So, you can put one anchor then this is this is your sheet piles, which is going continuously then you can put another anchor like this, then another anchor like this, this is sheet pile, this is the anchor this is the anchor rod.

So, this is the plan. So, there will be some spacing between the this anchor rods ok; and another way this is the discontinuous one. So, another way this is the sheet pile. So, you can get the continuous anchor ok. So, this is the continuous anchor and you can put the rod here. So, this is the sheet pile.

So, this is the continuous case this push this is the continuous case continuous case; where the, your anchor plate this is the anchor plate which is continuous and sometimes it cannot be it may not be the continuous also. But if so, it is the length and it is the t.

So, now if I have a anchor is at a point here. So, this is the ground surface G L. So, and you are applying force here this direction. So, your force is applying in this direction because your anchor is attached here, it is try to rotate. So, you are applying force of these anchors and anchor will move in this direction. So, this portion of the soil is active condition this portion of the soil is passive condition because you are you are pulling this anchor, your anchor is getting a reaction this is the force of the anchor force so; that means, here this side is passive and this side is active.

So, if I draw the diagram. So, I can draw this is the active pressure diagram and this side this is the passive pressure diagram ok. So, I will consider this portion only, because this is the anchor portion here also I will consider the passive pressure this is the active pressure this is the passive pressure. So, I can take and generally your this is the b b is this this this portion is b this is in section.

So, generally your b is greater than equal to h e by 2. So, now, if I draw the your passive force, this is the active force and this is the passive force ok. And remember that I am drawing this up to this portion because this is the anchor portion some you do not consider the above portion of the pressure, because that is the pressure which is acting on the anchor.

So, I can write that my P A P A what will be the, this value? And I am considering that b is equal to he by 2; if be equal to he by 2 then this portion is also he by 2 because your b is this is b which is he by 2 this is b which is h by 2 and this portion is he. So, these will also he by 2. So, he by 2 and. So, the my P A will be this portion this portion of the diagram. So, I can take one is rectangle another is the triangle.

So, this rectangle this portion is definitely it will be K A into gamma into he by 2 and this portion is also K A gamma he by 2 because this is from here 0 to here. So, this is all this b, this is b b is nothing, but he by 2. So, this will be k into gamma into h e by 2 and this portion is from the top this is also ka k he by 2 this will be the ka a a gamma into he by 2 and this is the rectangle. So, I have a rectangle and a triangle. So, I can write the P A expression is for the rectangle is gamma K A he by 2 into he by 2 plus the triangle is half K A gamma he by 2 into he by 2. So, if I take and simplify this, this will be 3 by 8 K A gamma he by he square ok.

Similarly, the passive will be the same passive pressure will be the same 3 by 8 k p gamma he square. So, the finally, the net pressure or net force P net which is equal to P passive minus P active; so, this will be 3 by 8 kp minus kA gamma he square. So, this is the value or we can write this is 2.1 by 2.67 kp minus ka gamma he square fine.

So, now this is the force and that will be equal to the force that is acting on the on the anchor plate. So, in the anchor the force is acting. So, this force that will be kilo Newton per meter so, that force is acting here. So, now, what I will do, I will take that force and into I will put factor of safety here.

So, that for this net force will balance this F. So, what I am doing that I am writing that for continuous case continuous case, you can write that you are l is equal to s; now what is l and what is s.

Now, first I will balance this forces and then. So, I can draw it here.

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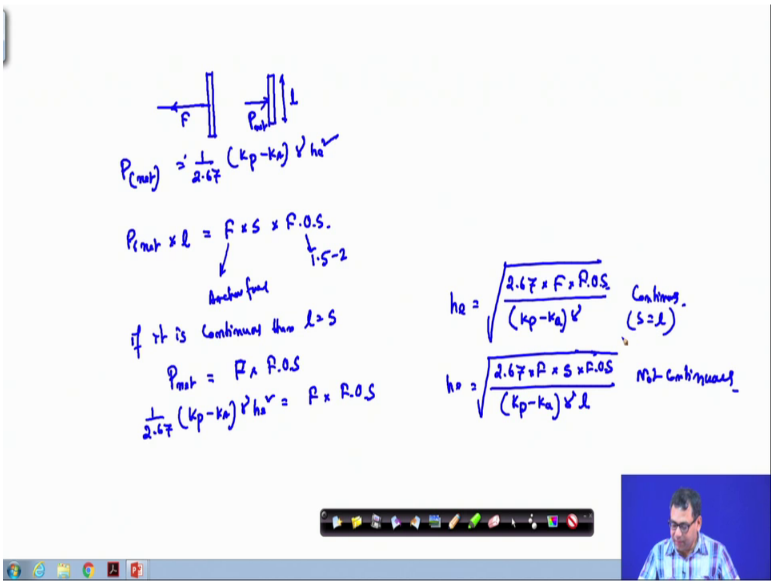

So, this is the anchor plate. So, where your since this is the force is acting and the P net is is equal to 1 by 2.67 k p minus k a into gamma into h is square that is the value into gamma he square. Now this P net into l that will be the total force ok. If this is the l, now P net is acting here. So, this is the b is vertical direction wise and this is the F this is the plan. So, this is the F which is acting. So, I can write that this F into l that is the total force.

Similarly the F that this is the p this is not F this is P net this is P net.

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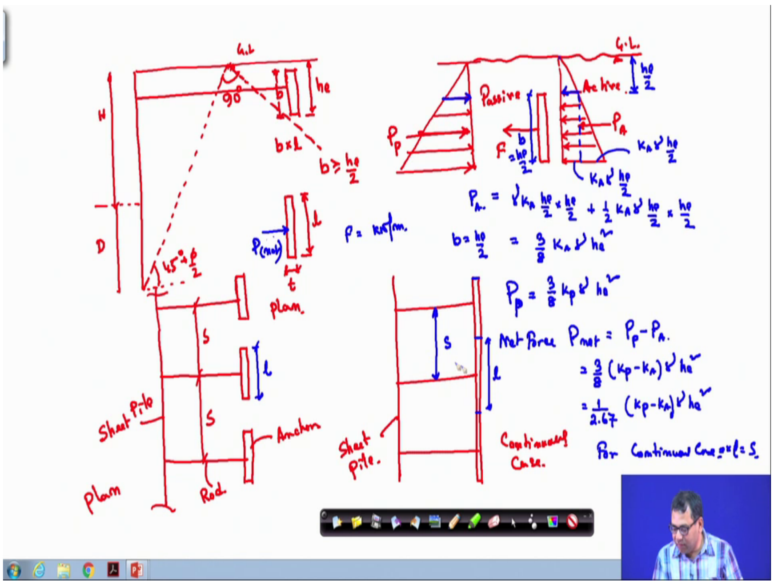

So this is the P net into l, similarly F into s; s is the spacing between the rod. So, because your F is acting because this is a continuous one and so, the one total s will be because the F as I mentioned kilo Newton per meter. Now if you multiply it with the s, spacing between the anchor rod, then you will get the total force that is coming on this anchor one particular anchor. Because we are this is the F is coming kilo Newton per meter, now if it is spacing is the s then you have to multiply that F the anchor force with the s then you will get the total force. Because it is kilo Newton per meter if you multiply the s then I will get the total force. So, that I am doing this is F the anchor force, this is the anchor force, you multiply the s.

So, I will get the total force; similarly the P net that is acting here. So, P net is also acting here into the length if I multiply with the length in the plan wise, then I will get the total force. So, this is and then I am getting giving 1 factor of safety this is the factor of safety on the force. So, this is factor safety generally I will take this 1.5 or 1.5 to 2 ok.

So, this is the total equation and this is for the, if it is not continuous. Now if it is continuous then I can write that your l is equal to s because in that case this is continuous. So, this is the continuous. So, I will I will write that in that case this will be the l will be equal to the s because now this is the I can say in that case your l will be this one; ha here also l will be this one; this will be the l if it is continuous.

Now, this is the one if it is not continuous in that condition will be the l and your, this is thus basing. So, if it is continuous then your l will be equal to s. So, now, if it is continuous then your l will be equal to s. So, I can write that P net will be equal to F into factor of safety. So, finally, I can write that P net is equal to 1 by 2.67 it is kp minus kA gamma he square will be F into the factor of safety

So, from here he expression I will get is equal to 2.67 into F into factor of safety divided by kp minus ka gamma ok. If it is continuous and he expression is 2.67 into F into s into factor of safety divided by kp minus ka gamma l; if not continuous ok.

So, if it is continuous s; s is the spacing remember that s is the spacing between the anchor rods, l is the length of the anchor rods. So, it is continuous your s equal to l fine. So, this way I can get the h e, and I will show you in the next class with a with a problem example problem how I will get the he and how I will place the anchor from the sheet pile.

Thank you.