Foundation Engineering
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Lecture – 53
Sheet Piles – II

So, last class I was discussing about the cantilever sheet pile in granular soil and as you have noticed that there are four regions of that cantilever sheet pile

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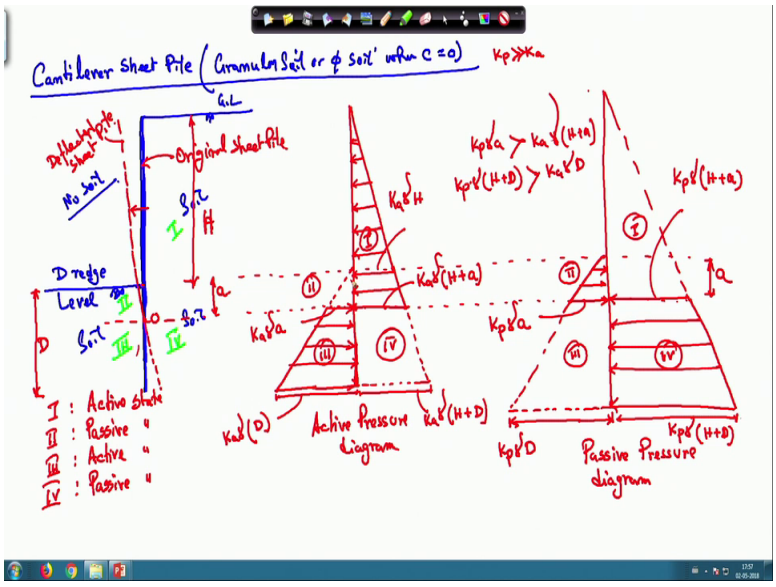

Region I, region II, region III and region IV and region I is in active state region II is in passive state, III is in again active state and IV is in passive state. So, I have drawn this active pressure diagram. So, you can see that this diagram will be this portion only ok, because the region I is only active and region III is active.

So, as you have noticed that here this value is K into gamma into H plus a here it is K into gamma into a because here it will start from this point dredge level and this is the a; a value is the distance of O from that dredge level. So, this is a depth of the sheet pile is D and height of the sheet pile above dredge level is H. So, this will be gamma K a into gamma into a. And similarly these value will be K into gamma into D, because I had the depth of the sheet pile is D and this value is K into gamma into H plus D.

Similarly, I can draw the passive pressure. So, though it is passive pressure diagram as the K p is greater than K a. So, this pressure diagram this pressure value will be higher. So, and I am drawing this diagram. So, it will start from here, ok. It will start from here because this is your region IV. Region IV is in passive. So, it will give the passive resistance in the region IV, ok.

And, then region II is also passive. So, the region II it will start here to here. So, this is region II it is also passive then it will go up to here. So, this is the passive pressure diagram. So, if I write down the values so, again from here to here it is a. So, I can write this value is K p gamma into a, ok. Initially it was K gamma into a, now it is passive K p gamma into a and definitely these value will be K p gamma into D and this value will be definitely K p gamma into H plus D this one will be K p gamma into H plus a, ok.

So, this is the active pressure diagram and this is the passive pressure diagram. So, I have this is my region I, this is region I, this is the region II, this is region III and this is region IV the region I is active. So, this is only active region II is passive so, this is passive region III, again active and this is region IV again passive. So, here also this is region I, this is region II, this is region III, this is region IV ok.

So, now if you look at these two diagram that up to dredge level there is no issue, the up to dredge level if I now draw the net pressure diagram.

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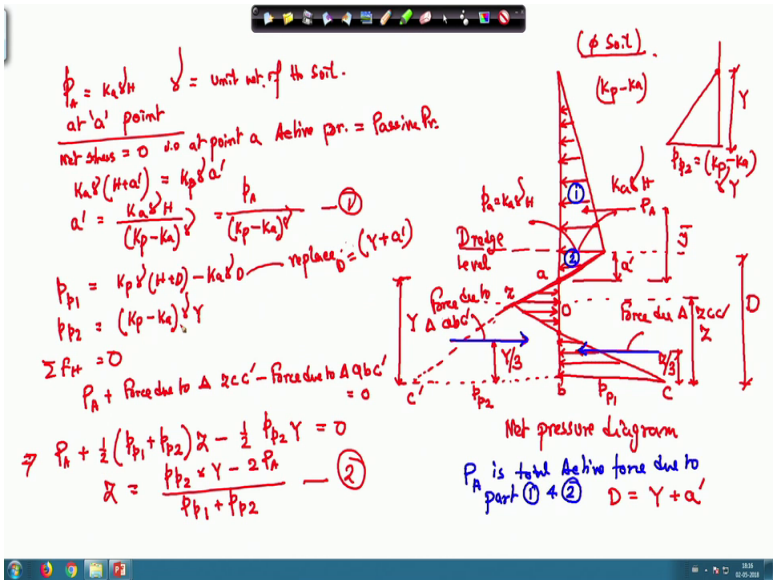

So now, I am drawing the net pressure diagram. So, now, I am drawing the net pressure diagram. So this is say dredge level this is the point O. So, this is point O this is the dredge level, and this one is the net pressure diagram.

So, now, if I look at these two diagram this is active pressure diagram, passive pressure diagram. So, up to this point that dredge level there is only one pressure that is active because in this side no pressure is there either active or passive. So, net pressure diagram up to the dredge level, this is the active pressure diagram, so that value I can write. So, this value is K a into gamma into H, ok. This is the active pressure diagram.

Now, below the dredge level, so this portion it is active, but the because right hand side of this wall is active, but the left hand side of this wall is passive and as I mention that your passive coefficient is very very higher compared to the active coefficient. So, you can see this distance is very small the a value from the dredge level is very small compare to the H value, but the K p value is very high. So, ultimately what will happen that your passive resistance or passive pressure will be greater compared to the active pressure.

So, point will come; so, because this is the passive resistance this side is the active resistance and as I mention the as we go towards the downward direction from the dredge level so, my passive force or passive pressure will increase as the K p value is very very high compare to the active value. Though the a value is small smaller than the H value, but still as the K p value is very very high as compare to the active value so, my passive resistance will increase.

So, what will happen that the there will be a some point the net pressure diagram in there will be a 0, where your active pressure and the passive pressure will be same and after that your pressure distribution diagram will shift from the right side to the left side. And then, that means, here it is passive. So, this passive at this point will be definitely greater than the active force at this level, as the K p is very high. So, what I am trying to say that these things will continue up to here then the net pressure diagram will shift towards the other side of the sheet pile and there will be a point where the net pressure diagram will be exactly 0, ok.

So, I can draw that this is the O point show up to this there is a or there is no passive resistance though, this is only active resistance. After that, that your passive resistance

will increase as we go towards the downward direction from the dredge level; so your pressure will start shifting form right side to the left side ok. So, this is the pressure distribution diagram now here it will be in this direction ok, because this point this portion because here your definitely your K p gamma a is greater than K a gamma H plus a ok. Because, the K p value is very very high as compared to the K a value, clear.

So, now as it is greater than this one, so, your diagram will shift. So, diagram will shift from this side to this side this is the net pressure diagram because as this portion K p gamma a is greater than the K a gamma H plus a. After that when it will shift here after that this is the active and this one is the passive. So, again I can say that K p gamma H plus D is greater than K a gamma into D. So, this value this value is higher than compare to this one.

So, again from here the diagram net pressure diagram will again shift to the other side. So, there will be two points where your net pressure diagram will be exactly 0. So, again from here to here it will shift to the other side, ok. So, this is the complete pressure distribution diagram of this cantilever sheet pile wall in phi soil. So, this is the total. So, distribution diagram net pressure distribution diagram. So, these are two points one is this one is this one where the net pressure is exactly 0, ok.

So, now to derive the mathematical expression for this net pressure diagram; so what I am doing that I am writing that only for this triangular portion above the dredge level, the force which is acting is P a which is acting is P a and that value is suppose this portion is this value is a dash where the stress is exactly 0. So, this portion the a at a distance of a dash from the base of the from dredge level your net pressure distribution diagram your net pressure is 0; so a dash, where the net pressure is 0.

So, I can write that this P a is at a height of y bar from this point which is you can say this is a dash point or you can say this is a point and then what I am doing. So, I am drawing some additional lines. So, this straight line I am just extending and then joining with this line ok, this is the straight line I am extending.

So, you say that this is a dash and from the base of the retaining wall these are base of the sheet pile this is capital Y, and from here where this is maximum I am writing this is z ok. So, where this value is maximum I am writing this is z or this distance is z from the base.

So, I can write that P a is equal to or small P a is equal to K a gamma into H small P a is this one small P a is K a gamma into H ok. So, where K a gamma is the unit weight of the soil where gamma is the unit weight of the soil. Now, at a point at a point your net stress is 0 ok. So, net stress is 0 means at this point if I look at this value at these two diagram. So, here this a point is somehow here. So, where the active pressure is will be K a gamma H plus a dash and passive will be K p gamma a dash.

So, I can write that a point that add the stress net stress is 0, that means, the active pressure is equal to passive pressure your net stress is equal to 0, that is at point a active pressure is equal to passive pressure. So, at point a my active pressure is K a gamma H plus a dash and that will be equal to the passive pressure at that point K a gamma sorry K p gamma a dash.

So, I can write that or a dash from here I can write that this is K a gamma H divided by K p minus K a into gamma. So, this if I simplify this equation above equation we will get the a dash value and K a gamma H is nothing, but a P a ok. So, this will be K p minus K a into gamma. So, this way I will get the expression of a dash. So, I will get that how I will calculate the a dash value.

Now, I can write that here I am writing this is p p 1 this is I am writing p p 2. So, the p p 1, p p 1 is equal to. So, p p 1 will be the net passive minus the net pressure that mean the passive minus active at this point. So, at this point the passive is at this point the passive is this one K p gamma H plus D and the active is K a gamma D. So, the net pressure at this point is K p gamma H plus D minus K a gamma into D and what will be the.

So, this is the p p 1 and p p 2 p p 2 it is originally is not existing because this is the net pressure diagram p p 2 I have drawn and I have extended this straight line. So, how I can calculate the p p 2? P p 2 is basically the net pressure if I extend this line up to the z up to the Y capital Y. So, I can write this p p 2 is K p minus K a into gamma into capital Y because if I extend this line. So, here it is 0 and this diagram is your earth pressure is K p minus K K a.

So, the earth pressure coefficient will be K p minus K a into gamma into Y because this is the Y, because this is the triangular form. So, now, if I draw a diagram suppose like these where my earth pressure coefficient is K p minus K a this is 0, in a sandy soil earth

pressure coefficient this one this value is capital Y. So, this value will be p p 2 will be K p minus K a into gamma into capital Y. So, that is the value of K p 2.

So, now summation of all horizontal force is 0, if I take summation of all horizontal force. So, 0 so, what are the forces that I am considering. So, this is the force p capital A is the force for the active pressure diagram above the dredge level. Then I am considering this is including this portion also this p p is if I draw this a part. So, this is part 1, this is part 2. So, my p p or P A is the total active force due to part 1 and 2. So, this p p is total active force due to part 1 and part 2. So, these above the dredge level and some portion below the dredge level up to a point. So, that is p p.

Now, what I am doing that I am taking this triangle ok. So, I am taking the triangle. So, if I give the name so, this is the a point, this is the b point, this is the c point and this is the c dash and this is c, and this point is say z. So, I can write that the total horizontal force p p is acting here this is the force and there is another force, what are these forces. So, this is the p p or P a then plus the force due to triangle due to the triangle z cc dash due to this triangle, ok. So, if I consider this triangle z cc dash then I am considering this portion ok, but this is the additional portion I am also considering.

Now, I have to subtract this portion. So, now, if I subtract this force due to triangle abc dash then I am considering this portion twice one is plus one is minus. So, this portion is subtracted and this portion is considered in this force and this portion is consider in this force. This portion is consider in this force as well as in this force. So, it is been subtracted, ok. So, that will be equal to 0. So, I can write this is force due to triangle z cc dash this is force due to tangle z sorry a abc dash a is this one clear.

So, now I will calculate the forces. So, I can write P a plus the force due to the triangle z cc 1; so z cc 1. So, this triangle height is z and base is p p 2 plus p p 1. So, I can write this is half p p 1 plus p p 2 in to capital Z because this is the height of this triangle and base is p p 1 plus p p 2 the minus force due to the triangle abc dash, ok. So, height of this triangle is capital y and base is p p 2. So, this will be half p p 2 into capital Y is equal to 0 ok. So, this is the all forces that I have taken.

Now, again I will write that from this expression that capital Z value is p p 2 into Y minus 2 P a divided by p p 1 plus p p 2. So, this is equation number 2. So, what are the unknowns I have because a dash is known I will get from here? So, unknown one

unknown is z another unknown is capital Y; ultimately we have to determine the value D. So, in the sheet pile we have to determine the value D what will be the depth will provide and D value is equal to capital Y plus a dash. D value is capital Y plus a dash. So, z I will get from here.

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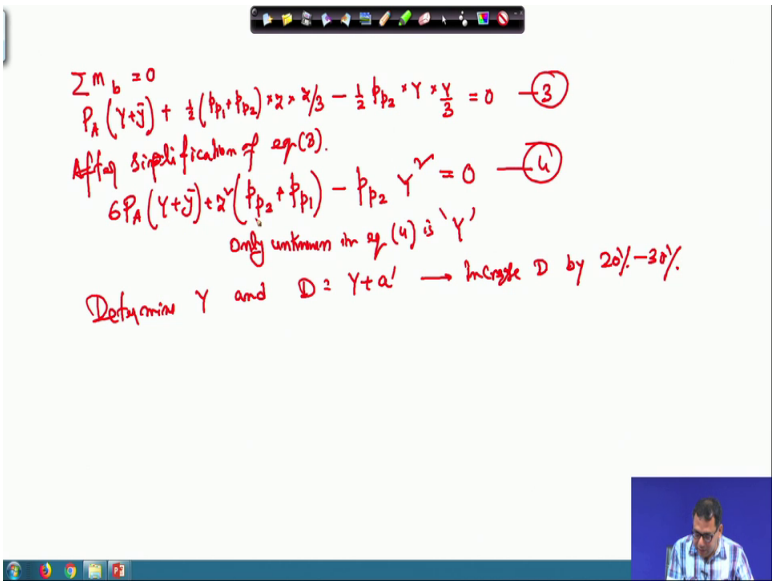

Now, I will take the moment at point b summation of all moment I am taking at point b and that is equal to 0. So, moment what are the moment. So, there are three parts one is the P A part, another is the force due to the triangle z cc 1 c dash and is the force due to the triangle abc dash. So, three part. So, I am taking the first part first part is the P a and the lever arm is. So, y bar is from a point. So, capital Y plus y bar, so, this will be the lever arm.

So, this is capital Y plus y bar plus. So, this again the force due to this triangle z c c dash and the lever arm will be z by 3 ok. So, this will be half p p 1 plus p p 2 into z into z by 3 this will be z by 3 because z is the height of this triangle then minus half p p 2 into capital Y into this is y is the height of this triangle. So, this base is height into y by 3. So, this one will act at a height of capital Y by 3 and this will act at a height of capital Z by 3.

So, this we will these two forces that I have drawn. So, this is the two forces ok, one is capital Z by 3 another y capital Y by 3. So, finally, this will be capital Y divided by 3 that is equal to 0. So, after simplifying the equation number 3 after simplification of equation 3 we will get 6 P a capital Y plus y bar plus z square p p 2 plus p p 1 minus p p 2 into

capital Y square is equal to 0 ok. So, here only unknown is capital y. So, only unknown in equation 4 is capital Y. So, you determine capital Y and your D will be capital Y plus a dash.

Now, this analysis I have done without applying any factor of safety because here just the equilibrium condition I have considered. So, factor of safety is 1. So, thus you increase D by 20 percent to 30 percent to give the factor of safety. So, how where you will get the p p 2 and p p 1? So, p p 2 and p p 1 you will get from these two expression this is the p p 2 and p p 1 ok.

And, when you are putting p p 1 you replace D by capital Y plus a dash. a dash you will get from equation number 1, capital Y is the unknown. So, you replace D by capital y plus a dash. So, you put this value here all the D you replace and this is capital Y. Now, put this p p 1, p p 2 in this equation and then in this equation. And then you simplify that solve it you will get the capital Y and then D you will get from y plus a dash and increase this D by 20 to 30 percent then you will get the total depth required for the sheet pile cantilever sheet pile in granular soil, ok.

So, next class I will solve one numerical problem, one example problem on cantilever sheet pile in granular soil. And then we will see how we can use these equations or theory to determine that depth of the sheet pile.

Thank you.