Application of Soil Mechanics

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Lecture – 03

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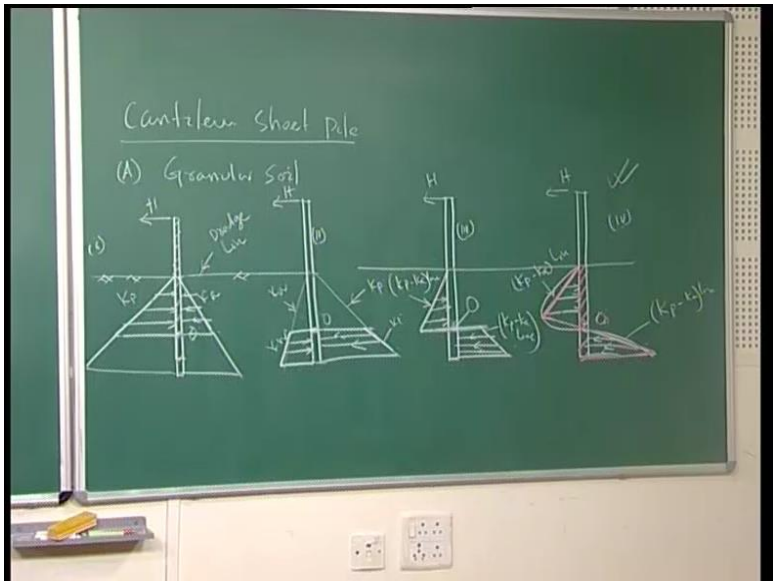

Now we are doing the derivation for cantilever sheet pile. First case is your for granular soil. Now as I say there will be a point of rotation in case of granular soil for cantilever sheet piles, if this is my point of rotation ‘o’. The next stage how this derivation has been derived if I so this is acted upon by horizontal load H, k p minus k a line. This is your horizontal force.

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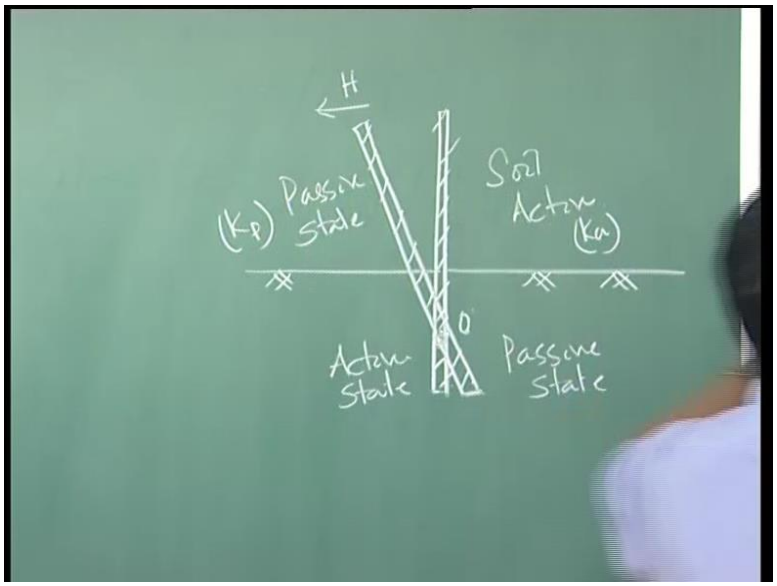

If we look at this diagram - complete diagram, and now if I take it the original what I explained earlier, this is my cantilever wall and there will be like, it is your dredge line. So, it says it will rotate some point at point ‘o’, this is called pivot point acted upon by horizontal force. So, then as I said earlier if it is rotate if this cantilever wall is rotating at point ‘o’, so what will happen, the top part, if I divide into two parts, one edge is your above the point of rotation, other is your below the point of rotation. If I say above the point of rotation this wall is moving away from soil. Suppose this is my soil mass, so that means, this part will be active, this is your passive state. And if we look at the bottom, it will be a reverse, and this is your passive state, and this is your active state.

So, generally passive state, we write k p line; active state we write k a line or k a we write it k a. Now the same principle if I apply here let us consider this is a cantilever sheet pile wall and this is my dredge line, and below this there is soil mass, now this is a point ‘o’. Now above this above this dredge line there is nothing. So, what will happen, if this wall cantilever sheet pile wall now it will rotate at point o, it will rotate at point o, that means, if it rotate at point at o, what will happen above these this is the passive state and this is the active state.

Now I can draw this is my k p line. If I draw the passive earth pressure it will be kind of like this and active earth pressure it will be kind of like this, so that means, I have taken consideration of passive state and active state up to at point o. Now this is the passive

line are passive state of the soil and this is the active state of soil; that means, always remember k p is greater than k a - passive state is greater than your active state or passive earth pressure is greater than your active earth pressure. So, that is why these triangle I have taken this your k p; that means, passive state or passive earth pressure, it is bigger than this line is your this triangle is your smaller this is your active state.

Now come back to if this is your first diagram, second diagram, third and fourth diagram. Now come back to second diagram; in second diagram, what is supposed to be happen, this is my point o, look at the point o, below point o what will happen. Below the point o, this wall is moving towards and this part is it is this wall is moving away; that means, if I draw a line here somewhere else below this, this is your active state and this is your passive state. Now same concept has been applied here, if I draw it completely below point o that means, this is my active state or active earth pressure will act this is passive earth pressure will act and I will remove the pressure from o to dredge line.

Because this concept below this is different than the concept above your point o. Below this points o, it is different passive state active state, above the point o this is passive state and active state, this is in a reverse. So, above point o, this has been neglected and below point o it is considered. So, this will be your k a line, and this is your k p line. Now for complete derivation, it has to be superimposed; both the cases has to be superimposed. Now these has been superimposed what happen this is k p and this is k a. So, this will be k p minus k a line, and this is your k p and this is your k a. In this case this is your also k p minus k a line.

So, now, the diagram has been drawn. So, this point is your point o. Now next question you can ask yourself will it with your failure lie, no. Why, because from passive state to active state soil cannot transit in the all sudden transition cannot be occur. Sudden transition means, if we look at at point ‘o’, all of sudden it is in passive state kept other side then it is moving moving and it is changing then all of sudden it is changing. So, these transition is not acceptable. So, these transition is not acceptable; that means, there will be a smooth transition from one state to other state; one state of failure and other state of failure, there should be a smooth transition. So, that is why it has been drawn. So, that it is slowly, slowly decreasing and it is achieving this other failure transition.

So, now this is your final failure mode of cantilever retaining wall below means in granular soil having a point of rotation o above the base. Now how it looks, it looks like this. Now these are the assumptions for particularly considering not non-linear actual case of this how it should be looks like, it should be a kind of curvilinear, it is a curvilinear it has been approximated to simple straight line or may be linear failure you can say it. So, if I take it this is my final failure surface of this cantilever retaining wall having embedded in granular soil that means, it is starting from one state to other state, there is a smooth transition. This concept has to be used for derivation of cantilever sheet pile wall for derivation of equation; that means, what is the capacity cantilever sheet sheet pile wall in granular soil.

If I remove all one, two, three and keeping only this part final form of this equation. So, we will start this derivation, how the derivation has been made. Now instead of suppose I say there is there might be a soil mass above the cantilever, there might not be a soil mass above the cantilever.

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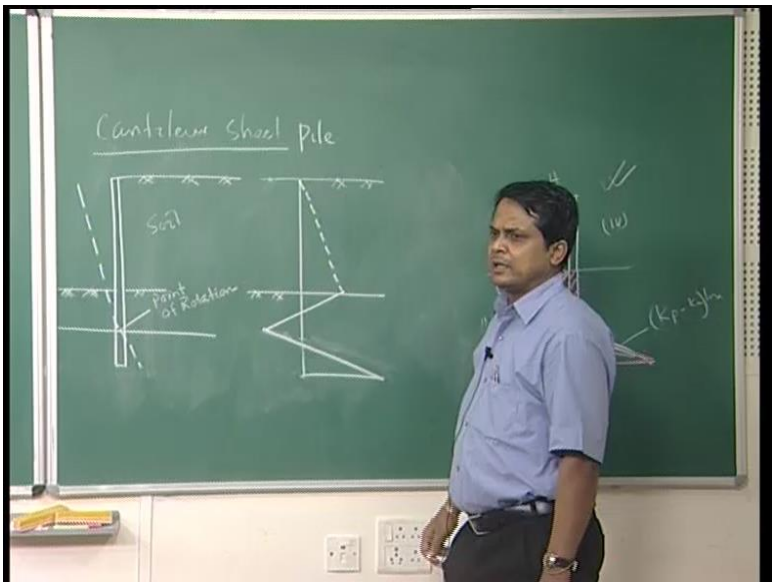

As I said cantilever sheet pile walls are two types one is your free cantilever other is your free cantilever, other is a simple cantilever sheet pile. In case of free cantilever, there is nothing in case of this is a typical case of free cantilever. So, both these sides, there is nothing this will the stability will be achieved by means of your embedded tip, but the moment I say that cantilever sheet pile that means, it has been embedded at one end. it

will retain your soil mass. Now if I modify this as only this is case of free cantilever. Now I am saying that only cantilever sheet pile wall, how it looks this is the cantilever sheet pile. Now this is your dredge lane line dredge line, now it rotate like this, now here at other end here, at this end it is retaining soil, because this is not a case of free cantilever sheet pile. So, it is retaining the soil now how the failure surfaces will be there.

If I take this principle of this, look at these derivation of this failure surface below the dredge line for free cantilever sheet wall has been taken. It has been taken, it has been put it here. Now if you consider the top part, as it is retain in this soil mass, it will generate active earth pressure up to this. Now this is the final form of your soil mass, this is the final form of this failure surface of cantilever wall retaining wall, cantilever sheet pile wall, one side it retain your soil mass.

Now you can say that with these conditions what are the most adverse condition may occur while it could derivation the water table may be at the ground surface may be somewhere else at the ground surface. So, there are conditions are there, but this failure surface whatever we derived from free cantilever sheet pile wall that has been applied for your cantilever sheet pile wall now coming back to your complete derivation.

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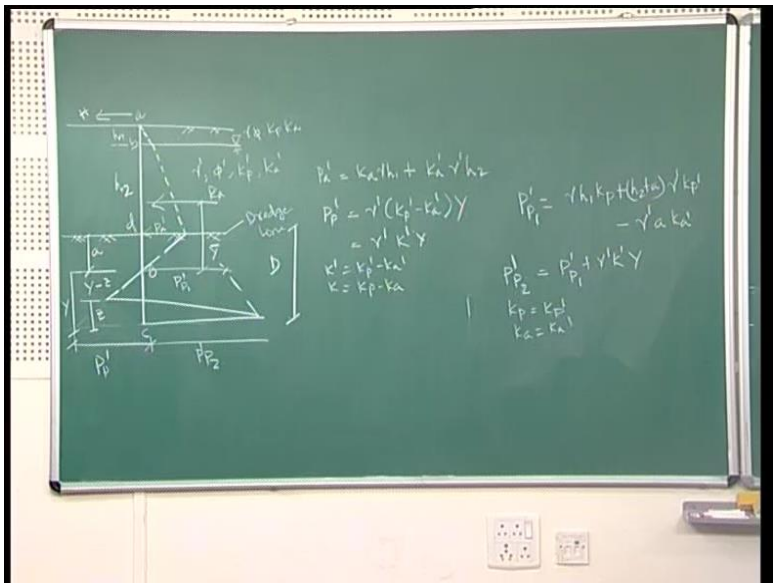

If I draw it, this is the dredge line. Now below this left, let us say this is my point of rotation. Now let us say at any distance below the surface - ground surface, at the top there is your water table, this is a symbol of water table. Now I am drawing the pressure

distribution diagram a b, now this is your b a. This is the complete failure surface how the derivation has to be done now. If I take it this is my dredge line, this is the water table. So, let us say this property is gamma phi k p and k a, and below the water table, the property is as let us say [FL].

So, this property, I can write it because water table is there this will be gamma prime, phi prime k p prime and k prime. Now let us say this distance is h 1 and this distance h 2 and a b, let us name d, this is point o, this is your c, now it will be acted upon by let us say a resultant force, this will be your P a - active earth pressure prime. Let us say all these forces, this is your resultant force R a. Particular from this to this, this is your resultant force R a. It acted upon by it say suppose say at a distance y bar from point o. Now this distance say a, because why I am naming this derivation has to be made for this to find it out what is the capacity what load these wall can take, this is your distance a. Let us say from here to here, this is your distance y. Now these to these, let us say y minus z and this is your distance say z, this your c.

So, now, if I put it like this, this to this, let us say it is P p prime, and this is your say P p 2 prime. And in between, if I take it this pressure distribution you will go like this. So, in between from o to this, I say P p 1 prime. Now this failure surface concept has been taken from once again I am saying from free cantilever sheet pile to cantilever sheet pile wall. And this below this whatever this free cantilever sheet pile, the failure surface it has been adopted and this failure surface is drawn. Now this I put it most adverse conditions what what may possible in most adverse condition may be possible during rainy season, may be this water table fluctuate from ground surface from the below from the dredge line this water surface, water table may be raise to a ground surface.

So, now if this complete of this what were suppose to get where suppose to get what is the capacity and what distance this is your complete distance d, I should know depending upon the capacity how much depth this cantilever sheet pile can be embedded below your dredge line. Or can be put it below your dredge line this is your output this parameter to be require to find it out as well as the capacity h what capacity it can take this two parameters to be find it out. So, k and k p is your Rankine earth pressure co-efficient.

So, let us start with this P a for this diagram complete. If we look at this for this diagram

this is your P a prime. So, what is your p a prime p a prime is your active earth pressure from a to up to your dredge line active earth pressure from a to active up to your dredge line. So, P a prime is equal to K a gamma h one plus K a prime gamma prime h 2. Now what is your P p prime; P p prime is your effective passive earth pressure at the base of pile. This is your P p prime which is equal to gamma prime k p prime minus k a prime into y, basically, earth pressure is your gamma either k. If we look at how the derivation here earth pressure will be k a, k gamma h; h is your distance, gamma is your unit weight of soil, and k should be either k a or k p.

From this concept, it has come here because your water table is lying here below this, this will be somewhat unit weight that is why it is gamma prime k p prime is your k p prime minus k a prime as I derived here. This is a k p minus k a, and the distance will be your y. Now it will be gamma prime k prime y. So, k prime is nothing but your k p prime minus k prime, and k is equal to k p minus k a. Now what is your P p 1 passive earth pressure at point o, what is the value of P p 1.

Now P p 1 prime is equal to at point o, it will be gamma h 1 k p plus h 2 plus a gamma prime k p prime minus gamma prime a k a prime. So, it will be your gamma h 1 k p gamma h 1 k p. This diagram plus gamma prime k p prime h 2 a, this is your h 2 plus a up to this how much it is coming minus gamma a prime a k a. If we look at a, this part will be your active state k a k p and minus this is your active state because this part is also soil is there. So, this part will be active. So, gamma prime a k prime.

Now similarly, it can find it out P p 2 prime, which is equal to nothing but P p 2 prime plus gamma prime k prime y gamma prime; k prime y, which is your gamma prime k prime and Y is your this distance, it should be added. If the value of phi, remember if the value of phi for both the persons is same for both the persons is same value of pi pi value then it will you k p is equal to k p is equal to k p prime and k a is equal to k a prime. Now these at the values you get it, P a P a P a prime P p prime P p one prime P p two prime based on your earth pressure distribution diagram know we have to find it out what is the resultant earth pressure that is the resultant earth pressure. So, let us say r a is equal to resultant of all forces above point o R a is equal to resultant of all forces above point o above point o the point o is located at a distance a below the your dredge line point o is located at a distance a below your dredge line. So, now, the pressure at point o is zero.

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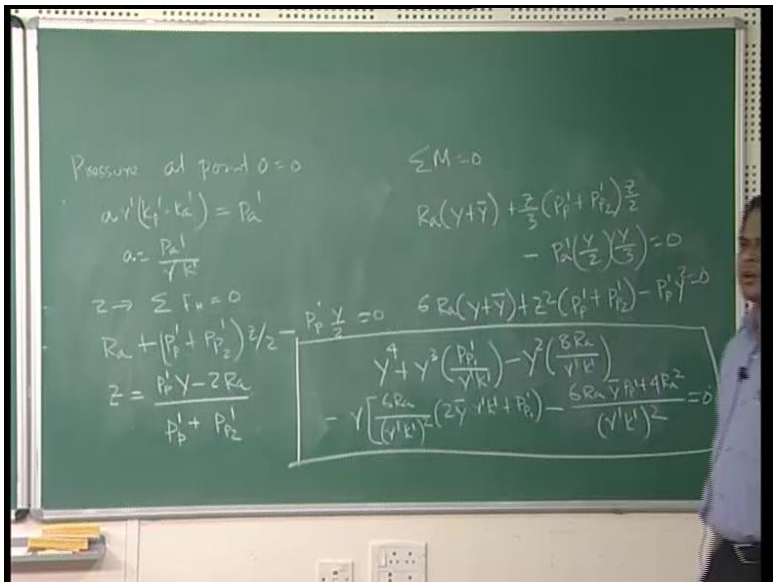

Now, the pressure at point o is zero. With this concept, pressure at point o is equal to zero; with this concept a gamma prime k p prime minus k a prime is equal to P a prime is equal to P a prime. Now a, it can find it out the distance is equal to P a prime by gamma prime and k prime k prime. Now this distance Z, now what are the other parameter, this distance Z has to be find it before before finding out R a, this distance to be find it out in terms of k a and k p now distance Z you can find it out. So, distance Z can be find it out Z. It can get it by taking summation of force in horizontal direction is equal to zero.

Now R a this force this is acting in this direction R a plus your P p prime P p two prime into Z by two into Z by two if we look at here P p two prime and P p prime P p prime into Z by two. This is a triangular distribution this will act with Z by two plus [FL] minus P p dash minus P p dash minus P p dash. This is your P p dash minus P p dash Y by two is equal to zero. From this you can find it out Z is equal to P p prime Y minus two R a by P p prime plus P p two prime. Now how many unknowns there are two unknowns you do not know Z you do not know R a so; that means, additional equation is required; that means, you take you take moment at the bottom should be zero

So, taking moment at the bottom is equal to zero. Now it will be R a Y plus Y prime plus Z by three P p prime plus P p two prime into Z by two minus P a prime Y by two into Y by three is equal to zero; that means, I have considered there are two unknowns two equation is required. One is your force in horizontal direction is equal to zero; other is

your moment taking moment at point, but the base is equal zero then you can find it out what is the value of this by simplifying. This you can find it out six R a Y plus Y bar plus Z square P p prime plus P p two prime minus P p prime Y squared is equal to zero.

Now it this putting this value of Z putting this value of Z here to here now this will be forth ordered differential equation is on will be derived. Now this forth ordered differential equation, if it write in a form, it will be Y forth plus y cube P p one prime by gamma prime k prime minus Y squared eight R a by gamma prime and k prime. It will be minus gamma six R a by gamma prime k prime is whole squared into two Y prime gamma prime k prime plus P p one prime minus six R a Y prime P p prime plus four R a squared by gamma prime k prime whole squared is equal to zero. This is your final form of equation this is your final form of equation in a fourth order differential equation sorry fourth order equation it is not differential equation it is a fourth order equation.

So, how you can derive it can be derive by means of trial by means of trial and error method, one in you put this values then whether it is becoming zero or not, satisfying or not. You see first what happen, you take a value, you see that whether it is negative or positive depending upon that you take, this second set value. Then it will be it has to be approximated by means of trial and error method, you have to solve it. And with this solution, factor of safety can be provided by two methods, one is you get it; once is get it, the end array value, you can provider to factor of safety by two methods.

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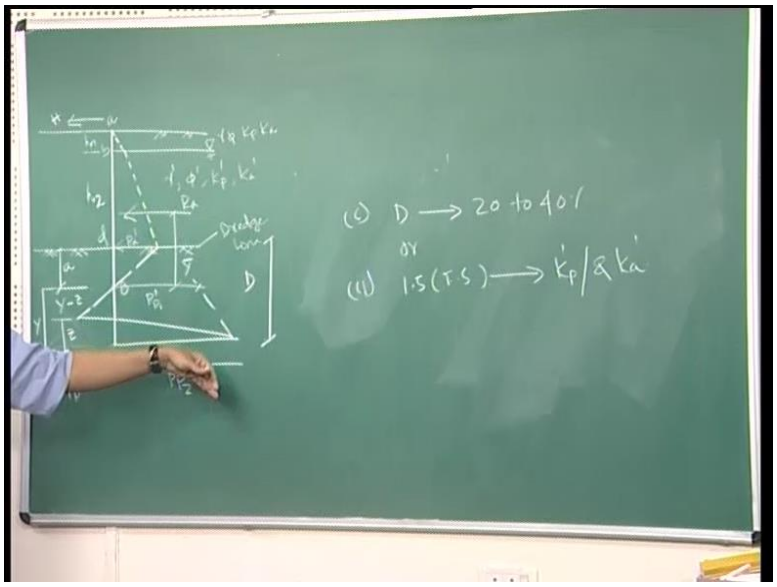

One is your the value of the obtain should be increased by twenty to forty percent or second factor of safety, you can take it one point five factor of safety one point five factor of safety. You can take in k p and or k a; that means, while designing at the end, what you are suppose to get the value of D, you are get at the end, suppose to get your value of D how much your depth D. So, how do take the factor of safety either whatever you are getting the point d, when distance this can be increase twenty to forty percent for your factor of safety or you can take one point five factor of safety in k p and k a in k p and k a. We will solve a problem may be next class.