Application of Soil Mechanics
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Lecture - 05

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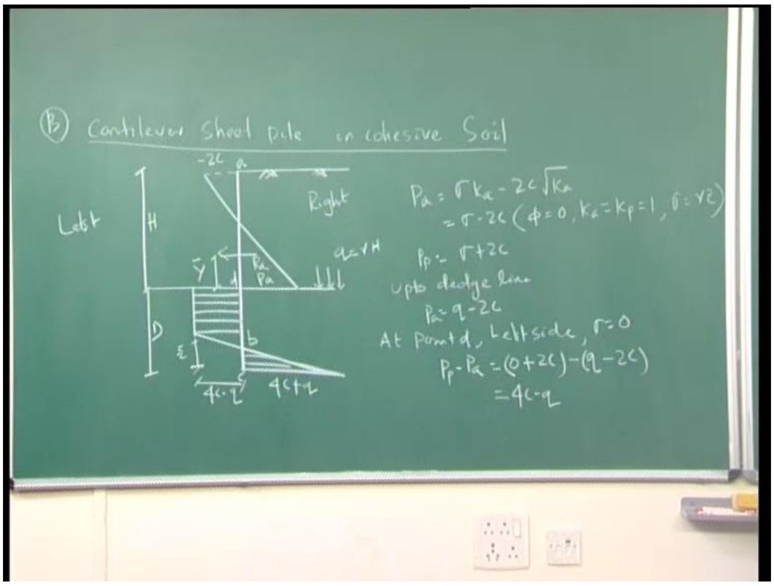

Next part is your cantilever sheet pile wall or cantilever sheet pile in cohesive soil. Earlier we have finished that derivation and one example solved example in particularly cantilever sheet pile in cohesionless soil. Now cantilever sheet pile wall in cohesive soil. Now let us see this, how the pressure distribution diagram for cantilever sheet pile wall in cohesive soil, it is varying. Let us say this is a, and this is your d. Now if I take b, this is your c, and this part will be completely this height is your d.

How this pressure distribution diagram for particularly cohesive soil, if we look at here this diagram I draw the pressure distribution diagram for cohesive soil, how this diagram has come. If I write active earth pressure and passive earth pressure particularly in cohesive soil, P a is equal to sigma k a minus two c root over of k a which is equal to sigma minus two c. When phi is equal to zero and k a is equal to k p is equal to one and sigma is equal to gamma z, similarly P p is equal to sigma plus 2 c.

If you look at here if you look at here here diagram this is your four c minus q this is your four c plus q. So, active earth pressure intensity at point a, it you can say that at point a equal to minus two c if you look at here active earth pressure is equal to sigma minus two c the minus sign is; that means, there will be a tension crack that will be a tension. So, if I put it, this is my minus two c, because this part will be acted upon by active earth pressure, and definitely this will be your p a or you can say that this is your sigma gamma z k a and that side will be your minus two c. If I write active earth pressure intensity that of up to dredge line, which is equal to P a which is equal to q minus two c, where q is equal to effective earth pressure effective means q is equal to gamma h.

Then if you write at point d this is your point d on the left of sheet of the pile at the dredge line the overburden pressure is equal to zero hence net pressure at d at point d. So, left side if I write this is my left and this is your right. So, left side sigma is equal to zero. So, hence net pressure at d; that means, P p minus P a, which is equal to zero plus two c minus q minus two c which is equal to four c minus q.

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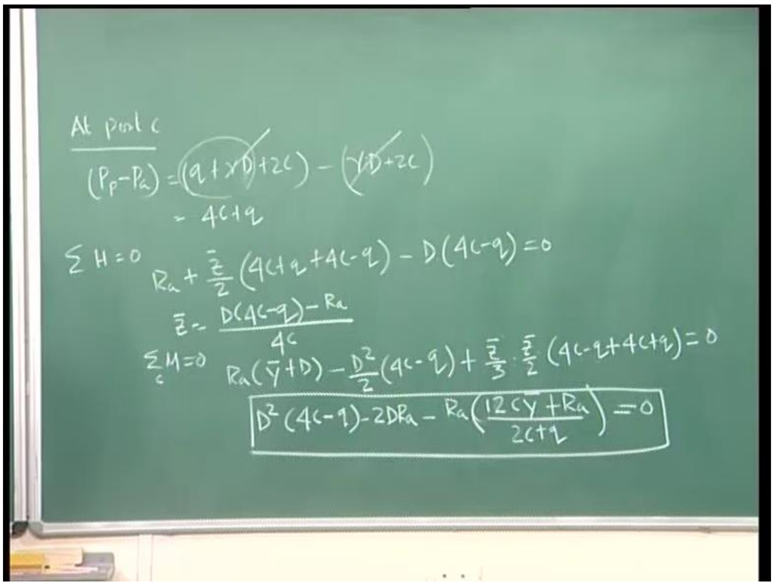

Now similarly if I go to the right side, at point c, point c - P p minus P a which is equal to q plus gamma z plus two c minus gamma z gamma d. Instead of z I am writing because this height it will d gamma d minus two c which is equal to four c plus q. If you look at the derivation, how the derivation has been made. Look at this, this is your sheet pile this is your sheet pile wall, and it has been embedded inside cohesive soil, it has been embedded inside the cohesive soil. How this pressure distribution diagram has come are arrived, if you look at here this is your right side, this your left side and this right side it will retain the soil, it will retain this soil.

As it will retain the soil, soil will exert pressure on the wall; that means, wall will move away from the soil. So that means, this part will be your active earth pressure, it will be acted. If I write that what is the P a - active earth pressure equation, it is sigma k a minus two c root over of k a. If I say k is equal to k p is equal to one for particularly case of one; that means, at rest when when phi is equal to zero when phi is equal to zero k is equal to one minus sign phi by one plus sign phi. If I say that for pearly cohesive soil phi is equal to zero k and k p is equal to one and also sigma is equal to gamma z. So, p a at the base it should be gamma z minus two c gamma z minus two c.

Now this is your gamma z if you look at here minus two c what is its showing that minus two c. What is it mean if it is a plus two c; that means, it will be somewhere else here a minus two c means it is a tension it is tension; that means, the two c part will be somewhere else here outside this tension. So, here it has been made tension minus two c now this is all about your how the earth pressure is starting from a to d a to d for this soil for this soil.

Now let us start the earth pressure from here to here at point d. If you look at at the boundary point of your d, this is your point d at this surface this side particularly this side; that means, left side, there is no overburden pressure, this is empty, there is no over burden pressure. That means, sigma is equal to zero if I write in terms of passive minus active P p minus P a. It will be sigma plus two c passive earth pressure it is sigma plus two c as there is no soil, it is blank no overburden. So, it will be zero minus two c minus q minus two c it will be four c minus q.

So, I put it exactly at this point it is 4 c minus q, I put this. Now at point c, if we look at at point c just at point at the point of d at the right. If you look at here at the right side it will be p p minus p a which is equal to q plus gamma z plus two c where is your q is coming this is your surcharge because here soil soil is their it is filling with this soil. So, q is equal to gamma z or gamma h whatever you can write it out. So, in this case, this surcharge will be above this d because this is your embedded. So, q is equal to gamma h plus gamma d plus two c plus two c minus minus q minus two c; in this case q plus gamma d is your surcharge plus gamma d and minus gamma d minus two c, means this is your p a gamma d minus two c gamma d minus two c.

Now gamma d gamma d will go. So, it will be it will be now this is minus minus these became will plus. So, it will be four c plus q four c plus q now if i write it if you look at here this is four c plus q. So, one side it is four c plus q other side is your four c minus q as i said there will be a transition it should not go in this direction there will be transition from one point to other point. So, that is why this is the smooth transition. So, it is coming four c plus q here it is coming four c minus q and I draw the a resultant array is here and this is my two c this is all about how this earth pressure diagram has come and how it has been plotted.

Now next step is your derivation from their we will half to find it out what is the depth d embedment depth d is required. Now if I take summation of h is equal to zero what it mean; that means, summation of horizontal forces is equal to zero. So, let us put it, this is my z zero or a zero or a zero. So, summation of horizontal forces is equal to zero; that means, if I take particularly this to this result and force your R a.

Now I am writing r a plus z by two into four c plus q plus four c minus q minus d into four c minus q is equal to zero. Look at here total horizontal forces, I am taking as a whole body total horizontal because it has to satisfied the equilibrium condition; that means, total horizontal forces is equal to zero, horizontal forces is equal to zero, means this is your R a. This is resultant force. From here to here, a to d or a in this direction and now, this is z by two if you look at this this is the distance z by two where the resultant force will all also act below this. So, this is a z by two because somewhere else it will act somewhere else it will act it will be z by two. So, this will be z bar by two four c plus q if we look at four c if i am taking complete one four c plus q minus four c plus q then this will be four c plus q plus four c minus q.

Now then minus d times four c minus q because this is a transition phase from active to passive passive minus active it is changing now up to whole of these this will be a active state. So, four c minus q into d it should be deleted or neglected from a. So, d into four c minus q, it should be equal to zero this is your total resultant forces i have taken it is it should be zero. From there we can find it out z bar is equal to d four c minus q minus r a divided by four c.

this is my z bar; that means, I have to find it out this distance below the point c, where the pressure intensity is changing where the pressure intensity is changing. It has to be first identify because where is your point b then z bar once you get it then what else is remaining because you have to find it out your moment, because there are two announce we have to find it out your moments. That means, moment at point c considering moment is equal to zero at point c at the base c is nothing but at the base you can said this is the c point, at the base know moment at c is equal to zero.

Then in this case, R a y bar plus d minus d square by two into four c minus q plus z bar by three into z bar by two into four c minus q plus four c plus q is equal to zero. How it has come, I am taking moment at point c, if you look at here R a - this is your resultant force from here to here R a into y bar; y bar is your distance from point d to resultant force plus d. Because I am taking moment at this point of the base minus d square by two into four c minus q. if i take it this area this is four c minus q into d into because moment d by two. So, that is why four c minus q into d square by two it will be neglected means detected then z by three into z by z bar by two.

If I take it like this, so it will be this z will be z bar by three it will be somewhere else. So, z by two area is your half half this half this into this. So, this is your half z bar four c four c minus q plus four c plus q into z bar by three triangular distribution. This is will be coming from z bar by three this equation if i put the z bar and simplify it, then it is coming d square four c minus q minus two d r a minus r a this is your twelve c prime y plus r a by two c plus q which is equal to zero. Now it is a square term, now it is a quadratic equation. So, we can solve it. So, you can get it. So, this is our final form of the this is the final form of the equation where you can find it out the embedded depth once you will get the embedded depth.

Once you get the embedded depth then you can use the factor of safety, and you can find it what is your factor of safety. Then with twenty two forty percent at additional factor of safety, you can say that with this height of edge, this distance from dredge line to this is of height is specified, and the load is given, then you can said that this depth of embedment is suitable for particularly cantilever sheet pile wall or sheet pile in cohesive soil.

Now we will solve the problem, example problem. Look at this immediate it is not necessarily that this should be clay and this should be clay only condition is that the embedded depth below this it should be clay. If above this, it is not clay. If it is a pile, if it is purely cohesiveness soil, if it is a purely cohesiveness soil then pressure distribution diagram will change for top part. This is not your pressure distribution diagram, this is for purely cohesionless soil, and c is equal to zero, but below the embedment depth the condition to be it should be it should be cohesive soil.

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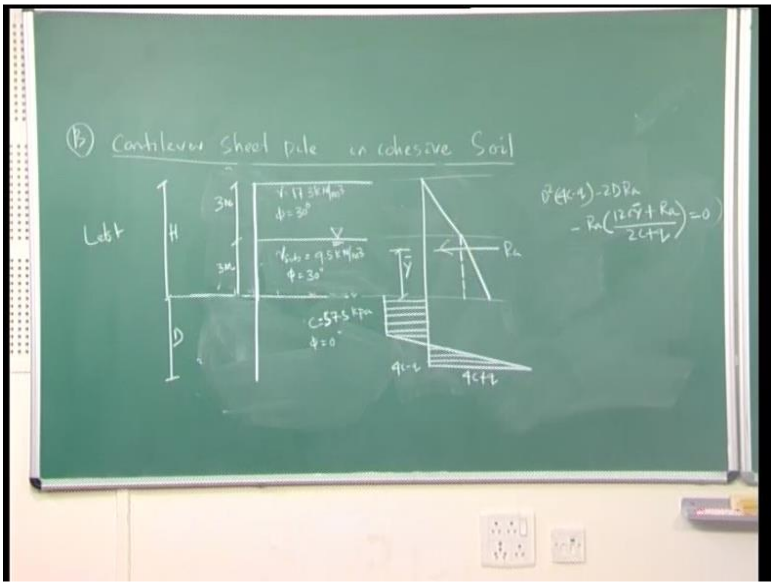

Now, if I start with this, what are the conditions given in the example. If you look at the example, the example is given. There are two parts, first is your three meter, second is also three meter; then your gamma is equal to seventeen point three kilo newton per meter cube. Phi is equal to thirty degree and this is your water table then gamma submerged is equal to nine point five kilo newton per meter cube; phi is equal to thirty degree phi is equal to thirty degree and this is your purely clay soil. So that means, c is equal to fifty seven fifty seven point five k p a phi is equal to zero degree, phi is equal to zero degree.

Now find out this embedment depth for particularly cohesive soil. Now first step, step one as I explain yesterday’s last class example problem, solved example problem, step one is to draw the pressure distribution diagram. Now for top one, this is my pressure distribution diagram, because there is no c, this is cohesion less soil, phi is equal to given thirty degree. And now if this is my R a - resultant force, and this distance should be y bar or the derivation from their now it will start with this. This is four c minus q, this is your four c plus q as we have derived earlier. Now this is the case if I am writing this final form of equation here it will be d square four c minus q minus two d r a minus r a twelve c y twelve c y bar plus r a divided by two c plus q is equal to zero.

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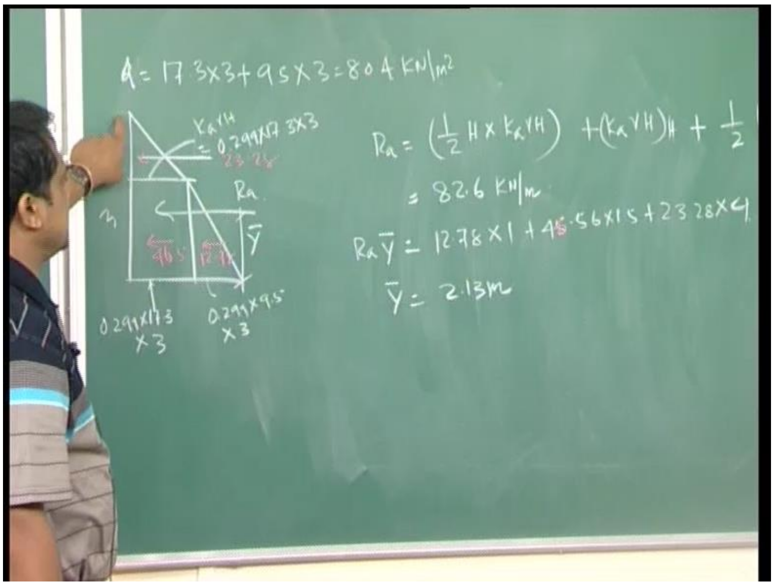

Now let us start this solving the effective pressure at the dredge line if this is my dredge line with this condition what is your effective pressure q q is equal to seventeen point three into three plus nine point five into three, which is equal to 80.4 kilo newton per meter square. Now step two from this earth pressure diagram, you can find it out, if the pressure distribution diagram of the top part whatever I have drawn earlier. If I draw it this is my pressure distribution diagram, now make it part by part. This part will be your k a gamma h which is equal to zero point two nine nine into seventeen point three into three.

And this is your zero point two nine nine into seventeen point three into three and this part is your zero point two nine nine into nine point five into three how the k has come zero point two nine nine phi value is given it. So, it will be one minus sine phi divided one plus sine phi, you can find it out, what is the value of k. It is coming up zero point two nine; from there now with this help of this pressure distribution diagram, we can find it out what is value of R a and what distance it is acted upon from the base y bar.

Now the R a is equal to, R a is nothing but your resultant force acted. R a is equal to you take this, this part this part and this part, then put the value you can find it out. This will be your half h into k a gamma h then plus k a gamma h into h then plus half k a gamma prime h into h. Look at this for this triangular distribution pressure is equal to half base into height. So, base is equal to your base is equal to k a gamma h k a gamma h this height is equal to h; h is nothing but this is three meter, this is three meter. And for this part, it will be k a gamma h into h, for this part k a half k a gamma prime h into your h, this is your R a. Now putting this value, now put all these values step by step, you can put all the value, you can find it out, it will be eighty two point six kilo newton per meter, this is your resultant R a.

Now you can find it out at what distance r a into y bar is equal to twelve point seven eight, I am just putting the value into one plus forty five point five six into one point five plus twenty three point two eight into four. So y bar is equal to two point one three meter. Now if you look at here the pressure here coming the pressure here coming the pressure, because I keep one step this pressure here coming is about twenty three point two eight and pressure here is coming about forty six point five six and here it is coming about twelve point seven eight.

So, how the y bar has been calculated R a into y bar at the base, which is equal to twelve point seven eight into one, because this is three three by three, it is your one meter about the c g. Then forty forty five point five six this is your forty five forty five point sorry it is a forty six point five six this is your forty six point five into three by two which is equal to one point five then twenty three point two eight. This is your three this will be acted by two by two third two by three into three, no it is not two-third, it is your twenty three point two eight, this your half into three into twenty three point two eight, it is coming, so this is not four. So, this will be three by two this will be you can say that half h into base. So, this is your half into three into twenty this much you can put it and it will be acted upon by this is the area and it will be acted upon by two third of three. So, it will be six by two whatever this calculation will come.

From there, you can find it out your y bar is equal to two point one three meter. From this you can calculate your y bar is equal to two point one three meter once you get the y bar is equal to two point one three meter then find it out the respective coefficients.

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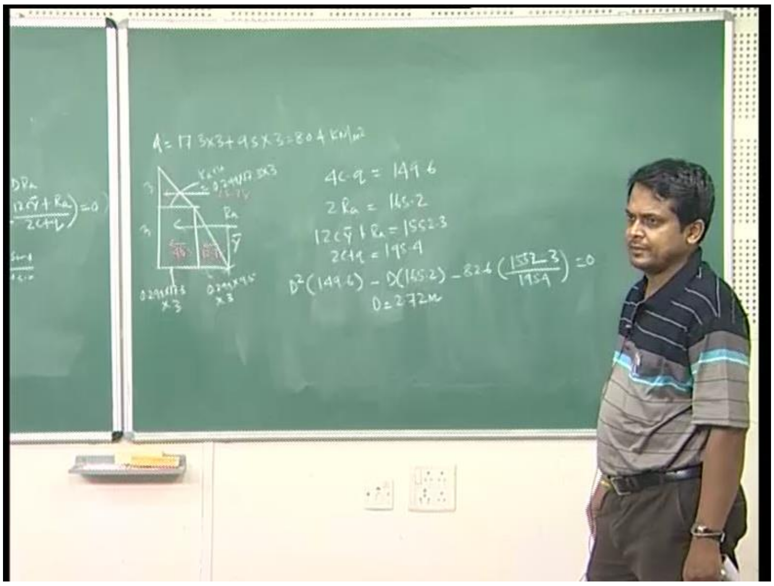

Now, i got r a and y bar now find it out respective coefficients four c minus q. You calculate it is one forty nine point six then two R a, which is equal to hundred sixty five point two hundred sixty five point two then twelve c y bar plus R a which is equal to one five five five two point three then two c plus q which is equal to one ninety five point four. Now with this values with this values because we calculated four c minus q take directly then two r a take directly then twelve c y bar plus R a is given take directly then two c plus q will take directly. And R a is given it will come in terms of some numerical value with d with value of d. If I write it, it will be coming like this d square into one forty nine point six minus d into hundred sixty five point two then eighty two point six into one fifty five point point three by one ninety five point four which is equal to zero now d is equal to two point seven two meter.

Now once you get the d, whatever you are getting the d, whether it is correct or not that has to be check, how you will check it from the base from the base pressure distribution diagram, whatever the d calculated whether it is correct or not. Now you can find it out what is your z bar once the d is over d is equal to two point seven two meter, I am writing d is equal to d is equal to two point seven two meter.

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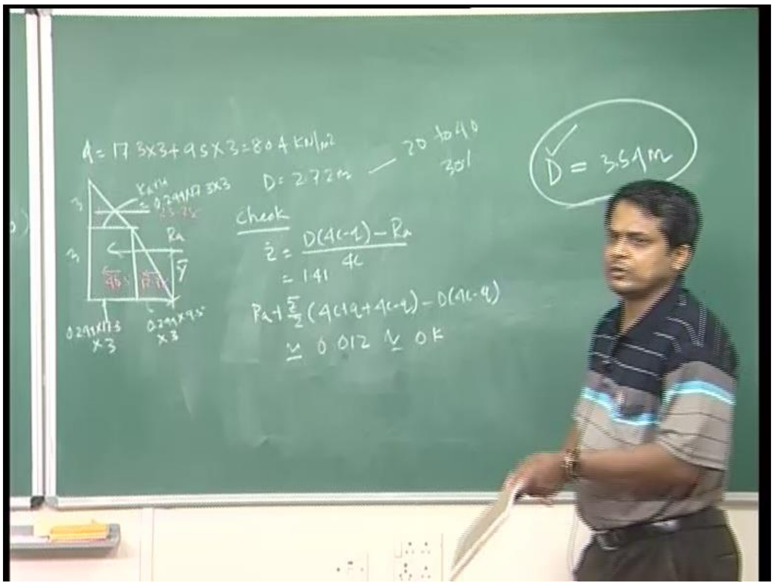

Now, for check, you can write z bar is equal to d in to four c minus q minus r a divided by four c which is equal to one point four one. Now you can calculated R a plus z bar by two four c plus q plus four c minus q minus d into four c minus q. From there, once you check it by taking moment about the base, you see by taking moment about the base once you know all the value taking moment about the base check whether it is coming zero or not this is our condition moment about the base. So, I have consider the taking moment about the base, and how much it is coming it is coming zero point zero one two which almost it is equal to zero. Now whatever value you are getting that is know after once you get the value the d is equal to two point seven two as just say you can take a factor of safety between twenty percent to forty percent.

So, let us say thirty percent factor of safety you have to put it. So, now, the d implemented d value will be three point five four meter with factor of safety is equal to thirty percent. So, this is all about cantilever sheet pile in cohesive soil as solved a problem if it is not let us say if it is not cohesion less cohesion less soil if it is a cohesive soil then what will happen only the pressure distribution diagram. This will minus this will be plus, it will change rest part will be the way I have calculated the R a with your centric distance same calculation will be done then you find it out.

And at the end you take moment at the base check, whether it is equal to zero or not. If it is coming approximately zero; that means, whatever you have done the calculation that is that has been cross checked and it is then apply your factor of safety between twenty to forty percent as we have already discussed. Then considering this case thirty percentage, you can take also twenty percent, you can take also forty percent though embedment depth to be implemented d is equal to three point five four meter.

Thanks a lot.