Geotechnical Engineering II / Foundation Engineering

Prof. Dilip Kumar Baidya
Department of Civil Engineering
Indian Institute of Technology, Kharagpur

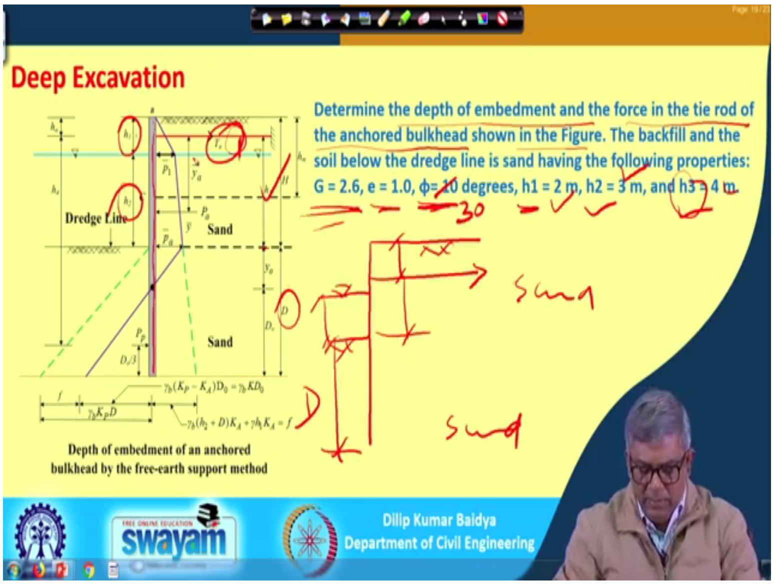
Lecture – 50
Anchor Bulkhead (Contd.)

In my previous lecture I just showed how to analyze Anchor Bulkhead and particularly anchor bulkhead can be of 2 time 2 types, that I have mentioned. That is one is free earth support another is fix earth support and again as I have mentioned that fix earth support I will not consider only I will consider free earth support.

And then free earth support design also can be done 2 ways, that is one is actually just by considering equilibrium find out depth required and then increased by 30-40 percent to have a factor of safety of 1.5 to 2. And, that is the method I have discussed and another method was actually we can apply that what are getting the earth pressure diagram in the passive pressure actually is the supporting actually resisting and active pressure is at disturbing.

So, the resisting pressure actually we can reduce by providing a factor of safety and then consider equilibrium and from there if you get the depth that become the final depth. So, that is another approach that is also I am not discussed, only I have discussed that free earth support with straight equilibrium pressure diagram consider equilibrium and find out the depth and then increased by some 30 to 40 percent. So, that is the way I have done and that same problem at one problem I will just try to show how to actually numerical problem how to solve. So, that problem let me start one problem.

(Refer Slide Time: 01:53)

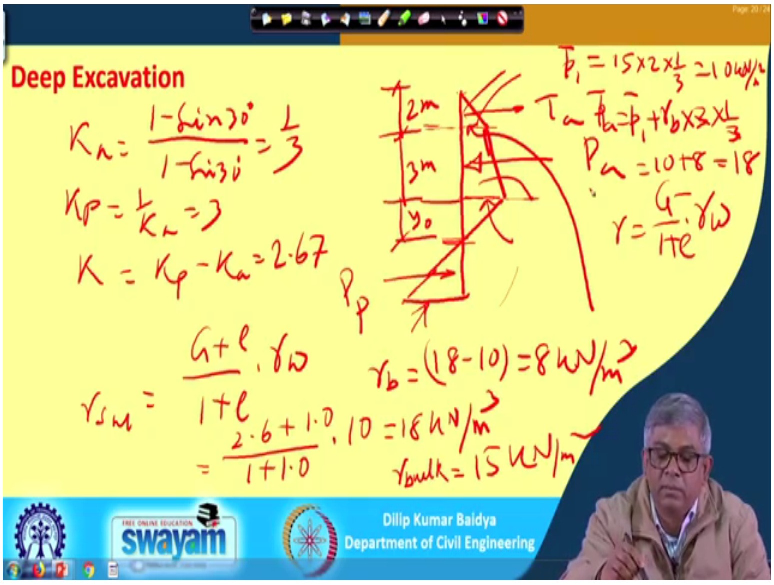


This is a problem suppose you can say the problem is given here determine the depth embedment and the force the tie rod of the anchored bulkhead shown in the figure. This may be the anchored bulkshead it is with pressure diagram of course, this will never be like that. In the problem always will be like this it will be like this it will be like this and it will be like this anchored bulkhead. And, then all dimensions will be the backfield and the soil below the dredge line is sand actually sand here, sand also here. I have shown actually this with pressure diagram because, same figure I have used otherwise most of the if in your in your exam problem all always will be like this.

And it will be shown this dimension it will shown this dimension it will show this dimension; if water table is here this dimension it will show and this is the unknown things ok. So, otherwise these are the things will be given to here also it is given you can see the both the sand and instead of unit weight it is given actually G value is given 2.6, e value might be void ration is given 1. And, phi that mean angle of internal friction is given as 10 degrees and it is 10 degrees or 30 degrees; it will be 30 degrees actually; do not you so, less cannot be it will be 30 degrees ok.

And h 1 h 2 h 1 is this one is 2 metre and h 2 is this one is 3 meter and h 3 actually from your h 3 is from tie rod to the dredge line that is actually 4 meter you can see this is 4 meter. So, this is 4 this is 2 and this is 3 show 2 3 5 and this is this is 4; that means, this distance will be 1 meter; so, that is not given, but one can find out. So, under this condition actually the; what is the thing you have to do; you have to find out the depth of embedment that is D and you have to find out what is unknown force T a acting in the tie rod. So, this is the problem; so this problem I will try to same diagram will be similar, but I will draw once again maybe in the next slide ok.

(Refer Slide Time: 04:23)



So, this is the one and you can see the your rod is here and this is T a this distance is 2 metre and of course, this distance is 3 meter and this is y naught and your we can find out there are many things to be obtained. So, with this actually we can find out actually your P p will be acting somewhere and P a will be acting somewhere and T a will be acting there.

So, we have to find out in the previous diagram whatever notation I have shown same notation will be used; I have corresponding to this present problem I have shown this. Now what would be the pressure here at this point what is the pressure? At this point pressure will be gamma dry times 2 2 times K a. So, K a is how much here? K a equal to 1 minus sin 30 divided by 1 minus sin 30 and if I do that it will come at 1.3 1 by 3 and your K p will be coming just 1 by K a. So, it will be 3 so, K will be equal to K p minus K a equal to 2.67 these are the things will come.

And you can see that gamma is not given instead of G and vertices given. So, gamma saturated will be equal to G plus e by 1 plus e multiplied by gamma w. So, if I put the all values that is 2.6 plus 1 divide by 1 plus 1 and multiplied by gamma w, suppose if I take

10 then this will come actually 18 kilo Newton per meter cube; 18 kilo Newton per metre cube this is coming ok. So, gamma gamma saturated is coming 18 18 point kilo Newton per where so gamma submerge gamma b will be 18 minus again 10 if I take; so, it will come 8 kilo Newton per meter cube gamma b will come 8 kilo.

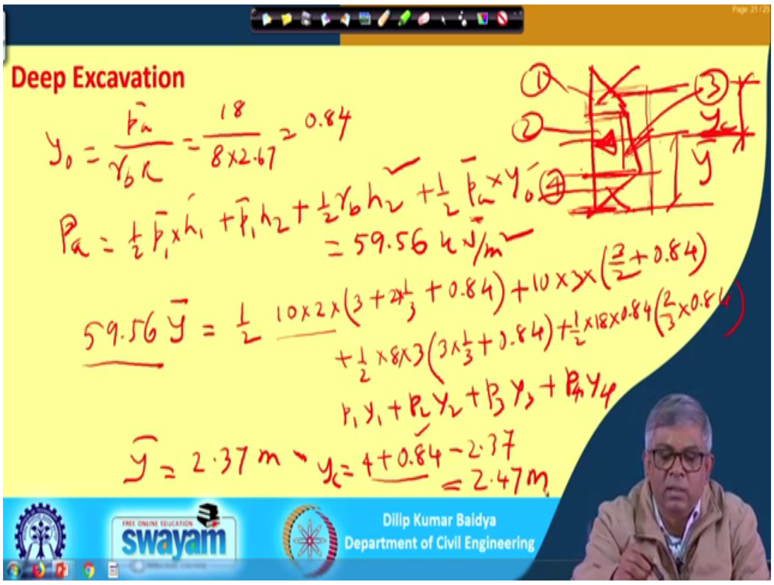
And now above dredge level above dredge level what is the value I could have done, but I have not done actually that will be actually your gamma dry will be equal to G by 1 plus e multiplied by gamma w this is the way it could have done. So, I have not done so, let me see I have used 15 let me see what is the value here; let me see by calculation. This may come something different I could have done that it is 2.6 divided by 2 multiplied by 10. So, it is 13 actually so, it is 13 actually dry unit weight actually 13.

So, as the close to water table the soil hardly will be dry ok. So, it will be generally some dry unit weight we have to take the bulk unit weight and bulk unit weight slightly more than the dry unit weight because, the other moisture present. So, in this calculation I have taken gamma bulk that mean or gamma bulk above water table as taken as 15. So, this is the way I have taken. So, 15 here gamma here actually gamma submerge 8 every everywhere gamma submerge 8.

So, now without going further I can find out straight this intensity here I can find out p 1 bar that will be how much, that will p 1 bar actually it will be 15 multiplied by 2 multiplied by 1 by 3. How much it is? It is coming 10 kilo Newton per meter square. Similarly, I can find out at this point what is the value. So, this is actually P a bar; P a bar will be equal to p 1 bar plus gamma b multiplied by this is 3 and multiplied by 1 by 3. So, it will be 10 plus 8.

So, it will be 18 at this point it will be 18 and similarly I can find out it here I will not going to find out it will be in terms d naught we do not know y naught and we do not know d. So, these are the things are known. Now, I will go to the next one I could have done this one in the differently, but anyway. So, next part will be if I do I will continue to the next part; so up to P a bar I have done.

(Refer Slide Time: 10:17)



And your what is y naught? y naught will be equal to P a bar divided by gamma b multiplied by K. So, it will be how much then P a bar is how much? We have got 18 divided by gamma b is 18 8 and K is 2.67. So, how much it comes? It will come 0.84 ok. And what will what about P a? P a is P a will be now actually we have got this diagram we have got this then we have got this and we have got this. So that means, how many component will be there? This is 1, this is 2, 3 and this 4 there will 4 parts.

So, this one first part will be half p 1 bar multiplied by h 1 ok; that means, P a total plus I will take this triangle this rectangle that will be equal to p 1 multiplied by h 2 plus this portion that will be equal to that will be half gamma b multiplied by h 2 square. Or, this way we can do yeah; this is the way we can do plus half P a bar; that means, this one this one P a bar multiplied by y naught nothing, but actually I am find out area of this area of this area of this and area of this. So, that become P a; so, if I put all values p 1 value is 10 p 1 bar is 10.

So, and h 1 is 2 meter then p 1 and here actually we can 10 and 2 and here actually gamma b 8 and h 2 square. P a bar actually 18 y naught is 0.84 all values if I put then this will come actually P a is coming actually 59.56 59.56 kilo Newton per metre square ok. And to find out the y bar, y bar actually what is shown actually the point of application from the tie rod. So, so 59.56 59.56 multiplied by y bar and then I will take half into 10 half; that means, first diagram 10 multiplied by 2 multiplied by from here actually it is 3 3 plus 2 into 1 by 3 and plus 0.84.

So, from here from here two point of application actually I will try to find out; this one the I have consider only this first part K. So, actually see this is 2 meter the point of application will be one-third of 2. So, that is what one-third of 2 then 3 then 0.4 so; that means, distance of this force from here actually we have got. And, then actually y bar actually we are calculating y bar is nothing, but your point of application from here ok. And, we are considering the all forces distance from here this is the reference I am considering this distance first that is done plus I will consider second one: 10 multiplied by 3 10 multiplied by 3 multiplied by that what distance. It will be 3 by 2; that means, it will be midpoint plus this 0.84. Then I will find out this third triangle that will be equal to half multiplied by 8 multiplied by 3.

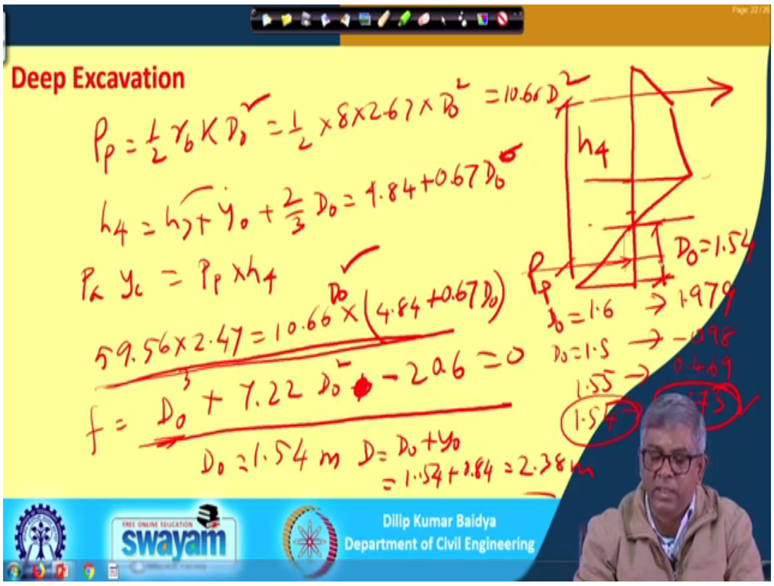
And this is the diagram and y bar will be how much, that will be this distance is 3 and it will be one-third from this side. So, 3 multiplied by one-third plus and this distance so, 0.84 Then I have to find out from here to centre of this triangle. So, that first of all I will take the area of the triangle; the area of the triangle will be half multiplied by 18 multiplied by this distance is 0.84 this is the area of the triangle. And, multiplied by two-third of 0.84 so; that means, from this side it will be two-third. So; that means, what I have done from here actually I have considered force 1 force 2, this is force 1, this is force 2, this is force 3 and this is force 4; 4 different forces they are lever arm distance from here I have done.

So; that means, what I have done p 1 y 1 plus p 2 y 2 plus p 3 y 3 plus p 4 y 4 I have done ok. So, I have calculated this diagram distance from here this diagram distance from here this diagram distance from here this diagram distance from here. So, this is the equation I have written and this is of course resultant. So, total force multiplied by y bar that must be equal and from here I will get y bar, y bar equal to I am getting 2.37 meter. That means, 2.37 meter; that means, from this 0 pressure point the point of application of P a total active force is at a distance of 2.37 meter ok

Then y c y c is actually what y c actually distance from the anchor rod. So, this force this force to anchor rod we have to find out. So, I have got from here to this force I have got 2.37 and from anchor rod to 0 force is how much distance; anchor the this is the anchor position anchor position somewhere here. Anchor position to your anchor position to your anchor position to your 0 position, that is actually it was 4 meter from anchor to the dredge level plus if I go y naught 0.84; that means, from 0 pressure to the anchor this much distance and, I know from here to point of application of force is 2.37.

So; that means, you are getting the distance between the point of application of force to the this is actually y c ultimately; that means, at force I have to take moment of force P a force to the anchor rod. So, I have to I have to know the distance so, that become y c. So, this become 4 plus 8 4; that means, from here to this 4 meter and plus I add 0.84 and then subtracted y bar that is 2.37 So, that become your y c so, that become actually your 2.47 meter ok. So; that means, now I have got the lever arm from P a to anchor rod I have got and I now P p 2 anchor rod I will get; then I will take the moment. Then I will be able to formulate the equation and then solve for D naught ok.

(Refer Slide Time: 19:37)



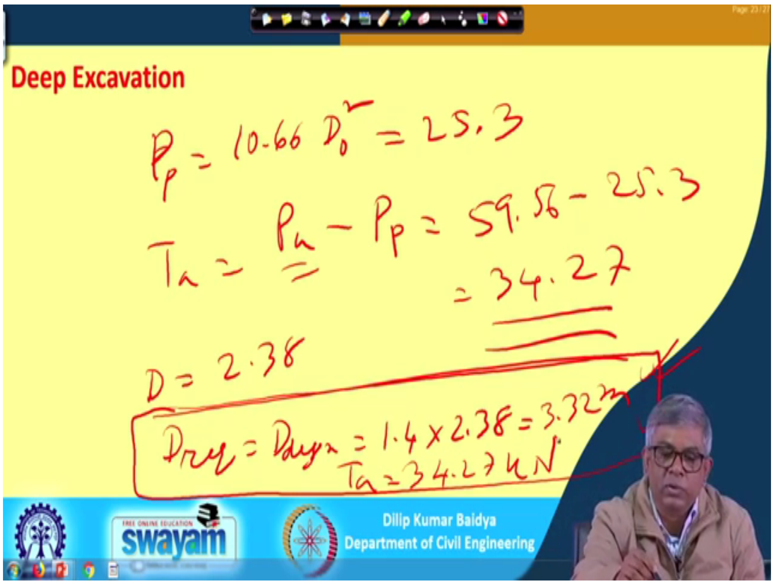
So, next I will go to and your P p actually your P p equal to your P p equal to half gamma b times K D naught square. So, that will be equal to then if I put the values half multiplied by 8 multiplied by 2.67 multiplied by D naught square. So, that if I equate then it will become 10.66 D square and h 4 h 4 actually is nothing, but the point of application of P p to the anchor rod. So; that means, if I draw the diagram once again let me draw the diagram once again this is dredge line sorry; let me suppose this line somewhere here h 4 actually your anchor rod is here and the point of application here. So, this is h 4 this is the anchor and the point of application of P p this is P p.

So, h 4 then it will be h 3 plus y naught h 3 actually from here plus y naught plus from here I am getting actually and then I have to go two-third of D naught. So, that plus two-third of D naught so; that means, it will be 4 plus; that means, this is 4 and this is y naught 84. So, it will be 4.84 plus 0.67 D naught square sorry D naught. So now, P a multiplied by y c equal to P p multiplied by h 4 that must be equal. And if I do this then it will be 59.56 multiplied by 2.47 we have got before equal to 10.66 is the P p multiplied by this 4.84 plus 0.67 D naught.

So, this is the equation I am getting and if I simplify this equation I will get equat[ion]- further D naught cube plus 7.22 D naught square plus minus it will be not plus minus 20.6 equal to 0. So; that means, this is the equation you can see oh; so, here I have wrongly written 10.66 D naught square. So, this D naught square and D naught become cube so, this I have got So; that means, if I simplify this equation I will get a equation like this 10 D naught cube plus 7.22 D naught square minus 20.6 equal to 0. So, this is a cubic equation and this equation we can solve only by trial and error. And that means, I can assume some depth and then if I assume D naught equal to D naught equal to 1.6 if I assume, then the value of this function become this function become 1.979 1.979.

And, if I take D naught equal to 1.55 or 1.5 if I take D naught equal to 1.5 then you are getting this value as minus 0.98 minus 0.98. If I take 1.55 1.5 I get this one as 0.6 0.469 and if I take 1.54 then I get 0.175. So, this is coming to very close to 0 so, I can consider as; that means, D naught value can be taken as 1.54 meter ok. So that means, so, this depth this depth is known now D naught we got equal to 1.54. Now, once you know the D naught then D will be equal to D naught plus y naught so; that means, 1.54 plus 0.84 that become your 2.38 meter. And then based on that 2.38 meter so, D naught already known now this D naught is known now P p is known P a already known 59 point something.

(Refer Slide Time: 24:57)

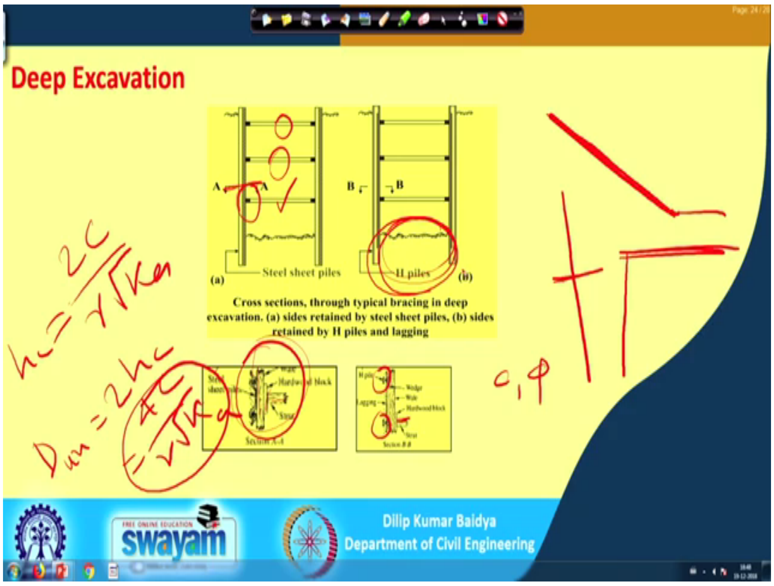


So, I can find out I can find out P p now; P p will be equal to your P p actually 10.66 D naught square. So, that become your something value 10.66 D naught square; D naught is actually we have got 1.54 1.54 multiplied by 1.54 multiplied by 10.66. So, it become sorry 1 sorry 1.54 multiplied by 1.54 equal to this multiplied by 10.66. So, that become 25 point 25.3 suppose and then T a will be equal to P a minus P p so; that means, how much it is 59.6 59.56 minus 25.3. So, the difference will become 34.27 so; that means, your in that anchor rod force T a is 34.27. So that means, you have got the solution now we have got D equal to 2.38 and we can multiply by 1.4.

So, D required or D design will be 1.4 multiplied by 2.38 so, that will be equal to 1.4 into 2.38 1.4 multiplied by 2.38. So, that become 3.3 so, 3.3 2 meter and your T a become 34.27 kilo Newton. And, this is the two things we have we have getting we are getting from here. And, if you want to find out the bending moment also first you find out what the pressure become 0 and then after knowing that you can find out the bending moment. So, that I am not done, but if you wish you can do it. So, otherwise this problem whatever asked actually we have achieved.

So, this is nothing actually simply you have to understand the pressure diagram and then this pressure diagram when the complicated pressure diagram we have to divide it into number of parts 1 2 3 4. The only triangle and rectangle if you divide so, that you know the c g and you know the area easily. And, based on that you can find out the lever arm to take the moment and by doing that we can find out the D and T; so this is actually 1 part that is over.

(Refer Slide Time: 28:01)



Now, let me after this actually this is the some sheet pile wall to retain the soil or to develop some facility water from facility. But, in some other purpose actually you need to excavate the soil sometime for different purpose. For example, for construction of metro railway suppose you have to excavate up to 30 meters, but that you know that we cannot excavate unlimited length without support vertical particularly. If you make a slope if you make a slope curve if you make a slope, then we can go quiet significant depth.

But, if you want to cut vertical then there is a limitation and that limitation actually while discussing earth pressure theories we have discussed actually that because, of that c phi soil the depth of tension crack actually 2 c by gamma root K a and that is actually depth of tension cap h c. And, your depth of unsupported excavation depth of unsupported excavation will be twice of h c so; that means, it will be 4 c by gamma root K a. So, that is the thing I have we have discussed while discussing earth pressure theory; that means, if there is a ground surface having value of c and phi then up to what depth we can excavate without support by this equation we can find out. But, my if your excavation is much larger than that much deeper than that then what you have to do you have to give the support.

And, then you have to design the support system; that means, this is the different types of support system; you can see this is the one type of support system there will be sheet pile wall. And, then well and then there will be a hardwood block and then there will be start these are the start.

And this particular section if you see the enlarge you will see this actually cross section, if I see the cross section you will see the different component. Again another type of wall actually you can see H pile is used and then laggings are used and then whales and then again starts are given here actually. So, this is the way also can be done. So, if this is the type of support system is done for the excavation purpose particular deep excavation how to how much force will be required taken by the each start; that means, how much force is coming to the start that to be estimated.

So, for that actually some analysis has to be done; again while excavation there can be instability in the bottom also that to be investigated. So, these are the things actually I will be taking in the next class maybe next lecture; today I will stop here ok.

Thank you.