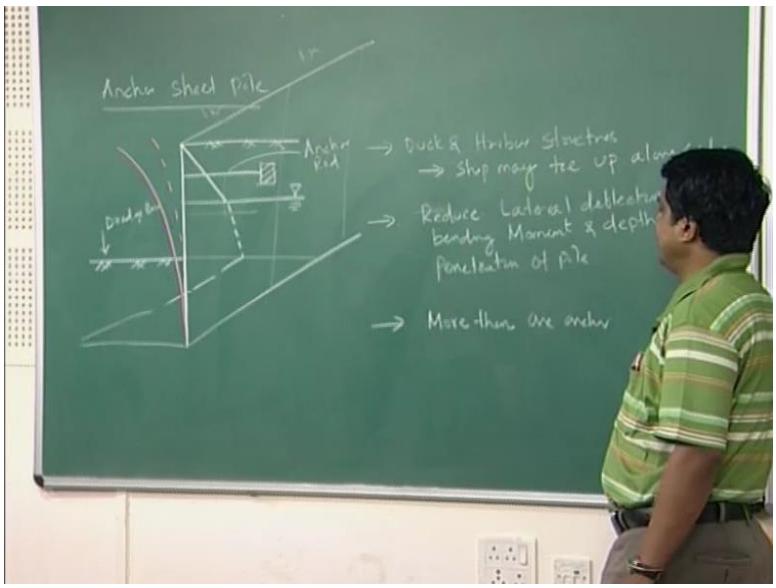
Application of Soil Mechanics
Prof. N. R. Patra
Department of Civil Engineering
Indian Institute of Technology, Kanpur

Lecture - 06

(Refer Slide Time: 00:25)



Next part after cantilever sheet pile wall, now let us start with anchor sheet pile. So, there are in anchor sheet pile, let me draw the anchor sheet pile. As I discussed earlier anchor has been provided in the sheet pile, so that this deflection and as well as bending movement will be reduced. If I draw a sheet pile wall, and this is my anchor or anchor rod and this is the water table. Now draw pressure distribution diagram. So, this is a complete kind of sheet pile which is your anchor dredge line, now where this anchor has been used.

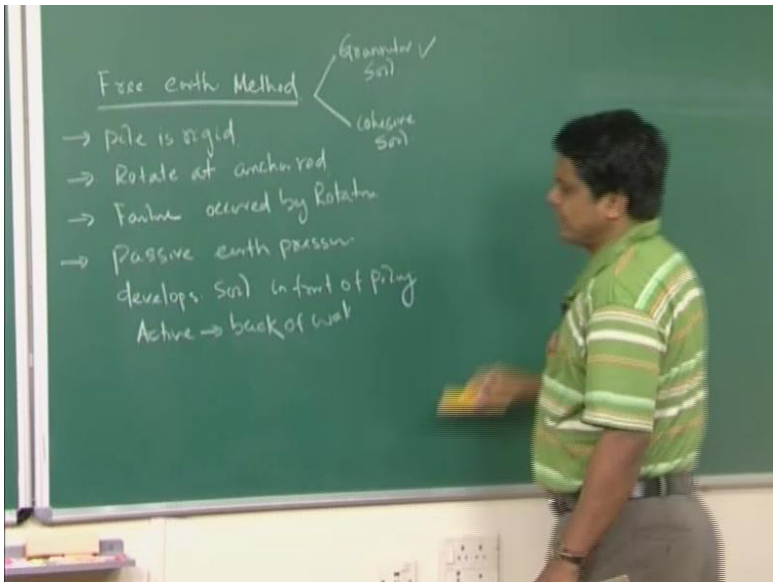
It is particularly dock and harbor structures. It may it will assist ship may tie up alongside; it will reduce as well as reduce lateral deflection bending moment. And depth of penetration of pile more than one anchor may be provided. If I take as sections like this, so this is one side of the wall. If you look at here, this is my sheet pile wall, this is the sheet pile wall, and it is going in this direction, and this side is your water sealable water sea level. So, it has to be embedded below the dredge line.

So, what will happen one sheet comes, it will tie up here. So, once it tie up will then it

will pull the pile wall. For more stubble, if you provide the anchor rod what will happen, if without anchor rod if this is your deflected without anchor rod, once you provide anchor rod the deflection will be drastically changes. That means, once deflection will be drastically changes, what does it mean; that means, risk of failure you can never edit also second part is that bending moment also reduced by providing the anchor rod. Now if this is your wall then I will wall design has been done in width wise for meter width one meter one meter in this direction.

So, anchors may be provided not one anchor may be multiple number of anchors you can provide along the depth direction. If this is my depth direction, suppose say in one meter depth, one meter depth is one meter long would direction if this is the anchor you can provide two anchor three anchor and then it will continue same way. So, what to you happen it will continue means in that depth that direction sorry lend direction it will continue it will reduces bending moment also to more factor of safety or may be more you can r in depth direction also anchor can be provided in both way length as well as depth direction anchors can be provided. So, this is the advantage of anchor sheet pile earlier there was a sheet pile as I said. So, this is the three end fix sheet pile, now this is anchored sheet pile in anchored sheet pile also it has been classified into two parts.

(Refer Slide Time: 06:09)

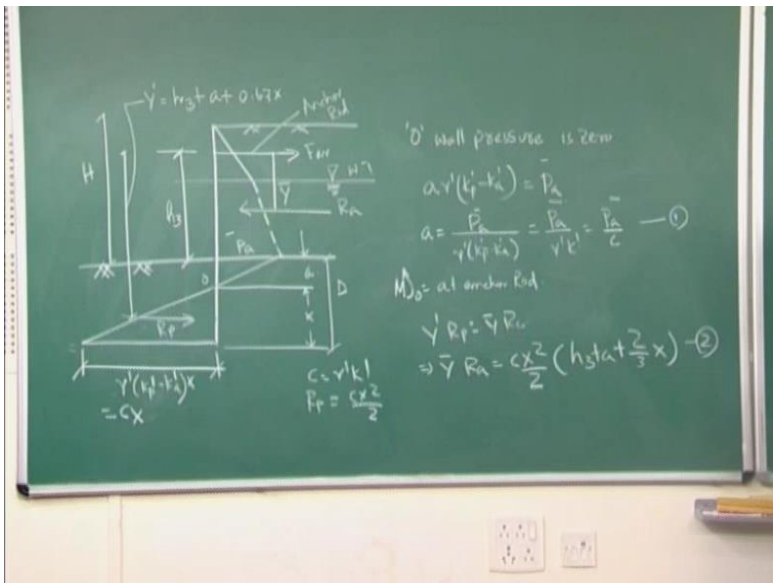


one is your free earth method one is your free earth method other is your fixed earth method in free earth method what is the pile is rigid pile is read it and rotate at anchor

rod passive earth pressure develops soil in front piling active back of wall.

Now if you see free earth method again this is the condition there are two cases free earth method one is your for granular soil and other is your for cohesive soil. Other is your cohesive soil in fixed earth method, the anchor is fixed; there is no rotation. If you look at this free earth method, it has been assume that the sheet pile is rigid once it is rigid; that means, it will not fail by means of bending it will not fail by means of bending, it will fail by means of rotation. And another assumption is that whatever the rotation is going to half n it is going to half n along the anchor rod along the anchor rod so; that means, failure occurred by means of rotation and rotation will occur at the anchor rod. So, passive earth pressure develop soil in front of the piling and active developed the soil back of the wall back of the wall will start with. These are granular soil will first start with the granular soil of free earth method these derivation of particular granular soil in case of granular soil what is the derivation.

(Refer Slide Time: 09:28)



And how do get for anchored wall plate embedment depth how do get it let us say this is my wall this is the dredge line this is f a r now this is your water table let us put. This will be h three and this is your distance will be completely h now by drawing rgt said there will be a rotation draw the distribution diagram. Now if I draw it this is my a and this is the distance say x this is your d and let us say this result and r p and this part will be gamma prime K p dash minus k dash into x. So, which is equal to let us say c x and

this is my x. So, c is equal to gamma prime k prime and r p is equal to c x square by two now let us say here will be p a prime. Lnd let us say resultant force above the base this is your r a then distance from the anchor rod because will take the rotation at the anchor rod say y bar and force in the anchor rod.

Let us say f a r a r means anchor f subscript ar means subscript ar means force at the anchor rad anchor rod. Then these distance from here to here, these distance from here to here it will be y prime which is equal to h three plus a plus zero point t six seven x and this is the anchor rod. Now if you look at this this is the complete pressure distribution diagram of anchor sheet pile wall in cohesion less soil or granular soil we are deriving now case one for particularly granular soil we are now doing now we are taking all conditions now there is a water table some here else this is the anchor rod.

Now, as it is assumption say it is a rigid and rotation has to be assumed at the anchor rod and failure anchored by means of rotation up of rotation at the anchor rod. So, let us say these from here to here this result and pressure is r a and from here to here result and pressure is your r p. So, r a active upon below y bar from the or anchor rod and r p update upon update at a distance below y prime from anchor rod which is equal to h three plus a plus zero point six seven x h three is your distance. How it has come plus a this is your distance plus zero point six seven x because this is a triangle. So, this will be two third two third of x. So, that is why this is your zero point six seven x now.

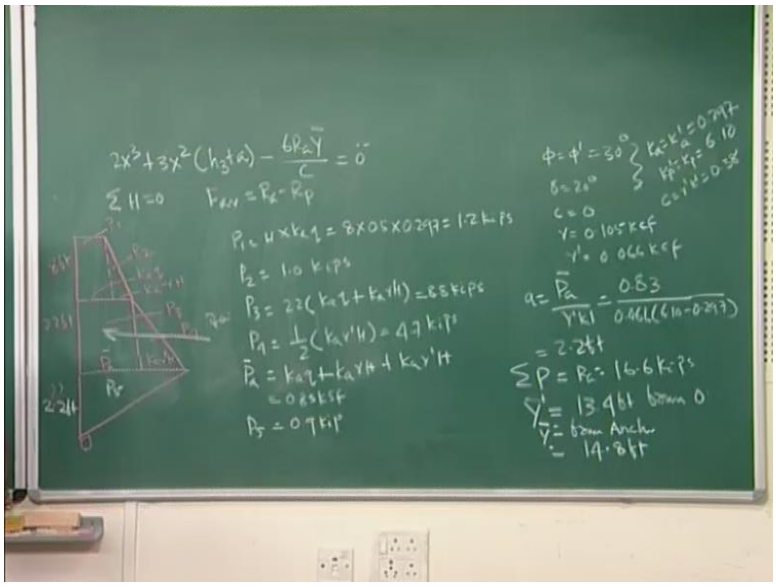
This gamma prime and k prime has been ta assumed as a c and this is your c into x now what is that is r p this course you can find it out c x square by two. So, if a r is your tensile force if you see this kind of things this is your tensile force at the anchor rod this direction going away the direction going away means outward direction of r o it says that this is tensile, if I put in this this way; that means, this is a compression member. So, that is why this is the anchor rod it will take complete tension. So, that it will not rotate or deflect more as expected. So, it will restrict the deflection and rotation. So, that is why this is a p a a r now if a r force in the tensile direction; that means, tension f a r.

Nw if you take this point o at pint o where is your point o this is your point o at point o the wall pressure is zero point o wall pressure is zero. That means, if i take point o a gamma prime k p dash minus k a dash is equal to p a prime a this is your distance gamma prime k p minus a this should be equal to whatever force coming here to a prime

because at point o it should be zero. Now you can get it a is equal to p a prime by gamma prime k p minus k a which is equal to pa prime by gamma prime k prime or pa prime by c.

Now take moment take moment is equal to zero at anchor rod this is our assumption it will pale by means of rotation and this rotation will occur at anchor rod. So, taking moment at anchor rod and equating to zero. So, it will be what is this r p into y prime into y prime is equal to this force anticlockwise and r a this is your r a into y prime this is your also anticlockwise. So, it will be equated to zero. Now if I put it in this manner y prime r p which is equal to y bar r a now from their you can get it y prime r a y bar r a is equal to c x square by two h three plus a plus two third x. Now if I combine both this term, that means, taking the value of a from here putting it here.

(Refer Slide Time: 18:23)



Now, you can get it two x cube plus three x square h three plus a minus six r a y bar by c is equal to zero. So, what is the second condition for this taking forces at h is equal to zero horizontal forces acting is equal to zero; that means, if a r is equal to r a minus r p the bottom line of d is yours the bottom line of d is why you are doing. There are two parameters, you want to find it out; one parameter you want to find it out what is this embedment depth d; that means, a as well as x. You have to determine x plus a is your d then once you get the d then you can apply the factors of the lateral twenty to forty percent another one would these case what is the maximum force.

This anchor anchor rod can take what maximum force it can take it. If I make this equilibrium conditions horizontal forces is equal to zero then force at anchor rod will be r a minus r p r a is your this direction r p is your this direction and this from there you can find it out your f a r now will solve here problem will see.

Now, with these derivations are there. Let me put in such a way that let us say this is example problem and here search are is equal to zero point five keeps per square feet. And given data is your phi is equal to phi prime which is equal to thirty degree delta is equal to twenty degree c is equal to zero gamma is equal to zero point one zero five keeps square cubic feet and gamma prime is equal to zero point zero six six keeps square cubic feet. This is the value of the soil profile phi is equal to phi prime which is equal to thirty degree delta what is the value of delta delta is your fix an angle between wall this is the wall and the soil delta is your fix an angle between the wall and the soil.

Delta is equal to twenty degree at c is equal to zero it is purely and gamma is equal to point one zero five keeps per cubic feet gamma prime is equal to point zero six six. With this conditions, what is your pressure diagram what is the other part has been given other part is given this is these two is equal to four a four four four p. And these two this is your four feet and below the water table this is given twenty two feet and now and total height is your from here to here it is given thirty feet. Now if I draw the pressure distribution diagram these pressure distribution diagram is not like this now the pressure distribution diagram will change because there is a search charge there is a search charge at the top. So, pressure distribution diagram will come.

These part will be your search charge if i draw the entire part if i draw the pressure distribution diagram here completely how it looks this height is your eight feet now water table here is a four plus four it is your eight feet then. So, this will be your p let us say this your p one let us say this is your p two then this part is your k a q q is nothing, but is your search charge zero point five now this will be your k a gamma h.

Now then this is your twenty two feet at pressure diagram from here to here this is your twenty two feet. Now this if I draw it this will come as a p three this is your p four and this is your p a bar this is your k a gamma prime h. And now I draw the pressure distribution diagram up to point o up to point o then here it will be you have to find it out what is the distance of this point a this is unknown. Now will have to find it out from

their now once you get these from their you can find it out value of delta and phi value of delta and phi.

As I explained earlier from value of delta and phi, you can find it out k a is equal to k a dash which is equal to zero point two nine seven. And k p dash is equal to k p which is equal to six point one zero and c is equal to gamma prime k prime which is equal to zero point three eight. Now will find it out r a now what is your r a resultant process active above your dredge line from here to here because if you look at this is my dredge line everything is given your search charge you know your phi know you can find it out what is your resultant at pressure. So, you can find it to not to make mistakes you can find it out individual force p one p two p three p four then you can add it.

So, p one is equal to h into k a q which is equal to eight into zero point five into zero point two nine seven which is equal to one point two. Then similarly p two is equal to one point zero kips p three is equal to let me calculate your p three p three is equal to twenty two into k a cube plus k a gamma h which is equal to eight point eight kips p four is equal to half k a gamma prime h. So, which is equal to four point seven kips now p a prime p a prime is equal to k a q this is your k a q plus k a gamma h plus k a gamma prime h which is equal to zero point eight three kips square or square feet.

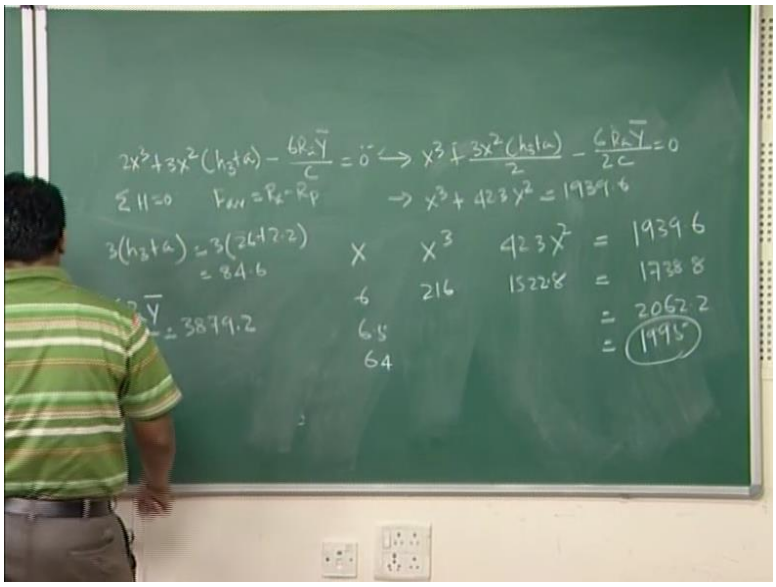
So, all process we have calculated why I do it, I can calculate directly complete taking this diagram i can find it out force, but not to do mistakes you make it small small and individual area you can find it out. So, that chances of doing mistake will be less now from their you calculate you're a value because these distance you have to find it out. If you go back to here a is equal to pc bar by c c is nothing, but your gamma prime and k prime. Now from there i can get it a is equal to pa bar by gamma prime k prime which is equal to zero point eight three by zero point zero six six into six point one zero minus zero point two nine seven and which is equal to two point two feet. Now this distance is we are getting two point two feet.

Now once you get it. So, from their you can find it out what is the value of p five. So, once you get a is equal to two point two feet the phi feet and find it out very easily zero point nine kip now summation of all process summation of all process; that means, p one p two p three p four p five this is nothing, but your resultant force resultant force r a. So, summation of process is equal to r a which is equal to sixteen point six kips. Now once

you get r a what is your next step your next step to find it out next step to find it out what is the result distance from here y bar that you can find it out very easily as the pressure distribution diagram is there. So, from their y bar you can get it thirteen point four feet from o from o thirteen point four feet from o; that means, this is not y bar that means.

From anchor rod from anchor rod y bar is the distance from anchor rod and from here to here this is your y prime. So, we are intend to find it out the moment at anchor rod that is. So, you are going to find it out y bar. So, y bar is equal to; that means, from anchor which is equal to fourteen point eight feet now this distance is your fourteen point eight feet now everything is their now you can find it out all these things this way you can find it out x and others all the calculation we have done. Now if I calculate this it is a equation first find it out this solve the equation.

(Refer Slide Time: 31:12)



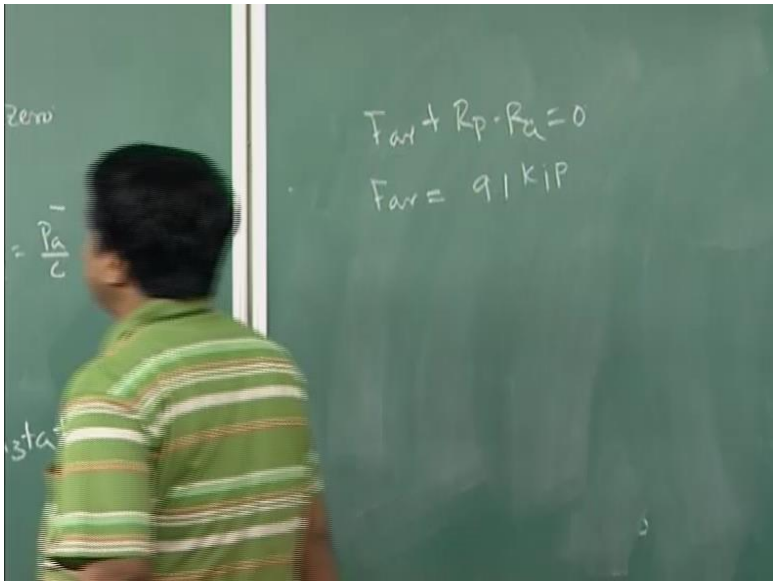
So, now what is the value three h three plus a which is your h three this is your h three; that means, twenty two plus four; that means, it is twenty six. So, it will become around three twenty six plus two point two which is equal to eighty four point six now next one is your six r a y bar by c which is equal to three eight seven nine point two now it has to be solve by trial and error. So, x and d now if I write x cube x square sorry this is your x cube, again if I rewrite this equation again this will be your x cube plus three x square h three plus a by two minus six r a bar ray bar by c two is equal to zero. So, it will become x cube plus if i put this value from here. So, it will be forty two point three x square

which is equal to one nine three nine point six.

Now you write x x cube forty two point three x square which is equal to one nine three nine point six by trial and error. If i start with six this value will got two one six and this is your one five two two point eight which is equal to it is coming one seven three eight point eight if you by trial and error. This is not actually we are not actually one nine three nine it is less now second part is your six point five you are actually in your two zero six two point two now it is slightly better slightly better means slightly greater than this value not like x is equal to six.

Now take six point four value x now you are getting the value of it will approximately six point four one nine nine five almost close to that so; that means, once you are getting x is equal to six point four; that means, you got x is equal to a six point four feet now with these value with these value you can find it out one parameter is over; that means, this distance a is two point two x. You are getting six point four six plus two point two eight point six you are getting total embedded depth now you have to find it out how much tension.

(Refer Slide Time: 34:55)



It can take now doing this far plus r p minus r a is equal to zero from their far is equal to nine point one kip nine point one kip now after getting all this things x, and your anchor force anchor force. Once it is you are getting then take moment about this all the values this moment should because this is a assumption this moment should be zero it should

come around zero; that means, zero point zero zero one or zero point zero one. If it is not zero; that means, there is something wrong then recalculation has to be done once you get the value of far and x plus a with these depth d are twenty to forty percent; that means, increase this depth means value of twenty to forty percent. This is complete solved example of case one that is your anchor anchor bulk head in.