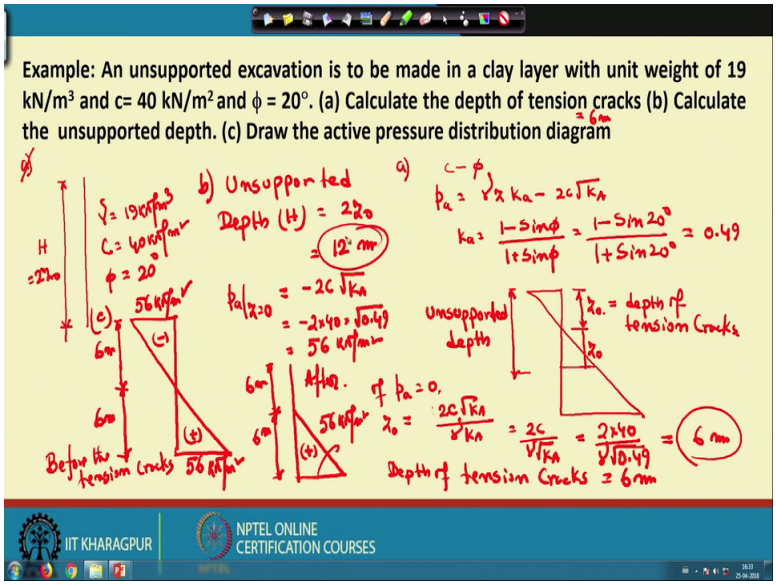
Foundation Engineering
Prof. Kousik Deb
Department of Civil Engineering
Indian Institute of Technology, Kharagpur

Lecture – 46
Earth Pressure – VI

In the last class I have discussed about the Earth Pressure theories. And I solved few problems to show you, how to calculate the Earth Pressure for layer soil as well as homogeneous soil and for cohesive soil as well as cohesion less soil and C phi soil. Now, today I will solve a more problems to show you how we can calculate the earth pressure for different soil conditions.

(Refer Slide Time: 00:53)



Now, first problem that I have taken is that is to be made in a clay layer with unit weight of 19 kilo Newton per meter cube, and cohesion value is 40 kilo Newton per meter square friction angle, phi is equal to 20 degree. So, you have to calculate the depth of tension cracks and calculate the unsupported depth and draw the active earth pressure distribution diagram. Now, first if I take that wall or the excavation so, we have to determine for the first case a that what would be the tension crack depth. And then the next one you have to determine what would be the height H where we do not need to provide any support; that means, without any support the excavation or soil can stand.

So, first one if I calculate that that (Refer Time: 02:02) depth of tension crack. So, for the it is a C phi soil. So, C phi soil the expression of Pa is equal to gamma into z into Ka minus 2 c root over K A this is for the active condition. And the values are given unit weight is 19 kilo Newton per meter cube, C value is 40 kilo Newton per meter square, and phi value is equal to 20 degree. So, we can calculate that Ka is equal to 1 minus sin phi divided by 1 plus sin phi.

So, 1 minus sin 20 degree, divided by 1 plus sin 20 degree, so that is equal to 0.49. So, as I mentioned that tension crack will developed up to that z 0 depth, z 0 means where the Pa value is 0 there is no earth pressure. So that means that if we have a C phi soil. So, we know this is the earth pressure distribution so our tension crack will develop up to Z 0. So, this is the depth of tension cracks and if I extend this another Z 0, this is the depth of unsupported portion.

So, this is the unsupported depth so my H value will be 2 Z 0. So, because this is a unsupported as this positive and this negative pressure will cancel out. So, there will be no support will be required up to these twice Z 0 depth. So, you have to calculate the first Z 0 then that twice Z 0. So, now, if I put p a equal to 0 then if p a equal to 0 then you can get Z 0 is gamma this is 2C root K A divided by gamma K A. So, it will be ultimately 2C K by gamma root K A.

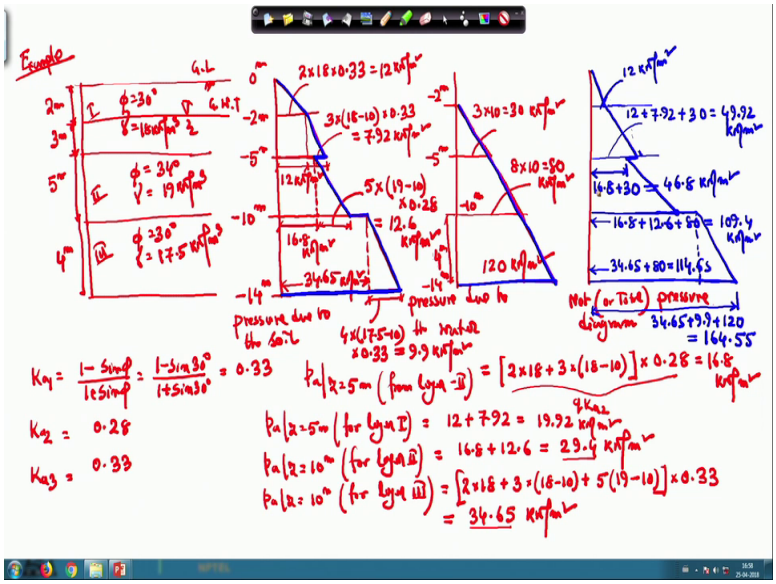
So, this is the Z 0 part and so if I put these value then the Z 0 will be 2 into 40 divided by gamma root over 0.49. So, that will be equal to 6 meter, so the depth of tension crack is 6 meter. So, this is the Z 0 is 6 meter so depth of tension crack is 6 meters. So, we can write that depth of tension cracks is equal to 6 meter. Now we will calculate the second part that is part b.

So, depth of unsupported portion, so unsupported depth H is equal to 2 Z 0 that is 12 meter. So, up to 12 meter no support will be required. Now for the c part that earth pressure distribution diagram. So, this is we are drawing the earth pressure distribution diagram for two cases. So, we are drawing the earth pressure distribution diagram up to the unsupported portion. So, this is 6 meter this is 6 meter. And this portion is positive earth pressure; this portion is negative earth pressure. And the negative earth pressure value will be that we can calculate the negative earth pressure value that p a at Z equal to 0 that will be equal to minus 2C root K A.

If I put Z equal to 0 this will be minus 2C root K A. So, this is 2 into 40 into root 0.49. So, these value is 56 kilo Newton per meter square. So, these value will be 56 kilo Newton per meter square. It is in minus similar this value will also be 56 kilo Newton per meter square. So, this is the diagram as I mentioned before the tension cracks are developed and after the tension crack as I mention we have to draw this diagram from here up to like this, for this particular case.

So, this is 6 meter and this value is 56 kilo Newton per meter square, this is positive and this is also another 6 meter so, this is after the tension crack is developed. So, this is the two earth pressure distribution diagram this first one is before the tension cracks are developed and second one is the after the tension cracks are developed. And the unsupported length is 12 meter and the tension crack zone is 6 meter, so these are the all values that we require. So, the next problem that I will solve is the next example problem I am taking for a three layer case; first one we will do for phi soil then we will do the another problem for C phi soil.

(Refer Slide Time: 09:14)



So, that example problem that first one we are taking that we have a soil layer that is three layer soil systems. This is the layer 1, this is layer 2 and this is layer 3. So, this is the ground surface this is the GL and water table is here, this is the water table location or a ground water table you can say. So, now this thick depth of this water table is 2 meter from the ground level. And this 1st layer is total 5 meter, so this is 3 meter 2nd

layer is 5 meter and the 3rd layer is 4 meter another. So, this is the 14 meter high wall and we have three different layers. So, we have to determine the earth pressure diagram we have to draw the earth pressure diagram and we have to determine the total force per unit length and as well as the location of that a force where these force is acting.

Now, the first we have to draw this diagram. So, here is water table is there and the soil is there, so I am drawing first separately the what pressure due to the soil and the pressure due to the water then you will take the net pressure due to the soil as well as the water. So, first this is the diagram that I am drawing this is the pressure due to the water soil. This is pressure due to the water and then we will do for the net one. So, the first one is the pressure due to the soil, this is the pressure due to the water, and this is the net pressure or the total pressure; net or total pressure diagram. So, first up to 2 meter we are drawing these and the values that are given for the first layer. This is the layer I, this is the layer II, this is the layer III. For the I layer your phi value is given 30 degree and unit weight of soil is given 80 kilo Newton per meter cube.

So, as one unit weight is only given so that we will consider as a unit weight or saturated unit weight as well as the unit weight above the water table, if both the unit weights are given. Suppose the unit weight above the water table and unit weight of the soil under saturated condition. So, then you have to consider both the unit weight, but here one unit weight is given so that we will consider as unit weight of soil above the water table as well as the saturated unit weight. So, now, the second one is phi value is given 34 degree and unit weight is 19 kilo Newton per meter cube. Third layer phi value is 30 degree and unit weight is given 7.5 kilo Newton per meter cube.

So, first we will calculate that what is the value of Ka, Ka 2 and Ka 3. So, the Ka 1 will be 1 minus sin phi divided by 1 plus sin phi. So, phi value is 30 degree. So, 1 minus sin 30 degree divided by 1 plus sin 30 degree so that will be equal to 0.33. Similarly, Ka 2 is, if I put the phi value is 34 then Ka 2 will be 0.28. Now Ka 3 will be 1 minus sin 30 degree again 1 plus sin 30 degree. So, Ka 3 will be again 0.33. So, these are the earth pressure coefficient as per the Rankin's theory. So, now, first we will do the first layer up to the water table. So, this is the earth pressure up to 2 meter. This is 0 meter minus 2 meter this is minus 5 meter this is minus 10 meter and this is minus 40 meter.

So, up to 2 meter the value will be, this will be 2 into unit weight is 18 into 0.33. So, that is the earth pressure for that part and that is equal to 12 kilo Newton per meter square. Now, the below the water this twelve kilo Newton per meter square pressure that will continue because that will act as a surcharge for the portion below the water table and as the K value is same so it will continue like this in this zone. And the next one there will be a more pressure due to the soil. So, this portion is the pressure due to the soil. So, that value will be your, this is 3 into unit weight is 18 minus 10 into 0.33. So, this value is 7.92 kilo Newton per meter square. And this one as usual this is equal to 12 kilo Newton per meter square, this is the for the first layer and for the water pressure up to these up to 2 meter there is no water so water pressure is 0.

After that the water pressure will start and for minus 5 meter this is minus 2 meter. So, this will be the water pressure. So, water pressure value will be how much? Water pressure value will be this is 3 into 10 that is 30 kilo Newton per meter square because that is the water pressure we are considering and unit weight of water is taken as 10. So, that is the diagram for the soil and the water separately up to 5 meter depth for first layer.

Now, as I mentioned if there is a change in layer and if the change in property; then we have to take a each interface the earth pressure for the first layer, top layer and the bottom layer. So, in the second layer also we will calculate that what would be the earth pressure. So, in the second layer so the p a at Z equal to 5 meter. So, this is for the for layer II will be equal to. So, that the top layer overburden pressure will act as a surcharge for the second layer that is that is surcharge amount is the overburden pressure will be 2 into 18 plus 3 into 8 minus 10. So, that is the surcharge.

And then that will be into 0.28 because that is the Ka 2. this is basically this portion is q into Ka 2 and q value is the effective overburden pressure which is coming from the first layer. So, that value if I calculate into, so the 2 this is 16.8 kilo Newton per meter square. So, this one the total value is 12 plus 7.92. So, this value is coming out to be this is the total I here. So the total value is so we can write that Pa at z equal to 5 meter for layer I is equal to total I is 12 meter plus 7.92 meter. So, that is 19.92 kilo Newton per meter square. But this is 16.8 kilo Newton per meter square so this value will go inside. So, now, if I draw the net one that it is this blue one. So, it will go, then it will go inside because it will go inside as this is 16.8 for the second layer and this is 19.92 for the I layer so for the second layer it will go inside.

So, next one that so these things will remain uniform up to this portion. So, this value is equal to 16.8 kilo Newton per meter square. Then the unit weight of second layer is 19. So, you have to calculate the earth pressure due to the second layer. So, that value this value is equal to is gamma unit length is 5 meter unit weight is 19 minus 10 and then into 0.28. This is the value will be 5 19 minus 10 into 0.28. So, that value is coming out to be 12.6 meter, 12.6 meter per 12.6 kilo Newton per meter square.

This is 5 so I can write that p a at z equal to 10 meter, for layer II will be equal to the total one 16.8 plus 12.6 that will be equal to 29.4. So, this will be 29.4 kilo Newton per meter square. So, this totals one 29.4 kilo Newton per meter square, so I am just drawing this part also so up to this. Similarly the water table is also increase, so water table value water table pressure due to the water that will also increase.

So, this point this value is 30 plus the additional one additional for the 5. So, this is 8 into 10 that will be 80 kilo Newton per meter square at this point. So, we have drawn up to the 10 meter, now we will draw for the third layer for the last layer. So, p a at Z equal to 10 meter this is for layer III. So, because it is the interface between two layer so we have to check it for the both the layers at that point or that depth. So, here the total overburden pressure will act as an surcharge on the layer III.

So, total overburden pressure is 2 into 18 plus 3 into 18 minus 10 plus 5 into 19 minus 10 and that total is into 0.33. So, that is equal to this value is coming out to be 34.65 this is 34.65 kilo Newton per meter square. So, here the total value is 29 point, 29.4 this total one this is 29.4 and this one is 34.65, for the second layer at this depth is 29.4 and for the third layer this is 34.65 so for the third layer it is more. So, we have to increase it, this side this value and this will continue like this up to the 14 meter. So, I can write this value is 34.65 kilo Newton per meter square. So, now, we have drawn that so now, I can take the blue one and this is the up to this value. Now we will do for the pressure due to the third layer. So, this value is 4 into 9, 17.5 minus 10 into 0.33 so this value is 4 into 17.5.

So, this is coming out to be so this value is coming out to be 9.99. So, this is 9.99 kilo Newton per meter square. So, this is 9.99 kilo Newton per meter square and so the final earth pressure distribution diagram for this due to the soil is this blue one, so this is the final earth pressure distribution diagram for the soil. Similarly I can draw the earth

pressure distribution diagram for the water. So, this value is 100 so this is total 5 meter plus this one is also another 5 meter. So, this will be 5 meter plus 5 meter because this is minus 10 and this is minus 14. So, this is total depth of this one is 12 meter because this is, this one is 4 meter.

So, this is 5 meter this is 4 meter and this is 3 meters. So, this is 3 meter this is 5, 8 and this is another 4. So, this is minus 14 meter so this one is 12 so this will be 120 kilo Newton per meter square for the water. So, I can write, draw the earth pressure distribution diagram due to the so, the pressure diagram due to the water. So, this is pressure due to the water.

Now, if I draw the net one, so the net one I am drawing here or the total pressure distribution diagram. So, for the first top one as usual it will be the 12 kilo Newton per meter square. Then this total is at this 5 meter the total is 19.92 plus 30, so this will be 19.92 plus 30. So, this pressure will be 49.92. So, this is the pressure or it will just increase like this so I am just reducing this value because the space, that is the space it is friction reducing the dimension. So, this one is the 14 then it will increase so this value is nothing, but you add this all the values. This is 12 plus 7.92 plus this 30. So, this will be equal to this value is equal to 49.92 kilo Newton per meter square. And then the next one is this is 16.8 so 16.8 this portion so 16.8 plus 30 so again this will go this side and then it will increase further.

So, this value is nothing, but this is 16.8 plus 30. So, this will be equal to 46.8 kilo Newton per meter square. And then this portion this is total 34.65 and then we have to add so these value is this portion will be you can add this one that 16.8 plus 12.6, because this is 12.6 this is 16.8 plus this one is 80 plus 80. So, this is equal to these value is 109.4 kilo Newton per meter square. So, up to this portion is 109.4. Now here it will increase because here it is increasing so we will increase this one and then the finally, this will be the diagram. So, what are the values of this portion? So, this portion value is your, this is 34.65 so 34.65 plus this is 80. So, this will be equal to 114.65 so I am talking about up to this portion and then the final portion, this final portion up to this value is so this is your 34.65 plus 9.9 plus 120.

So, this will be 34.65 plus 9.9 plus 120. So, this is ultimately 164.55 kilo Newton per meter square. So, this is the total value is 164.55 kilo Newton. So, this 109.4 is up to this

remember that, this 109.4 is up to this. And 114.65 is up to this; this is the total. So, this is the total earth pressure distribution diagram for the soil for the water and this is the net or the total earth pressure distribution diagram.

So, I have explained step by step for all the layers, now what I will do I will calculate the force that is coming. So, you can calculate separately the force which is coming from the soil; due to the soil and due to the water then you can add these two, but as I have the net pressure diagram or the total pressure diagram. So, I will calculate this force from this total pressure diagram. So, next class I will calculate this force and the point of application of this force from the base of the wall.

Thank you.