Soil Mechanics/Geotechnical Engineering I
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Lecture – 53
Earth Pressure (Contd.)

Let me take few more problem. In my last lecture, I have taken 3 problem to explain or how to use the (Refer Time: 00:27) condition. Then a combination of everything water table and then surcharge and then we have taken another when there is a sloping back in the wall how to consider the analysis.

And next I will take problem which will have different layer; two layers actually sometime; the soil have top layer will be something, bottom layer will be something else, there may be c soil, there will c phi soil, there will be only phi soil. So, all combination is there, then how to calculate or what is the changes in calculation. Let me show one by one.

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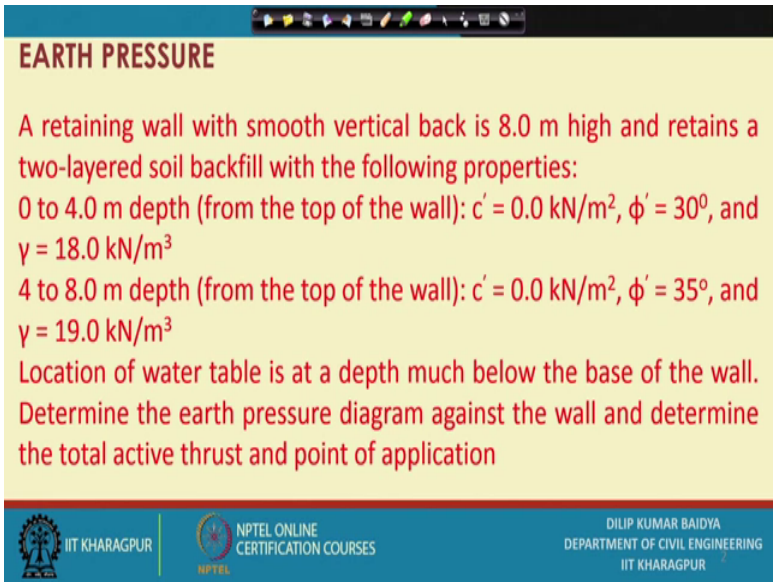

So, let me take problem number 1. The problem number 1 is like this; a retaining wall with smooth vertical back is 8 meter high and retaining a two layered soil backfill with the following properties. so 0 to 4 meter depth from the top depth, from the top of the wall c is 0 phi 30 degrees and gamma 18. So, this is a cohesion less soil, basically, first layer, second layer 4 to 8 meter depth from the top of the wall also again c 0, phi 35

degrees and gamma 19.0 Kilo Newton per meter cube. So, again this is also cohesion less, but two different cohesion less soils are there so and the location of water table is at a depth much below the base of the wall so; that means, in between water table could have come, but here it is given that water table is much below the base of the wall. So, that pressure calculation and water table effect will not come in picture.

So, determine the earth pressure diagram against the wall and determine the total active thrust and point of application. So, this is a smooth vertical wall. So, simply straight will go Rankines method and when it is two layers. So, only there will be some changes in calculation. So, that will show one by one.

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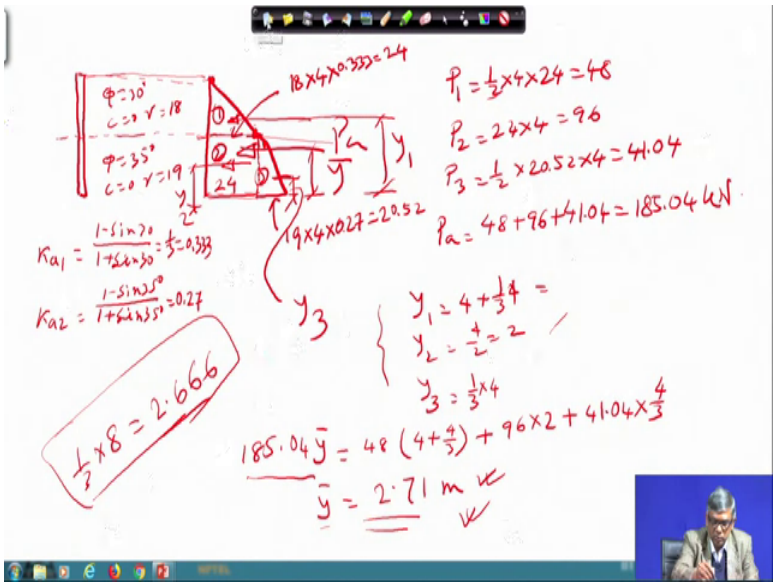

So, let us take the wall first; if it is a wall, 8 meter wall and up to 4 meter, the soil is something this is your phi equal to ah, phi equal to 30 degrees and c equal to 0 and gamma equal to 18. And here phi equal to 35 degrees c equal to 0 and gamma equal to 19 so and backfill also this level backfill. So, for this you have to find out I can say K a 1 will be equal to 1 minus sin 30 by 1 plus sin 30. So, it will be 1 by 3 and K a 2; that means, layer 2 active earth pressure coefficient 1 minus sin 35 degrees divided by 1 plus sin 35 degrees.

So, this gives you a value 0.27 this is 0.333. Now to draw the pressure diagram, I do like this and so, from here, pressure diagram will be something like this. So, how it will be how much? It is this will be 18 multiplied by 4 multiplied by 0.333. So, it will be equal

to ultimately 24 ok. And after this so because of this soil; this much pressure is acting here and you can assume at this level, you can assume that this is a surcharge. So, this will be constant or to this, this will be constant for this soil because of this soil layer; what will be the pressure at this level? This much now because of this soil layer; so, you have to find out additional earth pressure.

So, assume this is a 0 level. So, from here, we will get the pressure diagram. So, this will be suppose something like this and what will be this value this is already 24 and what is this value this will be equal to 19 multiplied by 4 multiplied by 2.27. So, that is equal to your 20.5 this is 20.52. So, we have now; that means, we have to find out the thrust on the wall because of this backfill active thrust. So, this can be divided into three parts. Now 1 2 and this is 3 and so, you can find out P 1 will be equal to half multiplied by 4 multiplied by 24, it will be equal to 48 and your P 2 will be equal to 24 multiplied by 4 that is 96 and P 3 will be equal to this 1. So, half multiplied by 20.52 multiplied by how much this height is 4.

So, that is actually 41.04, then your P a will be equal to 48 plus 96 plus 41.04. So, that gives you total 185.04 Kilo Newton. And now you have to find out your point of suppose this thrust is acting somewhere here P a. So, you have to find out what is the distance Y bar. Now this individually this is 3; this is suppose Y 3 and this one suppose acting in the midpoint. So, this will be suppose Y 2 and this was suppose acting somewhere triangle. So, this is suppose; Y 1. So, Y 1 will be equal to this 4 plus; so this reference 4 plus one third of 4 ok. So, this is actually 4 plus 1 third of and Y 2 will be equal to Y 2 will be equal to this is. So, from here Y 2 will be 4 by 2 3 2 and Y 3 will be equal to this one.

So, one third of 4 meter; So, this is the distance now you can find out 185.04 multiplied by Y bar will be equal to P 1 is 48 multiplied by 4 plus 4 by 3 plus 96 multiplied by 2 plus 41.04 multiplied by 4 by 3. So, if I solve for Y bar you get Y bar equal to 2.71 meter. So, when there is a two layer; if it is a single layer it could have been one third from the base one third of 8 how much it is it is 2.666.

So, if it would have been a single layer whatever may be the phi then I could have gone a single diagram and your point of application of the thrust would have been at 2.666 meter from the base and because of this you have done so much of calculation and you can find out that your the point of application is at a height 2.71 slightly above 0.5 meter

almost above, no slightly actually you have 0.1 meter above. So, the so this much is the so this is actually; what if there is two layers soil what is the change this is the change up to this the diagram will be 1 and this diagram at this level whatever pressure will be that will be the surcharge to the next layer and then additionally you have to find out for the second layer separately.

So, then we can find out the inter area to get the thrust, but instead of doing entire area together what we can do we can divide into known parts known different parts of known areas suppose triangle rectangle etcetera area easy to find out. So, you divide it into square and rectangular square triangle rectangle and based on that you have determine the area of different components and we have also determined the point of application of individual forces. And then the assume that resultant forces acting at a distance Y bar and then you take moment with those all other force and now resultant force you have to take moment and they will be balanced. So, there will be moment balance so that from there actually you can find out Y bar.

So, 2.71 and you could have been is homogeneously it could have been 2.66 meter. So, this is the difference finally you are getting.

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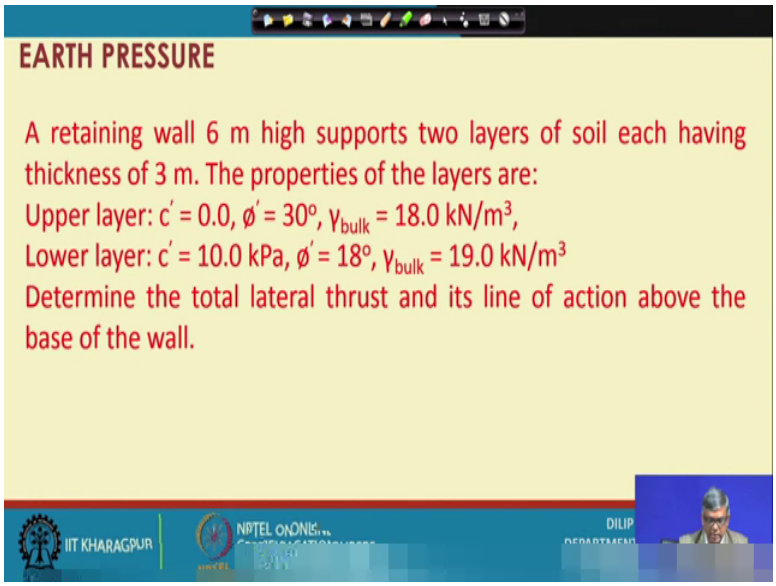

So, let me go to the second application, second application somehow is a two layer soil again top layer is you can say is a phi soil and bottom layer is c phi soil, retaining wall six meter high suppose two layers of soil each having thickness of 3 meter the properties

of the layer are upper layer c 0 phi 30 degree gamma bulk 18 and lower layer c 10 phi 18 and gamma bulk 19 determine the total lateral thrust and its line of action above the base of the wall.

So, this is a two layer soil upper layer soil is cohesion less and bottom soil is with cohesion. So, you have to do again another layer soil. So, let me see what are the changes will be here. So, here 6 meter high wall 6 meter high wall.

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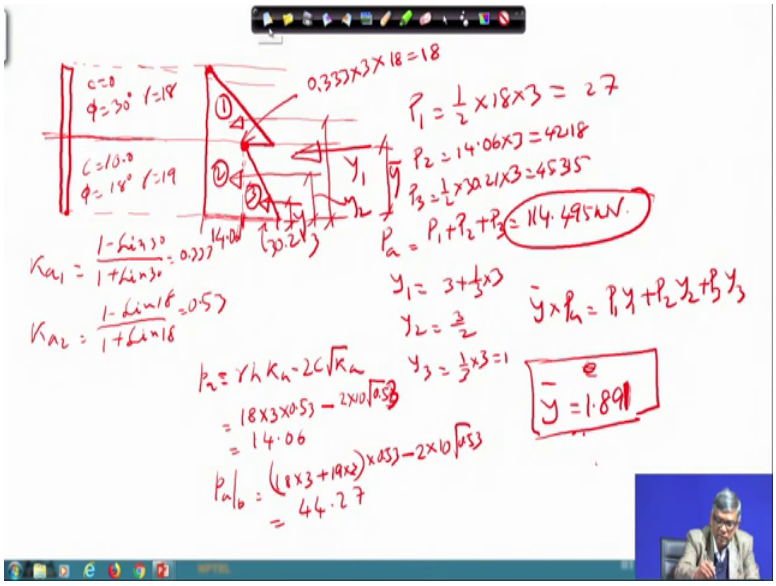

And layering is at midpoint 3 meter 3 meter and here actually c 0 phi equal to 30 degrees and gamma equal to 18, here c equal to ten only phi equal to phi equal to 18 degrees and gamma equal to 19. So, this one you can find out the pressure diagram here; so I again once again we can find out K a 1 1 minus sin 30 divided by 1 plus sin 30 equal to 0.333 and K a 2 will be equal to 1 minus sin 18 by 1 plus sin 18. So, that will gives you 0.53. So, since up to this it is a cohesion layer a cohesion less soil the pressure diagram or lateral earth pressure diagram will be something like this ok. So, this value will be equal to 0.333 multiplied by 3 multiplied by 18.

So, that will be equal to finally 18. And now this will be acting as a surcharge, but now when I will be doing this layer. So, this layer I can forget about the presence of this now equal to if I assume from here then c phi soil you know P a will be equal to gamma h K a minus 2 c root K a ok. So, here what I can do now at this level what is the sigma? Sigma I will take 18 multiplied by 3 already there and k since I am doing the second layer. So,

K a for this layer to be used. So, 0.53 minus 2 c 2 multiplied by 10 multiplied by root 0.52 or 0.53.

So, if I do this value will be your; it will be point 14.06. So, 14 so this was 18. So, 14.06; that means, you go at this direction. So, it will be somewhere here. So, 14.06 here so; that means, your and from here actually it will be going my straight line something like this. So, so; that means, I if I if I want to find out value at this point how you can find out P a at the base will be equal to you can find out.

So, that can be find out 18 into 3 plus 19 into 3 this much sigma is acting multiplied by K a 0.53 minus 2 multiplied by 10 multiplied by 0.53. So, this if you calculate you get 44.27 so; that means, ah. So, this is 14. So, this entire value the entire value this is actually up to this is 14.06 and this value, then it will be 30.21. So, this point to this point 30.21 this point is 14.06. So, now, this is the pressure diagram you have got you have to find the thrust. So, to find out the thrust I can find out different component 1 2 and this is 3 so; that means, p 1 will be equal to half multiplied by 18 multiplied by 3. So, it will be it will be 27 and P 2 will be equal to it is 14.06 multiplied by 3.

So, that is actually 42.18 and P 3 will be equal to half multiplied by 30.21 multiplied by 3. So, that will be equal to 45.315. So, P a will be equal to altogether P 1 plus P 2 plus P 3. So, that gives you 114.495 Kilo Newton. Now individual suppose this is Y 1 then this is suppose Y 2 and this is suppose Y 3. So, force 1 acting here force 2 acting here force 1 acting here. So, 3 acting here 2 acting so then, Y 1 I can find out Y 1 will 3 plus 1 by 3 into 3. So, this is the 1 Y 2 will be equal to 3 by 2 and Y 3 will be equal to 1 by 3 multiplied by 3. So, that will be 1. So, now if I assume the thrust resultant thrust acting somewhere here and that is at the distance Y bar then Y bar multiplied by P a is equal to P 1 Y 1 plus P 2 Y 2 plus P 3 Y 3 and if I do that all value if I put, then you will get Y bar equal to 1.891 you get Y bar equal to 1.891.

So; that means, because of this 2 layer soil the thrust on the wall is equal to 114.495 Kilo Newton per meter length and it will be act; it will act at a height 1.89 meter from the base of the wall. So, this is another application and then let me go to the third application.

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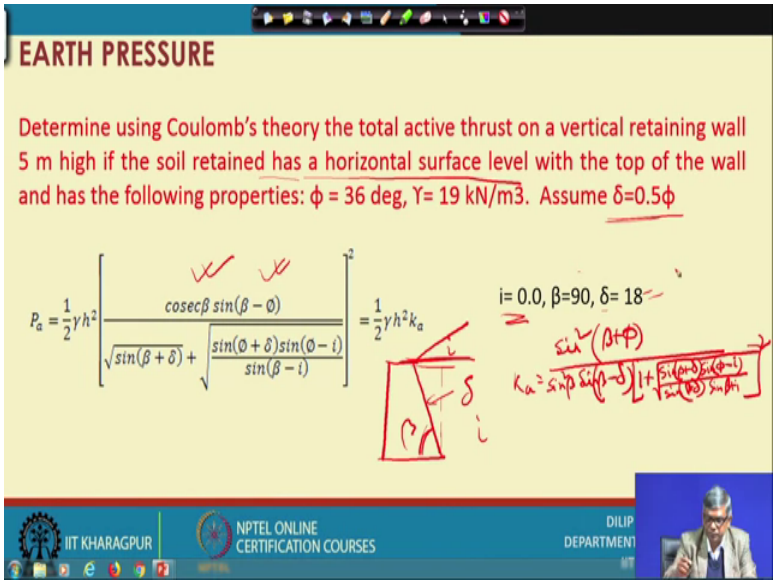

So, this problem actually though I have not given much importance to Coulomb's theory and this may be for this undergraduate course may be awarded, but since I have introduced to find out the difference between Coulomb's and active sorry Rankines. So, I have taken 1 problem, but I may not able to solve fully just see just show what is the differences here; actually you can see the determine using Coulomb's theory the total active thrust on a vertical retaining wall 5 meter high, if the soil retained has a horizontal surface level with the top of the wall and has the following properties phi 36 degrees gamma 19 degrees and assume delta equal to 0.5 phi.

So, while discussing this Coulomb's theory and we have I have used this formula this is the very classical problem and where very old solution different people get different ways the solution and in some books you get in this form and some book also you get in some separate form which may be little better, also while comparing with different books I found some mismatch between in some places and I could not decide which exactly the correct one I have to see the original publication to see the difference. So, for the time being though this is another type of expression somewhere here there will be small change may be there.

So, I am not using this instead of that I will be using another form of equation, equation was given in this form like if the wall is something like this. And if this is i and this angle is beta and friction angle is delta i beta delta then your expression for K a is given by sin square beta plus phi divided by sin square beta sin square beta sin beta minus delta i plus

under root sin phi plus delta then sin phi minus i divided by sin beta minus delta and sin beta plus i and this is whole square.

So, this is on expression is given. So, all angle beta is this angle here i is this angle here and delta is friction between the in the wall friction angle. So, this is another form of equation can be used. So, I will try to use this, but with respect to this problem you can see the vertical retaining wall with retained has a horizontal surface level; that means, it is like this. So, i become 0 and beta since this is angle beta which is vertical actually is mentioned total thrust on the vertical wall. So, beta becoming 90 degrees and delta will be 0.5 phi. So, delta equal to 0.5 phi minus it will be 18. So, this is the values then based on that we can put the formula we can move the formula there you can get sin square ok.

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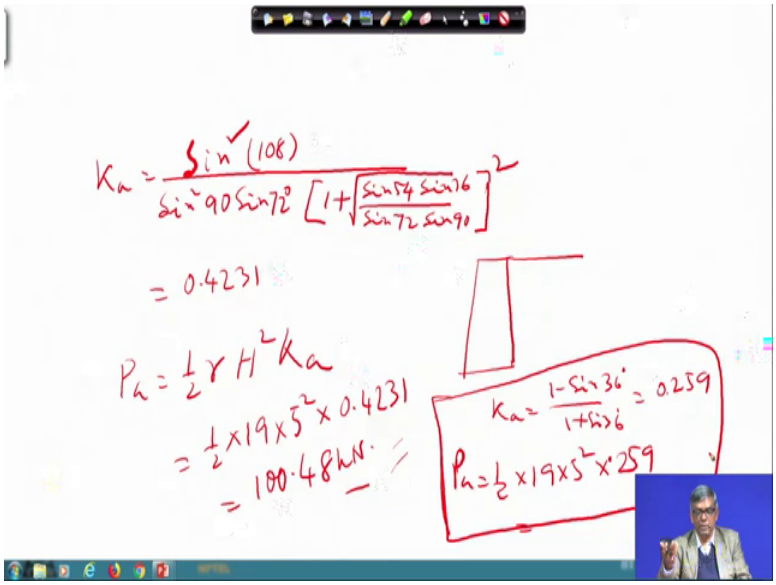

It is K a will be equal to sin square beta sin square 1 is 0 1 is 0 8 it will be divided by sin square 90 sin 72 1 plus sin 54 and multiplied by sin 36 divided by this is under root off course divided by sin 72 and sin 90 and this is square.

So, if you all are in terms of sin values the angle see if you calculate this comes 0.42 0.4231. And then your thrust will be p a will be equal to half gamma H square K a that is another formula. So, half multiplied by gamma is given somewhere you can see gamma was 19. So, gamma was 19 and H was I think how much 5 meter. So, you can say 5 square multiplied by K a is 0.4231. So, this gives you a value 100.48 Kilo Newton.

And of course, this problem if I do this is the vertical we have considered vertical wall and this was a 36 degrees. So, your if I this wall is something like this 5 meter and this is the 1 only delta is there. So, if you ignore delta here and you could have got K a you could have got 1 minus sin 36 degrees divided by 1 plus sin 36 degrees then that value could have come 0.259 and then your P P a could have come half multiplied by 19 multiplied by 5 square multiplied by 2 0.259.

So, whatever the value it could be it will be it could have come much smaller compared to this one. So, this is the difference between Coulomb and Rankines of course if you know the Coulomb's theory and if you want to use Rankines theory the appropriate values actually you have to see when Coulomb's is a generalized and Rankines is special form like wall inclination you can put beta equal to 90 degrees. So, it become Rankines.

Similarly, I if you put 0 then become Rankines level surface. So, like that the the in combination both can be done, but in general we use Rankines theory because the expressions are simple if necessary we can increase the value little bit for the design to make it safer otherwise it is enough. So, this is one problem I have taken for with the purpose since I have discussed Coulomb's theory what way it is different and all those things I want to highlight. So, I hope that is enough. So, with this I will stop this one and let me close here.

Thank you.