Soil Mechanics/Geotechnical Engineering I
Prof. Dilip kumar Baidya
Department of Civil Engineering
Indian Institute of Technology, Kharagpur

Lecture – 52
Earth Pressure (Contd.)

Good morning friends, Once again welcome you to this lecture and we have completed the recent topic that is the earth pressure, different aspect of earth pressure we have completed. First of all what is why earth pressure is required, then what are the different types of earth pressure, earth pressure addressed, earth pressure active earth pressure, passive earth pressure, how to estimate them the different theories basically I have spend more time on Rankine's theory where in fact, we have the similar assumptions the most important assumption a is the wall is vertical and also there is no friction between the wall and the soil. And those two those two things and then additionally there is a level backfill the backfill also the same line with the top of the wall.

And this is the initial thing we have done and then later on we have introduced inclined backfill also by Rankine and then earth pressure coefficient little modified. And also we have introduced the just Coulomb's theory, what way they are different basically with there actually any angle of the wall, if the wall is sloped, that can be incorporated also, if the if the fiction between the wall and the soil is considered, and any sloping angle in the backfill is also can be considered.

So, these all the Coulomb's theory is advantageous and perhaps it gives more closer value to the than value to the actual value and by estimating it comes little higher and; so since the expressions for this coulombs theory all calculations are this little lengthy. So, because of that people sometime avoid. So, alternatively people what they do? They do a Rankine's theory and increase by some amount.

So, this is what we do. And then finally, if there is a and while doing all those thing we have considered by an large cohesion less soil; that means, granular less soil backfill. And also if there is a c phi soil, how did this will change; that also we have introduced towards rain. So, with this earth pressure topic we have completed. Now, I will show the several applications like small wall problem will solve and then this will I hope it will once again I will repeat whatever required and then solve the problem.

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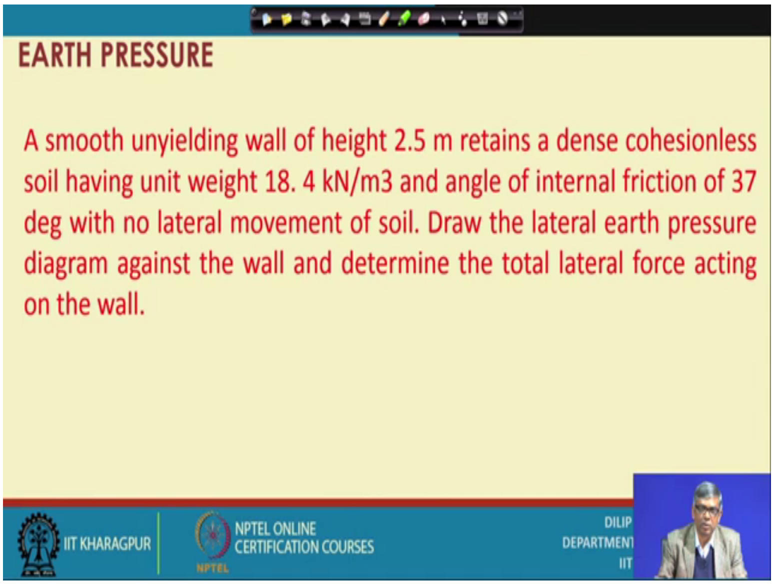

So, first problem used like this smooth unyielding wall of height 2.5 meter return retains a dense cohesionless soil having unit weight 18.4 kilo meter per cube and angle of internal friction of 37 degrees with no lateral movement of soil. Draw the lateral earth pressure diagram against the wall and determine the total lateral force acting on the wall.

So, this is actually the problem; you have to read the language word proper language you have to very carefully you have to see here it is mentioned smooth unyielding, so and smooth means it is Rankine's theory, unyeilding means and there is no movement of soil; that means, it is a address condition. So, this we have discussed three different types of earth pressure.

So, here from this statement the unyielding wall; that means, there is no movement of wall. So, you have to consider this as a earth pressure addressed condition. So, this is the very simple problem, but still to understand, when we will you apply or used address condition while solving problem. So, language sometime to be mentioned unyielding wall sometime also it will be mentioned as a prevented from movement. So, this type of language it is added, then automatically you have to understand that the it is a earth pressure addressed condition.

So, accordingly you have to solve this problem. So, if you take this problem this is a very simplest possible problem and you can see, if I do; the suppose the wall is this is 2.5

meter high wall, and it has phi equal to 37 degrees and gamma equal to 18.4 this much information is required nothing else is required.

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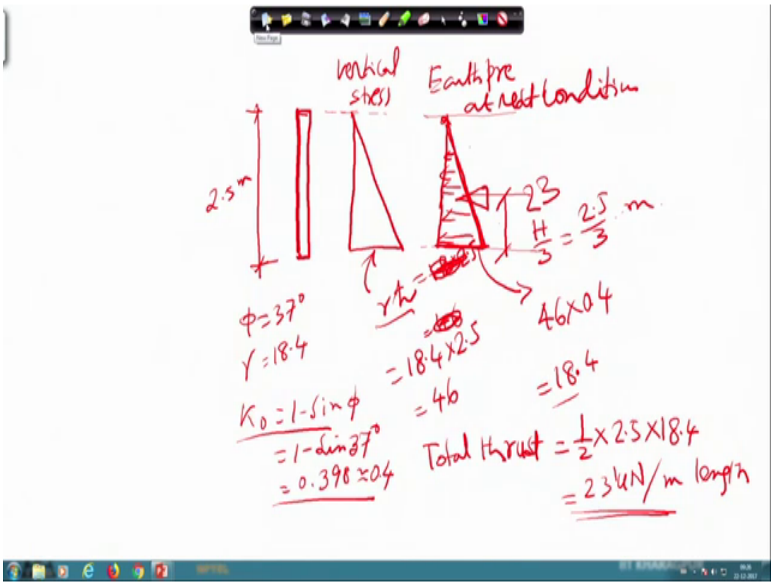

So, here we know K naught equal to 1 minus sin phi. So, 1 minus sin 37 degrees that gives you 0.398 or equivalent to 0.4, I can take. So, if I do intensity of vertical stress over depth. So, if I do intensity of vertical stress over depth, this will be gamma times gamma times h. So, it will be equal to 18.4 multiplied by 2.5. So, this will be your 18; that will be 46 and then, if I want to this is actually vertical stress.

Now, if I wanted to lateral earth pressure addressed condition, it will be multiplied by K naught. So, if I do this, sorry; this is it cannot be; so it will 0.4 times of; so this will be 0.4 times of 46 it will be again, so this will be, sorry; this is I have written also wrongly this will be 18.4 multiplied by 2.5. So, so 46 that is 46 and 46 multiplied by 0.4 that will give you here, so this will be equal to 46 multiplied by 0.4.

So, that will be equal to it will be 18.4. So, ultimately 18.4; so this is the; this is actually earth pressure at rest condition and the pressure distribution in the behind the wall over the depth is something like this. So, maximum is 18.4 and here; obviously, there is no. So, it will be 0 and so the total thrust or total thrust will be equal to area of this diagram. So, area will be half multiplied by height is 2.5 multiplied by 18.4. This is the pressure.

So, this gives you ultimately 23 kilo Newton per meter length of force, per meter length, because the wall I have shown only two dimension, but the wall will be extended perpendicular to the board, so three dimensional, so I am taking some of the one unit width. So, for that unit 23 kilometer log will be acting on the wall. So, this is the very straightforward application we have calculated; what is the active coefficient of earth pressure addressed condition, 1 minus sin phi. Then we have got vertical stress that multiplied by K naught we have got lateral stress and then we have found out the area to calculate the thrust and where it will be acting, this will be acting somewhere the thrust. Finally, this will be suppose how much 23 and this will be acting at a height that will be equal to H by 3 equal to 2.5 by 3.

So, whatever it meter ok. So, with this let me take the second problem.

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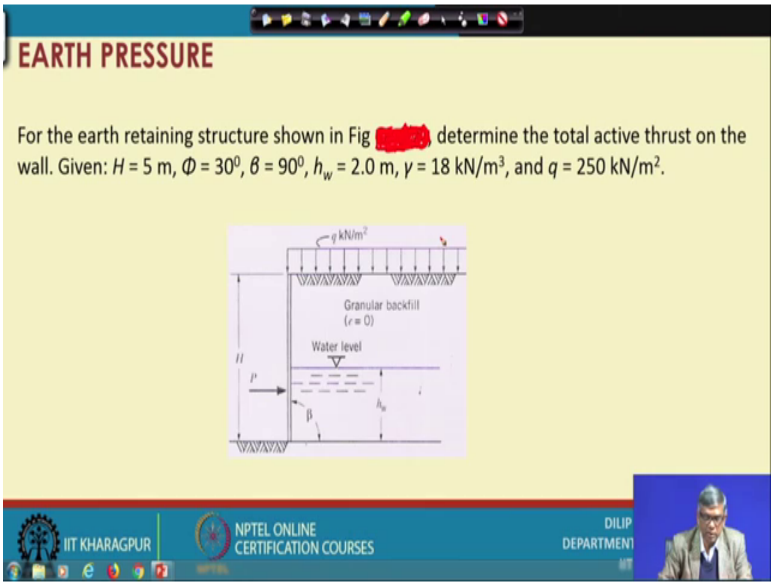

The second problem will be something like this, this problem you can see has, sorry; this problem had sorry; this will be next second problem is this for the earth retaining structure shown in figure sorry; this is wrong figure all the figure number is not required, oh sorry; figure this is not required. Suppose; so, this is the figure given as below.

So, this figure; so determine the total active thrust on the wall. Given H equal to 5 meter, phi 30 degrees, beta 90 degree; that means, this angle; that means, vertical wall h w is 2 meter, gamma is 18 kilo per, q is surcharge 250 kilo Newton. So, this is a all combination there in this problem and this is since vertical wall you can use the Rankine's wall

Rankine’s theory. So, by that let us start Rankine’s theory. So, since your phi equal to 30 degrees, you are phi equal to 30 degrees.

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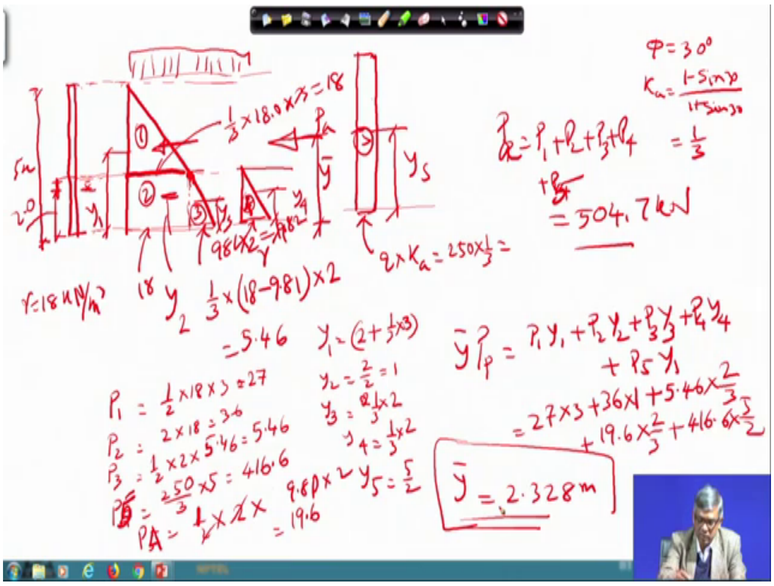

So, you have K a equal to 1 minus sin 30 divided by 1 plus sin 30. So, that gives you 1 by 3, and then you can find out gamma equal to 18. So, suppose I can take a wall somewhere here, I take a wall somewhere here and this height is 5 meter and water table was somewhere here, that is 2 meter and the total unit rate above and below the water table is can be taken as same. So, unit rate is given 18 kilo Newton per meter cube gamma equal to 18 kilo Newton kilo Newton per meter cube it is given.

So, you can do the pressure diagram here, first of all because of the soil and you can see upto this, upto this, that upto water table, upto water table the pressure distribution will be something, suppose I will draw the reference from here take the reference from here. So, upto it will be something like this and what will be this value this value will be 1 by 3 multiplied by 18.0 multiplied by; so 2 meter is there so 3.

So it will be ultimately this become 18, this intensity here 18. And now below the water table, what will be value this will be; so you can assume this much pressure already active here, and because of the soil from here to here additional pressure will come. When I consider soil here to here their surcharge; so surcharge you need to do it again, so that one diagram may come something like this. So, how to find out this one already 18 there, and what is the value of this? This reference can be taken as 0. So, it will be ultimately your K a is the 1 by 3 multiplied by gamma is 18 minus 9.81, this is nothing, but gamma surcharge; somultiplied by h equal to 2. So, this gives you the value equal to 5.46.

So, this is actually the; we have got three parts: 1 part, 2 part and 3 part. And this is regarding only the soil and now since the water is there; so water also will give a pressure on the wall. So, that water pressure diagram will be something like this, already I have discussed will be something like this and this value will be this value will be this value will be 9.81 multiplied by 2; that means, it will be your 19 point 19.82.

So, this value will be this one and then and here actually you have not multiplied by K a mainly, because K a for water is 1. And then we had a surcharge here already we have discussed that surcharge, because of the surcharge it will have uniform lateral testers; lateral pressure on the wall throughout the depth. And that the magnitude of the uniform pressure is it will be equal to this will be equal to q times K a.

So, that will be 250 multiplied by 1 by 3; so that will be equal to whatever value we will see that; so these are the things now four components we have got; one component, two comma three component this is fourth suppose this is forth and this is suppose fifth. Now, I can find out; the to find out the total thrust, I can find out the thrust one, thrust two, thrust three, thrust four, thrust five add all then I will get the; so P 1 P 1 will be half multiplied by in multiplied by 18 multiplied by 3. And so this will be equal to something, then your P 1 equal to 27 and P 2 will be equal to it is 2 multiplied by 18. So, it will be 36, P 3 will be equal to half multiplied by 2 multiplied by 5.46 so; that means, it is P 3 is 5.46, then P 4 will be equal to 250 by 3 multiplied by 5, 416.6.

And P 5 will be equal to ok; so this is the as per notation I have used. So, this can be use as a this is can be this can be as this can be used as P 5, this is P 5 suppose and this is P 4 this is P as I have mentioned. So, P 4 will be 19.6, P 4 will be half into 2 multiplied by 19 18 no 9.81 into multiplied by 2. So, this gives you 19.6. So, 9.80 suppose I have taken; so 19.6. So, these are the value we have got. And liberal suppose this is acting from here, this is suppose y 5; so y 5 and this is actually suppose y 4, and this is suppose y 3 and this is suppose acting here this is y 2 and this force acting here. So, these distances suppose your y 1. So, your y 1 will be equal to 2 plus 1 by 3 multiplied by 3.

So, that is actually ultimately it will be 3, and then y 2 will be equal to half of this too 2 by 2; that means 1; y 3 will be equal to y 3 will be equal to 2 one-third multiplied by 2 and y 4; y 4 will be equal to again one-third multiplied by 2 and y 5 will be equal to 5 by 2 ok. So, then I can consider the resultant force acting somewhere here and that is y bar distance. So, y bar multiplied by P will be equal to P 1 Y 1 plus P 2 Y 2 plus P 3 Y 3 plus P 4 Y 4 plus P 5 Y 5.

So, if I do that, then P 1 is something 27 and Y 1 is 3 plus P 2 actually is 36 and Y 2 equal to 1 plus P 3 equal to 5.46 multiplied by 5.46 and it is 2 by 3 plus Y 4 this is Y 4; Y 4 is actually 19.6 and it is multiplied by 2 by 3 plus P 5 is 416.6 multiplied by this is 5 by 2. Now, if I do this then I get P P already I have got P P is equal to P P equal to P 1 plus P 2 plus P 3 plus P 4 plus P 5, when if I do that then it gets actually 504.7 504.7 kilo Newton.

So, this one if I put here, then I get y bar equal to 2.328 meter so; that means, what you have to do? You have to draw the earth pressure diagram and for soil thrust, then there is water, then water you have to find then surcharge. So, all how to find how to use them already I have discussed, when there is surcharge simply multiply by the coefficient of earth pressure and that will be constant throughout and effective stress for finding out earth pressure you have to first find out the effective stress at any depth and then multiply by active earth pressure coefficients. So, that is the thing we have to done upto this since, there is no water table directly gamma times h time K and that upto this I have this ensure this is constant.

And from here actually since it is changing, so I can take another diagram, which will be equal to gamma effective multiplied by h into K a. So, if I do that that gamma you are getting. So, this all components are shown here and P 1 P 2. So, I have divided into four parts to easily get calculation. So, four parts P 1 P 2 P 3 separately I have done. So, total P P sorry not P P this is P a, P a will be nothing, but P a P 1 plus P 2 plus P 3 plus P 4 plus P 5. So, this is P 5 and that gives you 504.7 kilo meter and then by taking movement resultant 4 suppose acting as; suppose this is P a at y bar distance. So, this movement must be equal to the movement of all forces with respect to this line. So, that I have done based on that I have got this y bar equal to 2.328.

So, this is one application I have done. So, let me go to the next one.

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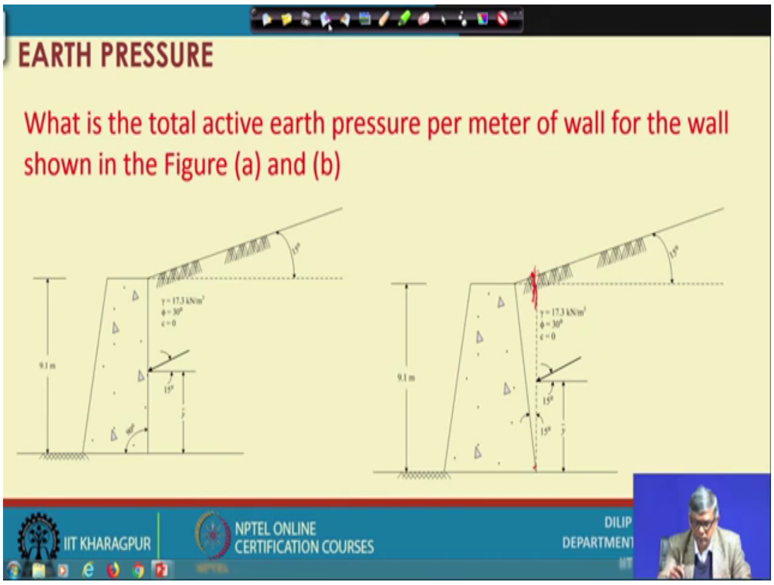

So, this is another problem you can see, this is simple application of you can say simply application of Rankine's theory when there is a slope is there and as I have mentioned, if there is a vertical phase is there like this, and if there is a if there is back slope is there, then how to consider I have mentioned that you have to extend line like this and then you have to consider this as a wall height from here to here this has to be considered as a wall height. And then your pressure will be acting at two-third or one-third height from the one-third from the base and it will be parallel to the sloping surface.

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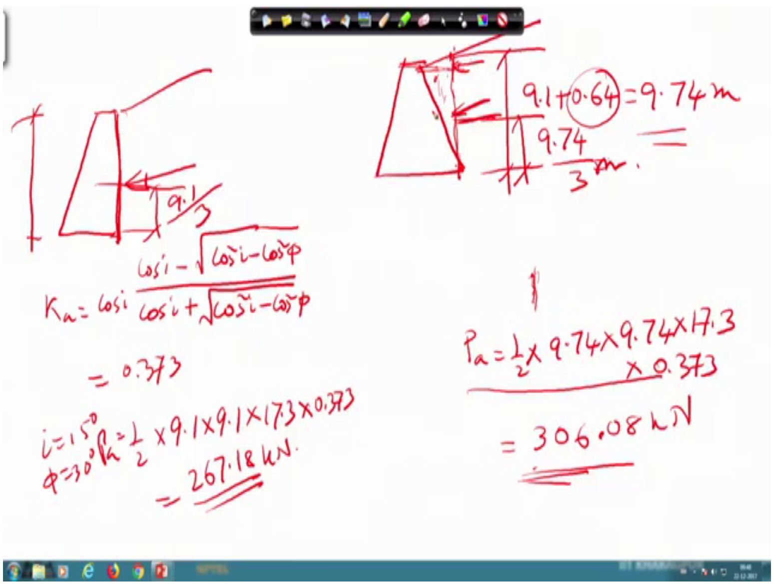

So, to do that I have taken the same problem twice as you can see the next slide sorry; so this one the wall is the wall was vertical wall is totally vertical, then your K a was equal to cos I and then cos I minus under root cos square I minus cos square phi divided by cos I plus under root cos square I minus cos square phi. And, if you find out this value comes, here i equal to 15 degrees and phi equal to 30 degrees.

So, if find out you get a value 0.373. And then your active earth pressure here will be this wall height was how much 9.1 meter. So, it was this was 9.1 meter. So, half multiplied by 9.1 and multiplied by 9.1 half gamma and gamma was gamma was 17.3 this is the volume and to multiply by K a, so 0.373 and if you do calculate; so this is P a if you find out the value this gives you 267.18 kilo Newton ok.

And this will be acting somewhere here and this, this height will be 9.1 by 3, but another problem was this is there and in addition to that this is also slope like this and which is like this. So, what I have to do now? I have to find out this height. So, the ultimately geometrically you can find out this distance. So, your ultimately height, ultimate height of the wall become 9.1 plus 0.64.

So, this becomes 9.74 meter rest of the thing K a everything was same. So, your P a will be equal to half multiplied by half multiplied by 9.74 multiplied by 9.74 multiplied by 17.3, multiplied by 0.373, that is K a. And that will be equal to gives you 306.08 kilo Newton. So, this is the difference actually you can see 267 was there and 306 almost 40 kilo Newton change is there, and it will be acting somewhere here parallel to this and this height will be now this height will be now 9.74 divided by 3 meter, whatever so; that means, by Rankine's theory, if there is a wall back is sloped like this, so what we have to do?.

You have to do from the edge you have to draw a vertical line to intercept the sloping surface and then from the top of the from above the top of the wall you have to take this additional height. So, to this additional height can be calculated geometrically, if it is i and then you can find out from geometry this length, and then if you know this angle then there is find these and these angle you can find out these. So, 0.64 height you have got actually; then 9.1 plus 0.46 that 9.74 become the new height and based on that height your calculation is 306 kilo Newton.

So, there is almost 40 kilo Newton difference by calculation if you take this. So, these also and when you do the stability analysis additionally this weight has to be taken etcetera that I will not bring again here or we will discuss later on may be in several in course.

So, these actually this is the third application, I may do some more in the subsequent places. With this let me stop for this module.

Thank you.