Foundation Engineering
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Lecture – 50
Retaining Wall – III

So, last class, I have calculated that the total forces horizontal and vertical forces of a gravity retaining wall, and then I determine the moment also. Now, this class I will apply those values.

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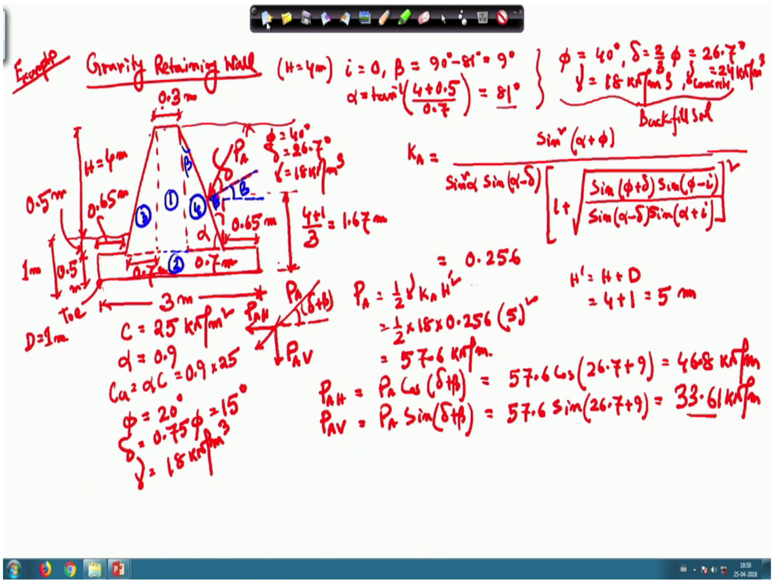

So, now for that purpose so let us go for that problem so that. This is the problem that was chosen.

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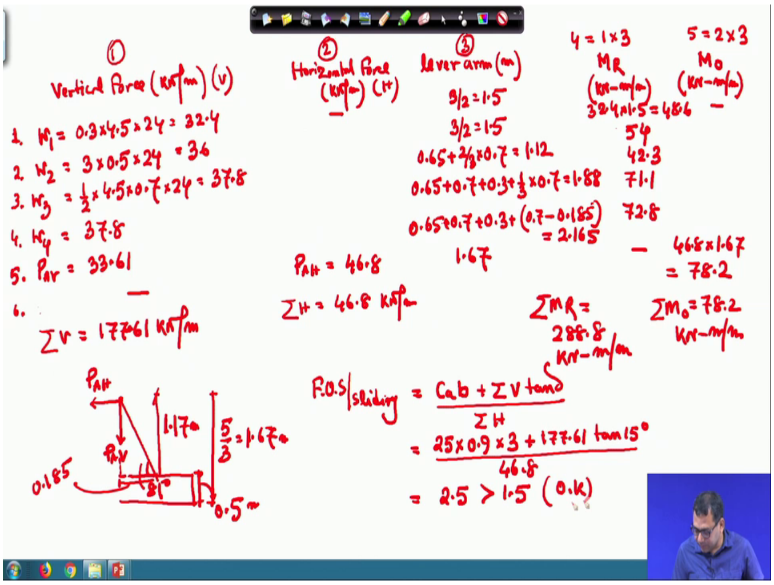

And these are the values the of that total vertical force was 177.61, total horizontal force is 46.8, total resisting moment is 288.8, total overturning moment is 78.2 ok. So, now first check I will do for the for the sliding ok. So, factor of safety for sliding. And as I mention that is if your base soil it is a C phi soil ok. So, the sliding will be equal to that C a into the b plus summation of all vertical forces into tan delta divided by summation of all horizontal forces. So, C a value is 25 is the C value into alpha, alpha is the 0.9 and b is 3 then plus summation of all vertical forces is 177.61 into tan delta, tan delta is 15 degree ok.

So, remember that when you calculate the earth pressure, that delta will be the delta of the backfill. And when you use this sliding check, then that delta will be delta of the base soil ok. Here we are using two different properties backfill soil is one proper one property, and the base soil is the another properties ok, because base soil is basically the existing soil and backfill soil is the filling soil.

So, we are taking two different properties. If the properties are same both the soils, then you can use the same delta for the stability calculation or sliding calculus of sliding check and the K A calculation, but here we are using two different delta. So, remained of remember that when you are calculating K A, that delta will be the backfill delta. And when you we are calculating the sliding stability, then that delta will be the base soil delta ok. So, base soil delta is the 15 degree. So, we are taking 15 degree and then that divided by all the summation of vertical horizontal forces is 46.8. So, this is equal to this value is equal to we are getting that 2.5, and which is greater than 1.5, so it is ok.

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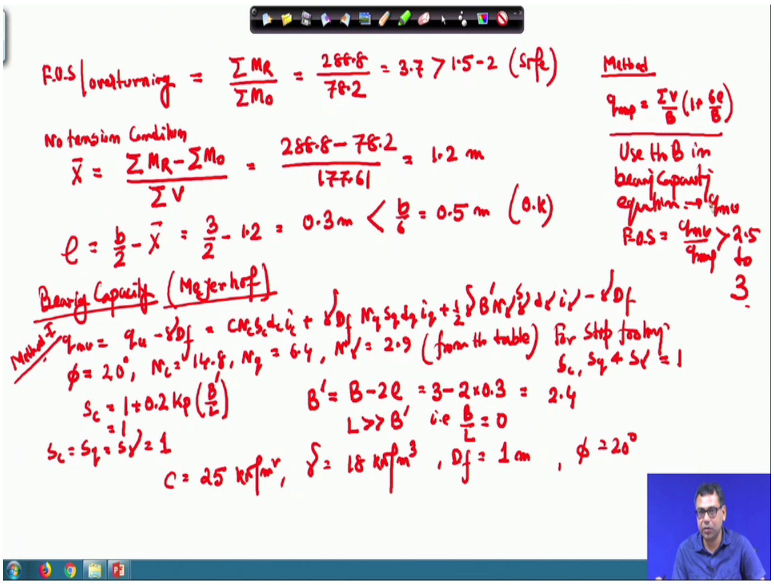

So, next one I will do the factor of safety for overturning ok. So, factor of safety for overturning is summation of a all resisting forces devises by summation of overturning resisting moment divided by summation of overturning moment ok. So, this summation of resisting moment; summation of resisting moment is 288.8 and summation of overturning moment is 78.2. So, summation of resisting moment is 288.8 and the resisting overturning moment is 78.2, resisting moment by overturning moment. So, this is coming out to be 3.7, which is greater than 1.25 to 2 to safe ok.

Then we will for the no tension check ok. So, the X bar that I discuss that I have already discussed how to calculate this X bar. So, this X bar is summation M R minus M 0 divided by all vertical forces. So, this is 288.8 minus 78.2, and vertical forces 177.61 that is equal to 1.2 meter. So, the eccentricity e is b by 2 minus X bar, now b is 3 meter divided by 2 minus 1.5. So, this is 0.3 meter now that is less than b by 6, which is 0.5 meter ok, so it is.

Now, for the bearing capacity calculation, so bearing capacity calculation what I will do, I will use, because we have various bearing capacity expressions available level, Terzaghi, Meyerhof, so Skempton, Hansen Vesic, but the here it is a inclined load condition you can see, because reaction that is a horizontal force as well as the vertical force. So, it is an inclined loading condition ok, so that is why we will use here the Meyerhof bearing capacity expression.

So, I am using here Meyerhof bearing capacity expression to calculate the bearing capacity. And you know that q net ultimate is equal to q ultimate minus gamma d f and that is equal to C n c S c d c i c plus gamma D f N q S q d q i q plus half gamma B n gamma S gamma d gamma i gamma minus gamma D f ok. Now, from the Meyerhof table, we have a phi value, phi value of the base soil ok. Phi value is 20 degree, so we have a phi value of 20 degree ok.

So, corresponding bearing capacity factor will get from the table. So, phi value is 20 degree. So, N c we are getting as 14.8, N q we are getting as 6.4 and N gamma is equal to 2.9 from the table. From the table that was provided during the shallow foundation bearing capacity calculation and it is a plane strain condition, so it is a strip footing retaining wall is length is very large compared to the width, so it is a strip footing. So, my for the strip footing I can write that S c S q and S gamma all are equal to 1 now, because it is a strip footing. So, your this b by 0 b by l is equal to 0. I can write the expression also that for example, S c expression for Meyer as per Meyerhof 1 plus 0.2 K p B by L ok.

And another thing is that here as there is a eccentricity. So, your B will change ok. It, now the new B will be B dash and that B dash is B minus 2 e ok. So, B is 3 meter minus 2 into 0.3 meter your you is 0.3. So, your B value B dash is 2.4. So, everywhere we have to use the B dash here also we have to use the B dash, because your this is the acentric loading, so B dash fine. So, now, as for strip footing your L is very very large compared to the B dash. So, I can write that B by L is equal to 0. So, if I put B by L is equal to 0, then S c is equal to 1.

Similarly S q and S gamma will also be 1 ok. Now, our C value is given 25 k p a, and gamma is so C value is 25 kilo Newton meter square gamma is 18 kilo Newton per meter cube ok. So, I am writing that that C is 25 kilo Newton per meter square, and gamma is 18 kilo Newton per meter cube. Now, we have to and D f depth of foundation is 1 meter, because here this is the depth of foundation D below the existing soil, and that is 1 meter. So, this is D f is or D or D f is equal to 1 meter. So, now, I have to calculate D c depth depth factors and the inclination factors.

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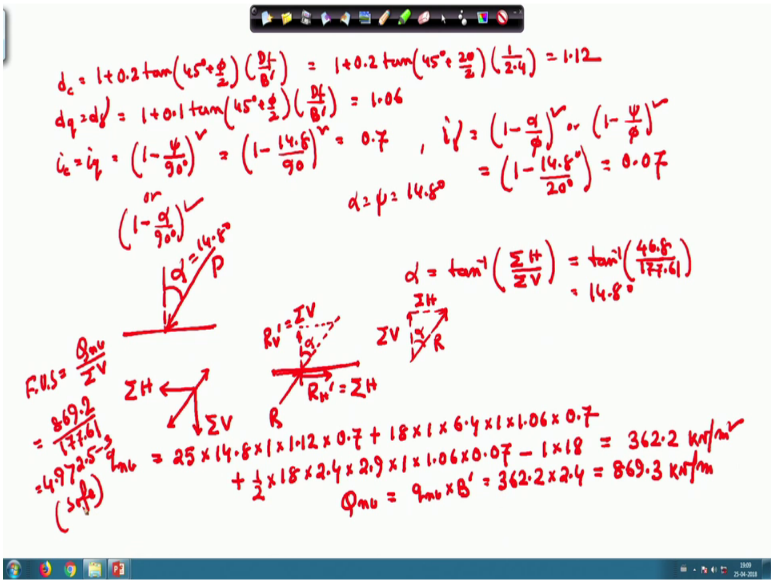

So, I will calculate now d c. So, as per Meyerhof d c is 1 plus 0.2 tan 45 degree plus phi by 0 into D f by B dash ok. And again your phi value is 20 degree ok. So, I can put these things 1 plus 0.2 tan 45 degree plus 20 divided by 2 Df is 1 B dash is 2.4, so it is coming out to be 1.12. Similarly, d q is equal to d gamma is equal to 1 plus 0.1 tan 45 degree plus phi by 2 into D f by B dash. So, if I put this value, it will be coming out 1.06.

Now, i c equal to i q is equal to 1 minus psi divided by 90 degree square or in the actual table it is given 1 minus alpha 90 degree square. What is alpha suppose this is your footing, this is the vertical line, so this is the direction of the force, and this is the alpha or psi. So, how I can calculate alpha here? Because here I have the alpha, this is the P and I have the horizontal forces as well as the vertical forces ok.

So, this is the summation of all vertical forces, this is summation of all horizontal forces ok. The reaction is your acting in this way, nah because this is the base of the retaining wall your reaction is acting in this way ok. So, I have discuss that and here this will be the R V dash that is the summation of all vertical forces. These will be the R H dash that is the summation of all horizontal forces ok. So, this is the reaction R.

So, the alpha value will be equal to here is tan inverse summation of all horizontal forces divided by summation of all vertical forces ok. So, because we are calculating this angle actually we are calculating this angle. So, this angle this is all summation of all horizontal forces, this is summation of this is the alpha angle ok. So, this is the summation of all horizontal forces, which is acting in this direction. And this is summation of all vertical forces, which is acting this direction. So, this is alpha this is the summation of all horizontal forces. This side is summation of all vertical forces I can write so that means here this is the reaction is acting R, this is the alpha. So, this one is the summation of all vertical forces, this is summation of all horizontal forces.

So, alpha will be tan inverse summation of all horizontal forces divided by summation of all vertical forces. So, I can write tan inverse summation of all horizontal forces is 46.8 and vertical forces is 177.61. So, this is 46.8 divided by 177.61, this angle is14.8 degree, so this value is 14.8 degree. So, this is 1 minus 14.8 divided by 90 whole square. So, this is equal to 0.7. Similarly, the i gamma is 1 minus alpha divided by phi square or 1 minus psi by phi square, and here alpha equal to psi equal to 14.8 degree. So, if I put that value 1 minus 14.8 degree and phi is 20 degree, so that is equal to 0.07 point ok.

So, now, I am putting all this value here q net ultimate, and I am getting that C is 25, N c is 14.8, S C is 1 dc is 1.12, then i c is 0.7 plus gamma is 18, i q 1 N q is a gamma is 18 D f D f is 1 N q is 6.4, because N q is 6.4 and then S q is 1, d q is 1.06 and i q is 0.7 then plus this is half unit weight is 18, then B dash is 2.4 then N gamma is 2.9 then S gamma is 1 d gamma is 1.06 and i gamma is 0.07 minus D f is 1 and unit weight is 18 so that is equal to 362.2 kilo Newton per meter square and, so that this is the stress. Now, the total force Q n ultimate will be equal to q net ultimate into B dash. So, this is 362.2 into 2.4 that will be equal to 869.3 kilo Newton per meter ok.

So, the factor of safety will be equal to the Q net ultimate divided by total vertical force ok, so that is equal to 869.2 divided by total vertical force is 177.61. So, total vertical force 177.61, so that is equal to 4.9. So, this is greater than 2.5 to 3. So, it is safe. So, this is the total design of this gravity retaining wall.

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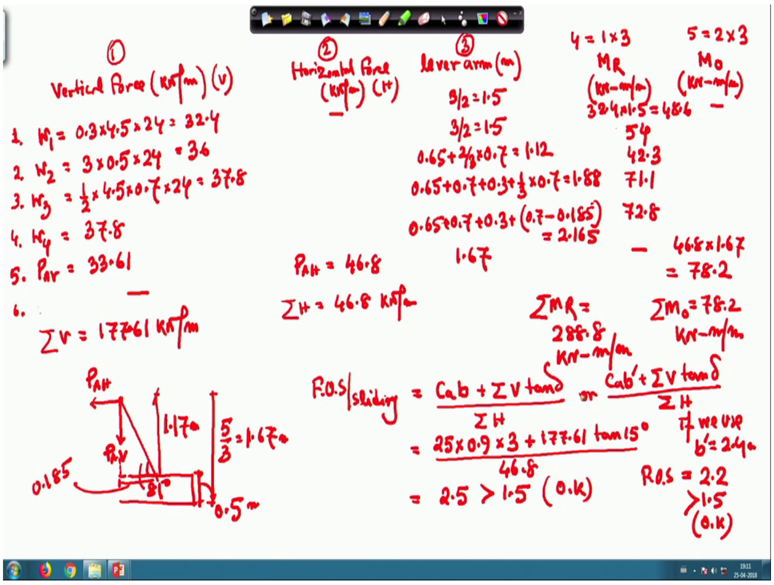

So, before I finish this design, one thing I want to mention that some sometime instead of using this table instead of using b you can use b dash also because this is the effective area you should use the b dash. So, instead of using b you can use c a b dash summation of V tan delta divided by summation of H. Now, if we use these things if you use b dash if we use b dash is equal to 2.4 meter, then the factor of safety will be equal to for the sliding will be equal to 2.2 instead of 2.5.

So, I will recommend you use b dash instead of b and then this is again it is greater than 1.5. So, it is ok. So, this is the total design that I have done. So, first the sliding check, then for the overturning no tension condition and the bearing capacity check that I have done for this particular problem.

So, in the next problem that I will solve it is a your cantilever retaining wall. So, I have solved the problem for gravity retaining wall. So, next problem that I will solve it is a cantilever retaining wall and I am choosing one particular problem for this case ok.

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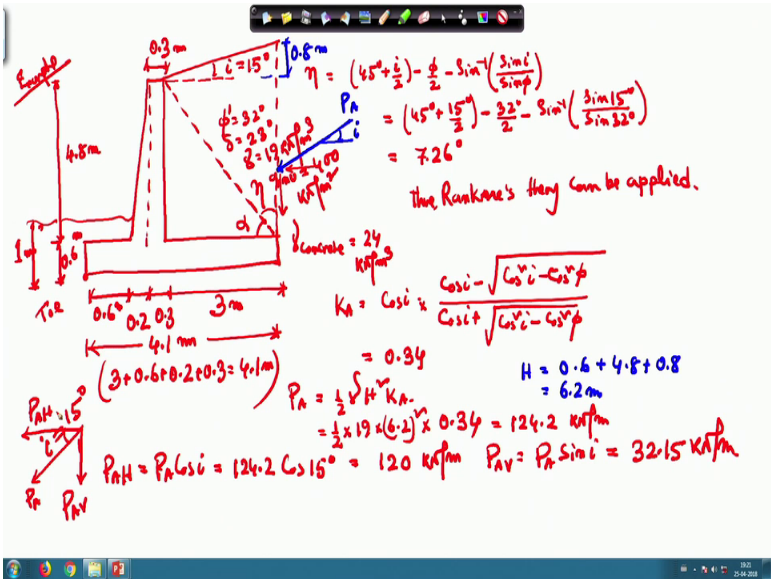

So, the first the example that I am taking is a cantilever retaining wall ok. So, this again the height of this wall from here to here this height is given 4.8 ok, and this one we have chosen for the first trial 0.6 meter, and the depth of this foundation is again I have chosen 1 meters. Now, the width of this top portion is 3 meter I am taking, and this is the inclined backfill ok, so the incline angle is i is equal to 15 degree, and this one is taken 0.6 meter or chosen 0.6, now this part is 0.2 meter, this one is 0.3, and this one is chosen 3 meter. So, this is the total dimension that was the these total dimensions are chosen for the first trial.

So, the total this dimension is 4.1 ok. So, this is 3 meter plus 0.6 plus 0.2 plus 0.3 that is 4.1 meter and this is the toe of the wall. So, first we will check whether we can use Rankine equation or not ok. So, as I mention this is the line and this is the alpha, and this is the psi. And psi expression is given that 45 degree plus i by 2 minus phi by 2 minus sin inverse sin i divided by sin phi.

So, here the backfill soil phi is given 32 degree or phi dash in terms of effective this is this is delta is taken 23 degree is given, unit weight is 19 kilo Newton per meter cube, and q net ultimate is given 400 kilo Newton per meter square. So, what is the difference in the previous problem the soil properties was properties were given. So, we determine the load carrying capacity of the foundation, but here the load carrying capacity q net ultimate is given ok. So, we have to determine the factor of safety.

So, the unit weight of concrete is equal to 24 kilo Newton per meter cube and you have to design this retaining wall. So, first check that, so this is 45 degree plus 15 degree divided by 2 minus phi is 32 degree divided by 2 minus sin inverse sin 15 degree divided by sin 32 degree ok. So, this is equal to this value is 7.26 degree, so it is a 7.26 degrees.

So, definitely you can check that this is 4.8 meter, this one is 3 meter, so it is 7.626 degree means it will pass through the backfill it will not touch the wall. So, we can use the Rankin theory thus theory can be applied. So, we will apply the Rankin theory here ok. So, this problem we can apply the Rankine's theory and. So, for the Rankin's theory K A expression for the inclined backfill is cos i into cos i root over cos square i minus cos square phi divided by cos i plus root over cos square i minus cos square phi.

So, i value is 15 degree and phi value is 32 degree. So, if I put this value this K will come out to be 0.34. So, my P A is equal to half into gamma into H square into K A. Now, here as I mention we are applying the Rankin's theory. So, the force will apply here, and it is parallel to i parallel to the backfill surface. So, it will be I, so this is P A.

And, now we have to consider the total height of this surface or this face. So, total height in this case H will be this is 0.6 then plus 4.8 plus this portion this portion is how much? This is 3 meter, this is 15 degree, so this one will be 0.8 ok. So, you can calculate this portion is 0.8 meter. How we are getting that, because this is 15 degree, and this one is 3 meters. So, you can calculate this is 0.8 meter. So, total H is coming out to be 6.2 meter ok. So, this is 6.2 meters. So, K A so that is why half into gamma is given 19 H is 6.2 meter whole square, and K A is 0.34 so that is equal to 124.2 kilo Newton per meter.

So, now it has two components again P P A V that is equal to P A cos i ok. So, sorry P A H first we are calculating P A H, which is the horizontal one PAH is cos i. So, this is 124.2 into cos 15 degree, so that is equal to 120 kilo Newton per meter. Similarly, PAV this is P A sin i so that is equal to 32.15 kilo Newton per meter so that means, now it has two components one is acting this direction, another is acting this direction ok. So, now, if I taking this is the P A, now this is the P A V, and this is the P A H ok. Now, this angle is i which is 15 degree so that is the all the forces I have calculated.

So, next task is that we have to calculate the forces, then the moment and the again we will do the check ok, so that checking we will do in the next class. So, before I finish this class, I want to mention that in the previous problem that we have use this B dash part ok. So, this B dash part, so in this problem we can solve in two ways in 2 methods ok. So, first method that I have discussed this is the first method.

In the second method so, this is the method 1 that I have discussed. Another method that you calculate q max ok, you calculate q max by this summation of V divided by B 1 plus 6 e divided by B ok. Then compare this q max with the ultimate net ultimate bearing capacity. But remember that during the calculation of net ultimate bearing capacity, if we are using this expression, do not use B das H you have to consider only B ok.

So, the either you if you use B dash, then you have to follow this technique. If you use this method, then do not use B dash, you have to use the B, then you use the B in bearing capacity equation. Then you get the q net ultimate ok. Then the factor of safety will be q net ultimate divided by q max that should be greater than 2.5 to 3.

So, this is the information I should share with you that if we are using B dash, then use these techniques that you calculate the force then you compare with the force, but if you are using q max, then do not use B dash use B and then calculate the load carrying capacity q net ultimate, then compare with that q net ultimate with the q max, and that should be greater than 2.5 to 3. So, any one of them you can use. So, I prefer to use the method 1 then or you can use the method 2 also I have use the method one here.

So, in the next class, what I will do, I will do the checking for this these cantilever retaining wall also that the as I have done for the gravity retaining wall. The similar way I will do these checkings that those four checkings that is sliding, overturning, no tension, and the bearing ok.

So, this with this I am finishing today’s class. And then the next class I will first do this checking. Then I will go for the next section of this course that is the design of sheet pile, another kind of retaining structure. And then I will also discuss what are the difference between the sheet pile and this retaining wall. Basically, these are the rigid retaining wall, rigid type of retaining wall, but the sheet pile is the flexible kind of a retaining wall, but where we will use those retaining wall. So, those things I will discuss in the next class.

Thank you.