Foundation Engineering
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Lecture - 51
Retaining Wall - IV

So, this class I will solve the remaining part of that cantilever retaining wall problem. So, the problem that was taken is a cantilever retaining wall. So, the example problem was so it was a cantilever retaining wall ok.

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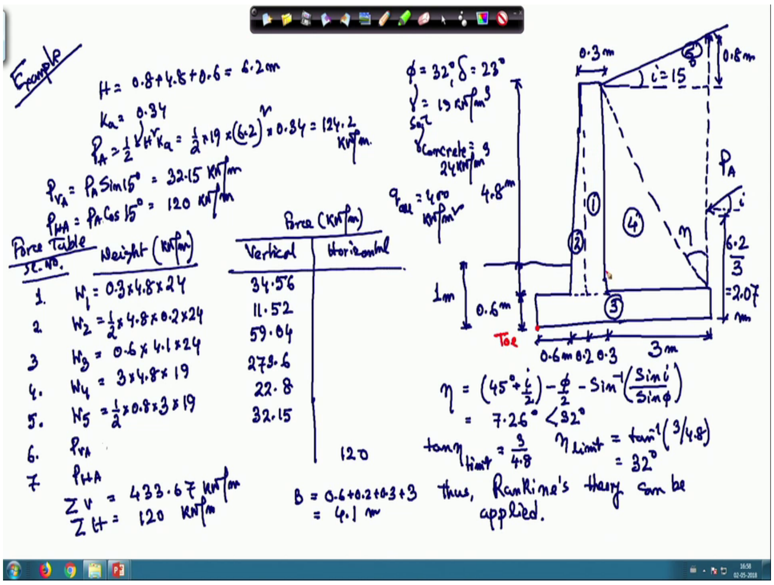

So, the dimension that was chosen for this cantilever retaining wall, so that thickness of this base was chosen as 0.6 meter, this is the foundation level and it was a inclined backfill with the inclination of 15 degree ok. So, this is the inclined backfill, this is the foundation and this foundation depth was 1 meter, and from here to here it was 4.8 meter ok.

And the other dimensions this one is 0.6 meter, this is 0.2, this one 0.3. So, this is also 0.3 meter, and from here to here it is 3 meter. So, that value of eta, so this is the eta, eta expression was 45 degree plus phi by 2 minus 45 degree plus i by 2 i by 2 minus phi by 2 minus sin inverse sin i divided by sin phi. So, this value was coming out to be 7.26 degree.

And so if I want to determine the limit of eta, because as I mentioned if I want to use the Rankine's theory, then your this line should not pass through the wall. So, the limit of eta, so I can write from here that this is the limit is equal to this is eta, this is 3 meter, and this one is 4.8 meter; so this will be 3 divided by 4.8. So, eta limit or the eta maximum was tan inverse 3 by 4.8, so this is 32 degree, but this case this eta is less than 32 degree. So, we can use the Rankine theory, thus theory can be applied.

So, we can use the Coulomb's theory also, but the previous problem I solve considering the Coulomb's theory. So, this problem I will solve considering the Rankine's theory. So, here because this is the limit is 32 degree. So, 32 degree means this line we just cross this wall and touching this top point. And if it is less than that means, it will pass through this portion, so that is less than 32 degree, so Rankine's theory can be applied. And another one that the total height was calculated, so this value is 0.8 meter, because this is i value is 15 degree, this one is 3 meter. So, we can calculate this is 0.8 meter. So, the total H value was 0.8 plus 4.8 plus 0.6; so this is 6.2 meter.

So, the force that this was acting that P A is with a height of 6.2 divided by 3 that is equal to 2.07 meter ok. So, as I mention the P A for the Rankine case always parallel to the backfill. So, here it will also act with an angle of i equal to 15 degree with the horizontal. So, and this is H by 3 H is 6.2 meter. So, and the values were given that phi value was 32 degree, delta value was 23 degree, unit weight of soil was the 19 kilo Newton per meter cube, and unit weight of concrete was 24 kilo Newton per meter cube. And q allowable was 400 kilo Newton per meter square ok, this is kilo q allowable.

So, these were the properties I remember that here the backfill properties and the base soil properties both are same, in the previous problem on gravity retaining wall that time the backfill properties and the base soil properties were different, but here both the properties are same. So, when you calculate the P A, you have to consider the backfill property, when you are calculating the base soil, when we are checking the sliding and the bearing capacity, those times you have to consider the base soil property, but this case this problem both are same. So, we will consider the same properties for backfill and the base soil.

So, this was the problem, and the K a value was calculated as 0.34 and P A is equal to half gamma H square into K a; so that is equal to half into 19 into 6.2 whole square into

0.34. So, this value was 124.2 kilo Newton per meter. So, the P V vertical component was P V A that P A sin 15 degree so this value was 32.15 kilo Newton per meter. Similarly, P H A is P A sin sorry cos 15 degree, P A cos 15 degree; so this is equal to 120 kilo Newton per meter ok.

So, now we have to check the all four conditions that the sliding overturning no tension and the bearing capacity. So, first we are calculating the weight of the different loading. So, as I mentioned that in case of Rankine's theory, we will apply the force in this line the face of the wall, but in case of coulombs theory we applied on the wall itself. So, in the coulombs theory we did not consider the weight of the soil, but here in the Rankine's theory we will also consider the weight of the soil, during the stability checks ok.

So, we are talking of the weight of the soil. So, we are taking the five parts. So, this is part 1, this triangular portion is part 3, this part 2, this rectangular portion is part 3 and this portion is part 4 this total rectangular one, and part 5 is this triangle one ok. So, these are the all five parts. So, first one is the serial number, second one is the weight that is kilo Newton per meter and so that the force; that is kilo Newton per meter; and this is vertical; and this one will be the horizontal ok. So, these are the table for the force table ok.

The first one is the first serial number; the first weight whose height is 4.8 and width is 0.3 meter. So, the W 1 is equal to it is the rectangle. So, 0.3 into 4.8 and it is the retaining wall; so it is a concrete is 24. So, and this will be the vertical force. So, the vertical force will be 34.56 kilo Newton per meter ok. Second one is the W 2; W 2 is this triangular portion. So, this is equal to half into 4.8 then width is 0.2, 0.2 into 24 is the unit weight of the concrete, and this is also vertical; so this is 11.52.

Then the third component, a third part is this rectangular part of this wall. So, this will be the 0.6, this is the height and the total length of this portion is 0.6 plus 0.2 plus 0.3 plus 3; so this is the B value, and B value is equal to 4.1 meter. So, this is the width of the retaining wall. So, this is 0.6 into 4.1 into 24 so this is equal to 59.04 kilo Newton per meter.

And the fourth component, fourth part so this is also will act, this will also in the vertical direction. Fourth component is the rectangle portion of this soil. So, this rectangle portion of the soil, whose height is 4.8 and width is 3 meter because this is 3 meter. So, you can write 3 into 4.8 and it is a soil; so unit weight will be the 19. So, this is also acting in the vertical direction. So, this will come 273.6 kilo Newton per meter.

Similarly, the fifth portion the W 5 is equal to this triangular portion upper triangular portion of the soil. So, whose height is 0.8 meter, width is 3 meter, so this will be half into 0.8 into 3 into it is a soil; so it will be the 19. This will also act in the vertical direction. And then the sixth part is the P V A. P V A is the vertical component. So, this is equal to vertical part. So, P V A will be 32.15 kilo Newton per meter.

Seven component is P H A, and it is the only horizontal part. So, this value is 120 kilo Newton per meter. So, these are the all forces that I have consider ok. So, this column is the vertical forces and this column is the horizontal forces; so, next one that we have to take the moment. So, now if I take the summation of these all vertical forces, so you will get the summation of means the if I add all these forces, then this is coming out to be 433.67 kilo Newton per meter. And the summation of all horizontal forces that is 120 kilo Newton per meter. So, first force table this is the force table is done.

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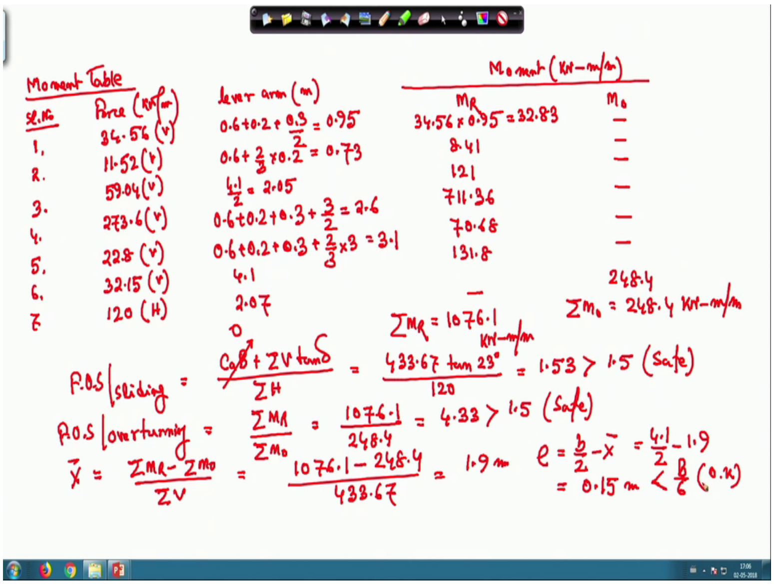

Next one is the, we will consider the moment table ok. So, again I am taking the serial number, then this is the force kilo Newton per meter, then the lever arm meter. Then the moment which is kilo Newton meter per meter and eta two parts, one is the resisting moment, another is the overturning moment ok. So, the first force that is the serial number one which is 34.56; so, this is 34.56, and it is vertical force. So, I am writing V means the vertical. And lever arm will be so first force lever arm, we are taking the all the moment about the toe.

So, I am taking the moment about the toe, so this value will be 0.6 plus 0.2 then plus 0.3 divided by 2, because it will act center of this portion. So, the lever arm of the first W 1 will be 0.6 plus 0.2 plus 0.3 divided by 2; so this is equal to 0.95. So, this will give the resisting moment; so I can write that this is 34.56 into 0.95 so first one is equal to 32.83 kilo Newton per meter; so this is the resisting moment. So, all the vertical force this will give the resisting moment except the only the horizontal force that will give the overturning moment.

So, the second one the second force is 11.52. So, this is 11.52 again it will act in the vertical direction, and this force is 0.6 plus two-third of 0.2, because this is from this side, so this will be two-third of 0.2. So, I can write this is 0.6 plus two third of 0.2 which is equal to 0.73; so I can if I multiply with these, the resisting moment will be 8.41 ok. So, I am directly giving the resisting moment. So, and then for the third part the force is 59.04. So, this will be the 59.04, this is the vertical and the lever arm will be this is the 4.1 divided by 2, because this will act at the center of this rectangular portion. So, this is a lever arm will be 4.1 divided by 2 this is 2.05.

So, the resisting moment will be 121. Then for the fourth part, fourth part of this rectangular portion of the soil and this is 273.6, this is 273.6 and this will act in the vertical direction; so and the lever arm will be 0.6 plus 0.2 plus 0.3 plus 3 by 2 ok. So this will be 0.6 plus 0.2 plus 0.3 plus 3 divided by 2, so this value is 2.6. So, if I multiply this 2.6 with 273.6, so this is 711.36; so, the fifth portion. And the see fifth portion it is third fourth fifth, fifth is 22.8. Fifth is 22.8, this is vertical, so lever arm is this triangular portion; so this will be 0.6 plus 0.2 plus 0.3 plus two third of 3 ok; so this will be 0.6 plus 0.2 plus 0.3 plus two third of 3 ok, so this is 3.1. So, the total resisting moment is 70.68.

Then the sixth part, the force is P V A is 32.15. So, this is 32.15, this is also vertical, and the lever arm is so this will act at a height of 2.07 from the base and add this face, this face is 4.1 from the toe. And this is the vertical one, so this will act 4.1; because it has two component, one is vertical, one is the horizontal. This is P H A, this is P V A, and P V A is acting the height as a distance of 4.1 meter from the toe; so that is 131.8.

Then the seventh one is 120 kilo Newton per meter. So, this is 120, but this one is the horizontal. And this will act with a height of 2.07 from the base. So, this will be 2.07 meter. So, if I multiply that so this value will be 248.4, because this is the overturning moment. So, the summation of the resisting moment is 1076.1, and the summation of overturning moment is 248.4 kilo Newton meter per meter, this is kilo Newton meter per meter.

So, now I will calculate the factor of safety, first for the sliding ok. So, as I mention the this is C a into b or b dash plus summation of vertical forces into tan delta divided by summation of all horizontal forces, as C a value is 0 here, so I mean cohesion is 0, there will be no addition part. So, because this is the cohesion value, there is no cohesion value C value is 0 ok; so this part will be 0. So, the summation of all vertical forces is 433.67. So, summation of all vertical forces is 433.67 then the tan delta, tan delta value is 23 degree. So, this is 23 degree divided by summation of all horizontal forces is 120 kilo Newton per meter. So, this will be 120 ok.

So, this is equal to 1.53 which is greater than 1.5. So, I can write this is safe, because I have given the limit 1.5 to 2 ok; then for the factor of safety for overturning. So, this is the all summation of resisting moment divided by summation of overturning moment. So, the summation of resisting moment is one point 1076.1 resisting moment is 248 point overturning moment is 248.4 and the resisting moment is 1076.1. So, this is 4.33 greater than 1.5, so this is also safe.

Now, we will do the no tension check X bar is the net moment divided by summation of all vertical forces. So, net moment is 1076.1 minus 248.4 divided by all vertical forces is 433.67 ok, this is 1.9 meter. So, the eccentricity e is b by 2 minus X bar ok; so that is equal to 4.1 divided by 2 minus 1.9. So, this is equal to 0.15 meter and this is less than b by 6, because b is 4.1 divided by 6; so this value is less than b by 6 or capital B or small b ok, this can be capital B or B dash; so this is. So, next one that we will do the bearing capacity check.

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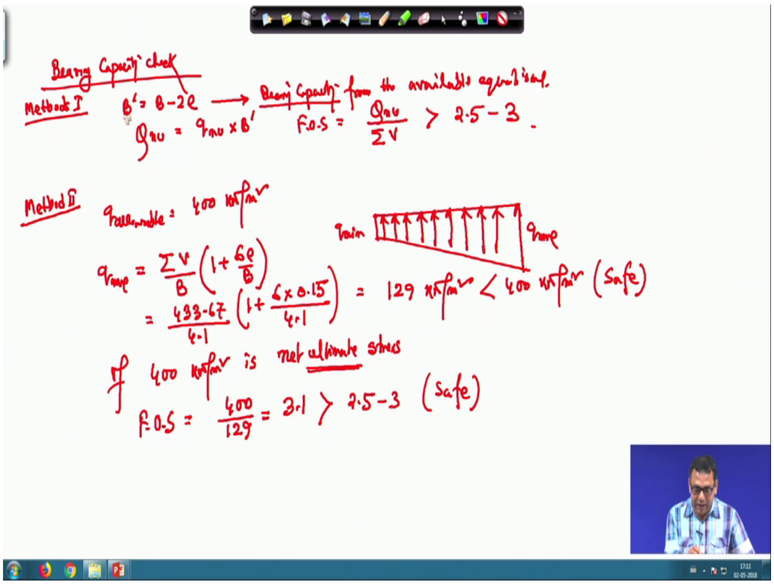

So, for the bearing capacity check, as I mentioned that we have two methods; method 1, so method 1 I applied in the first problem or the gravity retinal problem, where we are calculating B dash in the form of B minus 2 e; then we use these B dash to calculate the bearing capacity from the available equation ok. So, we use the so we calculate the bearing capacity by using the available equation.

So, last problem I use the mirror equation, then we calculate the total force Q net ultimate by multiplying the q net ultimate into B dash ok. Then I got the factor of safety is Q net ultimate divided by a summation of all vertical forces ok; so that should be greater than 2.5 to 3 ok, that is the method 1.

In the method 2, as the bearing capacity value is already given, because this is the q allowable is given 400 kilo Newton per meter square. So, here what we will do as we know that we have a bearing capacity or the soil stress distribution is like this, because of the eccentricity; this is q max and this is q min [noise. And if your e is equal to B by 6, then this point will be exactly 0 ok. So, but it is not exactly B by 6, so it will be some q minimum and q maximum. So, this will be your soil pressure distribution.

So, I can calculate the q max is equal to summation of all vertical forces divided by B 1 plus 6 e divided by b and if I put minus here then that will give you the q min, as I am checking the bearing capacity; so that is why I am taking the maximum stress that is coming on the soil ok. So, summation of all the vertical forces is 433.67 B value is 4.1

then this will be 1 plus 6 e value is 0.15, so e value is 0.15 again B is 4.1; so this is 129 kilo Newton per meter square, so which is less than 400 kilo Newton per meter square, so that is safe.

Remember that that is a q allowable is given that means, the q allowable the amount of stress that you can allow, but if that 400 kilo Newton per meter square is the ultimate or the net ultimate, ultimate stress this if it is ultimate ok, then you have to determine the factor of safety. So, this case the factor of safety will be 400 divided by 129, so that is equal to 3.1 so greater than 2.5 to 3, so it is also safe.

So, remember that if it is q allowable 400, then your stress should not be greater than that, but if it is ultimate then you have to determine the factor of safety, and the factor of safety should be greater than 2.5 to 3 ok. So, these are the all the four checks are done, but remember that do not mix these two methods. If you are using B dash by B minus 2 e then do not put or then do not use this expression. Then you calculate the bearing capacity by using the available expression, then multiply it with the B dash, then determine the factor of safety.

And if you are using the method 2, then do not use B dash ok. In that case, in method 2 all the values you have to calculate, all the stresses you have to calculate by considering B. And in method 1 by considering B dash ok. So, do not mix these two methods, if you are using method 2, then it will be only B, and then you do the checks in this way, because this is a checks in terms of stresses, but here the checks in terms of factor of safety in terms of force ok. So, these are the two different things for these two methods ok.

So, in the next class, I will discuss that few small things related to retaining wall that if generally we prefer to use a retaining wall with cohesion less soil; so that they should not be the water inside the soil or you can easily move that water from your side, because this water will increase the stresses on the on the wall ok. So, what are the procedures that you should follow to minimize the water table effect during the retaining wall design ok.

Thank you.