Application of Soil Mechanics
Prof. N. R. Patra
Department of Civil Engineering
Lecture – 15

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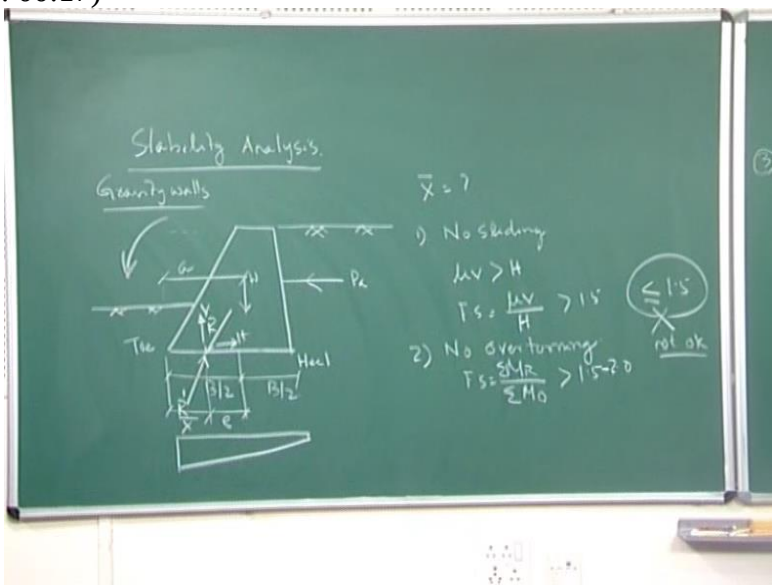

Last class, we have started this stability analysis. If I quick redraw what has been drawn in the last class. A gravity retaining wall has been taken into consideration, simple retaining wall without any backfill is horizontal, and there is what are the forces acted on these, these has been taken into consideration. This is toe, this is your heel and total half of the part is your B by 2, this is my B by 2. Then distance from here to here is X, distance from here to here is your e. So we have consider this last time stability analysis, if you take a simple retaining wall of a kind of gravity retaining wall, what are the different forces acting, one is your force because of soil retain, this is your active earth pressure and retaining wall self weight – this is W, and this is weight-W. This is a distance a from the toe of the retaining wall and total resultant force R will be acted at a distance of X from the toe.

And what are the different stability you are going to find it out. First part you will find it out X bar, what is your distance. This you can say that X prime. What is the distance of resultant forces acted at this point from the toe? If you take momentum about this point toe, you will find it out X prime that I have already said. Then once you get X prime then you find it out all these factor of safety. First one is your no sliding; for case of no sliding, so mu V v should be greater than is

your horizontal forces. So factor of safety is equal to mu V by horizontal forces, mu is your coefficient friction between the wall and soil, H is your total horizontal forces, ah reaction forces, horizontal forces, V is your vertical forces. This factor of safety should be greater than one point five, if there is no sliding. No sliding means, this wall is suppose to, if it is a less than one point five what will happen entire wall will slide along the base and it will go somewhere else. So for no sliding factor of safety should be greater than one point five. If it is less than equal to one point five, so may be shear key may be provided at the regular interval, will see in the example problem.

Then after no sliding, the second factor of safety you will have to consider that is your no overturning. In no overturning, factor of safety is equal to moment of resistance, summation of moment of resistance by summation of moment of overturning. And it generally varies between 1.5 to 2.0 1.5 to 2.0. If you look at no overturning, what do you mean by this retaining wall, because of earth pressure P a, it may possible that it will overturn above the toe. So that means what is your moment of resistance by moment of overturning. Moment of resistance is by self-weight, it will not allow to overturn; self-weight times of a this is your moment of resistance that means it will not allow to overturn.

What is your overturning moment, this active earth pressure acted, it will take a distance from here to here, it will your overturning moment. So check this for no overturning the factor of safety should be 1.5 to 2.0.

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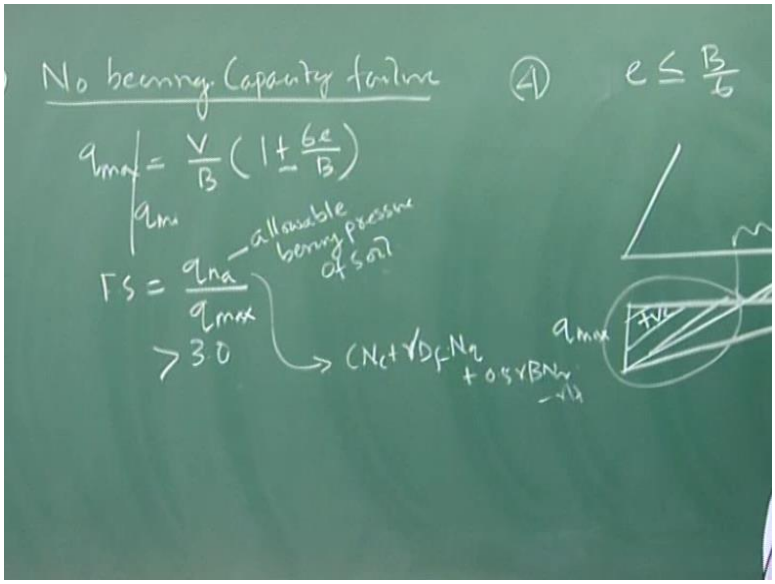

Then third is your no bearing capacity failure. No bearing capacity failure means this retaining wall should not fail by means of bearing capacity, because this retaining wall rest on the soil, it should not fail by bearing capacity. So find it out the pressure below the maximum pressure below the retaining wall, this is your V by B, V is your summation of vertical forces, B is your width into 1 plus 6 e by B. If I write q maximum by q minimum, so it will be plus minus 1 plus minus 6 e by B. So for factor of safety against no bearing capacity failure, it should be q n a by q maximum; q n a is your allowable bearing pressure of soil. So it should be, for no bearing capacity failure, it should be greater than - factor of safety should be greater than equal to 3 - for no bearing capacity failure.

Then fourth part is your no tension. For no tension, for no tension crack, e should be less than equal to B by 6, that means this eccentricity e, it should be less than equal to B by 6. For that you will have to find it out your means this is for your no tension. So what will happen, these are the stability analysis case one for say gravity wall, all walls, but I am writing it right now gravity walls. A simplified case, what are the forces, the disturbing force is your active earth pressure, because of your soil. And this stabilizing force is your, because of your self-weight. So you find it out what is your resultant force, and find it out what is the distance X bar. Once you get distance X bar, you can find it out e – eccentricity, you can find it out.

And check all the factor of safety. First case is your no sliding; if there is a sliding, then what will happen, the factor of safety should be less than equal to 1.5. In that case, what will happen, this retaining wall will be entirely move at the base of the wall. So if it is less than equal to 1.5, that means this design is not ok. So then remedy should be taken either shear key will be provided here at the toe, or may be at intermediate position below the base of the wall. And for no overturning, that means moment of resistance force should be greater than moment of overturning, and this factor of safety should be greater than 1.5 to 2. If it is less than one point five or two, then what will happen, the retaining wall will tuple, the retaining wall will tuple along the toe that means as a body as a whole body, it will rotate along the toe. So there is a failure of chance is there because of overturning. Then for bearing capacity, once it is resting on the soil, you find it out what it is the maximum pressure at the base of the wall. Maximum pressure at the base of the wall, you can find it out maximum and minimum.

The moment suppose this is your retaining wall, let us say this is my base of the retaining wall. So what are the possibilities, what are the possibilities for the two conditions, let us start with no tension. No tension mean e should be less than equal to B by 6. In that case, what will happen, the pressure will be positive side, what is the below this wall, the pressure will be in positive side. If this pressure is not in positive side, suppose this kind of pressure distribution you are getting that means this is positive and this is negative. What is it means, it is say it is a negative pressure that means these part of the base of the wall, these part is not going to in contact with your soil. So what will happen, your pressure distribution will be done by only this part. So redesign has to be done. So as far as possible, you always satisfy no tension criteria. So once you satisfy the no tension criteria that means your q maximum and q minimum, there should be in positive side, positive side below the retaining wall. So how do we find it out q maximum and q minimum; q maximum and q minimum, it should be V by B. V is your summation of vertical forces, B is your width, one plus minus six e by B. If it is a plus, then you are getting q maximum; if it is a minus, you are getting q minimum.

So once you get q maximum, so you check your factor of safety against bearing capacity failure of retaining wall. So q n a is your net allowable bearing pressure of soil, from where you will get it, you can get it from ((Refer Time: 11:16)) bearing capacity theory, C n c gamma D v N q plus 0.5 gamma B N gamma. Once you find it out divided by net allowable bearing pressure that

means net means minus gamma D f, minus gamma D f will be there; allowable means a factor of safety will be there. So factor of safety, complete factor of safety is your net allowable bearing pressure divided by your q maximum, what is your q maximum, you are getting from your ah pressure distribution below the wall and it should be greater than three. Once this stability analysis has been satisfied, then you will go for a structural design.

There are two parts of retaining wall. Two parts of retaining wall design; one is your geotechnical, other is your structural. In geotechnical part, you first have to satisfy all these stability criteria, force stability criteria; once it has been satisfied, then you go for your structural part. For gravity retaining wall, no need for structural wall, structural design, what for enforced ah means kind of your count of your retaining wall and other retaining walls, you need to have your structural design. We'll see these other parts of your stability analysis.

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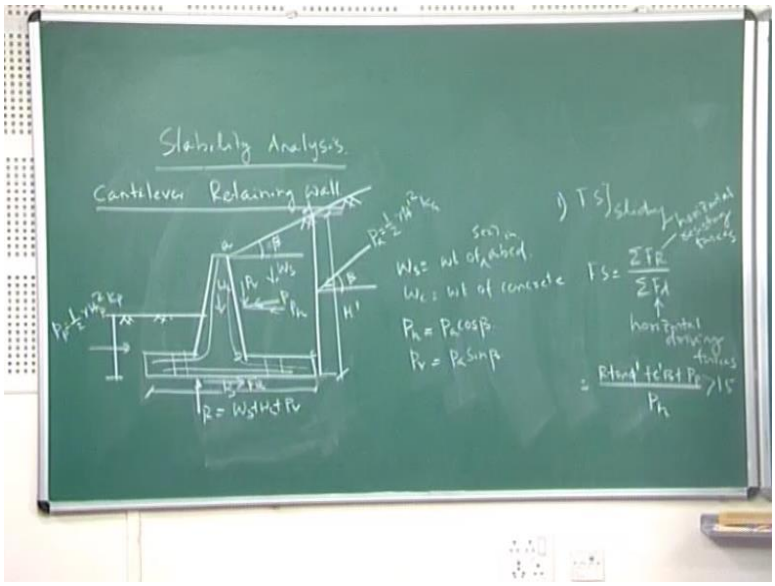

Second case is your cantilever retaining wall. Let us consider a cantilever retaining wall. This is B – width B, then your suppose say resultant forces R is equal to W s plus W c plus P v. Now this is your W c – weight of the concrete; and this is your P, so it will be coming P v as well as P h; then this is your F R. And if I put it in this way, so your active earth pressure will act upon at an angle beta with P a is equal to half gamma H one prime into K a, so this is my H one prime. So W s is your weight of a b c d. If I write this is my a, this is my b, this is c, this is your d. So W

s is equal to weight of a b c d; W c is equal to weight of concrete. And P h is equal to P a cos beta, P v is equal to P a sin beta.

Now if I write it factor of safety against sliding, factor of safety against sliding – first one then it will be factor of safety equal to F r by F d. F d is your horizontal driving forces, F R is your horizontal resisting forces, and F d is your horizontal driving forces. So factor of safety, If I write it, this will come R tan phi prime plus c dash B plus P p by P h. Then it should be greater than 1.5, it should be greater than 1.5 as I said earlier.

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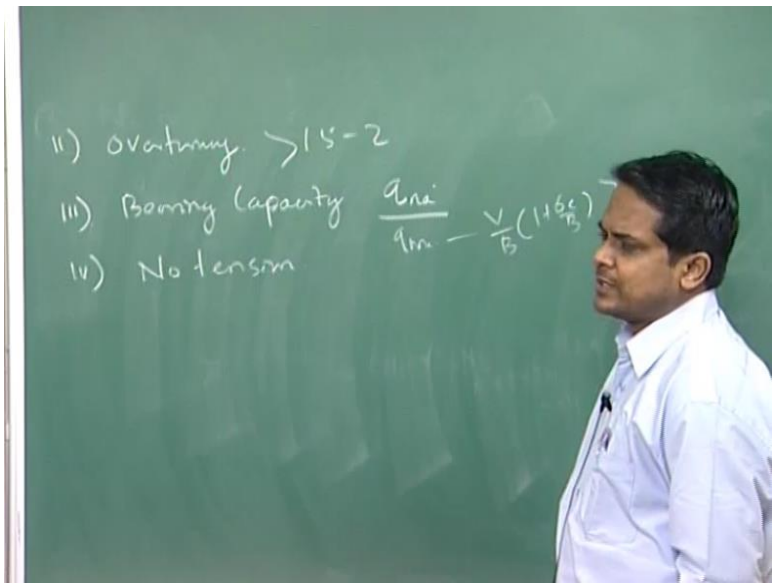

Then other checks are, other checks are as usual. There are what are the different, other factor of safety, this is your sliding, second is your overturning, third is your bearing capacity, fourth is your no tension.

If you look at here, I have consider a typical cantilever retaining wall and this cantilever retaining wall has been constructed by means of RCC concrete – reinforced concrete material with along with the steels. These are the steel bars has been provided along with the steels. So typically I have consider also a surcharge will be there means this soil it is with an angle it will retain the soil mass. So first you identify what is your stabilizing forces, what are your stabilizing forces. So if you take a typical cantilever retaining wall, this part is your retaining soil mass may be with this label of the ground, may be inclined. I have consider a typical inclined ah phase of this ah soil mass - retaining soil mass, so active earth pressure will be acted upon by at an angle

beta, so it will be it has two components P v and P h. First you identify what is your means resisting forces, what are the resisting forces, weight of the concrete acted on these, these are vertical downward weight of the concrete, because this has been constructed by means of RCC reinforced concrete. So this is your stabilizing forces.

Similarly, the weight of these part of these wall retain, it has a self-weight. It is say W s, W s is your weight of soil soil in a b c d, a b c d weight of soil. So this is your also stabilizing forces. What is the other stabilizing forces, P v; this P a has two component P v and P h. So it is again a stabilizing force. So what is your destabilizing forces or may be you can say that driving forces, this is your horizontal – horizontal forces P h. This will try to push this wall or overturn this wall, this will be your /// driving or this P h is your horizontal forces. If I consider all these P h, P v and all these, so there are as I, as we have discussed, there are core stability criteria, factor of safety against sliding, factor of safety against overturning, factor of safety against bearing capacity, and there should be no tension.

If you look at the factor of safety against sliding, it is your resisting forces by driving forces. So resisting forces what is coming, whatever the vertical forces coming W c, W s, P v, you find it out its resultant R. So each action has equivalent opposite reaction, so R has been taken into consideration. R is equal to W s plus W c plus P v. So it will be R tan phi, because phi is your angle of angle between this soil, angle of the this is your phi, angle internal friction angle of your soil, R tan phi. c dash B, what is c dash B, if this soil has 2 parameter c and as well as phi, c and phi - c prime and phi prime, this is your strength parameter c strength parameter. This unit cohesion will act along the base of the wall, so that’s why it will be your c prime, B prime; this is your horizontal resistance forces as well as R tan phi, and P p.

What is your P p. Once you retaining wall you place, once you place the retaining wall for retaining the soil mass, you cannot place all along above the ground surface. You have to take the retaining wall some depth below the ground surface so that it can be achieved some stability. So this force, because of this soil mass here, it will be acted by passive earth pressure P p. So it will be R tan phi prime, c prime B and P p by your what is your horizontal driving forces as I said earlier, your horizontal driving forces will be P h. So this factor of safety should be greater than one point five, it should be greater than one point five. So then all other things overturning and bearing capacity, and no tension. For overturning, moment of resistance by moment of ah ah

overturning means driving, so with these help of these forces, you can find it out what is your resisting moment. So resisting moment will become all along your weight of the soil, weight of the concrete and P v above the toe.

If this is my toe, and this is your heel, the resisting moment will be because of your weight of concrete, weight of soil, and P v along the toe, this will give resisting moment. And what is your driving moment, because of P h, it will try to drive. So, you can find it out both the moment and check, this factor of safety overturning moment, it should be varying from 1.5 to 2. Then bearing capacity check then once c and phi is there, you can find it out q n a. Bearing capacity will be your net allowable capacity of your soil by your q maximum; as I said q maximum is equal to V by B into 1 plus 6 e by B. Then it should be greater than three. Then your no tension, it should be less than equal to B by 6, this is your no tension.

So what are the steps, then this is part of your geotechnical engineering that means your first for making these stability analysis this kind of wall, this kind of wall, you follow this procedure. So there will be a less chance of committing mistakes again and again. So if I follow this…