**Advanced Foundation Engineering**
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**Lecture - 30**
**Reinforced Retaining Wall**

In last class, I have discussed about the reinforced earth, and how this behavior of reinforced earth beneath the foundation. So, those things I have discussed in the last class. Now in the last session of the last class, I have discussed about the reinforced retaining wall.

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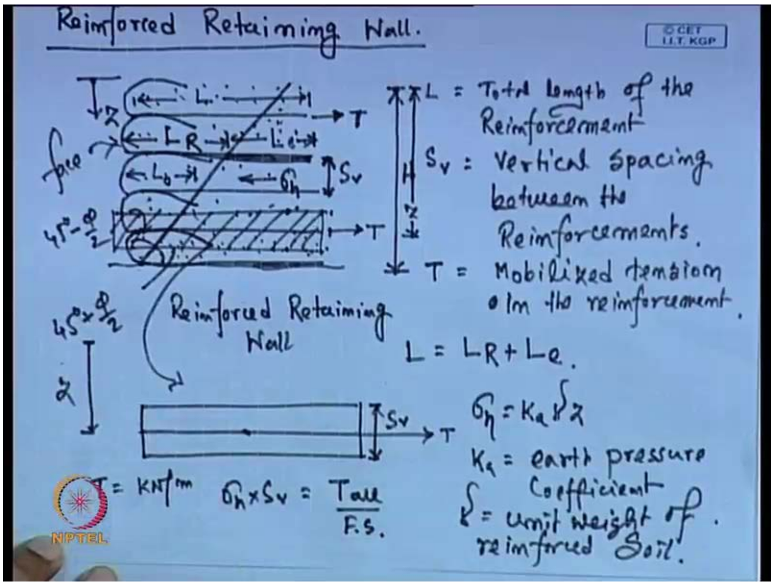


Now, today I will discuss how to design a reinforced retaining wall, and what is the behavior of this structure. Now, first, if I go for that reinforced retaining wall. So, I have discussed that, suppose if this is a existing ground, and above that we will construct this reinforced retaining wall, so we placed one reinforcement here. Then we will place another reinforcement here, so this, we will fold there, and then within that two layers, this is the compacted sand. Then this is the next layer, this is the next layer. So, this is sand. So, this is our reinforced retaining wall. Now if we consider the failure surface, if it is fails like this, and it is your 45. This angle is 45 degree plus phi by 2, if this is the, phi is the friction angle, of this compacted field with reinforcement, this filling material.

Now, here, as I have discussed that the main design components, of this type of structure is; one is S v is the vertical spacing between the reinforcement, then next one is the length of the, total length of the reinforcement, and then this folding portion, length of this folding portion L 0. So, L is the total length of the reinforcement, then S v is the vertical spacing between the reinforcement. And again, the T this tension, mobilized tension, that is developed, that is the material property, so T is the mobilized tension in the reinforcement. Now this T cannot be greater than the axial strength of the reinforcement, because; otherwise this total info system that will, a possibility that this will fail. Now, when we are talking about the S v and the length. Length we can see that, this is the failure surface of the reinforced earth, then up to, we can divide this a L into 2 parts; one is L R, and another is, we can divide into L e. So, L is equal to L R plus L e.

Now, the question is, what is L R and what is L e. L R is the length from the face, suppose this is the face, face of the reinforcement to the failure surface. So, this much of reinforcement is within this failure zone, so that is L R, and L e is basically the anchorage length, which is from this failure surface to the end of the reinforcement. Now, this L e is very important, as I have mentioned, then every reinforced structure we should have some, we have to provide some anchorage length beyond this failure surface. The reason why, if I consider this reinforced retaining wall, then if this is the failure surface, this inclined line is the failure surface. Then what is happening actually, this total soil mass along with the reinforcement, trying to slide along this failure surface; it is failure. Now, somebody has to resist this force; that means, when it is moving downward direction.

So, some resistance we have to offer, so that it stands in a stable condition. So, who is giving this resistance. Now actually when we have providing sufficient anchorage is length of this reinforcement. Now, this reinforcement anchorage, because of this anchorage length, it is getting some resistance, because of the soil and the reinforcement interaction. So, in the, when if this total system, or this soil mass is trying to move downwards. Now, there is a interaction between the soil and the reinforcement, because of that the friction will develop, and when this friction, and because of this friction, there is a bounding between the reinforcement and the soil. And these bonding will allow to hold this total system, as if this total system mass is sliding, and because of this bonding between the soil and the reinforcement, this reinforcement is holding this soil mass, so that it cannot slide. So, now this bonding depends on the how much length we are providing in the reinforcement.

If we do not provide a sufficient anchorage length, for this type of structure, then what will happen, this total system is slide along this surface. So, now for this purpose, this providing of the sufficient anchorage length, is very important. Now this things we will discuss, how to calculate this provide this sufficient anchorage length, and what are the different expression, which is available to get this sufficient anchorage length. So, that means, we have to provide this anchorage length; such that there is a sufficient bonding between the soil and the geo-synthetic, so that a tension can develop within the reinforcement. And this because of this bonding, total system this will it will not slide along this surface; it can hold this surface, this total mass. Now, if I there are, so first we have to decide the, what is the S v in the vertical spacing, then this anchorage length, because L R we can easily calculate. If we consider this is 45 minus phi by 2.

So, definitely this will be 40 phi minus, this is phi by 2, this is 45 degree minus phi by 2 this angle. And if we consider this is the z is in the downward direction, from the top, and if this is H is the height of the reinforced retaining wall. So, then at any depth L R we can easily calculate. Now, the question is how we can calculate the L e. Now, when we are talking about this S v, as I have mentioned that when this force is developing here. So, that means, because of this bonding, or because of this friction between the soil and the reinforcement, as I have mentioned in the last class also; that the tension will mobilize, so tension will develop. Now, and the question is, when this lateral earth pressure is acting in this direction, because lateral earth pressure is acting, this is the sigma H at any depth, it is lateral earth pressure is acting from this direction. Now who is resisting this lateral earth pressure. Here in case of traditional retaining wall, that retaining wall is resisting that lateral earth pressure.

Here that lateral earth pressure, it counterbalance by this tension force. So, now, because this is acting in this, from right to left, and tension is acting in the opposite direction. So, these two force will counterbalance each other. So, now, if I consider in that way, and if we consider segment, suppose if I consider a segment between the two reinforcement wall. Suppose this should be consider this segment. So between, so if I draw this segment. So, this is the segment, where reinforcement is here, this is T reinforcement. So, this segment I am drawing here. Now, here at any depth, this is a any depth z from the top, so this depth is z. So, now, the amount of lateral pressure at this point, will be k into; that means, sigma H, amount of lateral pressure in this point k into gamma into z, where k a is earth pressure coefficient. Gamma is the unit weight of reinforced soil, gamma is the unit weight of this reinforced soil and k is the.

So, now this sigma H, is basically equal to taken by this T tension force. So, if I consider this sigma H, and which is acting in this region. So, this is sigma H the unit of T e kilonewton per meter. Now, this is the force per unit length, and now here the unit is kilonewton per meter square. So, we have to multiply with some length. So, that is equal to the S v, because this is easy, because here we have taken this segment, from the center of between two reinforcement wall to, center of another two reinforcement. So, this is S v plus 2 by 2 this is also S v by 2. So, S v by 2 plus S v by 2, this is S v. So, we can write that sigma H into S v; that is equal to T allowable, or that is equal to T allowable. Now why this is T is the mobilized tension. As I have mentioned that this T mobilized cannot be greater than T allowable. So, we provide this is T allowable, with some additional factor of safety F s. So, this is F s is the factor safety.

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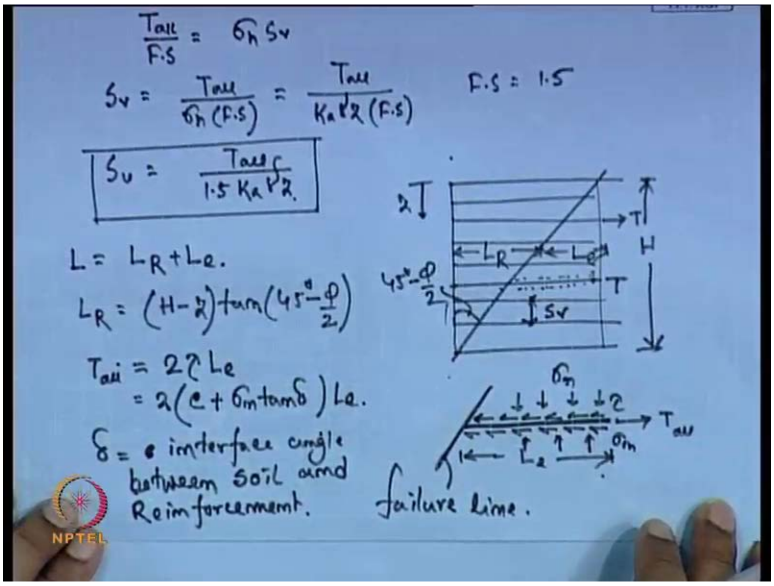


Now finally, if I write this expression, that our T allowable divided by factor of safety; that is equal to sigma H into S v. So, S v is equal to T allowable divided by sigma H into factor of safety. So, that is equal to T allowable divided by k a into gamma z into F S. This F S is generally taken as 1.5. So, now we can write S v is equal to T allowable divided by 1.5 into k a gamma into z. So, we can see that if we keep all the other parameter constant, then T allowable constant, k constant, and gamma constant. Then this S v is inversely proportional to z. So, that means, at the top required spacing is more, compared to the, at the bottom, because inversely proportional. So, that means, S v value is more at the top, and is less at the bottom. So, now, if I consider in this concepts. So, this will give us the. So that means, if I consider this is the retaining wall, and this is the spacing of different retaining wall. Now this is the failure surface. So, this will be the L R, and this is L e. So, this is S v. So, requires spacing here will be very less, compare to the top. So, next one to calculate the length; total length. So, total length L is equal to L R plus L e.

So, L R we can easily determine. So, this is 45 minus phi by 2, this is any z. So, L R we can determine this expression that H, because this is H minus z into tan 45 degree minus phi by 2. So, at any depth z H minus z is this one, so into tan 45 minus phi by 2. The next one we have to calculate the L e. So, L R we can calculate by this expression. Now when we are talking about this mobilized tension is developed, so del e is basically the anchorage length. So; that means, this resistance that we are getting is, because of this interface action of the soil and the geo-synthetic. Now, if I draw particular soil geo-synthetic section. So, this is the soil geo-synthetic section, where T. This is the line. This is L e beyond the failure surface. This is failure surface. This is failure line. So, how is this. So, L e T is the mobilized tension, which is developed, and how this is counter balance. So, if T is acting this direction, so there will be shear stress, that will act between the soil and the reinforcement.

Now, here the sigma n that is acting here, is the normal stress. So, this is acting normal stress, and this is tau is the shear stress. So, now, we can write, that our T allowable. This is also we can consider T allowable, that is equal to tau; that is the shear stress into L e, and this is acting both the sides, so into 2. So, tau is the shear stress, which is acting opposite to the direction foundation the T. So, tau into L e; that is tau into L e; that is equal to T allowable, as this is acting both the sides, so that is into 2. Now how we will get the tau. So, that is 2 into tau, is we can get the tau is expression of the shear strength; that shear strength c plus sigma n into tan delta into L e. Where, delta is the angle, interface angle between soil and reinforcement. So, this is the interface angle between the soil and the reinforcement. So finally, if I go for this expression of this L e.

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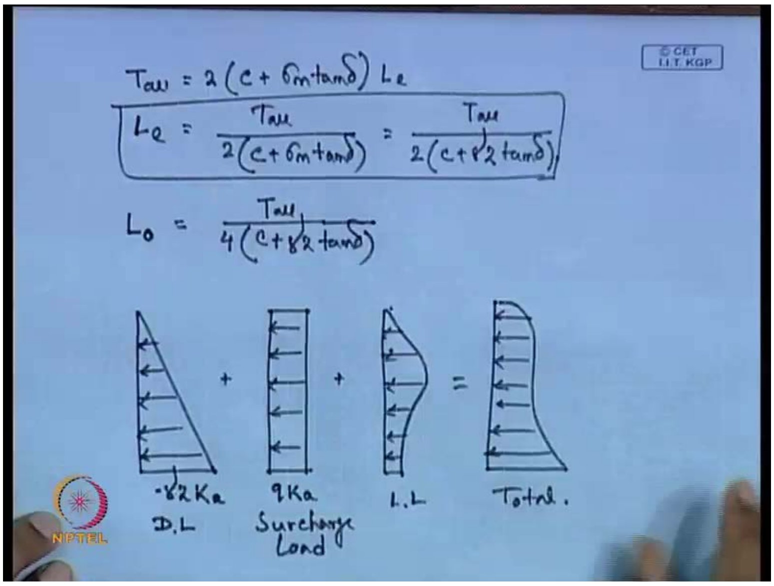


So, this is T allowable is equal to 2 into c sigma n tan delta into L e. So, L e expression is T allowable divided by 2 c plus sigma n into tan delta. And sigma n is at any depth the normal stress, this is 2 c plus gamma into z into tan delta. So, here also we can see and if z is equal to 0, or if z is very small, then L e is more. So, that means, the required length of geo-synthetic at the top surface is more, as compared to the bottom surface, bottom of the reinforcement. Now, generally in the field soil, the c value if c value is 0, then we have to consider gamma z into tan delta. Now here we can say, so; that means, the most safest design, that that it is observed from these two expression; that is the expression two, and previously sigma v expression; that is the expression one. So, these are the two main expression; one is to how to determine the sigma v, and this is how to determine the L e, anchorage length. So, here we can see this at the bottom of these reinforced wall, require spacing is more. And the and here L e at the top of the reinforcement wall, required length of the reinforcement is more.

So, that means, here if I put the spacing, which is required at the bottom of the reinforcement, and the length which is required the top of the reinforced wall. So, bottom of the reinforced wall; that is spacing in the top of the reinforced wall the required length, then design is safe. But we can see, that this spacing requirement is not uniform throughout the depth of the reinforcement; that means, the spacing at the top region requires spacing is less, compared to the bottom region. So, if I provide the uniform spacing; that is required in the bottom, then that is somehow is the wastage. So, that means, we have to design it properly, so that we can make it economical this design. Similarly the length which is required at the top region of the reinforcement, if we provide that is throughout the depth; that is also not economical. So, we have to provide the spacing and the length, according to that, so that we can make the design more economical. So, now here another consideration the L 0, which is the folding length require; that is basically T allowable into divided by 4 into c plus gamma z into tan delta. So, these are the 2 length required L e and L 0. So, now we will design a reinforced retaining wall.

Now before we go for the design purpose. Actually what are the loading condition in the reinforced retaining wall. So, one is our dead load, or the load of the reinforced soil itself. So, that is at any z; that is gamma into z into k a; that is the dead load. Similarly, if there is a surcharge, so that is surcharge load; that surcharge load is q into k a, that is surcharge load. Then we can go for the live load, so this is live load. Then this will give us the total load, this is total load. So, these three we can consider; one is the dead load or the load or the reinforced retaining wall itself. This is surcharge load. This is live load. So, these are the lateral pressure we are talking about. This is the lateral pressure due to the dead load. This is lateral pressure due to the surcharge. This is lateral pressure due to the live load, and this is the combination of this three. So, this is the total lateral pressure which is acting.

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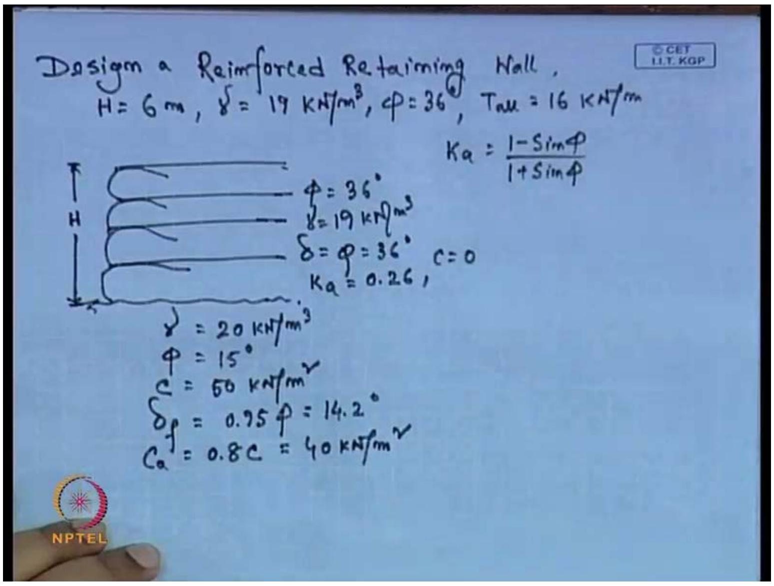

Now, we will solve one problem, and to see how these things are working. So, now, this design, a reinforced retaining wall, with H height of the reinforced wall is 6 meter, gamma of the reinforced soil is 19 kilonewton per meter cube, phi is 36 degree, and T allowable is 16 kilonewton per meter, so we are taking this, and here. So, as I have mentioned, that this is existing soil, and above that this retaining walls are constructed. So, the properties of these two soil can be different. So, here the phi of the, this filed is 36 degree, gamma is 19 kilonewton per meter cube, H is given 6 meter, and delta is assume equal to phi, but that can be anything, that can be delta can be 70 percent of the phi, or 80 percent of the phi, here it is taken equal to phi.

And now k value we can calculate is 0.26, k value we can use this expression 1 minus sin phi divided by 1 plus sin phi. Similarly, the foundation soil, it has the properties gamma is 20 kilonewton per meter cube, phi is 15 degree, c is 50, and here for this field soil c is taken as 0. So, c cohesion is 50 kilonewton per meter square, delta for the foundation soil, is taken as 0.95 or phi. So, that is 14.2 degree. And c a is taken 80 percent of the c; that is 40 kilonewton per meter square. So, now these are the properties, this is the properties of the foundation soil and this is the properties of the reinforce soil. Now I will have to design this reinforced earth, or reinforced earth foundation.

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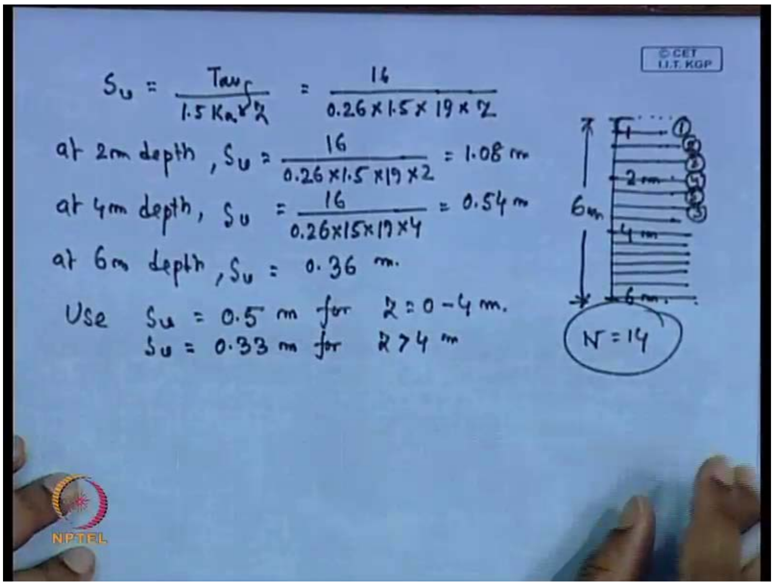


So, now this retaining wall, when you consider the, if I put this S v expression; that is S v equal to T allowable divided by 1.5 into k a into gamma into z. So, this T allowable is

16, k a is 0.26, 1.5 is the factor of safety, gamma is 19, and this is z. So, this is the S v. So, now at different level, here the height of the retaining wall is taken 6, is 6 meter. So, first as the spacing is not uniform, that because is the function of z. Spacing is the function of z, L e is also function of z. Then what we will do, we will take this at different section we will determine the spacing. So, here we are taking at 2 meter, at 4 meter, and at 6 meter. See different position I will determine the what is the required spacing. So, first if I consider at 2 meter depth; S v is 16.26 into 1.5 into 19 into 2, so that is 1.08 meter. So, at 2 meter that S v is 1 point. So, at 4 meter depth; S v is 16 into 0.26 into 15 into 19 into 4, so that is 0.54 meter. Similarly, at 6 meter depth; S v is 0.36 meter. So, we can see at the 6 meter depth 0.36, at 4 meter depth 0.54, and at 2 meter depth 1.08.

So, for this case we are taking that, I am taking that, use S v is equal to 0.5 meter, for z equal to 0 to 4 meter, and S v equal to 0.33 meter, for z greater than 4 meter; that means, 4 to 6 meter. So, we have to choose this spacing, such that, because here required spacing is 0.36. So, we can provide less, we cannot provide more. So, that means 36, we are taking 0.33. Now it is at 4 meter depth, required spacing is 0.54, we are taking 0.5. Now, we can another question that at the 2 meter we can provide 1. So, that is also possible, that at 2 meter 1, we can provide up to 2 is 1 meter, then 2 to 4 is 0.5, then 2 to 6 is 0.33. So, that means, there is many variations. So, to just minimize the variation, I have taken two, only two types of spacing. So, now, here why we have taken phi, because here we have to decide the spacing such that we can place them properly, because here from 2 to 6 meter, if it is required, we cannot place point, if I take 0.35, that will be very difficult to place here equal spacing.

So, to make it equal spacing and place within this 2 meter, we have taken 0.33. So, the number of reinforcement will be. So, that means, here at 0.5 meter, we will provide one. So, point, so this is one. So, at one meter we will provide another two, 1.5 we will provide third number of spacing and reinforcement. So, 2 meter, this is the 4 number of reinforcement. Then 2.5, 5$^{th}$ number of reinforcement. So, 0.51 1.5 2.2 2.5, then 3 3.5 4, then 4.33 4.67 5 5.33 5.676, because in the top portion z equal to 0, and not providing any spacing, because we will fold this one, and then we will keep this one open. So; that means, the number of reinforcement layer will be 1 2 3 4 5 6 7 8 9 10 11 12 13 14. So, number of reinforcement here is 14 numbers. So, that is decided, because this is the S v equation, and we have taken. So, here the spacing, is greater than 4 to 6 is 0.33 meter, and from 0 to 4 is 0.5 meter. So, that means, this spacing part is over.

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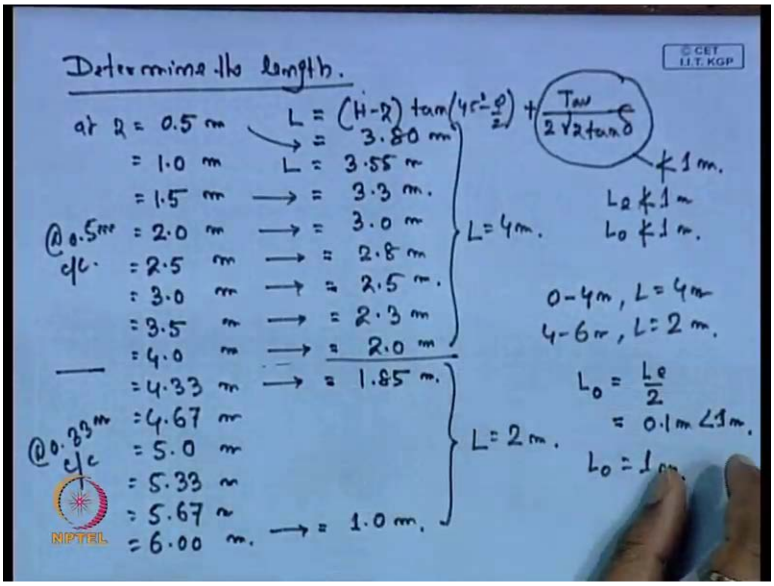


Now, here what we can do, now next step is to determine the length. So, first we take that, at what depth we have provided the reinforcement. So, the depth that we have provided that at 0.5 meter, that we have provided the first reinforcement. Then at 1 meter depth, at 1.5 meter, then at 2 meter, then 2.5 meter, then 3 meter, then 3.5 meter, then 4 meter. So, up to 4 it is at the rate of. So, up to 4 this is at the rate of 0.5 meter center to center. Now, next 1 is 4.33, then 4.67, then 5 meter. So, next 1 is 5.33, then 5.67, then 6 meter, so total 14 numbers. Here it is point at the rate of 0.33 meter center to center. So, these are the total 14 number of reinforcement, and their corresponding depth. Now at every dept we have to calculate the length. So, if I consider the first layer length, so that is here H minus z into tan 45 degree minus phi by 2 and plus T allowable divided by 2 as c is 0. So, this is gamma into z into tan delta. So, now if I put z equal to 0.5 and every other factors, and here another thing that we should mention, that the minimum anchorage length is 1 meter.

So, for this particular factor, that cannot be less than 1 meter. So, L e cannot be less than 1 meter, L 0 also cannot be less than 1 meter. So, that is the condition, so; that means, if by calculating if it is coming 0.8, then you have to provide 1. By if it is calculation by its coming 2 meter, then you have to provide two. So, that means, this anchorage length cannot be less than 1 meter. So, 1 meter at least we have to provide L e and L 0. So, now here if I put z equal to 0.5, then ultimately required length at 0.5 meter depth is 3.8 0 meter. So, by putting this value in this expression at 0.5 meter depth, required L is 3.8 meter. Similarly, at 1 meter required L is 3.55 meter, at 1.5 meter required length is 3.3 meter. By calculation at 2 meter, if I put z equal to 2, then the required length, total length we are talking about; that is 3 meter.

So, at 2.5 that is 2.8 meter, so at 3 meter that is 2.5 meter, at 3.5 meter that is 2.3 meter, at 4 meter that is 2.0 meter. So, at 4.33 that is. So, these are the calculation that at 0.5 meter 1.5 meter, 2 meter 2.5, 3 meter 3.5, 4 meter. So, these are the requirement, and 4.33 it is 1.85 meter, and then finally, at 6 meter the required length is 1 meter. So, now we have to decide which length, because as length is varying from 3.8 meter to 1 meter, so which is not uniform. So, now as in the, during the spacing we have taken, the spacing at the rate of 0.5 meter, from 0 to 4 meter and 0.3 meter from 4 to 6. Here also here the maximum spacing requirement up to 4 meter is 3.8. So, in place of 3.8 we have taken, that up to 4 meter we will provide, total length is 4 meter.

And here minimum spacing requirement, maximum spacing requirement is 1.85 for 4 to 6. So, that we will provide from 4 to 6 is, total length is 2 meter. So this, but as we have mentioned, that if I take up to 2 meter different spacing from 2 to 4 at different 4 to 6, then according to that, we have to provide the length here, up to 2 meter we can provide 4, then from 2 to 4 we can provide 3, then 4 to 6 we can provide 2 meter also, but just to avoid the so many variation we have taken from 0 to, so; that means, from 0 to 4 meter, L is equal to 4 meter, and from 4 to 6 meter L is equal to 2 meter. So, this is the variation that we are using. So, now as again from the calculation part, we can calculate that L 0 is equal to basically L e by 2. So, now, if L e, calculation of L 0 is coming out to be 0.1 meter, so that is less than 1 meter. So, that at that is the minimum value so that is not satisfying the condition. So, L 0 value here will provide 1 meter.

So, L 0 is 1 meter, total length is 4 meter from 0 to 4, and from 4 to 6 total length is 2 meter. So, next one; so next category is the. So, during the design of reinforced retaining wall. So, in the other design of reinforced retaining wall, when we are talking about the cantilever retaining wall, or gravity retaining wall. Basically we consider the various factor of safety; that means, factor of safety for sliding, factor of safety for overturning, factor of safety for bearing, and no tension zone. Here also these things, that we have done till now, this is the spacing and the length, that is the internal stability of the reinforced retaining wall. Now we have to check for the external stability also. So, those external stability are again similar to the other type of retaining wall; that means, we have to check whether this reinforcement will slide or not, because the sliding may take place between the foundation soil and the reinforcement layer.

If, there is no sufficient bondage, between the reinforcement and the foundation soil, so there is the possibility the total reinforcement, reinforced wall may slide along the surface. So, we have to provide sufficient length of the reinforcement, so that that is your proper bondage or between the soil and the reinforcement, so that a sliding can be restricted or sliding can be stopped. And next one is the overturning, so we have to provide, such that this here also weight of the reinforcement is giving the resistance. We have to make the reinforcement retaining wall, such that there is no overturning. And another is that the such amount of the soil of the reinforce, coming from this reinforced retaining wall that will, if the pressure on the existing soil. If existing soil is very poor, then there is the possibility, that there is a very bearing capacity failure of the soil. So, we have to check this three again for this reinforced retaining wall.

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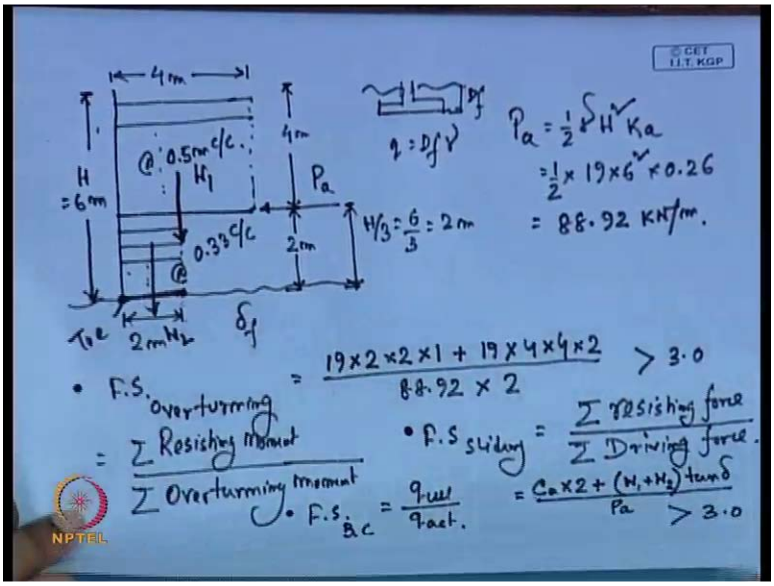


Now how to check this three, so that means here, if I consider that this is our total length of the, is equal to 6 meter, reinforced retaining wall. So, from there, up to 0 to 4, 0 to 4, so suppose this is 4 meter. We have provided the reinforcement whose length is 4 meter.

And from here to here, I mean 4 meter to the 6 meter, next 2 meter, we have provided reinforcement length is 2 meter, so this is 2 meter. Here the spacing is 0.5 meter center to center; here is 0.3 meter center to center. So, this is the reinforcement retaining wall, so; that means this is one, if I consider this is also. So, we have to 2 meter, which is spacing of 3 center to center, and this is up to 4 meter. Now, here the passive, these are this active earth pressure that is acting, here we can consider this is acting as p active, which is acting at a height of H by 3, so that is 6 by 3; that is 2 meter from the base.

So, now, when we consider the sliding and the overturning and bearing capacity failure. Now first we consider calculate P a, P a is half gamma H square into k a. So, half gamma here we will consider the 19, H is 6 square, k is 0.26. So, this is 88.32 kilonewton per meter. See if I consider this form, then first we have to consider the weight. First we calculate, then when we consider the factor of safety for overturning. That means, here this force p a is acting this side, now the weight of the reinforced retaining wall is giving the resistance. So, here we will consider the weight w 1 and w 2 both are the weight, which are acting, because this is the w 1 and the w 2. So, here first we consider the weight of this lower portion, so that is the weight of these lower portion is 19 into 2 is the width, and 2 is the height.

So, that is the weight. So, overturning means; that is the summation of resisting moment divided by summation of overturning moment or diverging moment. So, here summation of resisting moment; that means this weight into, if I take the moment with respect to this 2, so that w 2 is acting at a distance of 1 meter form this 2, because this is 2 meter, so w 2 of this center of this, so 1 meter. So, lever arm is 1. So, weight is 19 into 2 into 2, 19 into 2 is the width and 2 is the height, into the lever arm is 1. For the next one w 1, the total weight is 19 into, this is 4 into 4 and lever arm is half of this 4 is 2 into 2. So, this is the resisting moment, and the overturning moment here is acting here P a, which is 88.92 into, which is at distance of 2 meter. So, we have to calculate this things, and it should be greater than 3. So, if it is not greater than 3, then we have to redesign it.

Although it is internal stability wise it is fine, but we have to increase the width of the or length of the reinforcement, so that the weight of the reinforcement can increase. Similarly, the factor of safety for the sliding. Again this is the summation of resisting force divided summation of the driving force. So, when we talking about the sliding, here in this case, within the reinforcement whether taking c equal to 0, because the that was the soil property, but here c is not equal to 0. So, we have to consider the c, when we talking about the sliding. So, sliding mainly will take place between this layer, the last layer, and the existing foundation. So, this is existing foundation soil. So, this is the reinforcement. So, for only this length and the existing soil. So, now the c a addition into 2, 2 is the length here is taken, plus this is w 1 plus w 2.

It is the weight into tan, delta of what. Here delta of foundation soil we have to consider. This is not a delta of the field soil. Here delta of the foundation soil, because this is the sliding between the soil, foundation soil and the reinforcement. So, this is delta 2 divided by the P a, that should be always greater than 3. If it is not, then we have to increase the length again. So, now here c a is 80 percent of c, and w 1 and w 2 we can calculate, this is tan delta into P a. Similarly, for the factor of safety; so this is one factor of safety, this is another factor of safety, and this is another factor safety. Now, factor of safety for bearing capacity is B c. Now, how to calculate the bearing capacity; that means the q ultimate divided by q acting. So, how to calculate the q ultimate and q acting.

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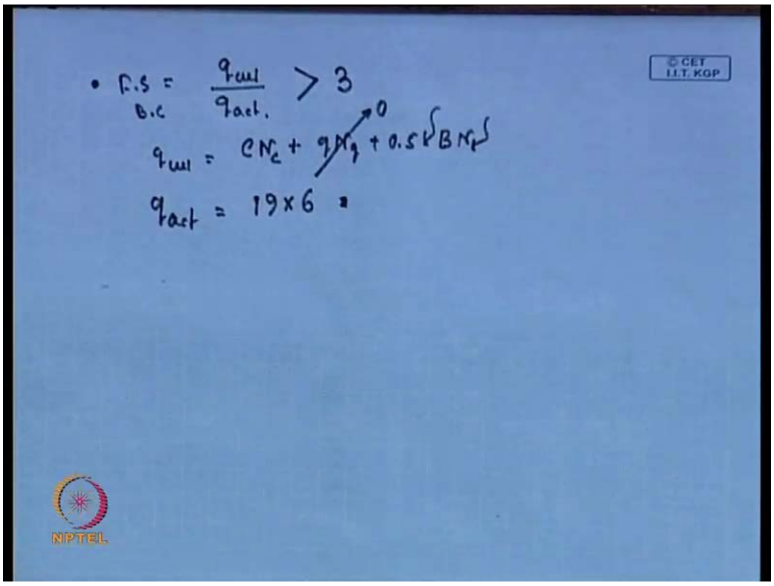


So, we can consider the last factor of safety that is bearing capacity, that is q ultimate by q acting. So, q ultimate will be c N c, you can consider into q N q plus 0.5 gamma B N gamma, so that property we have to consider for the foundation soil; based on the foundation soil phi we have to calculate the c N c and q N q gamma, and B width of the foundation we will consider the width or length of the reinforcement; that is the width of the foundation B, and gamma we will consider the gamma of the foundation soil. Here another thing is that here it is mentioned that, when you talking about this is the, this will act as a total load of the reinforcement; that means, and this is the footing which is resting on the foundation. It is not below the foundation, not at the surface, it is not below the surface. So, that means, here q value is 0 basically, because when you are talking about this is the foundation, if it is resting with some depth, if it is ground surface, then if it is D f, then we can consider q equal to D f  into gamma.

If it is placed at the depth of D f, but if it is placed at the surface then q is 0. So, here also it is placed at the surface. So, it can consider, that q value is 0 in this case. So, this is the expression, c will provide the c of the foundation, N c will calculate based on the foundation soil phi, gamma is the foundation soil unit weight, N gamma will calculate based on the foundation phi, and B is the length of the reinforcement. And q acting; that is basically the weight of the reinforced soil. Here we can consider the weight, which is acting. Either we can consider 19 into 6; that is the weight that is acting here. And then we put this value, B is the length of the reinforcement and here this is 19 into 6. Then this should be also greater than 3, if it is not, then we have to redesign this section.

So, we can see here based on the external internal stability, we have to determine the spacing between the reinforcement, and the length of the reinforcement, as which is not uniform throughout the depth of the reinforced retaining wall. So, we have to make it more economical. So, then different depth, different spacing and length we can provide. And then we have to check the external stability; that is a sliding, overturning, and bearing capacity failure. So, if although the structure is safe within the internal stability consideration, but if it is unsafe based on the external stability, then you have to redesign it, you have to actually you have to increase the length of the reinforcement, you have to design it, so that it is satisfy the external stability criteria’s also. So, this way we can design this reinforced retaining wall. And in the next class, we will talk about the other foundation, on the on improved ground, based on the other improvements.

Thank you