Advanced Foundation Engineering
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Lecture - 29
Reinforced Earth

….chapter that is a reinforced earth, so that means here how to design a foundation or any retaining wall if it is constructed by reinforcement. Now, before that first we if I discuss what is the reinforced earth? Now, as it is a similar to we can say that it is like our reinforced concrete as we can know that concrete cannot take the tension and in for to take the tension we provide the reinforcement. Here the similar way the soil cannot take tension.

So, if any tension is developed within the soil that has to be taken by some elements. So, that elements we provide that is as a reinforcement. Now, the question is why the reinforcement is required? Now, if when if a soil is there if I want to construct any foundation on that before that soil testing we will go for whether we will go for which type of foundation, either we go for the shallow foundation or either go for the group foundation. In the shallow foundation we can first try for the isolated footing then combined footing or if it is a raft. Now, if this shallow foundation is not suitable on that particular soil, then before we go for the de foundation or pile foundation then that is option that we can improve that ground and on that improve ground we can construct the foundation.

So, now this basically this reinforced concrete is a improve ground improvement technique. So, there are so many others ground improvement techniques are available, but on that I will discuss only the reinforced earth in this section. Now, before I go to the design part, now first what is reinforcement?

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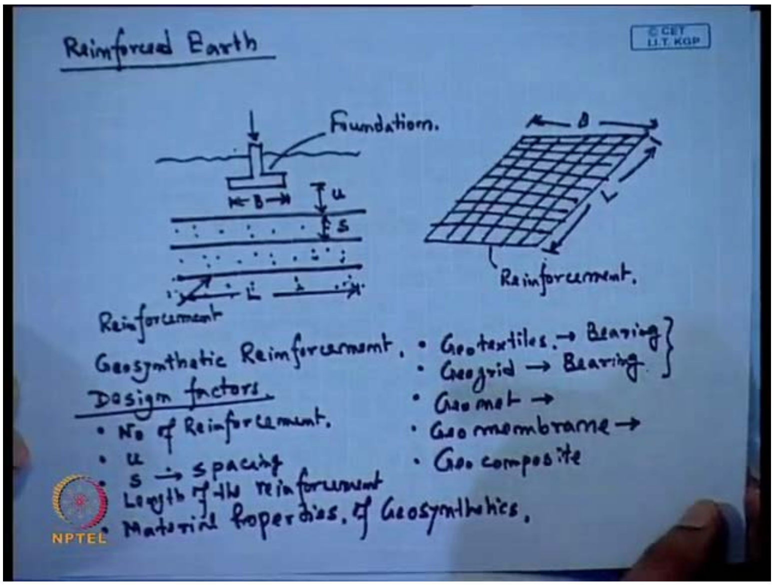

Now, in imposed that means suppose if we have this existing ground and that ground, this is the foundation. Now, suppose this soil is not suitable to take the load which is coming for this, from this super structure through this foundation. So, here we are providing this isolated footing or is B, width is B. Now, when here the one option we can place some reinforcement like this, suppose if this is the section so we can place the reinforcement below this foundation. So, that can be single layer or that can be multi-layer.

So, these are the reinforce, so if this is foundation, then these are the reinforcement. Now, these reinforcement is this is the section, actually these reinforcement are a sheet type of material suppose this is the, this is one type of reinforcement. This is sheet type of material, here we can get, this is one reinforcement or the this is we can say the reinforcement.

Now, here we are talking about the geosynthetic reinforced earth. Now, what is geosynthetic reinforcement? Now, geosynthetic reinforcement is a basically polymeric material, which have some groups. One is geotextile, next one is geogrid, third we can geonet, then geomembrane, then geocomposite. So, these are the different categories so this is all are called the together called the geosynthetics.

So, these are the different types of the geosynthetic, geosynthetic means this a polymeric material which is available in the in a market. So, that means here we get a sheet type of material here which is available in role type. So, here we will get the required geosynthetic according to our basic requirements. Suppose if it is a below the foundation if I place, so we will place that is the L and the B if it is a rectangular footing.

So, if I take the section this one we will get the this type, so that mean inside the soil we place this sheet type of material to increase the bearing capacity of the soil. So, that means, first and basically these geosynthetic type of reinforcement as we have to insert it in the soil and it is placed horizontally, so because it is placed horizontally so that means it is basically suitable for filling type of material. Suppose, if is this in the this area first we will place the reinforcement and if it is existing soil above that we can place some soil or filling soil granular type of soil, and then inside this soil. First we will place the reinforcement then again replace the granular soil, then again replace the another reinforcement then again replace the soil, then another reinforcement and then the foundation will constructed.

So, basically the filling type of material is this geosynthetic reinforcement is suitable. And again you are talking about the geotextile, geogrid, geonet, geomembrane and geocomposite. Now, these are basically used for different purposes, so that means we are talking about the geosynthetic suitable for the bearing capacity improvement. So, that is not only purpose of geosynthetic, geosynthetic that can it can acts as a separator, it can act as a bearing capacity improvement material, it can act as a drainage purpose, it can, we can used then we can usage for a barrier purpose.

So, suppose a geotextile, it is if use if it is bearing capacity mainly we use that is for the geo grid. Now, a geomembrane for the barrier purpose, geonet for the drainage purpose and geotextile is for smallest all purpose. Now, here the geocomposite basically we, if we use for multiple purpose. Suppose you want to use for the bearing as well as for the drainage purpose, then we clam this geogrid and geonet and we from a new type of material that is geocomposite.

So, basically here we will talk only the bearing capacity improvement part because we are dealing with the foundation. So, only the bearing capacity improvement part basically the, this geogrid is used and this geotextile is also use. So, these two type of material generally is used for the bearing capacity improvement. So, that thing we will discuss in this class. Now, here we are talking about the, so when you place the geosynthetic within the soil for the bearing capacity improvement so then what are the design factors, that is very important.

So, first design factors, so first design factor is the number of reinforcement. So then the next design factor the where we will place the top reinforcement layer, that means this is the u, is the where we will place the top reinforcement that is one thing that we have to decide, that is u. Then the spacing between two reinforcement layer, this spacing is also we have to decide and then what would be the length of the reinforcement.

So, this is spacing another one that is the material property of the reinforcement. So, these are the design factor for the reinforcement and obliviously as usually for the unreinforced soil, the soil properties and the load these are also some design factors, but these are the additional design factors that we have to consider during the design of the reinforced earth. Now, the first we have to decide what is the number of reinforcement that will provide; then the where we will place the reinforced first reinforcement layer and why this we so important. Then the spacing between tool reinforcement layer, now the length of the reinforcement. Why the length of the reinforcement is basically very important and the properties of material properties of reinforcement of geosynthetics.

Now, first we will discuss, let why what are the different types of failure of this reinforced earth. Now, first we discuss what are the different types of failure of the reinforced earth?

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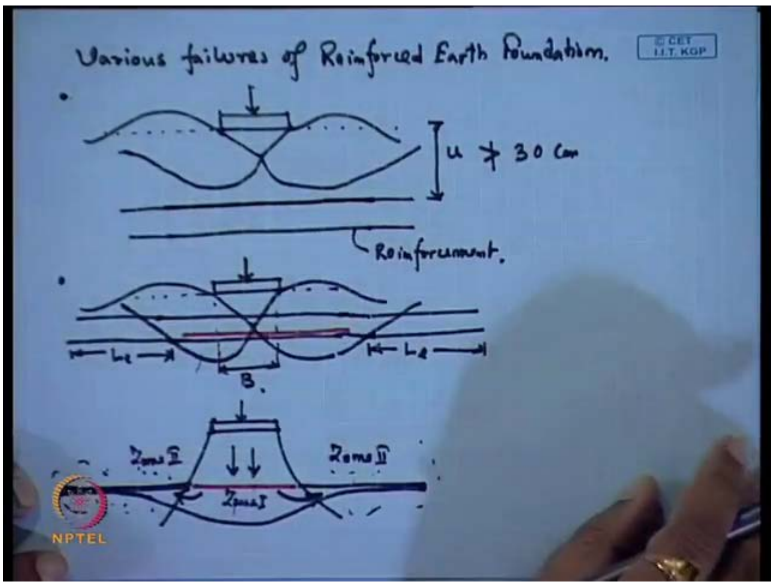

That mean the various, now first type of failure is that, this is the failure if that reinforcement. Suppose this is our foundation and this is the our existing soil is here and we apply the load of the foundation. So, what will happen? That it will inform in this form and then this is the failure surface and this is the failure surface. Now, if that reinforcement is place below this failure surface, then if this is the reinforcement, say. If reinforcement is placed below this failure surface, then if it is then this soil will act as a unreinforced soil, because most of the failure surface of failure has been occurred due before, above the reinforced soil.

So, that means the effect or reinforcement will not come into this formation. So, that means here the basically this material will be wastage, so there will be one type of failure. So that, so I placing of reinforcement is very important, reinforcement is the first layer and it is recommended that, but this u cannot be greater than 30 centimeter.

So, that means from the ground surface. So, that means for 30 centimeter depth one reinforcement layer we have to provide to avoid this type of failure. So, that means this is one type of failure where reinforcement is place far below the foundation and all of failure has been occurred above this reinforcement. So, there is this effect of reinforcement will not add to this, will not consider in this design. So, that is one type of failure. Now, the second type of failure that when the talking about, this is say foundation; this is the existing ground. Now if we place this reinforcement very small length, if I place the reinforcement is small length. Now, what will happen? That for this small length this total system will fail. Now, question is why? Now, if this is the foundation failure surface we should have some sufficient anchor length beyond two side of the failure surface. Suppose if I place it here what will happen? This reinforcement this failure surface will pass and it will not effect this reinforcement.

So, this is basically, it will similar like a unreinforced soil. So, we will not get any benefit from the reinforcement. When we place sufficient anchor length beyond this two sides of the reinforcement, then this is called say anchor length L e. So, this is the failure surface L e and if this is B, so that means this sufficient anchor length is required for this reinforced soil, beyond this failure surface to get give a proper anchor. Now, the question is why this anchor length is required? Now, that is why the length of reinforcement is also a very important issue when you design the reinforced earth. Basically, if I place the small, we saw if I place the reinforcement length equal to the width of the foundation, then this will not give any effective solution for the foundation. So, we have to provide sufficient anchor, so why we will provide this anchor length the question is that, this when we are applying this load.

So, that means these insides soil that will try to move this side. So, suppose if I this is foundation and if I apply the load, so suppose if there is two zone; his is a inside zone and this is the outer zone. Now, suppose this inside zone, the soil will try to move in downward direction and this outer zone, the soil will try to move in this direction. So, this soil is basically moving downwards and this soil, this is a zone two and this is zone one.

So, in this zone two soil is going in pushing the this zone one soil towards this direction and this zone one soil is moving going downward direction. Now and similarly, here also this in the failure zone this soil is moving downward direction, the center one and site soil is basically this soil pushing this soil in this two sides, and the center one is moving downward direction as well as the pushing the this soil in the other side. Now, what will happen if we place only the reinforcement into this level? So, suppose if I place only that the into this level or further here in only for this side.

So, what will happen? That this reinforcement will also move along with soil. Now, we should have a sufficient anchor if I place anchor, if I exchange this reinforcement in the side, so this reinforcement will provide and anchor. This this reinforcement is insert in the soil, within the soil it is inserted within the soil. So, what will happen? The soil and this reinforcement internal friction that will provide at anchorage within the soil, so that means these soil outside this reinforcement will hold this reinforcement in both sides.

So, this soil because of this internal friction mechanism this soil will hold this reinforcement in the both side and this soil will move downward direction. Now what will happen? Now, there will be a this type of deformation factor because there is a sufficient encourage. So, we will get this side of deformation pattern in the reinforcement, so and we have to provide such that the at the end of this reinforcement there is a very negligible deformation. So, that deformation is very negligible, where there is a sufficient anchorage and most of the deformation it is in the center.

So, now this reinforcement will not move along with this soil movement. So, it will hold, this soil is holding this reinforcement both side and this soil moving downward. So, that they will not be any movement of this reinforcement along the soil, so it will be in this position always in the outer side and then it will be deflect in this form. Now, if we provide only this length, in here also only this length, here also this is the failure surface beyond that if I provide the reinforcement, then it will give a this anchorage. So, that this reinforcement will not move within the soil and it will not come within this failure zone.

So, if I provide only within the failure zone, so because of the as there is a no outside anchorage of this provided within this reinforcement, then what will happen? This reinforcement will move along the soil, so it will be, it will not give any benefit for the improvement purpose. So, that is another type of failure because this is wastage of the money and then we will not getting benefit. So, this is a second type of failure.

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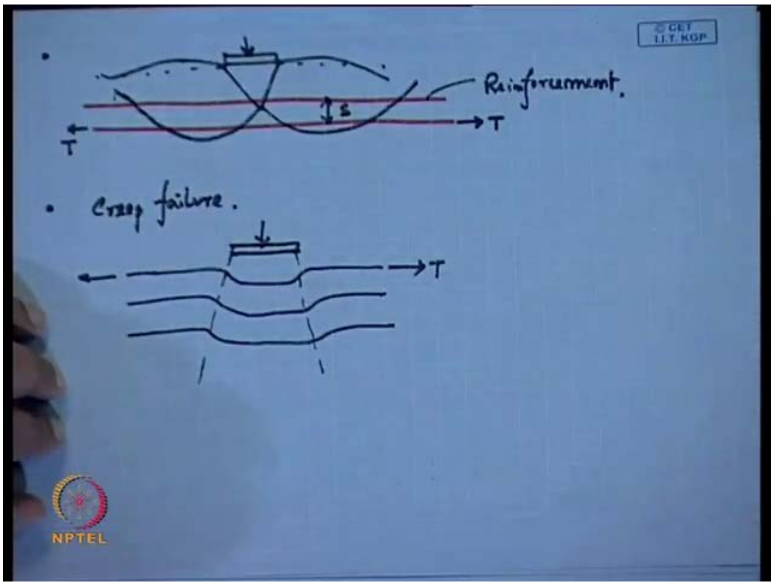

Now, the third type of failure which is also very important, there is a third type of failure that, when we apply the load here, this is foundation is existing round and then in the in insert this foundation we provide the reinforcement, suppose this is the reinforcement. So, this one, these are the reinforcement.

So, when your applying this so when your applying this load and here talking about there is a sufficient anchorage within the reinforcement, then what will happen? That because of this anchorage force, anchorage that will there is a tension is developed within the reinforcement, because why this tension is developed? Because we can say that, when this there is a sufficient anchorage is there, so that means this soil is holding this reinforcement and this reinforcement within the center region is moving downwards. So, if we hold something in both sides, suppose we are holding this reinforcement both side and this soil is moving downward direction, so it will one tension is developed within the reinforcement.

So, that means and this there is a internal friction is their within the soil and geosynthetic or reinforcement and because of that, and as we are applying as it we are holding this reinforcement both side and at the center region this because of this soil foundation pressure this reinforcement is moving downward direction, and we are holding the reinforcement because of this sufficient anchorage length we are giving. So, we are holding the reinforcement in the both side soil is holding the reinforcement in the, in the both side and the center one is moving downwards.

So, because of that the reinforcement in the subject tension, and this mechanism is that, the internal friction is acting in because also that this friction is mobilized, this tension is mobilized. So, that means there tension will develop within the reinforcement. Now, if the geosynthetic is not such steep that that can take that tension, so what will happen? There will be a failure.

So, that mean geosynthetic should be steep, such that and you have to choose the geosynthetic during the design, such that the mobilized tension or induced tension within the geosynthetic that tension, this geosynthetic can carry. So, if the strength or tensile strength of the geosynthetic is less than the mobilized tension or induced tension within the geosynthetic, then this geosynthetic will fail, so will not get any improvement. So, that means this geosynthetic should be sufficiently strong, so that it can sustain it can take the tension which is developed within the geosynthetic. So, that is another type of failure that is called tension failure.

Next one is, the creep failure or long term failure. Suppose, if it is a geosynthetic reinforced earth, so we have this is the geosynthetic that we are placed here. So, after very long term what will happen the creep will occur within the geosynthetic, creep means that is they strength against constant stress. So, that means at the when we apply the, this tension will developed within the geosynthetic. So, that means if tension is developed within the geosynthetic, so at very long time, this if this geosynthetics under tension for the long time, so if it is and the tension for the long time, so that means what will happen? They are will be a strain within the geosynthetic.

So, one is the deformation of the geosynthetic, that is the vertical deformation due to the soil moment; another is because of that when the tension is developed within the geosynthetic, so geosynthetics are under pressure tension. So, because of this tension there will be strain within the geosynthetic. So, if this strain within the geosynthetic is occurred so there is a possibility the strength of the material will reduce. So, if the strain is their material will reduce, if the strength of the material is not could in a then will get a failure, there chance of failure.

So, that is if the strength of geosynthetic is very high then then also this total system will failure. So, this type of failure is call for the creep failure and in this creep can occur for the reinforcement as well as for the soil. Now, for this creep failure that means this this strain within the material because of this tension and this tension strain, if this strain is height and this strength will reduce and this total system will fail. So, these are the four different types of failure for the reinforced or the foundation on the reinforced soil. Now, we are talking about that, we here a talking about that this geosynthetics we will place because of this improvement of the load carrying capacity of the soil. Now, the question is, how these improvement will occur because of this geosynthetic?

Now, as we have mentioned that is four different things, that one is number of reinforcement; so another is u part, we have already explained that we have sufficient u and then then the length of the reinforcement that also you have explained. Then the material property of the geosynthetic, that will, that means the this u length it is sufficient length you have to provide, such that they are will not be any, that means this there there is this there should be anchorage of the reinforcement, other ways this reinforcement will move along that the soil. And then the material properties then we have to choose geosynthetic such that it can sustain under that induced strain.

Another is this in the spacing also, if the spacing between two geosynthetic is very high, suppose this is this spacing between two geosynthetics is very high, then what will happen? The failure will occur within that soil, within two reinforcement because if the failure spacing is very high, then if we very large spacing will provide, then what will happen? The failure occur within that two geosynthetic layer, within that soil or between two geosynthetic.

So, what will happen? We have to proper or else the total system will fail. So, we have to provide proper spacing within the reinforcement. Another is the number of reinforcement, that is very important issue that that where that how much improvement we will get, if we increase the number of reinforcement. Is it linear, that if I improve, if I get 10 percent bearing safe for 100 percent bearing capacity improvement, if I provide one layer, if I provide two what would be the amount of the improvement, that will be 200. If I provide three layer that will be 300, it is linear or what is the relation.

So, that means we have to, now we have to understand how much reinforcement we have to provide, why this is not a linear thing, then if it is a linear thing then you can provide infinite number of reinforcement which is actually not a good idea or it is not possible. But why, so that thing that we will explain.

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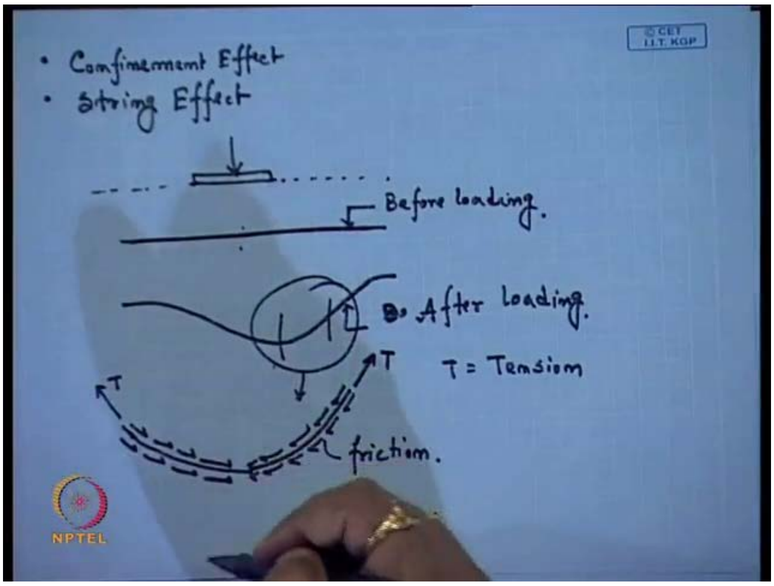

That how we will get the improvement other soil, now this improvement we will get so because of the two major action, one is your confinement effect another is string effect string effect. Now, what is confinement effect and what is string effect? Now, suppose this is the foundation, this is the existing ground level, now this is the reinforcement your providing, this is before loading. Now, when we apply the load in the foundation this this soil will also loaded, so we will get one deformation of the reinforcement. So this is before loading, sorry after loading.

So, now if I check this, this portion of any portion of the reinforcement, suppose we are taking this portion of the reinforcement. So what will happen? So, because if there is no deformation of the reinforcement, there is no friction will develop. So, once we will get a deformation of the reinforcement, what will happen? There will be a friction, so there is a relative movement and there is a movement between the soil and the geosynthetic. So, there is no movement between the soil and geosynthetic, it is placed as it is. Now, when this will deform there is a moment between the soil and the geosynthetic.

Once this movement will start, so that the friction will develop, it is similar to the pile, so if I apply the load on a pile, vertical pile so that means the this friction will act in the, side friction will act in the upward direction, that means loading is the applying in the downward direction. The same thing when we apply the load, so this tension will develop as I have mentioned.

So, it is tension is developed that is because of this, that means if the tension is developed so the, who is countable is this tension. So this tension there is a something that will countable in this tension. So, that means these things, this friction is acting within the reinforcement. So here if I take the other side, so there is a tension T, if I take the symmetric figure, so this is the friction. So, T is tension and this is friction. Now, we can see that when we apply the, we are applying the load when there is a deformation of the soil reinforcement, then there is a movement of the between soil and reinforcement and then this friction is developed within the soil interface of the soil and the reinforcement. Once this friction is developed in the soil and the reinforcement and the result in this tension is induced within the reinforcement.

So, as we have mention that if I anchored, this soil within and this anchorage force reinforcement is getting because of these friction between the soil and the reinforcement. So, first clear this part that, this reinforcement is anchorage force this reinforcement is getting because of this interface friction. So, because of this interface friction mechanism soil is holding the reinforcement and because of that this tension is developed within the reinforcement, and this will occur if there is a deformation between the soil and the reinforcement. Once there is no deformation of the reinforcement, this phenomena or this action will not come into picture.

When we apply the load in the reinforcement is deformed, then we will get this type of action. So, that means this is a friction is developed and because of that the tension is induced mobilized within the reinforcement. Now, once we can say there is tension is developed within the reinforcement, so that means somewhere compression is also acting, so that means we can say the tension is developed in the reinforcement.

So, that means the some amount of the that the, similar amount of the completion is also developed somewhere. So, once just as I mentioned the soil converting the tension it can take only the compression. So, tension is developed in the reinforcement and compression is develop within the soil. So, as soil compression force is developed within the soil, then what will happen? The soil become dense, that means if soil is under compression, so its strength or properties that will improve.

So, if we apply a compressive forced on the soil and then is strength or properties that will improve. So, that is call the confinement effect, that mean it is the soil is and the confinement condition, so that is under compressive force is developed, that is in the confined compressive condition. So, that is why its properties is also improvements and strength of this soil that will also improve. So, that is called confinement effect, where because of this action this soil strength is improve.

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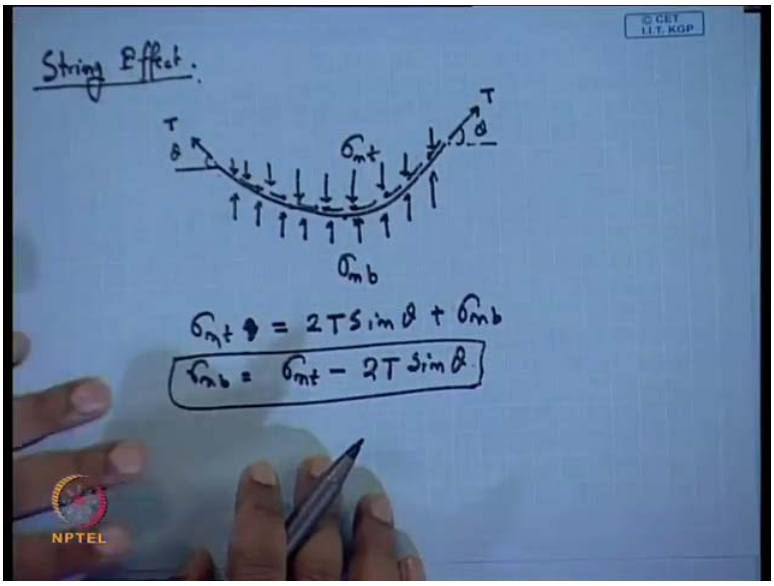

Next one is the string effect that is also very important. What membrane effect we can says, so that means the, if so there is a reinforcement pattern. So, here the T is developed here, here T is tension is developed and this angle is set theta, this angle is also theta. So, that means at the top of the reinforcement this force is acting, this is the normal force sigma n tau.

So, because of this things this shear force that will act, here also, shear force that will act, here also the reaction force here this will act in the bottom direction, so this is sigma n b. So, these are the two stresses that will, this are the two vertical stresses, so this is sigma n t is the top of the reinforcement and sigma n b is the bottom of the reinforcement. So, now if I take the cost component of these two, so this two forces will be cancel out, if it is symmetric. Now we can say that if I take the sin component the sigma n t plus, sorry that is equal to 2 T sin theta plus sigma n b. So, sigma n b is equal to sigma n t minus 2 T sin theta. So, that means we can say that the stress below the reinforcement is less as compared to the top of the reinforcement.

So, at this top level and the bottom level if I compare the vertical stress, that at the bottom level stress is less as compared to the stress at the top level. So, this is, is because of this string action or this membrane action. So, that means here we can see this is sin theta and if there is no deformation theta is 0, then then sigma in b is equal to sigma n t, but when there is a sufficient deformation then this stress in the lower region, that will reduce. So, once says is the soil is reduce then the definitely the load carrying capacity of the soil, that is increase, that means some stress is taken by this mobilized within this reinforcement. So, that means the stress carrying capacity of the soil that will also increase.

So, this is one action that is string able. So, because of these two effect, one is string effect; one is confinement effect this bearing capacity is improve for the reinforce soil, reinforce foundation. Now, a very important thing is that what would be the number of reinforcement? What is the improvement pattern if I increase the reinforcement?

So, one thing is that, if I compare and if I compare, see this expression. That if theta is, if I increase the theta then what will happen the sin theta value will also increase, as the same time the sigma in b will further decrease. So, if there is a more reduction of sigma n b then stress in below the soil layer, so that means that will efficiency of the reinforcement that will increase. So, that mean the if the, so if there is a sufficient amount of the deformation within the reinforcement layer, then the efficiency of this bearing capacity efficiency of the reinforcement that will increase. Because the stress below the reinforcement that will decrease further. So, that means there is one very important conclusion, the to get sufficient amount of effectiveness they should be a sufficient amount of the deformation of the soil.

So, that means if the soil is very good condition, if the settlement of the soil, unreinforced soil itself is very less then providing reinforcement we will not give any effective, it is not a beneficial, it is very quiet obvious. But if the soil is very pore and there is a sufficient deformation of the soil in unreinforced condition, in that case if we provide the reinforcement then the effectiveness of the reinforcement that will increase.

For example, if I considering this way that if the with soil is good condition, this unreinforced condition the deformation is say 20 millimeter and if I provide the reinforcement will greater deformation, say 18 millimeter. So, that is a very small amount of the improvement, but for say if it is a soil is very poor condition deformation is a 100 millimeter. Now, if I provide reinforcement that deformation may come down to 60 or 70 millimeter. So, that is a huge amount of the, all though that 60 or 70 is greater than that 18 or 20, but the amount of the improvement or effectiveness of the reinforcement that is very high in case of soil with very poor condition.

So, that means we have to provide reinforcement when there is a sufficient amount of the deformation within the soil, this is a very important thing. So, another thing is that now, so the question is if I, so this is one thing that we have sufficient deformation another thing is that, so should we have increase the, if we increase the number of reinforcement how this improvement pattern will change. So, this is the linear, the thing is that if suppose we provide a one layer reinforcement or settlement will reduce, if we provide another layer of reinforcement then settlement will reduce further, if I provide say another layer of the reinforcement it will reduce further.

So, what will happen? Once we get we are trying to increase the number of layer, actually we are reducing the settlement and as I have mentioned that there should be a sufficient amount of the deformation to get the maximum amount of the benefit from the reinforcement. So, that is actually, that benefit is reducing because as we are increasing the number of reinforcement the settlement is reducing, so the effectiveness of the total system is also reducing. For example, if for the single layer of the reinforcement if there is a 30 percent or 40 percent settlement improvement of the soil.

Then if you, if I provide another layer so that will not be, see if it is 40 for the single layer for the double layer that not be the 80, so that will be list than 80 because the as we increase the, because of for the first case also the settlement has further decrease, if we use another reinforcement the settlement will further decrease. So, because of that the effectiveness of the reinforcement that will also decrease because as the settlement is reducing.

So, again if I provide the third layer so there do not be so if it is less than 80 for the second layer, then that settlement reduction will further, the effectiveness will further decrease, so this is not a linear case. So, after a certain time we will see that if I increase the number of reinforcement then there will would not be any improvement because then soil become so steep, there will be very, very little amount of the deformation and the effective of the reinforcement will be very small, so there will be known so much of the deformation.

So, that means we have to restrict with the certain number, so because after that if we increase the number that is useless. So, that is another case, the next one is the similar this is similar to for the length of the reinforcement also because if I increase the reinforcement length there will be a anchorage length that will increase, so that the anchor force will that will increase.

So, but after a certain length if I increase the reinforcement further, so that anchorage length that is useless. So that is not giving any improvement in the soil, because beyond that point that anchorage length is sufficient, so after that it is not useful. So, that means here we can say that for this one this number of reinforcement, that if I increase the number of reinforcement the improvement pattern is not not linear. So as we number the, increase the number of reinforcement the effectiveness of the total system that will reduce. So, up to after certain value you have to stop, that also depends on the type of loading, type of soil that we are using so all those things, so that number you have to decide first.

So then spacing and in the placement of the top reinforcement, length of the reinforcement, so those and properties of the, how much so that the this reinforcement can sustain within the induced tension. So, those things we have to check when you design the reinforced earth. So, that means this is very important issue you are talking about, this reinforced foundation, so some foundation on the reinforcement.

So, that means we have to consider all this things before we, when you design this type of foundation system. We have to consider the failure pattern, we have to consider the this all the design factors, when you design this things. Now, the next one another important structure that is our reinforced retaining wall.

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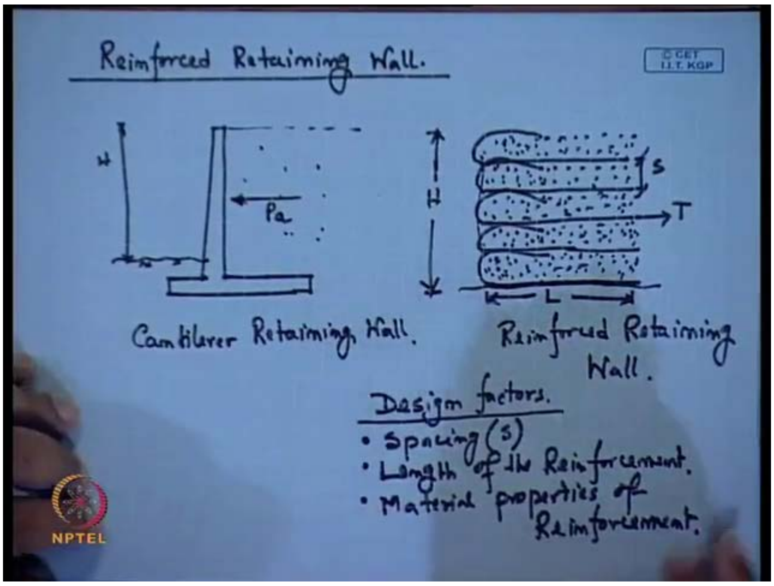

Now, this reinforced retaining wall, so we know this is our suppose, they are cantilever retaining wall. So this is a soil, this fill this side and this is the existing soil or foundation. Now here the soil is giving lateral pressure on the retaining wall, so this lateral pressure is taken by this cantilever retaining wall.

But here, we have providing say steel and if it is a gravity retaining wall, then the weight of the retaining wall is self is giving the resistance, but similar things there was this is cantilever retaining wall. Similarly, thus this things we can constructed by using the reinforcement, suppose this is our existing ground then we placed the reinforcement layer here ,then fold the reinforcement layer and place the soil inside these reinforcement layer.

Then we place another reinforcement layer top of this sand layer and folding and then put the sand layer inside this reinforcement. Then we place another reinforcement layer then we provide, fold it and put the reinforcement here, then we place another reinforcement on this top and again you folding and fill the sand, then we place another reinforcement and then fold it and place this sand.

So, this is call reinforced retaining wall. So, this is suppose this is the height of the retaining wall, here this will be the height of the retaining wall. Now, the here then what are the very important design factor when you talking about this retaining wall, one is again the if I go for this design factors or design parameters. Again first one will be one is your spacing between two reinforcement, again spacing is very important factor then this length, how much length will provide other design that is...

So, how much length will provide, that is also very important factor for the design. So, that means the length of the reinforcement, then again this material property because again here also this tension will develop. Then how divide the tension will develop, I will explain, but for this this material properties of the. That means this material property of the reinforcement is also a very important design factor.

So, that means, so we are talking about this things for the reinforcement case and again for the other case for the height of the retaining wall, the soil properties of the feeling material, as well as the foundation material, those are also very important design factors. But for the reinforcement purpose, this spacing this length and this material properties this are very important factor, when you consider this reinforcement.

Now, this how this tension is developed within the geosynthetic reinforced soil, that means the tension is develop. Suppose if this is the existing soil, if I another important thing that this folding length this is also very important. So, when I fold this reinforcement so this length is also very important. So, these are, that means the length of the reinforcement this total length and this L 0 also very important design factor.

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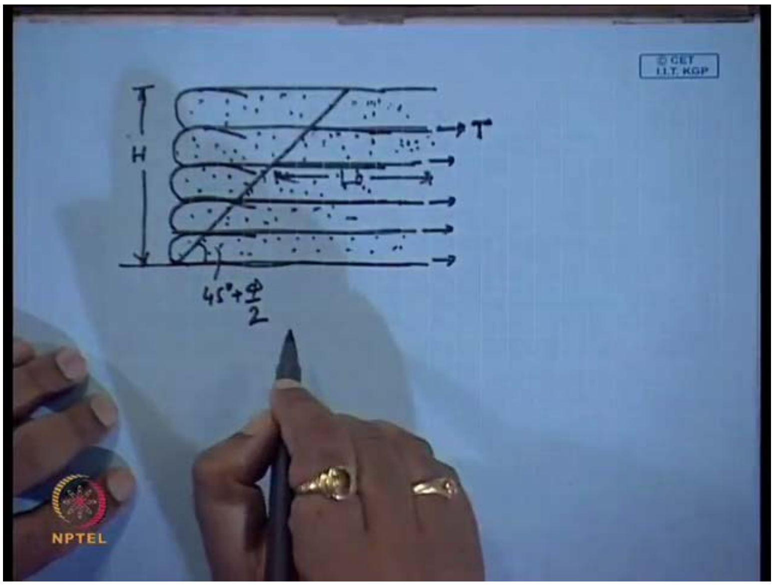

Now the how this tension is developed. So, if I place this one, if the place reinforcement here with soil, then place another layer, then place another layer. So, now if I consider a failure pattern like this, so this is 45 degree plus phi by 2, as we know this 45 degree plus phi by 2. So, if I consider failure pattern then what is actually happening here? So, that means this total system, this total soil mass along with this reinforcement is trying to slide along this failure surface. So that, but this reinforcement is basically actually holding this soil mass. So it will try to prevent, it will try to prevent for this slide. Now how it can be possible?

Now, if sufficient anchorage length, if we provide sufficient anchorage length of the reinforcement beyond the failure surface, then it is possible. So, as if the some something is sliding here that means this soil mass is sliding from this side and this soil mass along with these geosynthetic’s holding this sliding mass. So, this is possible if the geosynthetic’s sufficient anchorage length is provided beyond this failure surface, which is same as the previous case in the foundation in the reinforce soil. There also sufficient anchorage length is required beyond the failure surface.

So, that means we have to provide the sufficient length beyond the two side of the foundation. Here also we have to provide sufficient length beyond this failure edge, so that anchorage, so that this reinforcement, that means this soils both side of the reinforcement is holding this reinforcement like the previous case. It is holding the reinforcement and then this soil is try to slide.

So, when this soil that means this is the soil is holding this soil and this reinforcement and this soil is trying to slide, so what will happen? There will be a tension is developed. So, that means this tension is developed and this is this tension is developed and this anchorage force or this tension is developed that is T, and that means we have to provide the reinforcement such that, it can sustain this tension. That means this reinforcement should be sufficiently strong. So, that it can take this tension.

So, that is also very, that is why material property we have to choose such that it can take the tension, which is induced within the geosynthetic. And again these tension which is mobilized within geosynthetic that is developed because of this friction between the soil and the geosynthetic. So in the next class I will discuss about the various type of reinforcement and their application and also how to design reinforced retaining wall.

Thank you.