Ground Improvement
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Lecture 59
Geosynthetics in Ground Improvement (Contd.)

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NPTEL ONLINE CERTIFICATION COURSES

GROUND IMPROVEMENT

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Module 11: Geosynthetics in Ground Improvement

Lecture 09 : Geosynthetics in slopes

Hello, everyone. Let us continue with Ground Improvement, geosynthetics in ground improvement. And this is of course, almost the last lecture of this entire ground improvement class, ground improvement course. And I have one module, half an hour is left. I will try to do in that, about question type, and maybe summarize the entire thing in that one. So basically, this one is the last lecture covering the ground improvement technique.

So here we have, in this module actually dedicated for application of geosynthetics in ground improvement, and we have kept most of the module, actually five lectures, but here total nine lectures. So initially I have given some of the general application of geosynthetics. And then I have tried to give you, in detail, the application of geosynthetics in MSE wall design, and I have also shown how to design the MSE wall.

Basically any, any wall, any design you do, civil engineering design you do, generally, initially you take the, assume the section and then through analysis we try to show that all performance requirements are satisfied. And whatever, if you, your initial design or assumed value does not give you, or satisfy the required performance criteria, then we generally modify, or redesign, and again check. So finally, we arrive at final design. So that is the thing I have done in the previous lecture for MSE wall.

And I have mentioned that it can be applied to many other areas like in the pavement and there can be application in, in foundation, below the foundation and many other applications, there, it, it can be applied on the slope. And everything, I, cannot be considered, difficult to consider here. So as I have mentioned, I will just show some application of the geosynthetics in, reinforced, in the slope.

And so that slope, the how, we generally do slope stability analysis, different methods are available. These are quite classical problem in soil mechanics. And when you apply, when you give reinforcement to the slope, how that analysis changes, that actually I will try to show. And just only that. Introduction. So with this let me see the first slide. So let me take the first slide of the, on the slope, the application of geosynthetics in reinforced slope.

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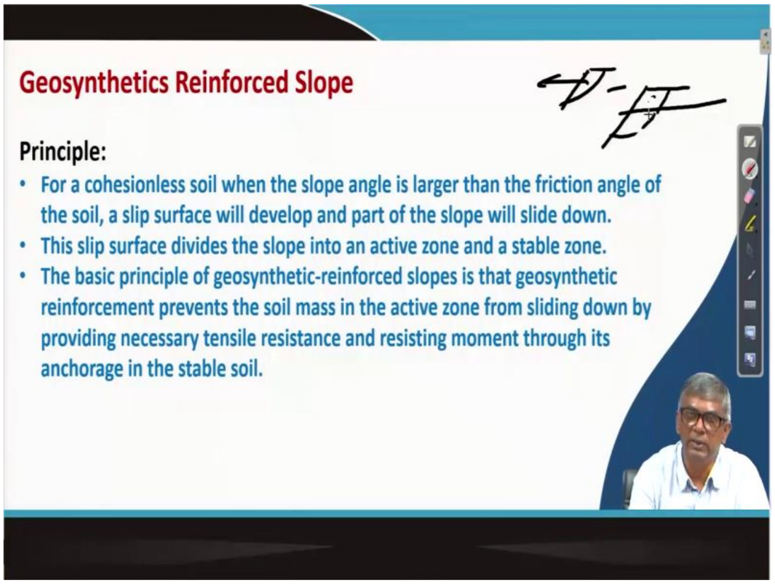

Geosynthetics Reinforced Slope

Principle:

- For a cohesionless soil when the slope angle is larger than the friction angle of the soil, a slip surface will develop and part of the slope will slide down.
- This slip surface divides the slope into an active zone and a stable zone.
- The basic principle of geosynthetic-reinforced slopes is that geosynthetic reinforcement prevents the soil mass in the active zone from sliding down by providing necessary tensile resistance and resisting moment through its anchorage in the stable soil.

And this is the one. what is the principle in it? So, we know that when you, when we have done the slope stability analysis, then we have we have seen that, that for cohesionless soil, when the slope angle is larger than the friction angle of the soil, then a slip surface will develop and part of the slope will slide down.

So, if this is the soil, and the inclination of the slope is more than the friction angle, then actually failure surface will develop, and the failure surface actually, actually divide the slope in two parts. One is stable zone, another, failure zone. And so, so that, so that is what.

So, if the slope become more than the friction angle, then slip surface will develop and part of the slope will slide down. And this slip surface divides the slope into two part, active zone and stable zone. We have already discussed that if it is a slope like this, and like this, and if it happens like this, so this part is active zone and this part is a stable zone. Why it is called active zone? Because this part will be moving. It is active. And this part actually stable zone, nothing is happening.

And the basic principle of geosynthetic reinforced slope is geosynthetic reinforcement prevents the soil mass in the active zone from sliding down. So that means if I now, if this is the slope, and there is a likely failure surface is this, if I put the reinforcement like this, then because of this reinforcement when it will move this direction then there will be friction between the soil and reinforcement develop, by that actually, this reinforcement, presence of the reinforcement will not allow to move the soil downward.

So that has to be designed. Of course, if I put one, it may slide. But if I put, design properly, in a particular interval if you give number of them, then the failure can be prevented. So that is what, the basic principle of geosynthetic reinforcement slope is that geosynthetic reinforcement prevents the soil mass in the active zone from sliding down by providing necessary tensile resistance and resisting moment.

So, this is actually the one. So this will have some moment also, resisting, resisting force also there, and also moment. So both actually, together, will provide the stability of the slope. So now, let me go to the next, let me go to the next slide.

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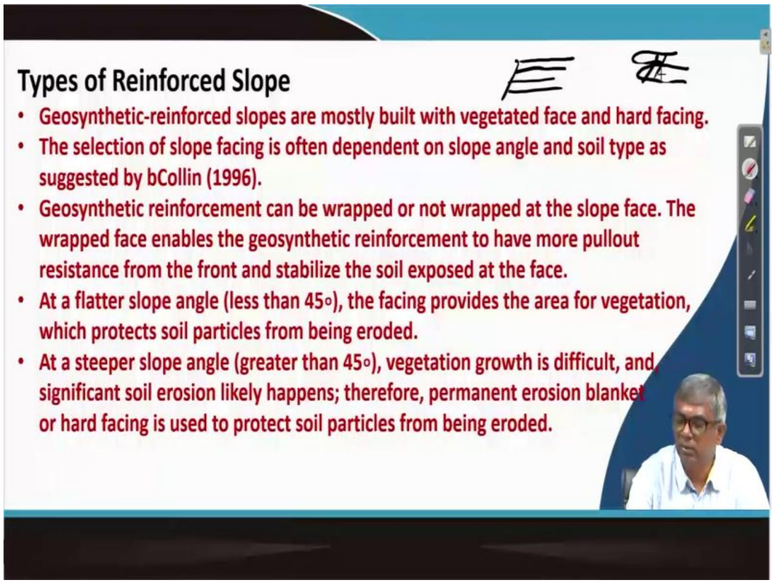
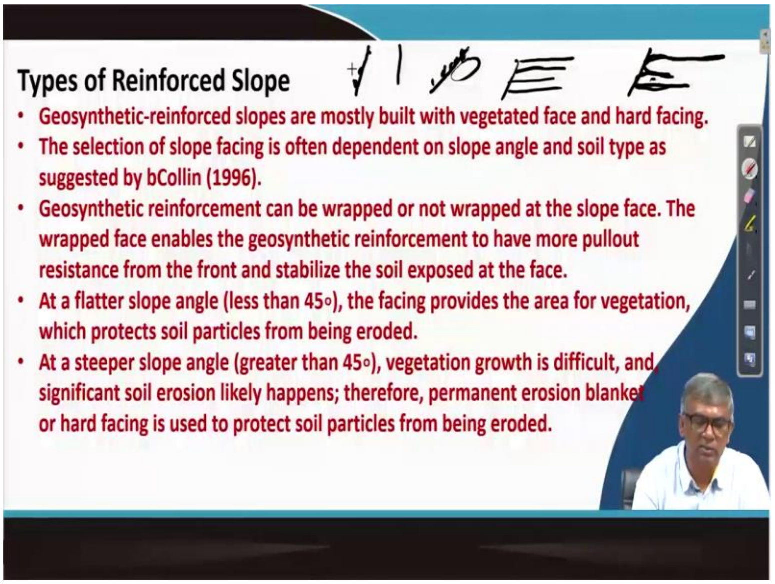


Types of Reinforced Slope

- Geosynthetic-reinforced slopes are mostly built with vegetated face and hard facing.
- The selection of slope facing is often dependent on slope angle and soil type as suggested by bCollin (1996).
- Geosynthetic reinforcement can be wrapped or not wrapped at the slope face. The wrapped face enables the geosynthetic reinforcement to have more pullout resistance from the front and stabilize the soil exposed at the face.
- At a flatter slope angle (less than 45°), the facing provides the area for vegetation, which protects soil particles from being eroded.
- At a steeper slope angle (greater than 45°), vegetation growth is difficult, and significant soil erosion likely happens; therefore, permanent erosion blanket or hard facing is used to protect soil particles from being eroded.



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So, types of reinforced slope. And, so you can see that geosynthetic reinforced slopes mostly built with vegetated face and hard facing. So vegetated style facing means, where we can allow to grow grass or artificially, you can grow the grass. You can provide, put the seeds and through that grass can grow or some plantation can be done. So that is one that is vegetated face.

Another is hard facing, that means you have to do something, either concrete or something else, blocks that cover the slope that is another type. And the selection of these two, that is whether it is a vegetated face or the slope face, that depends on soil type and the inclination of the, or slope angle. These two. And, so that I will show you some details in the table for different inclination and different types of wrapped or not wrapped, there are two types of, things are there.

So geosynthetic reinforcements can be wrapped or not wrapped. Wrapped means what? Actually, simply I can, this is the slope, this is the slope and reinforcement is provided like this. Another slope, the reinforcement is, one reinforcement is here, it is like that, and then another reinforcement, it is like that. So it is, sorry, bettor not, I will remove this.

So suppose, suppose this is the one. The reinforcement is here, this one will be going like this and it will be wrapped like this. Then reinforcement from here, it will be going like this. So this will be wrapped. It will start from here, it will be wrapped like this. So this, that means, this, this is, this, this is also reinforcement covered. The soil is not exposed. So that geosynthetic reinforcement can be wrapped or not wrapped at the slope face.

The wrapped face enables the geosynthetics reinforcement to have more pullout resistance from the front, and stabilize the soil exposed the face. Because of this wrap, so soil inside, so it will have more resistance. And at the flatter slope angle less than 45 degrees the facing provide the area for vegetation.

So, if the slope is something like this then because of the flat slope the vegetation growth et cetera is easy, and which protects the soil particle from being eroded. If lot of vegetation is there the surface will not prevent from the erosion, and that happens, then this the slope will be more stable.

And at steeper slope angle vegetation growth is difficult and significant soil erosion likely to happen therefore, permanent erosion blanket or hard facing is used to protect the soil particles from being eroded. So this is the one. And if the one other slope is some, sorry, another slope is something like this, in that case, you have to put hard face or some permanent erosion blanket should be, should be provided. This is the types of reinforced slope. Let me go to the next one.

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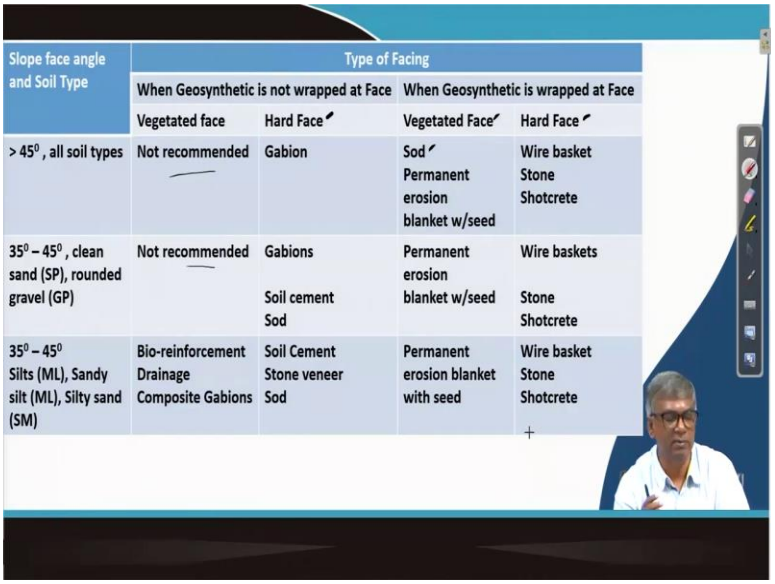

Slope face angle and Soil Type	Type of Facing			
	When Geosynthetic is not wrapped at Face		When Geosynthetic is wrapped at Face	
	Vegetated face	Hard Face	Vegetated Face	Hard Face
$> 45^0$, all soil types	Not recommended	Gabion	Sod Permanent erosion blanket w/seed	Wire basket Stone Shotcrete
$35^0 - 45^0$, clean sand (SP), rounded gravel (GP)	Not recommended	Gabions Soil cement Sod	Permanent erosion blanket w/seed	Wire baskets Stone Shotcrete
$35^0 - 45^0$ Silts (ML), Sandy silt (ML), Silty sand (SM)	Bio-reinforcement Drainage Composite Gabions	Soil Cement Stone veneer Sod	Permanent erosion blanket with seed	Wire basket Stone Shotcrete

So that is what, but we have mentioned that different, depending upon the type of slope angle and all, different types of slope possible, so there is a complete list in this, you can see here. If the slope angle is greater than 55 degree, 45 degree and all types of, all soil types, then this is actually, this giving actually slope angle and soil type, and type of facing, it can, when geosynthetic is not wrapped at faced, when geosynthetic is wrapped at face.

And again, under this, it can be vegetated face, it can be hard face. Under this also, it can be vegetated face, it can be hard face. So when slope angle greater than 45 degrees, then vegetated face is not recommended. And hard face actually, gabion et cetera can be used. Then only you can make, able to make such a steep slope.

And this is, more than 45 degree angle, and when it is wrapped, and vegetated face actually short, that means, the grass, the number of grass sprayed over an area, that can be, entire thing can be put in a, sequentially. That is called shot. And vegetate, then or permanent erosion blanket with seed, these two options can be there.

And then another option when the angle is steep, and it is wrapped also, hard face then wire basket or stone shotcrete can be done for permanent one. And if the angle between 35 degrees to 45 degrees, and clean sand or rounded gravel, this is the soil type, there also, if not wrapped, then vegetated face is not recommended, because it will be eroded.

And, and hard face can be there, it can be gabion, it can be soil cement, or it can be shot. And shot, actually, then, when it is a, this is the angle, and when it is wrapped face, then, the vegetative face actually permanent erosion blanket with seed is required because it is a slope, moderate slope, but it is clean sand, very easy to erode. Because of that permanent erosion blanket is that, if it is a vegetated face, actually, if you want to use, this is the way actually has to be used.

And if it is wrapped, then wire basket can be used, the hard face, wire basket, stone shotcrete can be done. Again, angle between 35 to 40°, but sail is silt, sandy silt, silty sand, and then the vegetated. So, it is not wrapped face, then vegetated face also can be recorded, Bio-reinforced, reinforcement drainage, composite gabions, like that, it can be used, or if it is a hard face then soil cement stones veneer, sod can be used.

And when it is wrapped, then vegetated face, the permanent erosion blanket with seed can be used. And when hard face, wrapped and hard face, then wire basket, stone shotcrete can be used. So when the angle between 35 to 45, and it is silt, or sandy silt, or silty sand. So let me go to the next slide.

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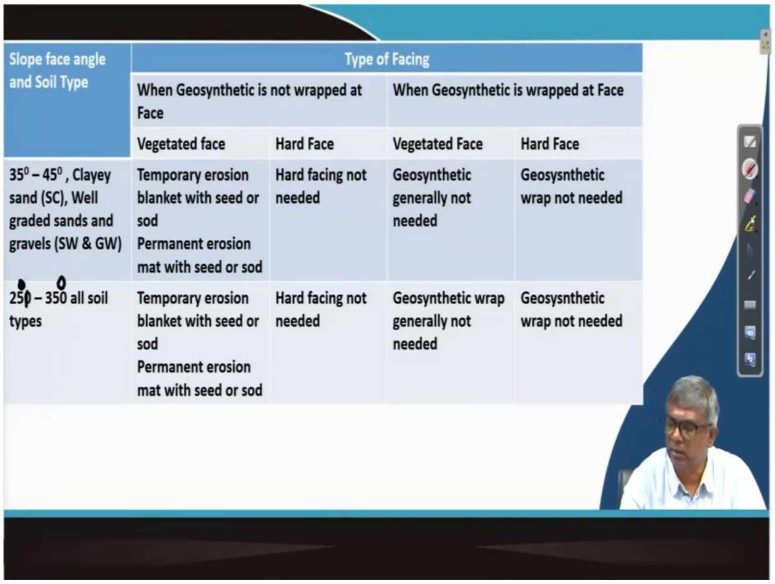

Slope face angle and Soil Type	Type of Facing			
	When Geosynthetic is not wrapped at Face		When Geosynthetic is wrapped at Face	
	Vegetated face	Hard Face	Vegetated Face	Hard Face
$35^0 - 45^0$, Clayey sand (SC), Well graded sands and gravels (SW & GW)	Temporary erosion blanket with seed or sod Permanent erosion mat with seed or sod	Hard facing not needed	Geosynthetic generally not needed	Geosysnthetic wrap not needed
250 – 350 all soil types	Temporary erosion blanket with seed or sod Permanent erosion mat with seed or sod	Hard facing not needed	Geosynthetic wrap generally not needed	Geosysnthetic wrap not needed

So, continuation of this table. This is actually again angle is 35 degrees and 45 degrees, between 35, but it is clayey sand, or well graded sand and gravels, in that case, when it is not wrapped at face, a vegetated face if you want to do, temporary erosion blanket with seed or sod, permanent erosion mat with seed or sod, these are the, arrangement can be done.

If it is a hard face, then hard facing not needed, actually. If it is a slope between 35 degree and 45 degrees and it is a clay or silty clay or something then this hard facing is not required. Erosion problem is less. And when this soil again, wrapped in face then vegetated face can be used. Then geosynthetics generally not needed. Geosynthetic generally not needed for this type of slope and soil. And if it is hard face, geosynthetic wrapped, not, the, here also, wrapping is not required actually.

And if the, sorry, this is not 250 and 350, it is 25 degrees and it is 35 degree and all soil type, there is quite mild slope. Between 25 to 35degree. And wrapped face, not wrapped face, then temporary erosion blanket with seed permanent erosion mat with seed or sod, all types of things can be done without wrapping also. And hard face is not required.

And when is wrapped actually, geosynthetic wrap is generally not required because this is soft oil, and I, the slope is very mild, wrap is not required, here also, wrap is not required. So, this is the different ways actually, the slope can be, whether reinforcement and, is required or not, that can be decided.

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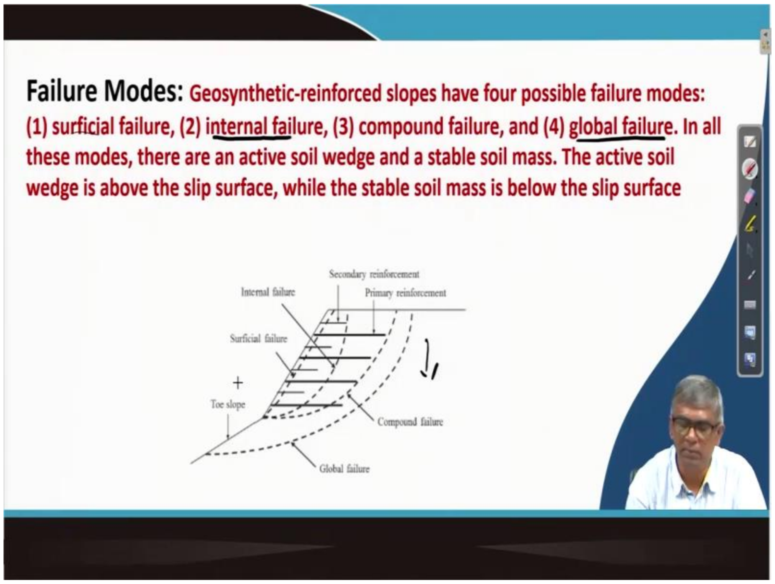

Failure Modes: Geosynthetic-reinforced slopes have four possible failure modes: (1) surficial failure, (2) internal failure, (3) compound failure, and (4) global failure. In all these modes, there are an active soil wedge and a stable soil mass. The active soil wedge is above the slip surface, while the stable soil mass is below the slip surface

So, failure modes, oh sorry, like your MSE wall, we have shown a number of failure modes. Here also, slope also, when geo, geosynthetic-reinforced slope, there are also number of failure modes. And you can see that there are a number of failure modes.

One is actually surficial failure. So that means this surface, the surface of the slope can move. That is surficial failure. Then you have internal failure, that means you can see here the reinforcement are provided. Internal failure, reinforcements are provided here actually, you can see. And the failure is taking place here, taking place from here. So that means it is internal failure.

That means, you have to, this is the typical design. So here actually, this amount of soil will try to move this time, and then during that that friction between the soil and reinforcement will try to hold. When it will not be able to, so it is, when it is not designed properly, then it will fail. So that is internal failure. That means. The internal failure again, can be of different types. We will discuss later on.

Then compound failure you can see here, this is the type of failure when it is passing through, actually reinforcement somewhere, actually beyond reinforcement. Some portion actually it is giving you resistance, some of the portion there is no resistance from the reinforcement. So that is compound, so this one.

And another is the global failure, that means that outside of the, reinforcement, somewhere else that failure plan develops, and entire mass can move, slide downwards. That is actually global failure.

And there are, there will be active soil, stable soil mass. The active soil wedge is above the slip surface, while the stable soil mass is below the slip surface. So this one is the stable and this is the active. So then, we have to actually design properly so that the active soil can be retained in place. So that is the principle actually. So now, we will try to see other aspect of reinforcement, so design, maybe design aspect.

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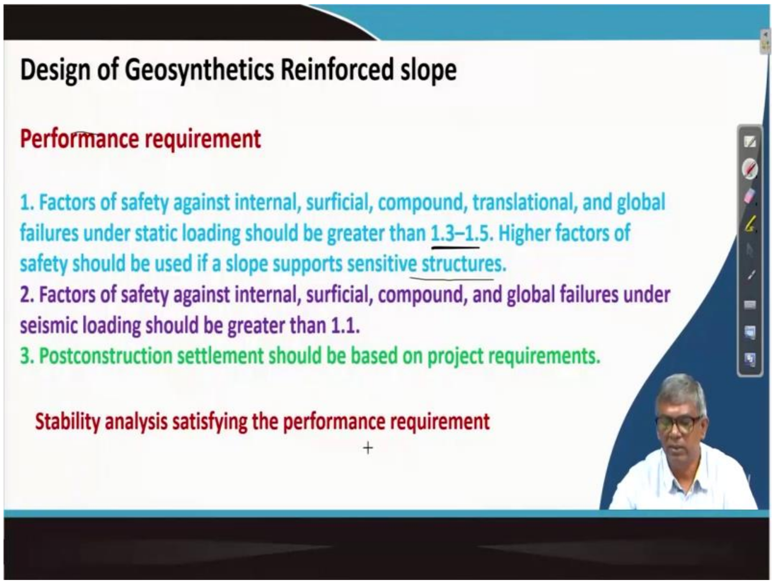

Design of Geosynthetics Reinforced slope

Performance requirement

1. Factors of safety against internal, surficial, compound, translational, and global failures under static loading should be greater than 1.3–1.5. Higher factors of safety should be used if a slope supports sensitive structures.
2. Factors of safety against internal, surficial, compound, and global failures under seismic loading should be greater than 1.1.
3. Postconstruction settlement should be based on project requirements.

Stability analysis satisfying the performance requirement

So, so design. So how to design, actually? The performance requirement here also, like previously, whatever we have seen in, MSE wall, or any other thing, performance requirement means factor of, there are a number of failure modes, and for each failure mode we have to find out factor of safety.

So here actually factor of safety against internal, surficial, compound and translational and global failures under static loading should be greater than 1.3 to 1.5. This is, generally factor of safety for slope most of the time is 1.5. So whatever different types of failure modes are there, everywhere it has to be, factor of safety has to be maintained 1.5. Higher factor of safety should be used in slope supports sensitive structure.

So obviously, it is given 1.3 to 1.5 range. If it is normal road, it is 1.5, or 1.3 or 1.45, anything, but when there is a sensitive structure is there, or sensitive, anything sensitive is there, then we do not allow it to fall, then in that case higher factor of safety to be used.

And factor of safety against internal surficial, compound or global failures under seismic loading should be greater than 1.1, actually. They are little lower because we are taking seismic loading, which is, chance is less. And when you are taking that then, then you have to take a little lesser value of factor of safety, but it should be, should not be less than 1.1.

And postconstruction settlement should be based on the project requirement. So postconstruction settlement also can be the reason for distress in many things. So that has to be some structure. Depending upon the structure, we can decide what should be the settlement. So, this is the performance requirement. It should not settle beyond certain limit. It should have certain factor of safety for this, those are the things to be satisfied.

And then, based on that, you have to do the stability analysis. Stability analysis satisfying the performance requirements. Like, a stable, mechanically stabilized earth, we have done stability analysis. Similarly, here also stability analysis has to be done. And here to show that factor of safety, each and every aspect is a, more than that desired value. So that, then design will be complete.

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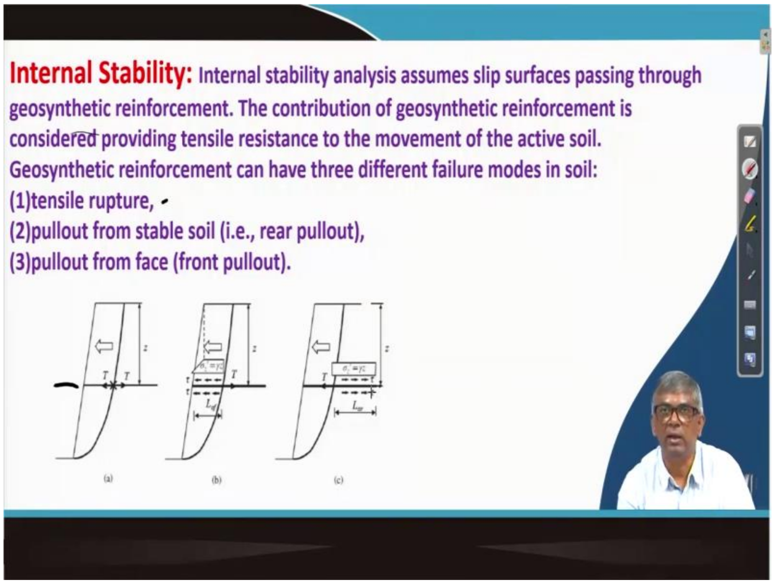

Internal Stability: Internal stability analysis assumes slip surfaces passing through geosynthetic reinforcement. The contribution of geosynthetic reinforcement is considered providing tensile resistance to the movement of the active soil. Geosynthetic reinforcement can have three different failure modes in soil:

(1)tensile rupture,

(2)pullout from stable soil (i.e., rear pullout),

(3)pullout from face (front pullout).

So, you can see, so internal stability. This is the most important, actually. How reinforcement is working, and providing the resistance. Through these, I can show you. You can see that the internal stability means what actually? You can see here; this may be the active zone and this is a stable zone. And reinforcement is passing through the both.

And when this try to slide, then what will happen? There will be some, friction will develop in this direction and because of that, there will be a tension, this one will try to pull, this direction, so you will, it will develop some tension in this direction. There can be three different failure for this.

Either the, this, this reinforcement can tear, or the reinforcement can come out from this, or, or this soil can come out from the reinforcement. These are, there are three, so tensile rupture can happen, pullout from the stable soil, that means entire reinforcement from the stable zone can come out because of this heavy weight, because, and that tension developed. Or pullout from the face. That means, this soil can be, this entire mass and come out from the, leaving the reinforcement out. So that three types of things will be happening.

And when you will do that, and you can see here that is actually, there are different zone which we have discussed before in other, in the nails also, similar to that, here also you can see that when it is this side then what is the, friction is this direction and how to find out, that calculation is shown here. Sigma z, gamma z is acting. And length is L.

And then friction can be considered, and then we can find out what is the total quantity. The tension, what is the tension developed. And if it is, when you want to try to pullout, then I will consider this tension here, and then resistance is this direction. So normal stress acting is γz, and then this is resisting zone Lar, length is there. And then friction, if you take, then you can find out what is the frictional, total frictional resistance, and that can be calculated. This is the way actually analysis can be done.

So let me see the next slide, how it is providing normal slope, factor of safety and how while providing this reinforcement, how the factor of safety is changing, that, let us see.

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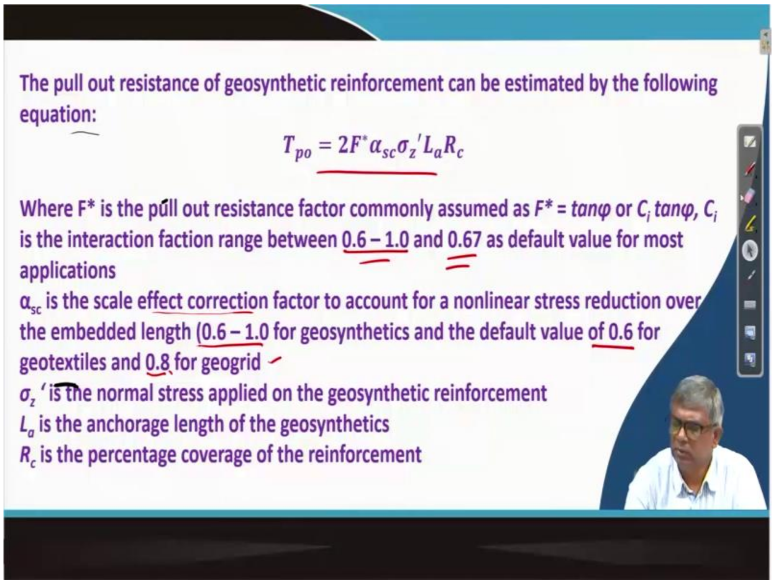

The pull out resistance of geosynthetic reinforcement can be estimated by the following equation:

$$T_{po} = 2F^{*}\alpha_{sc}\sigma_z' L_a R_c$$

Where F* is the pull out resistance factor commonly assumed as $F^{*} = \tan\varphi$ or $C_i \tan\varphi$, C_i is the interaction faction range between 0.6 – 1.0 and 0.67 as default value for most applications

α_{sc} is the scale effect correction factor to account for a nonlinear stress reduction over the embedded length (0.6 – 1.0 for geosynthetics and the default value of 0.6 for geotextiles and 0.8 for geogrid

σ_z' is the normal stress applied on the geosynthetic reinforcement

L_a is the anchorage length of the geosynthetics

R_c is the percentage coverage of the reinforcement

And then you can see that, this already we have done when we have done in the nail, and other places, and also in reinforced earth, so the Tpo, that means pullout capacity. Pullout resistance of geosynthetic reinforcement can be, that is the formula we have used before also. This formula, we have used. 2 F star alpha s c sigma z L a multiplied by R c. F star is the pullout resistance factor commonly assumed.

Tan phi or C i tan phi, where C i is the interaction, faction, interaction faction range between 0.6 to point, 1. And typically use 0.67 as default values. Alpha s c is the scale effect correction factor to account for nonlinear stress reduction over the embedded length. Generally, 0.6 to 1 for geosynthetics, and default value is 6. And geotextile, 0.6 for geotextile, and 0.8 for geogrid. So, default value is 0.6 for geosynthetics, and 0.8 for geogrid. Otherwise, the range is 0.6 to 1.

And σz is the normal stress applied on the geosynthetic reinforcement. L a is the anchorage length, R c is the percentage coverage. Percentage coverage means how much coverage is actually done by the reinforcement. That, I will show in the next figure. This is the way, actually, you can find out what is the pullout capacity of the particular reinforcement.

When it is extended beyond the failure surface, then what is the maximum pullout capacity that can be considered, compared with the, what is the tension developed because of the movement of the active soil. So let us now, it is not working. Anyway, let us go to the next slide, and show the coverage area.

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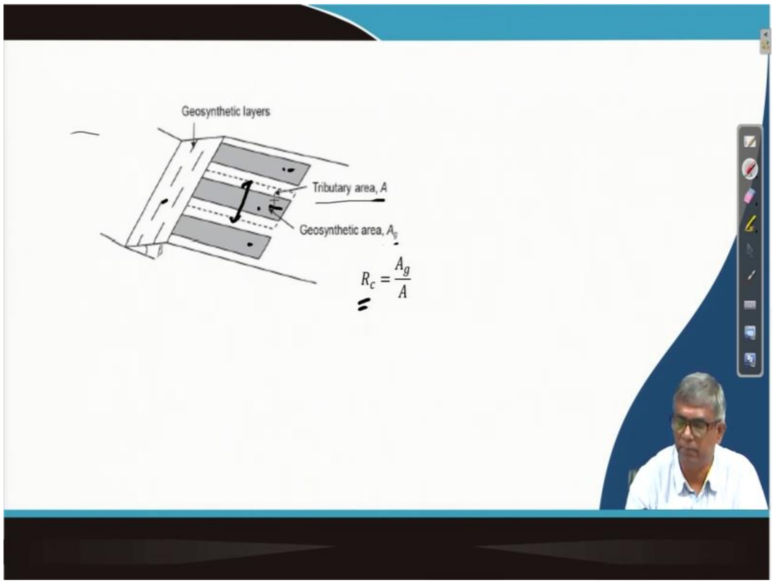

So, you can see here, reinforcement is laid, reinforcement is laid here. This is the reinforcement. And the tributary area up to, this is, up to the midpoint of this, midpoint of these. So geosynthetic area will be Ag, and the tributary area is a dotted line to dotted line. So that is actually, this tributary area is A. And this is the actual geosynthetic area, Ag.

$$R_c = \frac{A_g}{A}$$

So, Rc actually, coverage actually, Ag by A. It cannot be 100 percent because we are not putting the reinforcement one after another. It is, one reinforcement is here, another reinforcement here, next reinforcement here. When there will be reinforcement here, so then, another reinforcement here, midpoint, and another reinforcement here, their midpoint. This midpoint to this midpoint, this is the, the area for which this reinforcement is action, in, in action. That is called tributary area for this particular reinforcement.

So, this is the reinforcement, this is the reinforcement, this is the reinforcement. Midpoint between these two, midpoints of, between these, from here to here is the tributary area for this reinforcement. What is the total area, tributary area, and what is the reinforcement area? So that ratio is the Rc that can be calculated anytime. So let us go to the next one.

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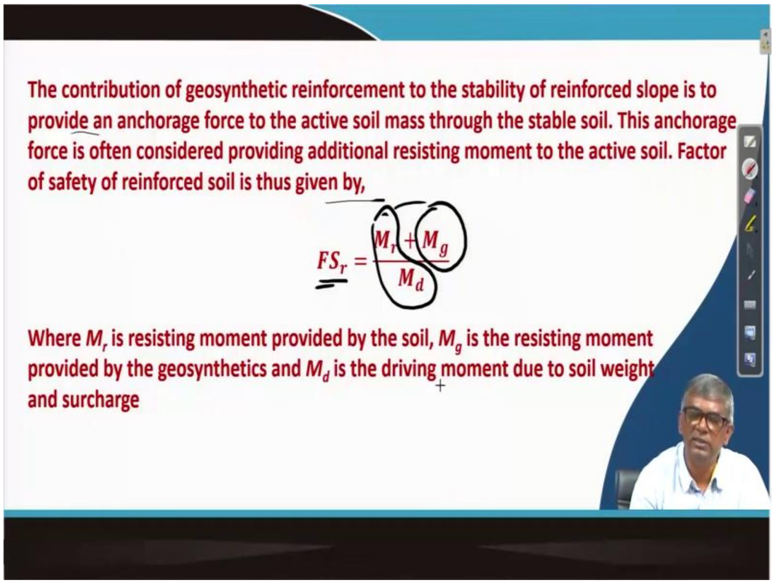

The contribution of geosynthetic reinforcement to the stability of reinforced slope is to provide an anchorage force to the active soil mass through the stable soil. This anchorage force is often considered providing additional resisting moment to the active soil. Factor of safety of reinforced soil is thus given by,

$$FS_r = \frac{M_r + M_g}{M_d}$$

Where M_r is resisting moment provided by the soil, M_g is the resisting moment provided by the geosynthetics and M_d is the driving moment due to soil weight and surcharge

And you can see that that contribution of geosynthetic reinforcement to the stability of reinforcement slope is to provide an anchorage force to the active soil mass through the stable soil. And this anchorage force is often considered providing additional resisting moment to the active soil. And factor of safety of reinforced soil is, so because of that, so factor of safety of reinforced soil, actually M_r by M_d is normal slope, but this actually Mg, that whatever resistance is providing, developing that resistance also contributing some resisting moment.

So, because of that, on this soil, M_r was there, and together with that Mg to be added, these two together will become total resistance, and, and driving moment also, this one. So that ratio becomes this factor of safety.

$$FS_r = \frac{M_r + M_g}{M_d}$$

M_r = Resisting moment provided by the soil
M_g = Resisting moment provided by the geosynthetics
M_d = driving moment due to moment soil weight and surcharge

So, what M_r, is resisting, this is, a number of times we have mentioned, so I will not read again. M_r, M_g or M_d. M_d is the driving moment, M_r is the resisting moment from the soil, unreinforced condition, and M_g is the resisting moment because of the reinforcement resistance.

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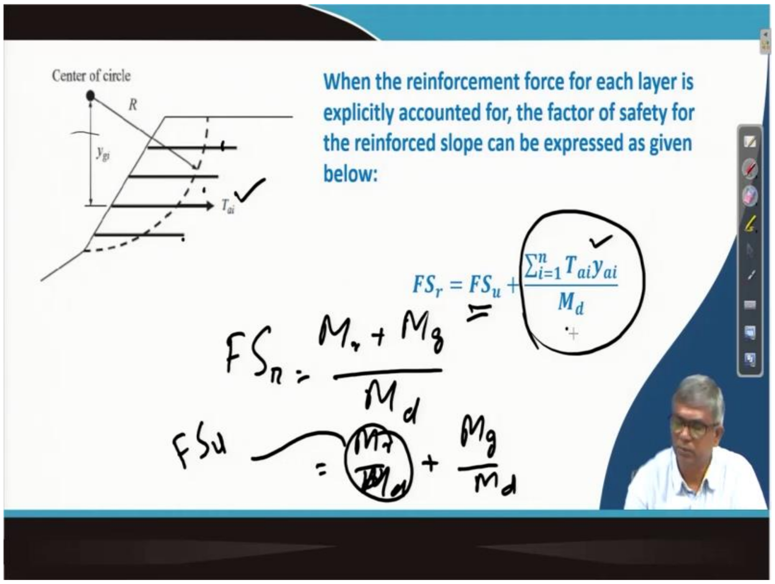

When the reinforcement force for each layer is explicitly accounted for, the factor of safety for the reinforced slope can be expressed as given below:

$$FS_r = FS_u + \frac{\sum_{i=1}^{n} T_{ai} y_{ai}}{M_d}$$

$$FS_n = \frac{M_r + M_g}{M_d} =$$

$$FS_u \quad = \frac{M_r}{M_d} + \frac{M_g}{M_d}$$

So now, after this can be modified or simplified like this. You can see here that the number of reinforcement will be there. So, 1, 2, 3, 4, like that, if a particular reinforcement at a position, I reinforcement, Ith reinforcement, then, so you can see that whatever it was equation was, F S r will be equal to M r plus M g divided by M d.

So, M r plus M d, so this M r by M d plus M g by M d. this is nothing but factor of safety in, on reinforcement. Because of that you have written factor of safety unreinforced reinforcement, factor of safety in unreinforced condition, and reinforced condition, how to find out?

You can see that at any position, actually suppose Tai is the resistance, and the, the distance from the rotation, that moment creating, so Yai. So that gives you moment. T a i multiplied by Yai. Like that, in number of them if we, the moment it is creating, that moment if you add, 1 to n, and then that will be the total resisting moment because of the geosynthetics, divided by M_d.

So, this will be the, because of the reinforcement, what is the amount of resistance, or factor of safety, additional factor of safety we are getting, that can be calculated. FSu plus FSr or FSg, you can say, FSu plus FSg become FSr. So, this can be calculated.

$$FS_r = \frac{M_r + M_g}{M_d}$$

$$FS_r = FS_u + \frac{\sum_{i=1}^{n} T_{ai} + y_{ai}}{M_d}$$

So, like that, actually, all analysis can be done. This is the one, I have just tried to show how it is providing the resistance, or additional resistance to, against sliding. So that is all.

Of course, with this, obviously, I have, there are a number of things as I have mentioned that. It is, it can be used in below the foundation, actually, or it can be used below the pavement. There are again, similar analysis will be there.

If you use below the foundation, again, there are a number of different types of, the failure will be there. And against this failure, you have to do the analysis and you have to provide some factor of safety. So, design principle almost similar.

So, if I assume the reinforcement is provided below the foundation, then what are the different types of failure modes possible, you have to examine, and then for each and every failure mode you have to provide certain factor of safety. Similarly, if it is used below the pavement, then similar design can be done.

So of course, I am not taking that. With this lecture almost it is, I have, the, it is the end of the lecture on ground improvement. Only one half an hour lecture, I will be giving to summarize the entire ground improvement, what we have done so far. And broadly, you have to visualize, when you are in the field, how to select a particular ground improvement technique. And like that, I, some summary, summary I will do in a, in one more lecture sometime.

So, with this, I will be closing this ground improvement lecture. And if you attend this course, and do the assignment and finally appear exam, perhaps it will be beneficial to you. And if it benefits you, I will be very happy, actually. That is all. Thank you, all.