Ground Improvement
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Lecture 53
Geosynthetics in Ground Improvement (Contd.)

Hello everyone. Let me welcome you to this Ground Improvement lecture and we are in a topic geosynthetics in ground improvement. There are ground improvement means actually when the ground is not suitable for use directly for any construction. So, before doing construction whatever modification we do to achieve the desired quality of the material that is ground improvement.

And we have discussed that the different ways ground improvement can be done, densification, removal of water that is also densification. Then solidification the rerouting, then sand drains and many other chemical stabilizations and those actually those cases somewhere we have applied force and some places we have added some material and now, we are discussing that summer we have discussed so, far only addition of chemical.

Now, we are discussing mainly the addition of some material in the (geo) in the inside the geomaterial to achieve or to improve the ground characteristics. Ground characteristics means what? We need to improve the strength, to decrease compressibility then increase strength decrease permeability like that so, many parameters are there and it has to be satisfactory.

We are already discussed on two lectures on geosynthetics in ground improvement and of course, I have already mentioned that there will be 5 hours lecture that will 10 modules on geosynthetics in ground improvement and initially general aspect of reinforcement you have discussed of course, characterization and all of those things we have not discussed, only based on the shape, size, manufacturing procedure and functional characteristics we have already classified.

And we have shown some figure and we are discussing the through last class that function; that is actually that functional geosynthetics. So, I am continuing to that.

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So, let me continue to this here actually we had discussed in the last lecture that geosynthetics in roads and pavement and again there are different ways or different purposes we use that in the roads and pavement and subgrade separation and stabilization already have discussed. Now based reinforcement. That is the thing we'll discuss, then overlay stress absorption and overlay reinforcement these are the things we will discuss one by one.

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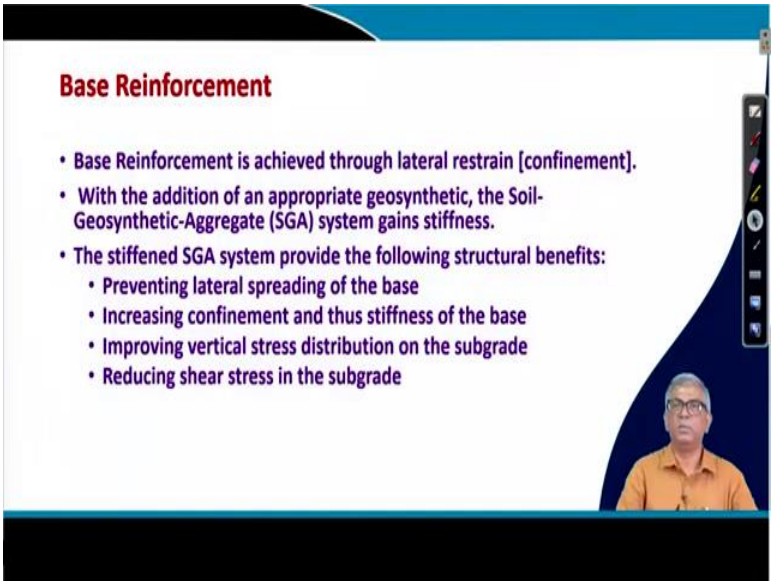

Here actually basically enforcement means what; that the below the bass actually that if the soil is not good enough, then we can use geosynthetics and this geosynthetics helps to improve the

strength in different ways that is the thing is mentioned here. Base reinforcement is achieved through lateral restraint, okay.

So, what whatever reinforcement or geosynthetics you are putting that is actually providing some lateral restraint that is actually acting as a reinforcement arm, it is confined, it is lateral restraint or confinement and with the addition of appropriate geosynthetics, soil geosynthetics aggregate system generally gains strength, stiffness, better stiffness.

And how; Because of these what are the structural benefits we get? It prevents lateral spreading of the base, suppose if the soft soil and if there is a wheel load pressure is applied then soil will be spread laterally and then below the tyre. We have a significant amount of depression and if it continues then road will spoil that is actually.

So, this is preventing lateral spreading of the base and increasing confinement and thus stiffness of the base that that is one. It is not allowing the soil to spread laterally at the same time it is also giving some confinement and that confinement increasing the stiffness and improving vertical stress distribution on the subgrade that means, particle size distribution we know that from the theory that is an equation.

But approximately we take some dispersion two vertical one horizontal something like that to most common soil and it of course depends on soil type and when the particular soil if the load is applied whatever way the load will be disperse and if I provide on reinforcement below, then your dispersion will be wider that means it test intensity below the loading point will be reduced and also reducing shear stress in the subgrade. So, if the load intensity reduced then automatically shearing stress also be decreasing.

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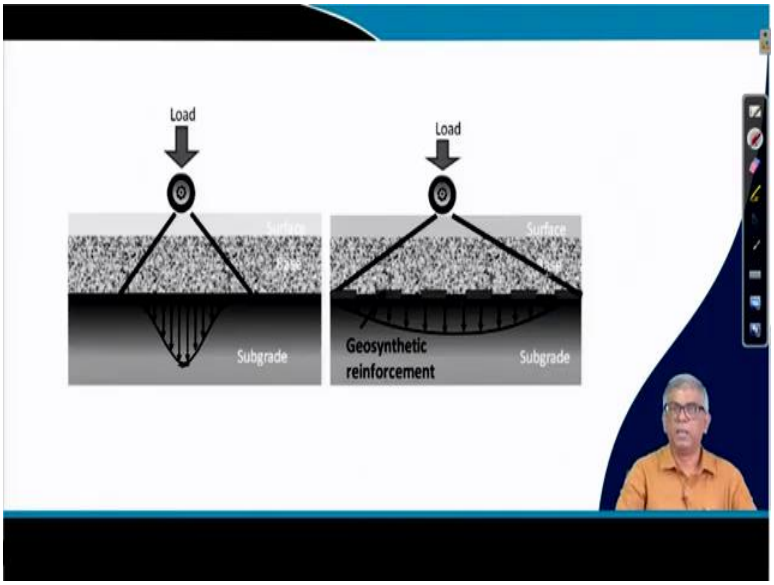

That mechanism is shown through this figure actually, you can see that before without reinforcement if this is the layer, this is top layer with sub base and subgrade, a base course and this is base course and this is a subgrade and this is suppose surface and the surface wheel is applied this figure already I have shown once, once again because it is relevant.

because then the spreading is this much and because of that stress distribution below that and away from the wheel load you can see that the middle it is maximum and away from the wheel point it will be decreasing, but the maximum value is quite large. Whereas if I apply, if I put between the base course and the subgrade there is reinforcement, then you can see that this dispersion is quite wider.

And as a result, it will be same, maximum will be at the midpoint and if you go away from this then it will be reducing, behaviour is same, but the magnitude of the maximum value compared to this is much smaller. So that is the way actually it is giving this is one benefit actually that stress decreasing and other benefits whatever we have mentioned that step because of this load.

Since this so much area is dispersed so lateral spreading will be prevented and it will become stiffer all those things or whatever I have discussed or mentioned in the previous slide sorry.

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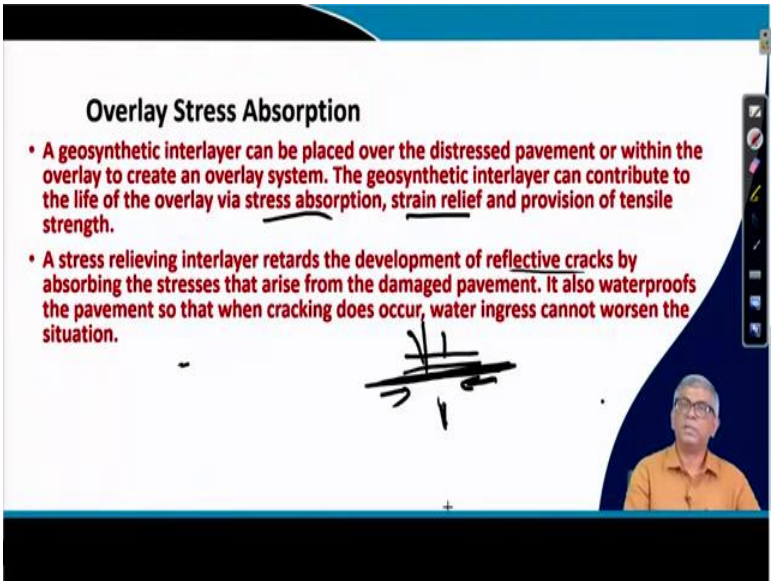

Next one, actually overlay stress absorption that is actually when if you apply stress if there is some mechanism to absorb, then sometime that cracking and other things will be avoided. So, it geosynthetic interlayer can be placed over the distressed pavement or within the overlay to create an overlay system.

Suppose there is a, that this is a one and below that if you give a reinforcement layer. So, these the geosynthetics interlayer can contribute to the life of the overlay via stress absorption, strain relief and provision of tensile strength. This is actually when it is applied load, it will have tensile strength, this way so that will give you some benefit.

Then this is stress absorption also take place, strain relieve also will happen. These are the benefit will get and stress relieving interlayer returns the development of reflecting cracks. Suppose if this is there is a crack here generated and if it if this reinforcement is provided here, then it will not propagate up to the surface.

That is one advantage and then and if the propagate after the surface, then through that water will enter and then further damage to the base, up to base course also will happen, a lot of maintenance will be required. So, that is the advantage that it also waterproofs the pavement to show that when cracking does occur, water ingress cannot worsen the situation. That is benefit, these are the two benefit, three benefits; one is absorbs strain relief and tensile effect and then again it will be prevent that reflected crack to develop propagate upward and also waterproofing

effect because when if this (reinforce) sheet is there then if this crack is there during rain it cannot penetrate through this.

And if the water penetrates in the sub, in the base or sub base generally, it spoils the entire pavement system. So, these are the several benefits and how we apply this let us see in the next base figure.

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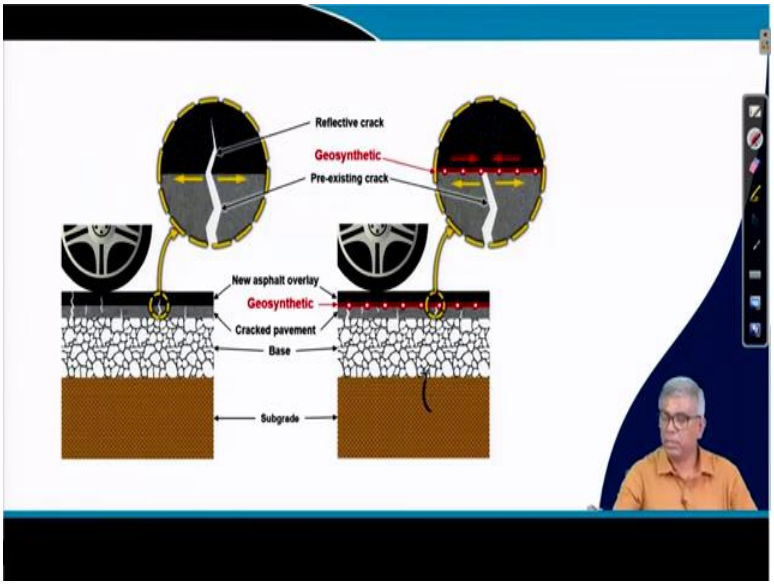

This is the one you can see here this is actually supposed at some condition the road pavement condition is like that crack are like this propagating upward and if there is no reinforcement it happens like that okay. But if you put a reinforcement layer here, then you can see whatever cracks because of adjustment in this base course layer or subgrade layer this is going to be restricted here, it will be restricted here, restricted here, it will not go beyond, and it will not reach to the surface layer.

The surface layer will be intact and also it will be waterproof again because this layer will, if it is waterproof layer is geosynthetics is used then it will be also act as a waterproofing and as a result water will not be able to enter in this zone or in this zone and whatever effect because of the contact of water with geomaterials that effect will be avoided. These are the benefits as when you use in the stress absorption effect.

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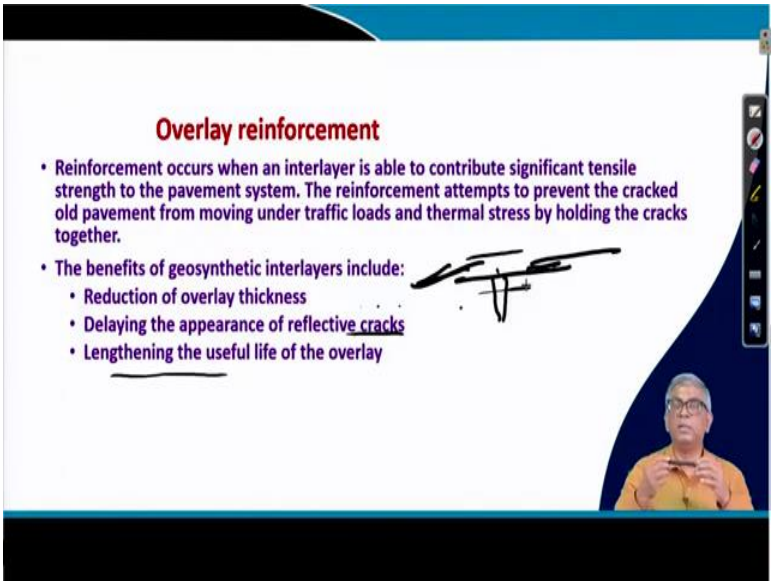

Next one overly reinforcement; overlay when it will be reinforcement occur when an interlayer is able to contribute significant standards tensile strength. Sometimes geosynthetics use in for different purposes like drainage or like separation, those purposes are there, but in addition to that, if it provides sufficient tensile strength, then that is called reinforcement actually.

And the reinforcement attempts to prevent the cracked old pavement from moving under traffic loads and thermal stress by holding the cracks together. If this is the cracks and if I provided, this geosynthetics layer here and when there will load then it will be having tension here it will be having tension to transfer this direction. It will not propagate here.

That is the advantage, the benefits of geosynthetics interlayers include reduction of overlay thickness. If I provide then this overlay thickness whatever we are giving base course about the base course thickness required will be less, if I use geosynthetics then delaying the appearance of reflecting cracks.

That whatever reflected cracks it will be sometimes will prevent it, it will complete prevention is difficult, at least a stop 1 year or 6 months, it can go several years. So, maintenance will be required but it will be required less frequently. That is why delaying the appearance of reflecting cracks and lengthening the useful life of the overlay. That overlay whatever you are using the below that if there is a reinforcement, then the life will be increased. These are the benefits you can get from this.

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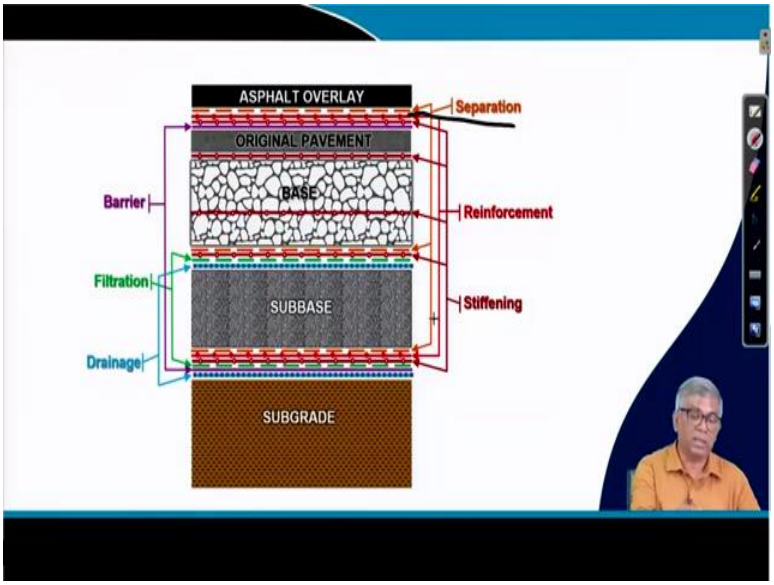

And you can see here in this figure actually use of reinforcement for various function, everything is given. But let us see only reinforcement. Reinforcement is here actually this is the reinforcement. And also, sometimes reinforcement is here also between this layer between these two layers, between this layer and this layer, there is enforcement is there.

Then there is other function like barrier, filtration, and drainage. They are all there but if it is between this layer there that is acting as reinforcement when it provides sufficient tensile strength.

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And next is whatever we have discussed that is regarding the road and pavement. Now for the geosynthetics can be used for drainage and drainage in subgrade dewatering, drainage, high groundwater whatever is there and that groundwater table that water when come in contact with some of the soil type which will come in contact with water either soil or when drying it sink and that actually creates problem.

Of course, the seasonal variation of the weather that pavement actually also sometimes going up and sometimes going down as a little cracks form. So, those things actually can be prevented by providing some drain and geosynthetics can be used as a very good drainage system.

So, high groundwater table can and often does interfere with stability of the subgrade soil for instance some clay soil can swell or sink as their water content increases or decreases respectively. When water content is increases then it will sink soil and water when decrease it sink. So, that is the one, so that means if water table is high then of course in high and rising will be low.

Because of that, that stability of the system will be a little disturbed because sometimes it is going up, sometimes going down and that happens then continuously a year after a year then maybe after two three cycles the cracks will form or sometime it become soft in rainy season. Those things can be prevented if you can provide appropriate drainage and keep the water table lower.

And geosynthetics materials have common place in subsurface drainage application, commonly geotextiles are being used in lieu of select drains of sand sometimes before geosynthetics is a come market before actually for drainage purpose a particular grain of sand is used, but that is actually sometime expensive and sometime providing uniform sand grade is difficult also the construction of sand drain is much more complex than that installing geosynthetics drainage system.

So, these are the advantages so subgrade dewatering that would that geosynthetics can be used for drainage purpose in subgrade dewatering subgrade. Some of the figure I can show you maybe that will help to understand how it is beneficial that will come later on together.

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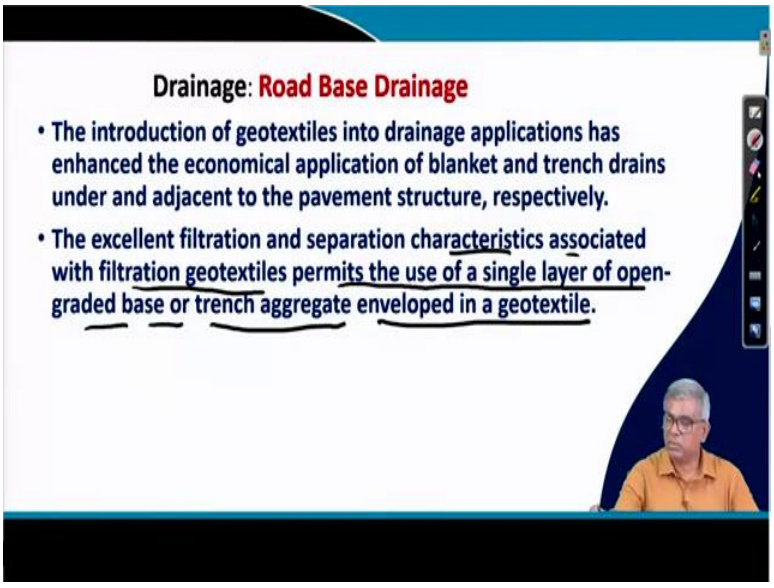

And drainage that is road base drainage, road-based drainage that is actually the interaction of geotextile into drainage application has enhanced the economical application of the blanket and trench drains, there are before actually blanket drain, trench drain is used. Now, because of these geosynthetics this can be more economically and quicker can be installed and that is actually under adjacent to the pavement.

Actually, blanket drain actually is use below the pavement and trench drain are used to that beside the road pavement these two things earlier used that is typical details are there for blanket if you send blanket or if you print trench. So that is typical details are there. In place of that if we can use geosynthetics drain is easy to install and also economic.

And it has an excellent filtration and separation characteristics. The geosynthetics you can manufacture according to the requirement and permits the use of a single layer of open grid base or trench aggregate envelope in geotextile. A particular type of that is, actually excellent filtration and separation characteristics associated with filtration geotextile permits the use of a single layer of open grade base or trench aggregate enveloped in geotextile.

So that, the trench can be in covered around by a geosynthetics that will enhance the performance so, that is what these are the two things, let me show some figure then it will be somewhat clear.

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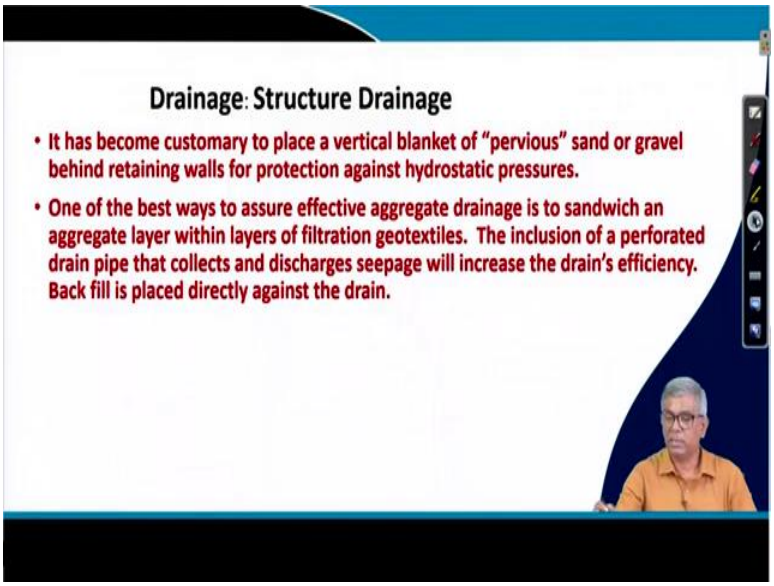

And then that one more let us see that drainage in structure drainage that means you know that when there is a retaining wall and we generally have backfilled and we know that free reading backfield to be used and in addition to that, behind the wall, there should be some drainage layer that water can drain easily instead of accumulating there. So, those are the application actually.

One of the best ways to ensure effective aggregate data is to sandwich an aggregate layer within layers of filtration geotextiles. The inclusion of a perforated drain pipe that collects and discharge sea face will increase the drains efficiency. Backfill is placed directly against that drain. Let us now show some of the figure whatever three aspect we have discussed that the drainage.

Drainage is structured as below and, then that lowering the water table or round order table in three aspects.

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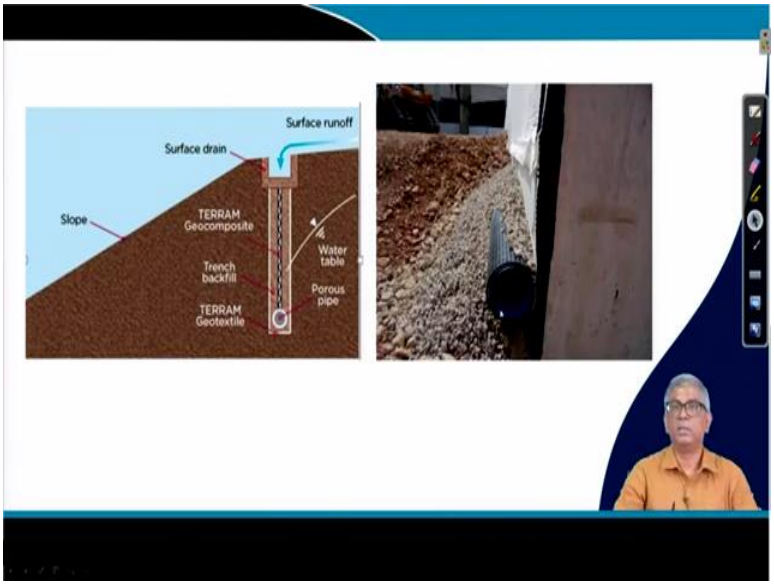

Some of the things are shown here. Actually, you can see here, these are actually drains if you have the this is the surface drain and water table is somewhere here and if you can provide a trench and we filled up with some particular grain of sand and then if I put a geotextile here or here, this figure I have taken from somewhere this is actually some brand name is mentioned here Terram geocomposite is used here which is very good draining characteristics.

Through this actually water will come here, this is a porous pipe and this will be again discharge from away and as a result this water table will be always low. And again, you can see that this is suppose a retaining wall backfilling is going on at the bottom this is actually some vertical drain and then this pipe also cape, water will come through this and then finally enter to these and then this will be laterally discharge away from the structure. That way it will improve the overall stability of the system.

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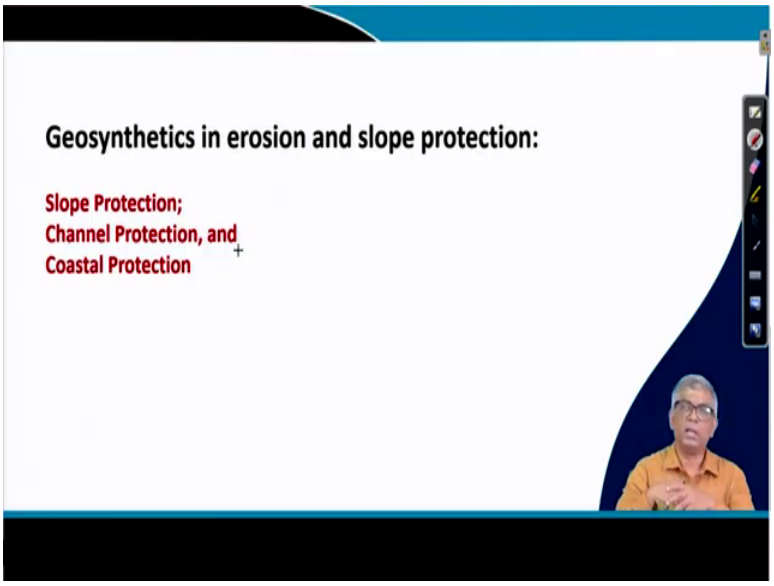

And then next is geosynthetics in erosion and slope protection. Here, it can be slope protection, it has channel protection, and it can be coastal protection. Coastal areas actually there can be erosion can be there. So, earlier different ways that slow protection using stone or something else though generally slope protection used to be done, but now with the application of geosynthetics different ways this can be done. Some of the figures actually are photograph are there. You can show quickly.

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This is actually as a slope protection actually, you can see, these are the things if you put then the soil it will not direct, the water is not directly coming into because of the flow of water it eroded and this is the installation process shown in this photograph.

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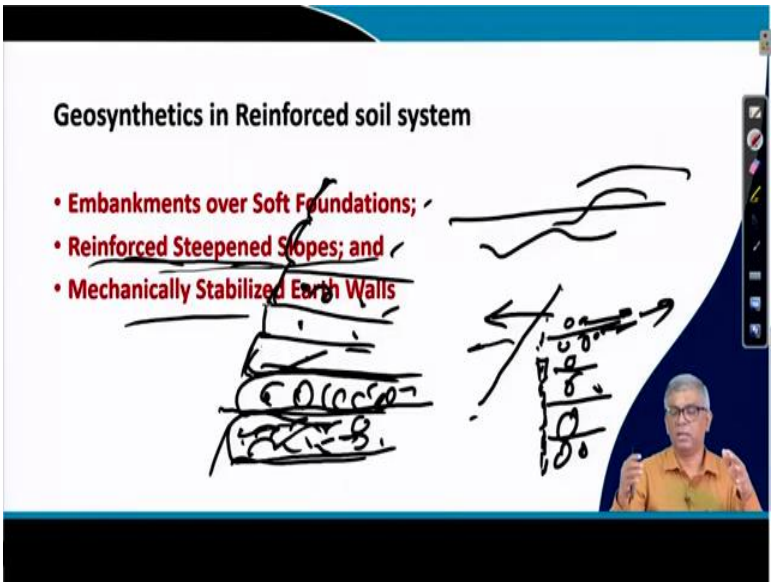

Similarly, geosynthetics in reinforcement soil system that is actually embankment over soft soil, the reinforcement steepened slopes, mechanically stabilized earth walls, so these three actually very-very important you can see advancement, maybe since 70s or slightly before that.

Embankment was short foundation like if there is muddy soil actually the equipment cannot go there, even for compaction or do anything.

Such a soft ground if I put geo-textile, and then equipment can go easily and then we can build embankment on that and that will be useful. Similarly reinforced steepened slopes that means generally in natural slope if I want to make fairly there will be standard slope will be there, but if I use instead of these, if this embankment is made by with the application of geosynthetics then there are different ways it can be used.

It can be used by using some blocks or it can be used by wrapped around, geosynthetics wrapped around, in geosynthetics what suppose that the bottom most layer there will be enforcement is laid and then soil will be placed here and compacted when it reached a particular layer this will be wrapped and it will be put there like this then there will be another layer of reinforcement laid here and then soil will be kept here and compacted and then it will be again wrapped around like this okay.

So, like that you can, we can reach like this you can reach like this quiet very mild slope we can have, but without disturbing the stability of the slope. That is actually reinforced steepened slope. These are the (reinforce) these are the seeds are acting as reinforcement, these are the seeds acting as reinforcement and within that soil and reinforcement because of the friction they will have some resistance.

Because of that more or stiffer slope we can make, but if I do not use this, the slope will be quite mild then area requirement will be large and then automatically it will be expensive. Similarly mechanically stabilized earth wall that is actually conventionally when you want to retain wall, retain soil then we make different types of retaining wall.

But mechanically stabilized earth is actually the wall actually is a very thin, this is not really well they are facing element and facing element different units will be there connected to each other and from there like these, like this reinforcement will be there and there in between soil will be there and because of this when the wall because of this loading will try to move this direction then the reinforcement will have tendency to move this direction.

And because of the soil and the reinforcement, friction between the soil and enforcement, it will have some developed some friction and that will have these directions. So, that direction or the direction that will balance that is the thing to be designed, how much, what is the length required, etc., that we will discuss in the, after one or two lectures, but this is our different use of the geosynthetics as a reinforcement.

It is an embankment where soft foundation that means if the soil is so soft you cannot use for embankment, then if you are laid a strong geosynthetics over that you can built the embankment that will be useful. Similarly, normal embankment if you want to do with a proper flow that slope will be quite mild then area requirement will require huge, cost will be more, the land requirement will be more.

So instead of that if I use the reinforced geosynthetics reinforced slope then it will, you can make much milder slope we can make as a result less area requirement and construction also will be faster and also it will be less expensive and making every civilized word that is replacing the conventional RE wall by mechanically stabilized wall.

Here actually the soil also part of the stability of the system. So these are the things we will discuss analysis how to design but these are the three different aspects as were used that your geosynthetics as reinforcement, let us go to the next slide.

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And you can see here whatever I have shown almost same thing this is a mud you can see that the equipment is sunk here, for instance that if I put a geosynthetics layer here and then if you make embankment then it will be a lot happened like this.

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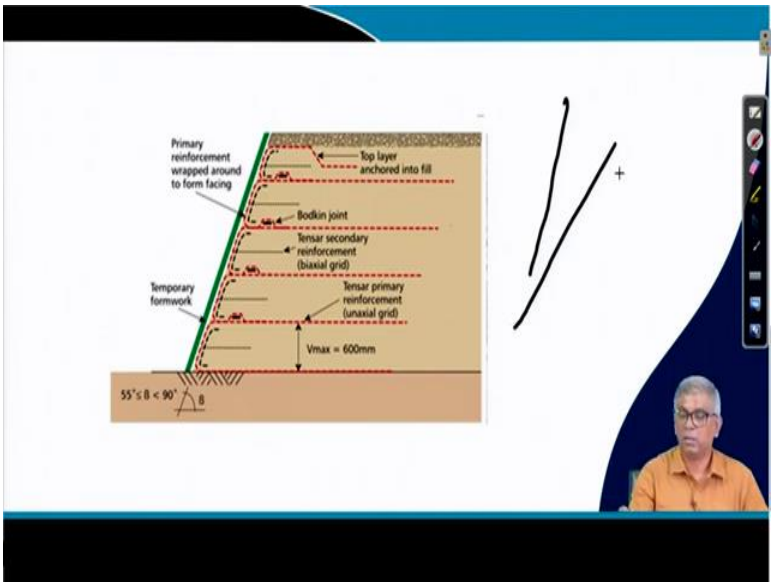

And you can see that whatever figure I have drawn that roughly it is similar you can see this reinforcement wrapped around, the reinforcement wrapped around like that quite steep flow we could make an whereas if I do not use this enforcement, the slope would have been like this. This is actually something like this.

And if it is without reinforcement, it could have been like this. This will help to more height you can make with less base value, that will land requirement will be reduced and land is very expensive that all of you know. This is some examples of that.

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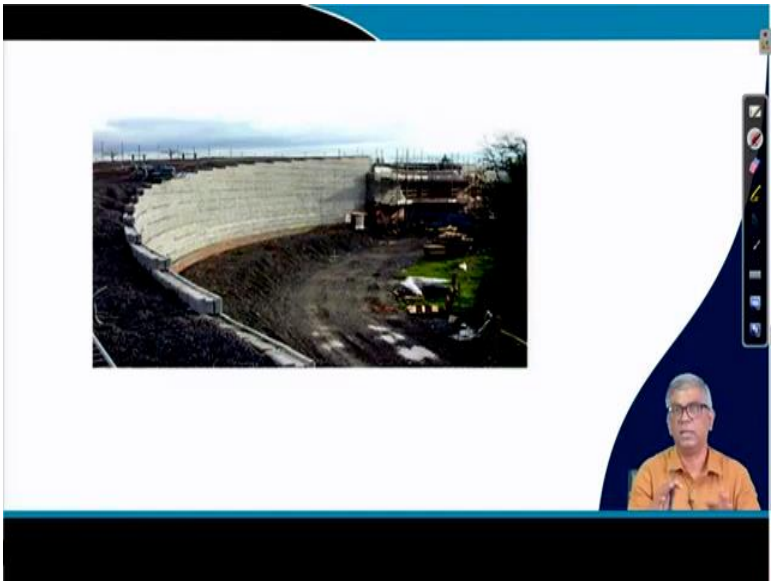

And this is the as I was telling that MSE retaining wall, this is the wall, these are actually the all facing elements and this with these facing element there are some reinforcements will be extended inside the soil and because of this weight when this wall will try to move this direction the other enforcement will have the tension in other direction. This way this entire thing will be in stable condition that analysis part we will discuss later on.

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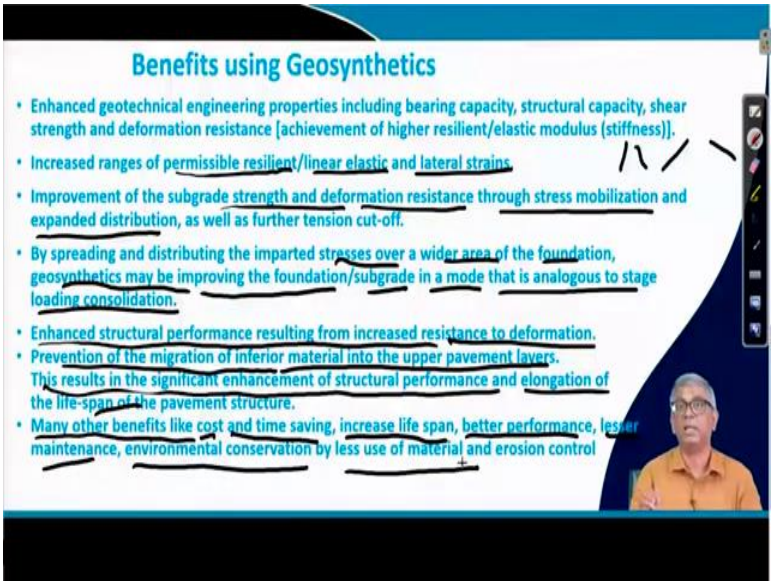

Finally, what if I use this geosynthetics in the different application what are the benefits. There are listed; enhanced geotechnical engineering properties including bearing capacity we have shown different example, because it is widening the stress. That means more load can take.

Bearing capacity, structural capacity, shear strength, deformation resistance all those things that means, higher resilient elastic modulus that thing actually will get when you provide geotextile. Then the increase range of permissible resilient linear elastic and lateral strain that is also increase, the improvement of the subgrade strength, deformation resistance through stress mobilization and expanded distribution which I have told instead of like this it will be like this.

As well as further tension cut up then by spreading and distributing the imparted stress over a wider area of the foundation geosynthetic may be improving the foundation subgrade in a more that is analogous to stage loading constant on consolidation. So, stage loading why we do? Because initially you apply some amount of load and then because of the consolidation a steady increase then only we will go for that.

But if I use geosynthetics without that stage lodging effect automatically it happens here but then enhance structural performance resulting from increased resistance to deformation. Structural that means finally, whatever increased resistance to deformation that will give you the perform better performance the prevention of the migration of inferior material into the upper payment layer.

When you are using as a separator then the from the base the fine particle will not enter to the base course and a lot spoiler situation this results in the significant enhancement of structural performance and elongation of the lifespan. So, that also helps and many other benefits like cost I have mentioned again and again, this is a very economical and also fast that the time saving also.

Then it increases the lifespan and better performance as I have told you that rotting etc. that crack propagation can be delayed then lesser maintenance; if you prevent so prohibit the crack up to the surface then maintenance also will be less frequently required, environmental conservation by less use of material like we use different types of material, if you can reduce the thickness then that means a lot of saving of stone and other materials.

That is the environmental conservation by less use of material and also erosion control. So, this you have already shown that this geosynthetics can use for erosion control also. There are so many benefits we can get. This is actually I wanted to mention as a general aspect of geosynthetics I ground improvement activities.

With this, that function of geosynthetics I just close and now I will try to there are several aspects are there as I have mentioned; design aspect I will try to take like reinforcement, or like MSE wall or slope or the bearing capacity improvement all those things, as many possible one or two I will take and design philosophy and then how to do design with some numerical example I will do that it will be the end. Thank you.