Ground Improvement
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Lecture 52
Geosynthetics in Ground Improvement (Contd.)

Hi everyone. Let us continue on ground improvement in particular, in general and application of geosynthetics in ground improvement activities in particular and just now, in our previous lecture. I have just completed the different types of geosynthetics. How it looks like manufactured, what is their function, all those things we have discussed. I have shown some photographs also.

Now, towards the end I have just mentioned the functions of geosynthetics are there and these different types of geosynthetics can perform different types of functions, also a particular type of geosynthetics also can perform more than one function also.

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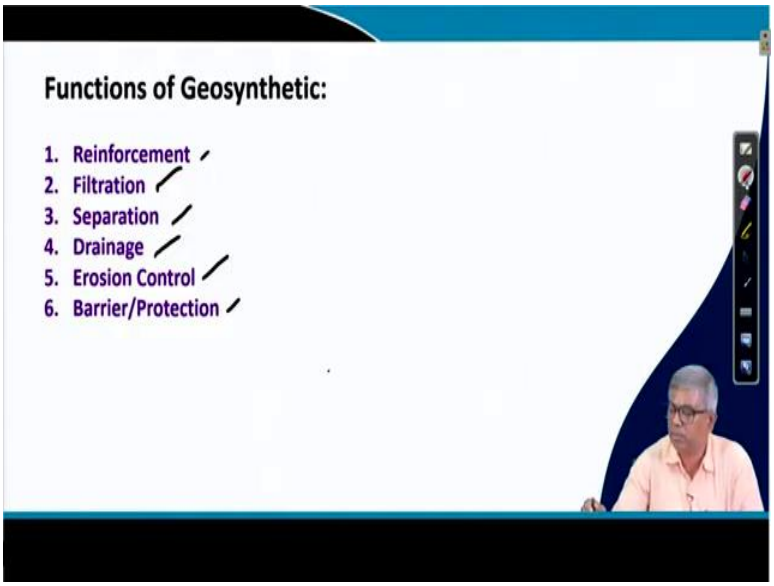

So, now, I will try to show you that functions of geosynthetics, different functions which I have listed in the previous lecture that geosynthetics can be a function as reinforcement, it can function as filtration, it can function as separation, it can function as drainage, it can function as, it can function as erosion control, it can function as barrier and protection.

So, there are by and large these are list of function which will be performed by geosynthetics and now will be one by one I will show the application of reinforcement, application of reinforcement.

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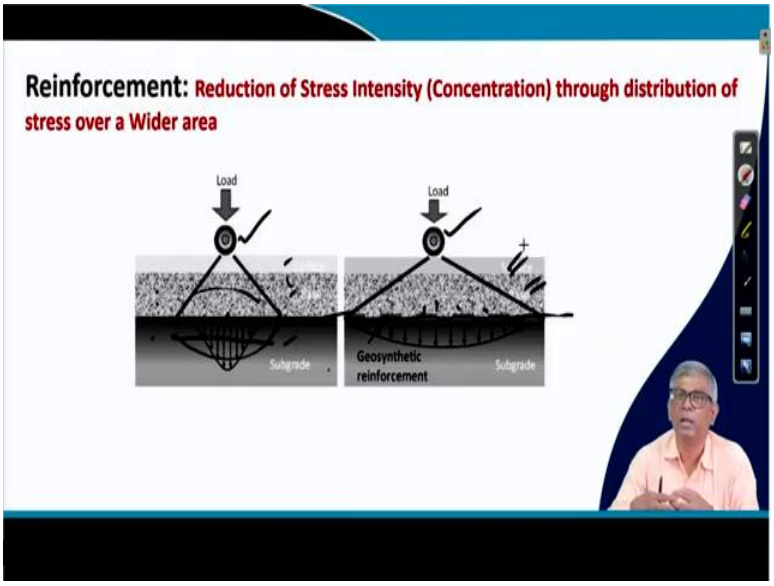

So, let me go to the next slide and you can see here application in the form of reinforcement. You can see I perhaps gave example of footing foundation and where actually if the footing foundation rests on a relative's good soil, while laying a soft soil, then what happened; there is a tendency or there is chance of more settlement a large amount of settlement to overcome that what we can do; we can lay one layer of geosynthetics and which actually will prevent or reduce the settlement or control the settlement or increase the bearing capacity that I have mentioned.

Here, actually I am giving another typical example you can see here; this is the wheels of the of the vehicles and if it is not, this is surface layer then in between layer, this is subgrade, okay. Now, when the vehicle moves an unreinforced soil layer and this soil subgrade suppose comparatively sharp then what will happen; because of these wheels pressure will be dispersed like this and as a result it will have pressure distribution in this job, we will have maxima in the middle and it will be less towards end.

But, average I can assume some value, but that value is comparatively more and if the pressure is more compared to the bearing capacity of the soil, then there will be a lot of depression and as a result the road will be this layer will break and as a vehicle a lot of maintenance will be required.

So, here to prevent that actually you can what you can do; we can in this, between these two layers we can provide one reinforcement layer.

And these enforcement layer if you provide then you can see that the initially the wheel pressure was spread up to this much width and if you provide the reinforcement is spreading over this much width is large area is covered or dispersed over a large area. As a result, the intensity of pressure here will be reduced and pressure on the subgrade will be reduced means actually less settlement and less protection or more protection for this pavement layers.

This is another application of the reinforcement, as a reinforcement there are many other enforcement footing foundations. I have shown, then mechanically stabilized earth walls, there is also it is working as a reinforcement. So, this is another application of reinforcement and this type of application is more compared to foundation application as reinforcement is more use in RE wall and road.

In the footing actually though a lot of research are carried out but because of construction difficulties, very rarely below the foundation reinforcement layer is used, but it can be used, it can give you significant improvement, but generally the construction difficulty because of that, it is generally avoided or it is used very less. So, this is the by and large the application of geosynthetic as reinforcement, this is the typical example.

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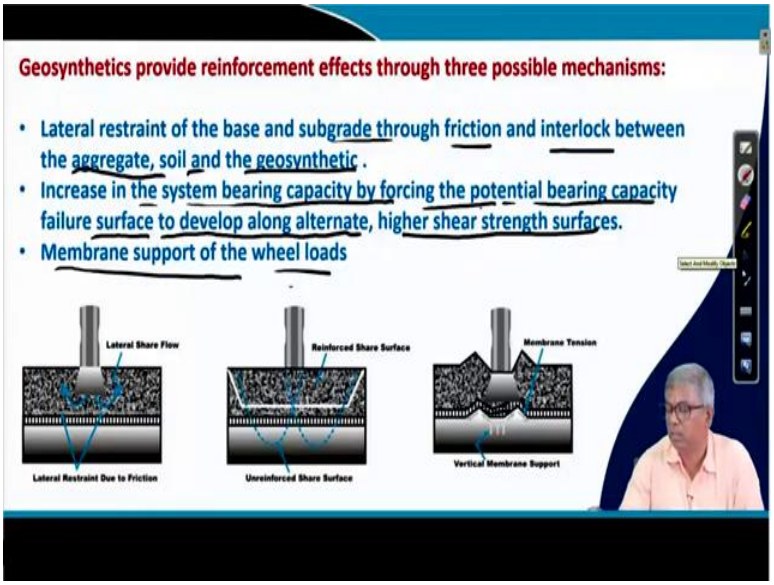

Next you can see the geosynthetics provides enforcement effects through three possible mechanisms, actually whatever I have mentioned also already whatever I have mentioned already you can see all those here also, you can see here. That lateral restraint of materials, you can see here, because of this reinforcement this the movement of soil particles or soil will be reduced.

So, lateral restraint of the base and subgrade through friction and interlock between the aggregate soil and the geosynthetics. That is one actually how it provides the benefit. The increase in the system bearing capacity by forcing the potential bearing capacity failure, surface to develop along alternate high shear strength surface.

You can see here that had it been this reinforcement layer was not there the bearing surfaces would have been different. Because of this provision of these, the bearing surfaces or shear strength surface will be increasing and as a result high being bearing capacity is giving and this third proverb, actually membrane support of the wheel loads.

Membrane support means, you can see here when it is loaded and then this soil will try to punch and because of the presence of these that reinforcement which is strong enough, it will not allow to move that, so that is actually another membrane effect that is not allowing to punch through this. So, these three effects together it will be giving you, the better performance together that is the reinforcement (part), reinforcement performance. Let us go to the next slide.

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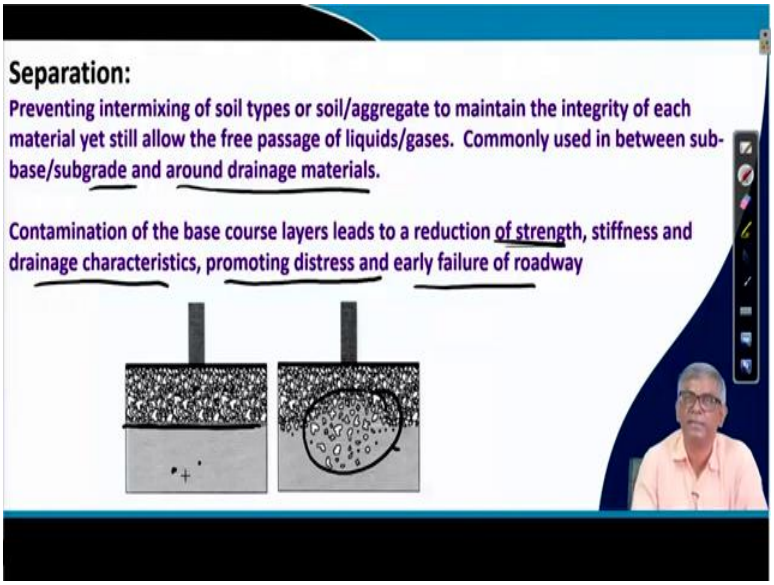

You can see the separation already you have mentioned some examples there, you can see here this is suppose a footing or anything or suppose wheel, it can be anything and this is a layer one and this is another layer one, this is another layer and because of some reason you can see that bigger particles can punch inside this and sub particle may enter into that the coarse aggregate material zone.

And if it enters like these then these become, this zone will become weak whereas, if you put a reinforcement layer here, then this material will not be able to enter this material also will not be able to enter this, way actually provide better stability. So, that is what preventing intermixing of soil types or soil aggregate to maintain the integrity of the material, yet still allow the free passage of liquid gas.

Water easily can pass if there is no waterlogging here because of this presence of these it will have the openings through that water and other things, if necessary, it can pass. Commonly used in between sub-base, sub-grade around drainage material. This is the typical application. Contamination of the base course layers leads to reduction of strength contamination of base course material. So, the contamination of base course material you can see, contamination means fine particles entering to this base coarse material.

Then actually, it will reduce the strength, stiffness and drainage characteristics and promoting distress and early failure of the roadway. So, that is what I have already mentioned before. When

this happens, then the road will be will have a lot of cracks and once crack started, then it will potholes and then when bigger potholes then finally a lot of maintenance.

Because of that, if there is the soil is not good enough, then one layer of reinforcement geosynthetics can be laid to provide the separation between these two materials. That it will not intermix. This is the as a separation, the application as separator.

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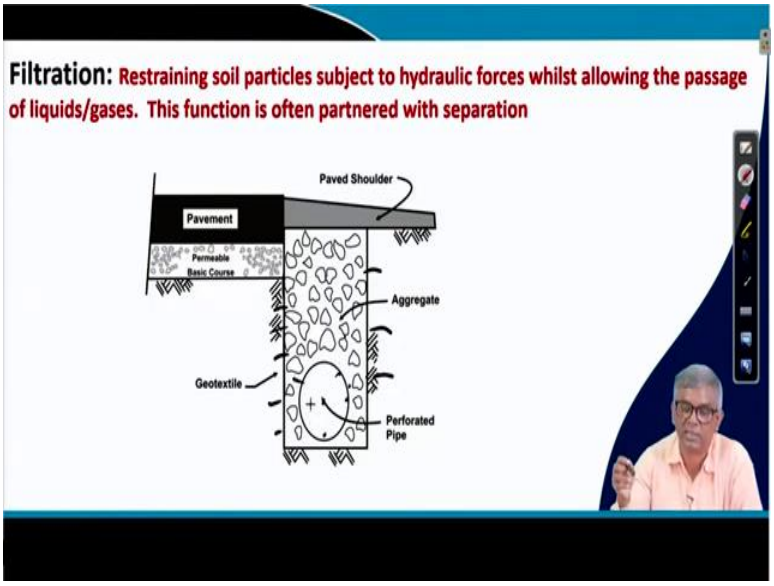

Then the filtration you can see here, restraining soil particles subject to hydraulic forces, while allowing the passage of liquid and gas. This function is often partnered with separation also, this is also act as a separation. So, here you can see that this is the road payment and this is below the road actually there is a permeable base course and water can move through these actually.

And if you water comes that water actually there will be particular drainage provision is made here and this province, this is actually for the purpose of drainage, this type of the side of the road this type of arrangement will made and you can see that these are all aggregates and this water will enter to this need directly water into to this aggregate layer, then some fine particle finally enters and it will again block those aggregates.

And finally, there will be hardly any movement through this, but water has to carried from the road. So, how to do that? To allow water to move or pass but not allowed to move fine particles, we can give geotextile layer, you can see here around geotextile layers are there and there is a

perforated pipe, this is perpendicular to the both, and water will come through this and all direction enter to this zone.

And it is a freely draining layers, free draining layers actually particles are bigger particles. And if water enters here, because of this perforation in the pipe water will enter to the pipe and to this pipe will be discharged. This is actually application of geosynthetics as filtration purposes. There are many other applications is there in the dam structure, many other places.

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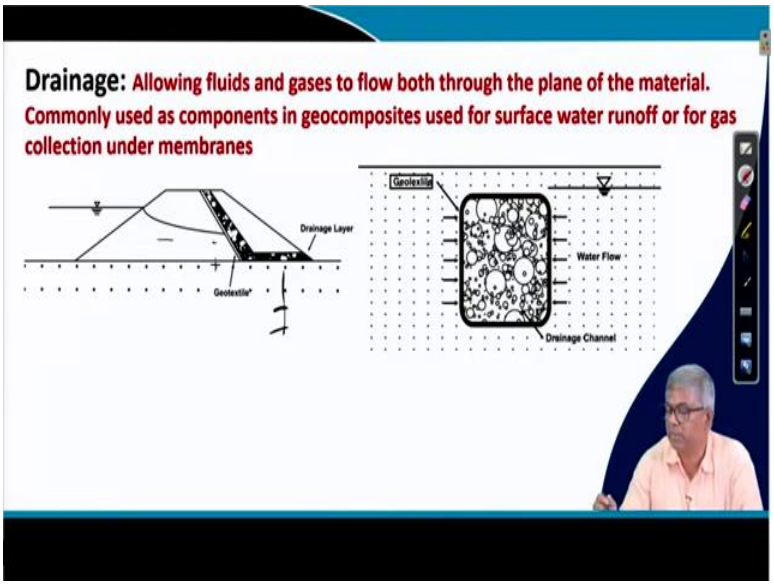

The drainage actually you can see here the similar to that only that we want to this is a drainage layer and this is drainage channel you can say, this is a drainage channel and water around actually. When water entered to the drain, then water there are fine soil particles also can enter and then this drainage channel can be choked.

To prevent that actually what we can do, we can provide a (geosynthetics) geotextile around which actually permits water to enter through this, but will not allowed to soil particles to pass through it. This will be intact and water can flow through these. This is a particular typical drainage channel whereas here is the suppose this is a body of a dam and these are all different drainage layer.

And this is drainage layer actually, if water comes it will be entering through this channel, when water will directly enter to this layer then what will happen; again, fine particles will flow inside

and it will choke. To prevent that, what you can do is, you have one geosynthetics layer here. This geosynthetics later will allow water to pass but will not allow soil particles to pass through it and as a result it will be, this drainage layer designed for this dam is very important.

If it is not there then the drain actually this dam will become unsafe, because this water whatever water is coming through like this sea face that has to go through these, that no excess pressure will develop within that dam structure. This is another application of drainage. Drainage function is allowing fluids and gases to flow both through the plane of the material, commonly used as components in geo composites used for surface water runoff or for gas collection under membrane. So, these are again something briefly we describe what it is.

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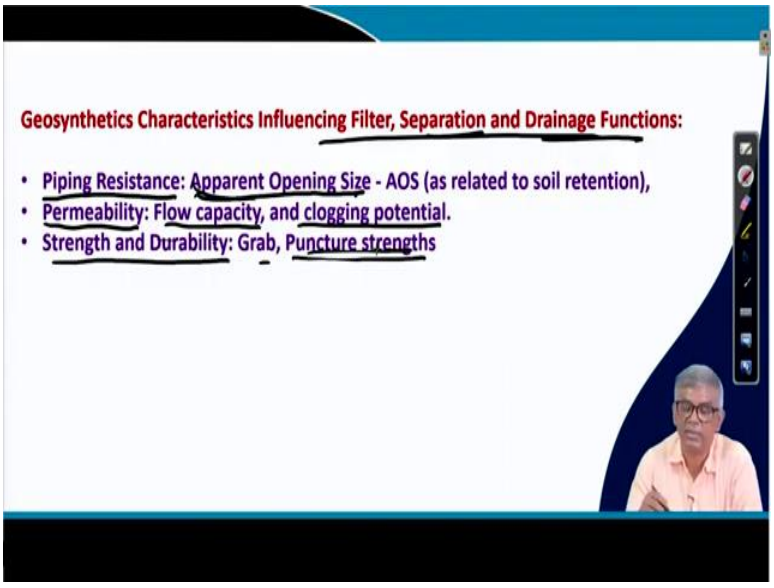

Let me go to next slide that is your geosynthetics characteristics influencing filter, this filter and drainage and filter separation and drainage this is actually a together actually is needed and so geosynthetics characters, geosynthetics characteristics influencing filter separation and drainage function three together. You can see piping resistance.

So, aperture opening size is important. If the aperture of opening actually is too big, then again flow may be good but sometimes soil particles will enter into that characteristic will be defined by aperture opening size. Then again permeability that will flow capacity and clogging potential okay, so, it will then sometimes it can be clogged also, if it is too fine and some particles again will be rest on that and again it can clog

So, flow capacity and clogging potential is another characteristics of the geosynthetics strength and durability. Grab that means that is and puncture strength actually. So, that is actually another structure. There is puncture strength and another important that means, it may be there, but whatever I have shown there is all around then pressure, around that pressure even punctured then actually entire things will be disabled, stabilized.

So, that is also the strength, puncture strength also important aspect as characteristics of filter separation and drainage of the geosynthetics.

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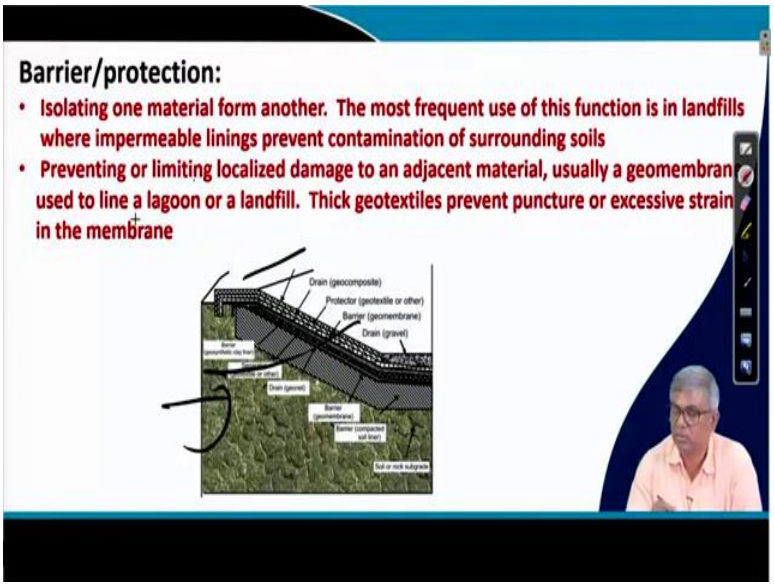

Next, is the barrier or protection. And you can see here that I have already discussed about geosynthetics clay liner, this is actually a clay liner, this is actually a dumping place and this is actually cover, portion is not shown and this is a bottom cover. It will be bottom cover and then when you filter top cover also be provided similar way.

And you can see that there are a number of layers this is a there is a barrier, geosynthetics clay liner then separator, this is the separator then drain geo-cells are there for draining purpose, then barrier actually again same thing is written on top also similar thing also with the upper side.

And what it indicates? Isolating one material from another. This is actually barrier means isolating one material from another, the most frequent use of these function is in land fields

actually you can see the land fields where impermeable linings prevent contamination of surrounding soil.

Suppose this is the groundwater and because of this land fields by waste, there are some different kinds of material will develop or liquid will form that can pass and mix with water and will give you, it will be contaminated this one. To prevent that contamination, this geosynthetics clay liner only clay liner also there very thick liner will be required, it will be expensive, but if I use same thing in addition to this geosynthetics there will be cheaper actually.

It will be better and cheaper. That is the application of geosynthetics. Another thing is preventing or limiting localized damage to an adjacent material. That is another function. The barrier preventing or limiting localized damage to adjacent material like whatever I have shown, the road subgrade and the base course, mixing; that is another problem.

Usually, geo-membrane used to line a lagoon or a land field. Thick geotextile prevents puncture or excessive strain in the membrane. Minimum thickness is required to avoid puncture also because you would puncture then actually function will not it will not be able to perform the function, altogether actually this can be used as a barrier and as a protection.

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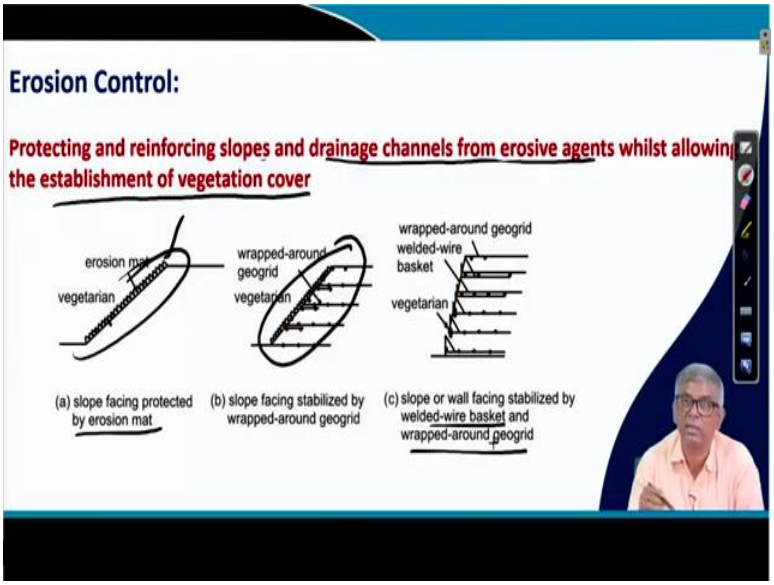

Next one, you can see the erosion control. Different ways erosion control can be done except. So, erosion control means protecting and enforcing slopes when there is a slope that is you might have seen that during rain there will be mud guard will be there because water will be flowing and then water, soil will be also be cutting and then finally, this will become wider-wider and then it will pull slope may fail.

To protect these slopes, sometimes geosynthetics liners can be given and then it can have some opening through that we can, (grass) vegetation growth can be allowed and then it will be permanent, permanently it will be erosion will be controlled. Protecting and reinforcing slope and drainage channels from erosive agents while allowing the establishment of vegetation cover.

So, here you can see slow facing protected by erosion mat, you can see this is the erosion mat and by this actually and then over that vegetation all that by that the slope will be protected. And here actually sometime that the slope can be made by geosynthetics as you can see wrapped around geosynthetics. Geosynthetics will be like that and then another layer of geosynthetics will be like that and slope will be wrapped around, geo-grids will be provided inside and then there will be vegetation.

And this way the slope can be slope facing, stabilized by wrapped around it. The slope stability also will be done, in addition to that there will be erosion control both will be there, this

geosynthetics provided here geo-grid provided wrapped around geo-grid provided, wrapped around geo-grid it is helping both stability and also to your erosion control.

Here actually wrapped around geogrid welded were actually basket and vegetation all together slope or wall facing, stabilized slope or wall facing, stabilized by welded wire basket and wrapped around geogrid. So, this is actually another function of erosion control. There are different ways the erosion control can be done by using geosynthetics.

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Geosynthetics in road pavement. We have now described the different functions and now in particular in the road, what are the different use of geosynthetics? So, here actually you can see, it is listed here; subgrade separation and civilization; that is one use, base reinforcement; another used. Overlay stress absorption, another use; overlay reinforcement another uses.

So, these are our base by large whatever you have discussed it is repeating but it is again in general in light of application in roads and pavements only we are discussing. What is the use of geosynthetics in particular road and payments? Let us see one or two.

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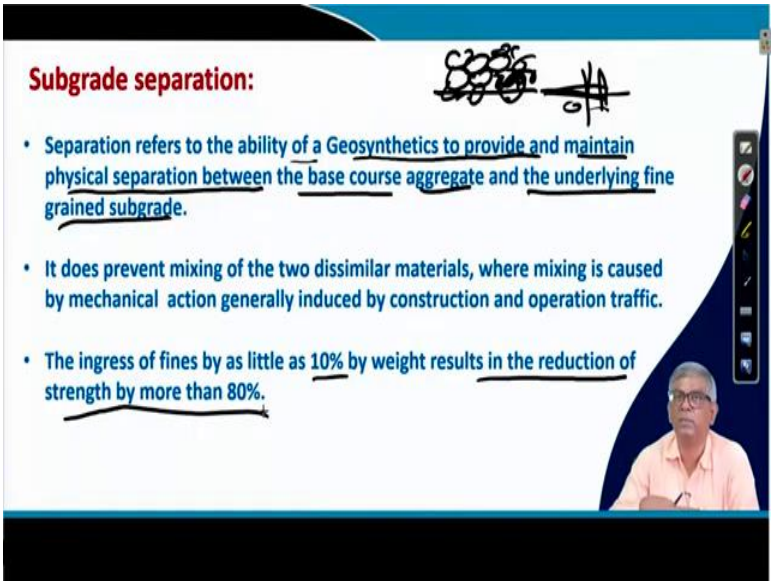

Subgrade separation and you can see here separation refers to the ability of geosynthetics to provide and maintain physical separation between the base coarse aggregate and the underlying fine grain subgrades. That is what we have mentioned, this is the base course and this is subgrade actually fine soil. So, if they are without the separation, then there is a chance of mixing, intermixing the base course layer partly can enter to the subgrade and subgrade material can enter to the base course. And that way it will be disturbing the stability of the road embankment.

So that is one application and it does prevent mixing of the two dissimilar materials where mixing is caused by mechanical action generally induced by construction and operation of traffic. That is what we have done already that is our one. And the ingress of the fines by as little as 10 percent, suppose this subgrade from the subgrade around 10 percent if it enters to the base course, then base course will become weaker.

That is what ingress of fines as little as 10 percent by weight resulting reduction of strength by more than 80 percent. So, this is actually one can consider this as a question that when you see there is a chance of mixing of two material that is subgrade and base material, base course material. And if you see that 10 percent mixing can reduce 80 percent of the string which is dangerous.

Because of that, when you find that very fine particles like very sharp particles like clay, then always one has to either replace the clay materials or it can be consolidated and strengthen or it can be used as it is by separating by using geosynthetics.

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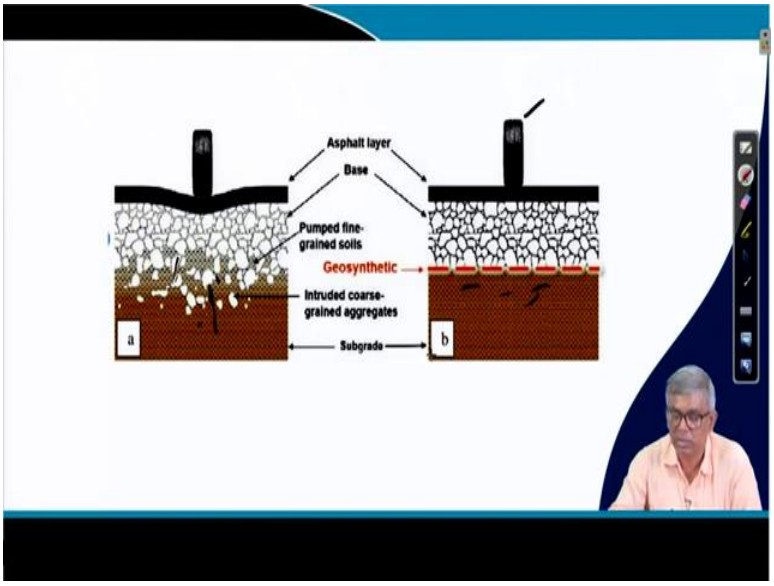

And you can see here, this is the application shown here. So, if it is no reinforcement is provided this is the wheels and this is the road and when wheel passes over the road, the generally the surface looks like this, and if this is soft layer and then this base course material can be because of these this can be post inside as slowly-slowly this can enter and when is entered then automatically this base course fine material also pumped in the fine-grained soil will be enter into the base course.

Whereas, if there is a reinforcement or geosynthetics is used between these two layers, then because of this wheel load, you can see that minimum depression because of this presence of geosynthetics and there is no mixing or very little mixing is possible if there is opening, so this is actually the this is the way actually one can perform the separation and which can result in the better performance of the road.

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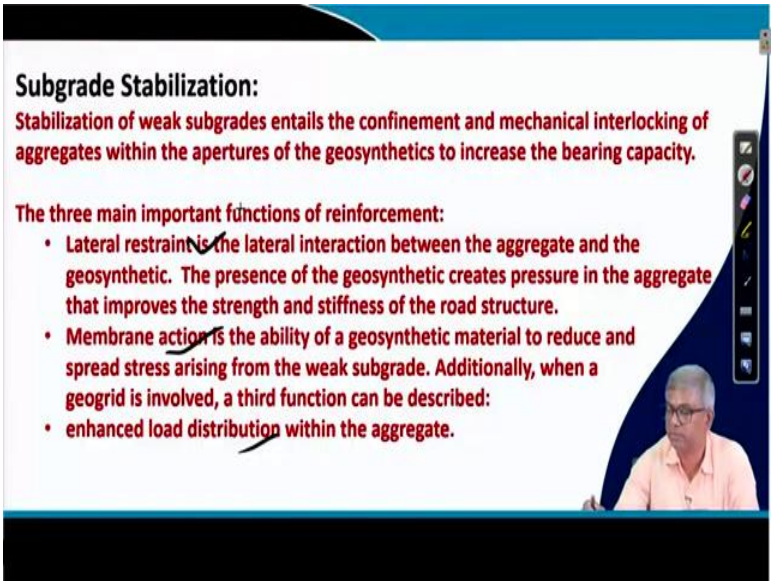

Subgrade stabilization, subgrade stabilization means stabilization of a weak subgrades entails the confinement and mechanical interlocking of aggregates within the apertures of the geosynthetics to increase the bearing capacity. Subgrade stabilization means basically it has to improve the bearing capacity, how it improves?

Because, of the interlocking between the geosynthetics and the base course material. The three main important function of reinforcement happens which already I have explained before; the lateral restraint and then membrane action and enhanced load distribution, these three actions will be there as a reinforcement which I have already explained so I will not repeat this part.

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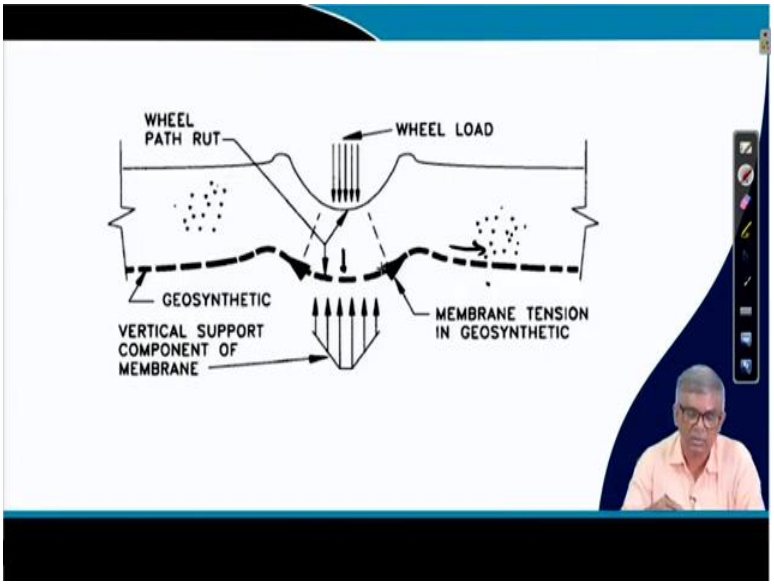

And you can see this figure, through this figure that already you have drawn before also when there is a wheel passing over the road and then the rotting of the top surface will be like this too exaggerated here, the rotting looks like this and because of this pressure and then this rotting will also propagate the subgrade also.

And if there is a reinforcement, you can see that this enforcement will be because of these when it will sorry when to try to push when it is pushing downward then it will be, this will be pulled this direction and this between this soil and this enforcement that because of this friction this will also hold it.

Because of that actually this rotting without reinforcement whatever rotting is possible and when reinforcement is provided the writing will be reduced and as a result the better stability better bearing capacity, a bit less damage and less maintenance will be required for the payment.

Like this, we can see the application of geosynthetics, different types of application. There are various functions and applications will be there. Some more who will discuss maybe in the next lecture right now I will close here. The basically this is the I am trying to discuss the geosynthetics in general, what is the geosynthetics? How it performs; some functions?

What are the different functions? And now maybe I will show some more and then subsequently, I will try to take the typical application suppose reinforcement, for example application in the, in

the MSE wall or in the embankment starting from the analysis and design that means, if I do not use on a particular sub grade, if I do not use geosynthetics layer, then what will the thickness above that base course another.

And if I use this geosynthetics, what will be the thickness of it will be reduced actually. So, those design and also when there is a MSE wall instead of conventional retaining wall, earth retaining wall, if I want to do a MSE wall that is mechanically stabilized wall then what will be the spacing, horizontal spacing or vertical spacing, then what will be the thickness, what is the width and all those things.

How, what should be the strength required, and all those things will be discussed and with example also, starting from analysis to design. Maybe I will take in the subsequent lecture, maybe another 6 to 8 lectures are remaining I will try to do all those things within that. With this today I will close here. Thank you.