Geosynthetics Engineering: In Theory and Practices
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Module - 2
Lecture - 7
An Overview of Geosynthetics Part II

Welcome to lecture 7. My name is Professor J. N Mandal, department of civil engineering, IIT Bombay, Mumbai, India. The name of the course is geosynthetics engineering in theory and practice. This is module 2, lecture number 7, an overview of geosynthetics. So, I will now address recap of previous lecture.

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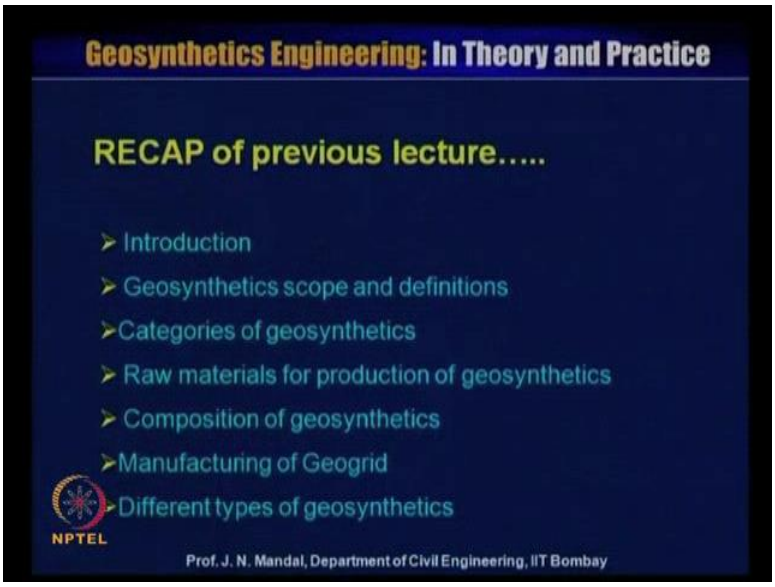

We cover introduction, geosynthetics scope and definition. Category of geosynthetics material, raw material for production of geosynthetics, composition of geosynthetics, manufacturing of geogrids, and different types of geosynthetics material. Now, I will address the function of geosynthetics which is very, very important. When you will design any geosynthetics engineering related project the one of the important issue is the functional concept. So, we should study the different function of geosynthetics.

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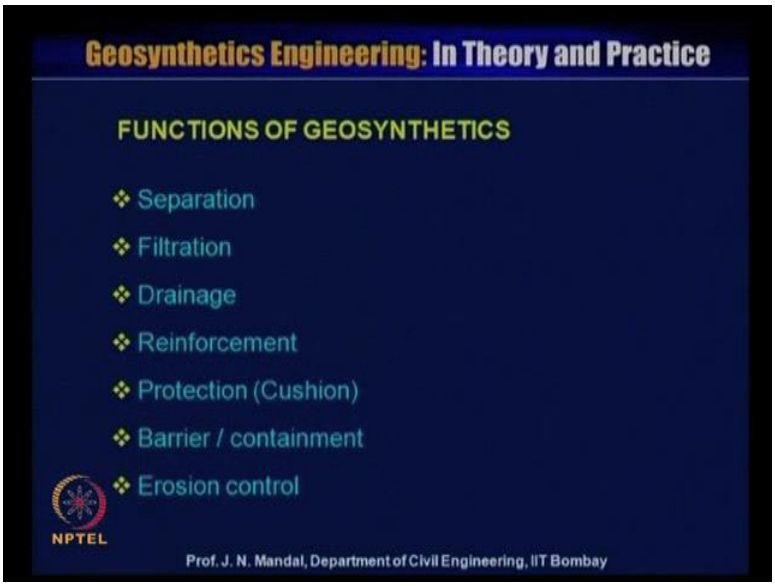

Geosynthetics have a separation as a function, filtration as a function, drainage as a function, reinforcement as a function, protection or cushion as a function, barrier or containment as a function and erosion control.

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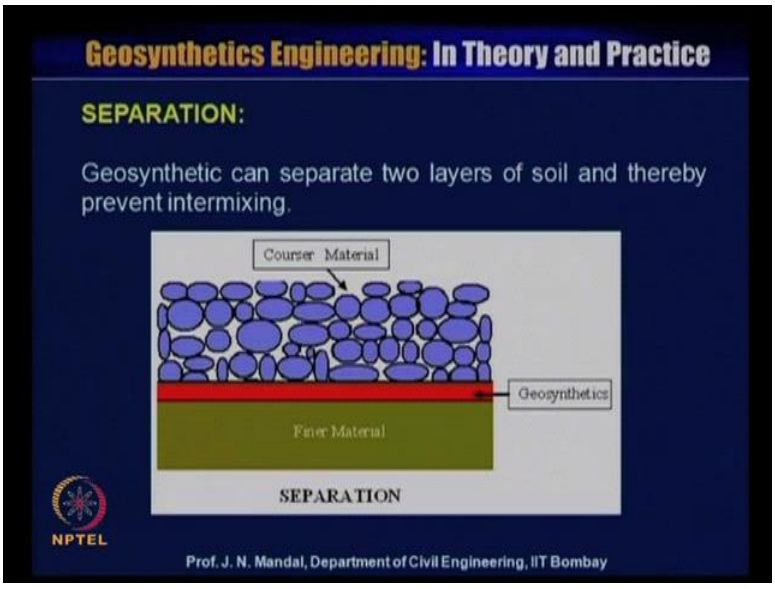

Now, what is separation? So, geosynthetics can separate the two layer of soil and thereby prevent the intermixing. Let us say that separation.

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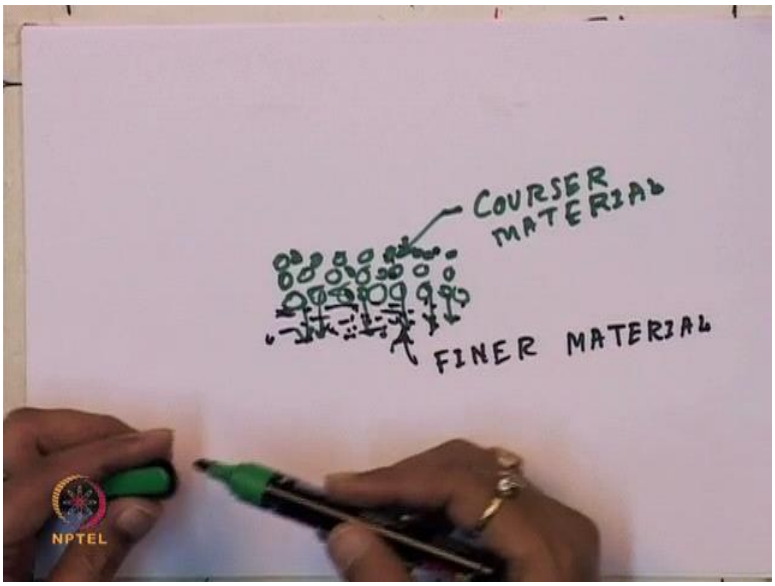

Let us say that this is the finer soil particle. This is finer, they are the finer material. So, this is the finer material. And what we do that we place the good quality of the aggregate on the top of the finer material. So, these are the courser material. Now this courser material will penetrated into the finer material and get lost. So, what will happen? For example, if you take 20 KG of the aggregate and place on the 20 KG of the mud. So, you can have a 40 KG of mud. So, there are dissimilarity of the material. One is the finer material another is the courser material. So, courser material will get lost into the finer material. So, what geosynthetics can help you?

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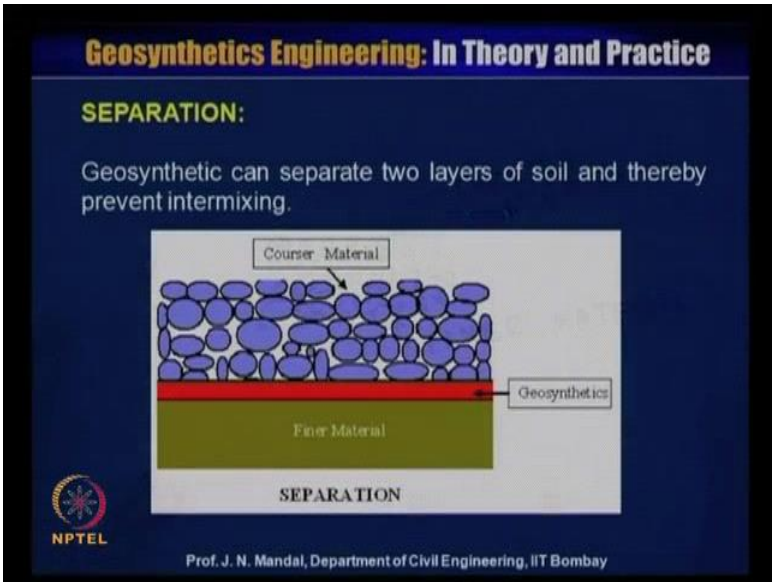

Now, if you place a one layer of the geosynthetics material in between the finer material or courser material.

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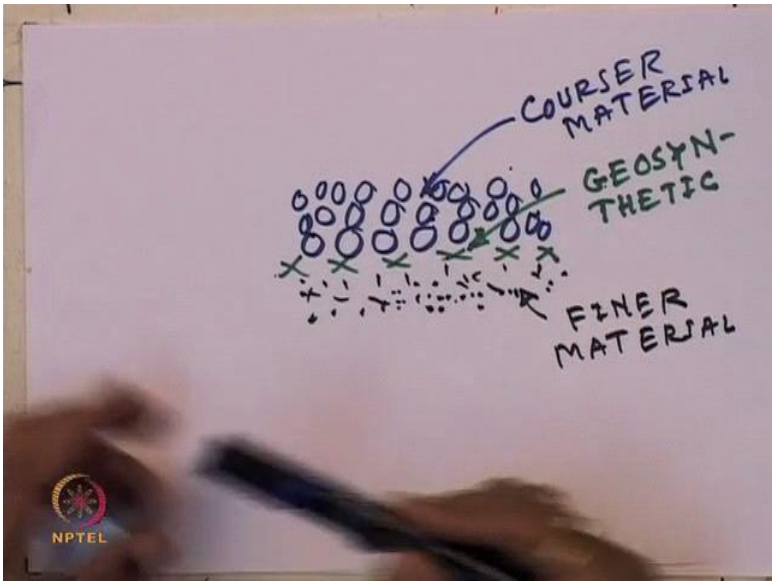

Let us say this is the geosynthetics material. This geosynthetics material which is placing between the finer material. This is the finer material and this is the courser material or aggregate. This is the courser material. So, when you introduce this geosynthetics material between the two dissimilar material like finer material and courser material, then courser material will not penetrated into the finer material. So, this material will not be lost. So, here geosynthetics material act as a separation. This is act as a separation. It separate the courser and the finer material. That is why geosynthetic material act as a separation. It can save very good quantity of the courser aggregate what we use during the road construction.

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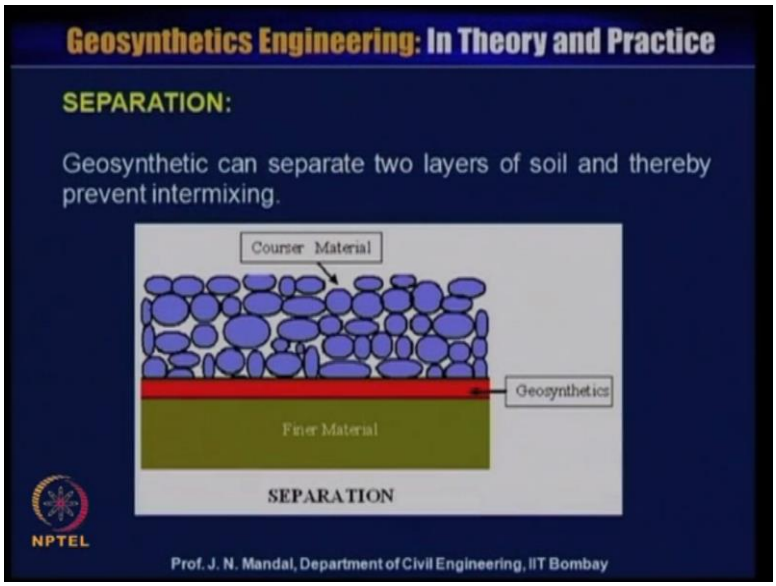

And also geosynthetics material also give a very good tensile strength. So, it can prevent the intermixing between the courser and the finer material. Next is the filtration, is the function.

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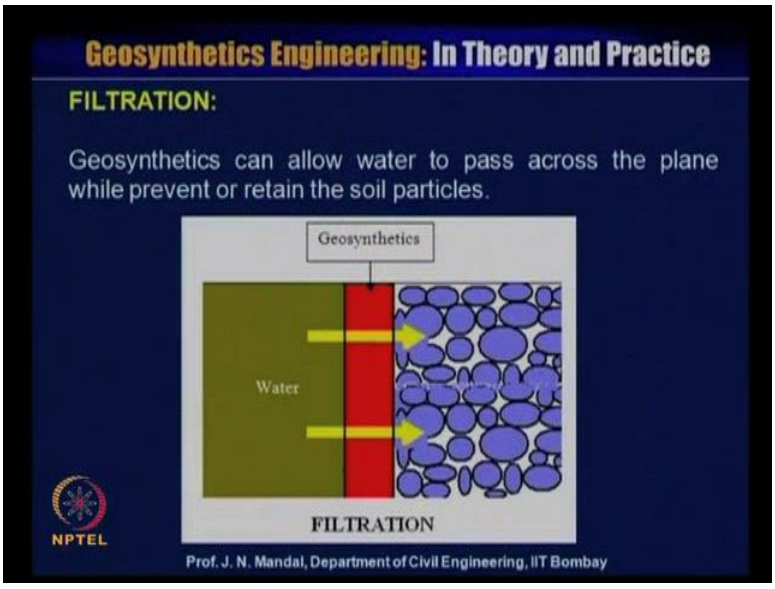

So, geosynthetics can allow water to pass across the plane while prevent or retain the soil particle. You can see here. This is the geosynthetics material and water or liquid which is rushing across the plane of this geosynthetics material. So, here geosynthetics material act as a filtration function.

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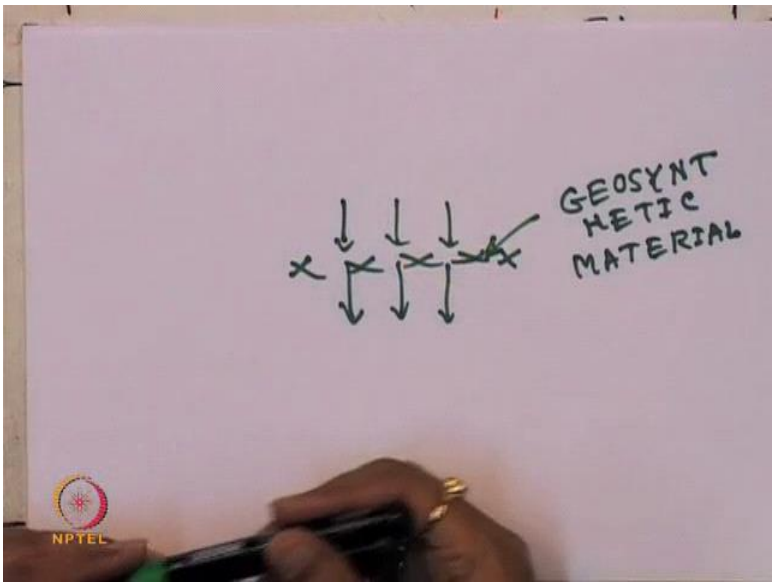

So, in case of the filtration function I am just showing you that if this is the geosynthetics material then liquid can pass across the plane of this geosynthetic material. This is geosynthetics material. So, you remember that when the water or liquid pass across the plane of this geosynthetics material, it called the filtration. And it call also the permittivity.

So, do not you confuse what should be the filtration and what should be the drainage. So, when the liquid passes across this material. It also there is a, you should know what will be the coefficient of permeability of the geotextile material or what will be the long term compatibility. So, this geosynthetics material can prevent or retain the soil particle as and when it is required.

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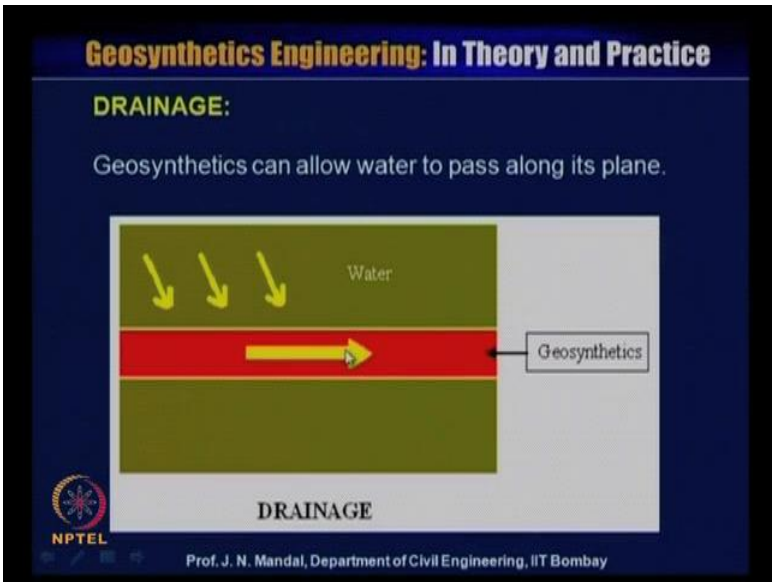

So, this is one of the most important function. Next is drainage. You can see this is the geosynthetics material. And what are all liquid pass along the plane of the geosynthetics material. It called the drainage. And what we have to determine from the drainage? That is transmissivity. We call in geosynthetics term; that is transmissivity, when the liquid or water can flow along the plane of the geosynthetics material. So, you can see that in the geosynthetics plays such a way as we transmit the liquid, the liquid should pass along the plane of the geosynthetics material.

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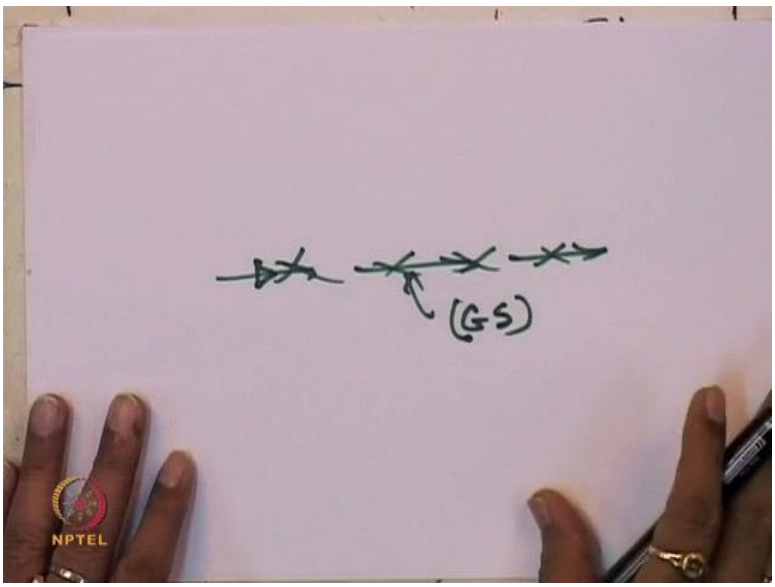

So, if this is the geosynthetics material which is designated at G of S and liquid should pass along the plane of the geosynthetics material which you call the drainage, and within the plane of the geosynthetic material, so at adequate liquid flow within the plane of the geotextile material.

So, this also you call the transmissivity. So, there is two different function, one is the filtration function, another is the drainage function. In case of the filtration function this water flow across the plane of the geotextile material. If this is the geotextile material water or liquid can pass across the plane of the geotextile material. If it is a drainage, the water will flow along the plane of the geosynthetics material. So, you have to keep in mind that what we talk about that filtration function as well as drainage function. Now, reinforcement is a function, very important function we use for the slope stability and reinforce soil retaining wall.

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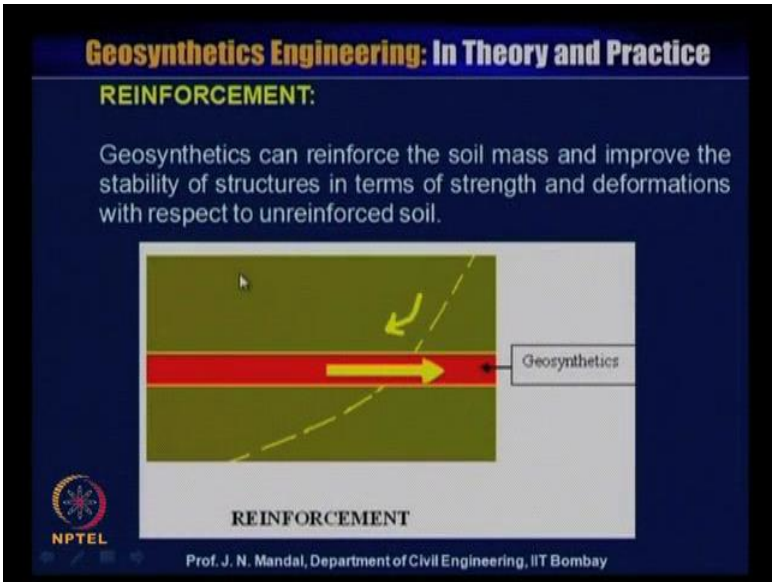

Geosynthetics can reinforce the soil mass and improve the stability of the structure in terms of the strength and deformation with respect to unreinforced soil. You can see if this is the slope and this is the geosynthetics material. So, this slope may fail along this failure surface, then geosynthetics material have in it reinforcement function so it can resist. So, geosynthetic material act as a good reinforcement. There will be a synergistic improvement of the total system strength created by the introduction of the geosynthetics material. For example, that if you wanted to construct a retaining slope, steep slope.

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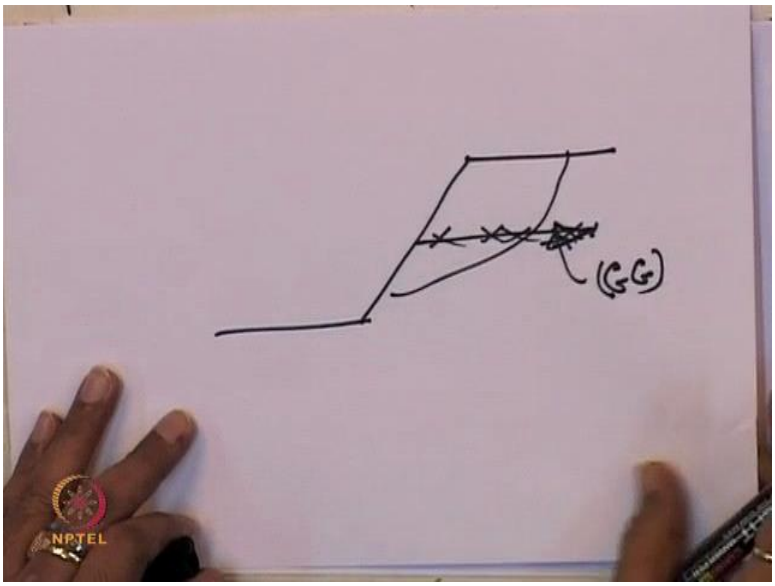

So, this slope without reinforcement may fail. But if you can place one layer of the geogrid material you can say that G G. So, it can be resisted because it has a tensile strength or it act as a good reinforcement.

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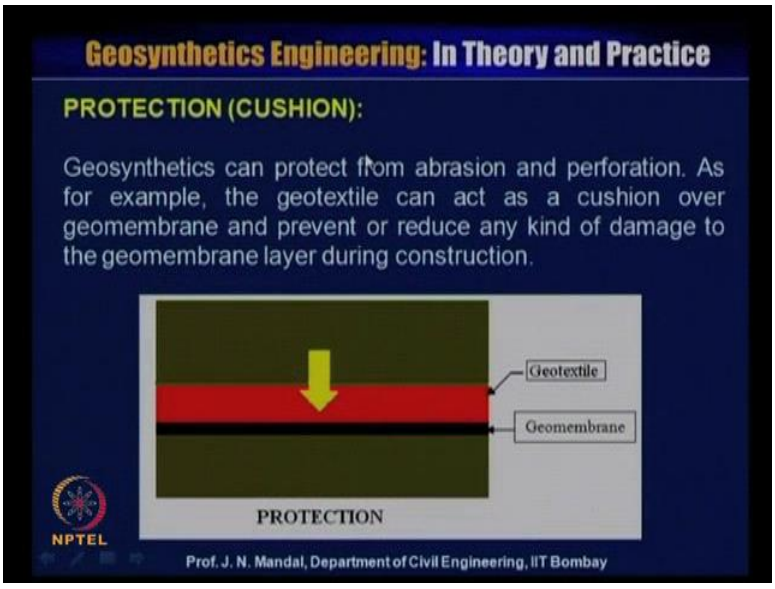

So, here geosynthetic material act as a reinforcement function. Protection or cushion. Geosynthetics can protect from abrasion and perforation. As for example, the geotextile can act as a cushion over the geomembrane and prevent or reduce any kind of the damage to the geomembrane layer during the construction. Here you can see this is the

geomembrane, this is the geotextile. So, any kind of the aggregate can damage the geomembrane material. That is why you are providing the one layer of the geotextile material and this geotextile material can protect the geomembrane and act as a cushion. For example, that if you wanted to construct a tunnel.

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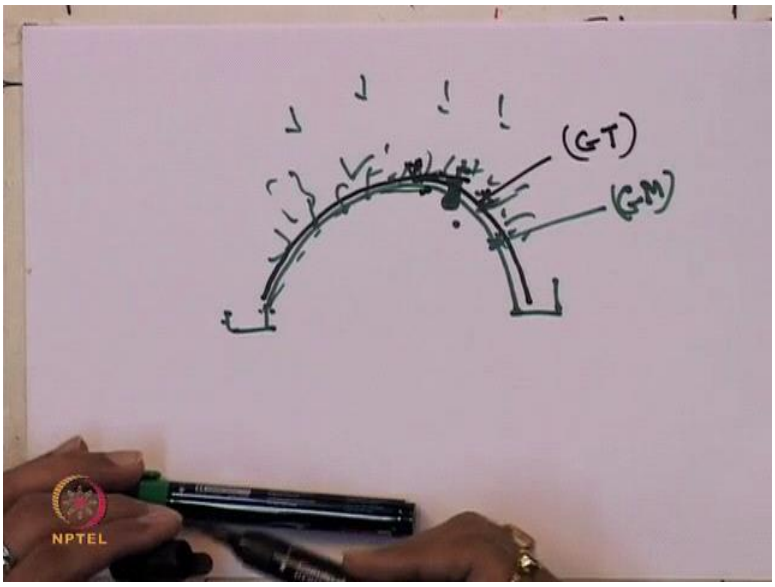

So, if you wanted to construct a tunnel like this. This is the drainage and you can see there are rock or there may be a triangular kind of the rock, which can if this is the geomembrane material. It is a geomembrane material, then this concept of the rock can penetrated into the geomembrane and there is a possibility for damage and leakage and when the rain, the rain water can pass through this geomembrane material.

So, on the top of the geomembrane you can provide one layer of the geotextile material. This is G T is geotextile material. So, geotextile material is act as a cushion. If we can damage, it can damage the geotextile material but not geomembrane material. Now, here geotextile material act as a filtration and drainage and geomembrane material act as a protection or the barrier.

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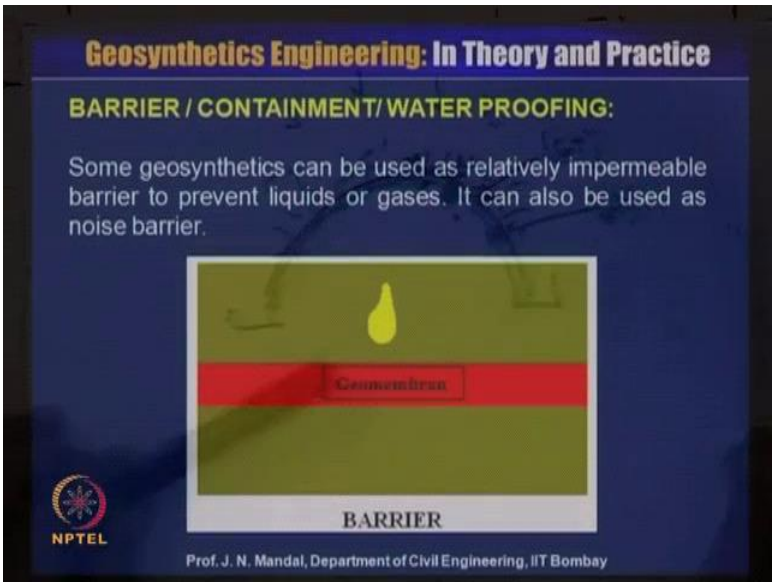

Then barrier or containment or waterproofing some geosynthetics can be used as relatively impermeable barrier to prevent the liquid or the gases. It can also be used as a noise barrier. You can see that some geotextile, non-woven geotextile material which can be impregnated with the bitumen material. So, when there is a opening of the non-woven geotextile material and it can be filled up with the bitumen material and it will act as a impermeable material. It can use also as a reflection cracking for road construction. So, this also will be relatively impermeable barrier and it act as a barrier or containment or water proofing, that is as a function.

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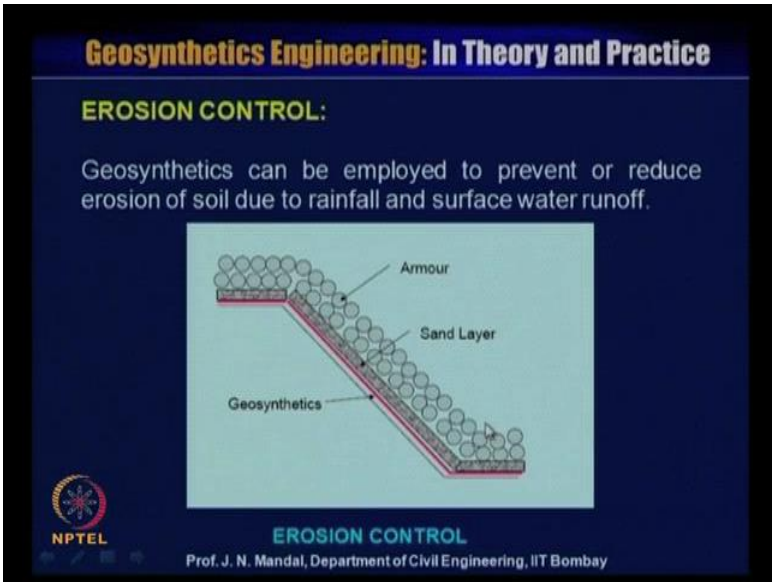

Now, erosion control problem. The geosynthetic can be employed to prevent or reduce the erosion soil due to rainfall and surface water runoff. You can place on the slope the geosynthetics material and then on the top of the that you can filled a little bit sand layer. And then on the top of the sand layer you can place the armour or the aggregate. Then two times you have to place the armour on the stone. Because there is a possibility for excess pore water pressure development at this subgrade level and there is a possibility for the erosion here. So, you can control by providing the layer of the geotextile material and geotextile material should not be damaged. So, that is why you place a sand layer and then on the top of the sand layer you provide the armour or the stone which can be prevent the erosion control. So, erosion control is a function.

So, there are showing, there are some application. Geosynthetics functional application. I say separation is an function. So, geosynthetics is placed. This is the geosynthetics material which is placed between the ballasts and the subgrade soil in the railroad. So, when you construct the railroad. So, you can place a geosynthetics material between the subgrade and the ballast. So, here geosynthetic material act as a separation. This good quality of aggregate will not penetrated into the subsoil. So, it can be prevented. So, here is the some application of geosynthetics as a separation function

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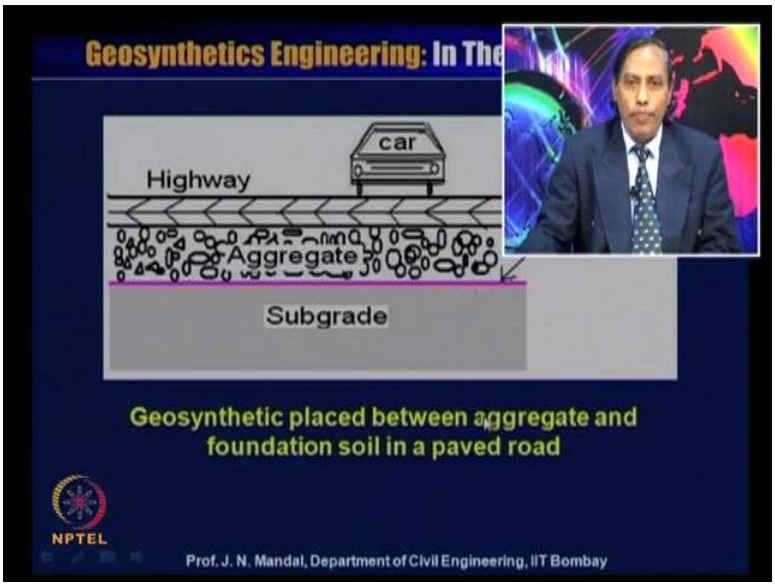

You can acts also geotextile placed between the aggregate and the foundation soil in a paved road. So, you can see that here geosynthetics material act also as a separation.

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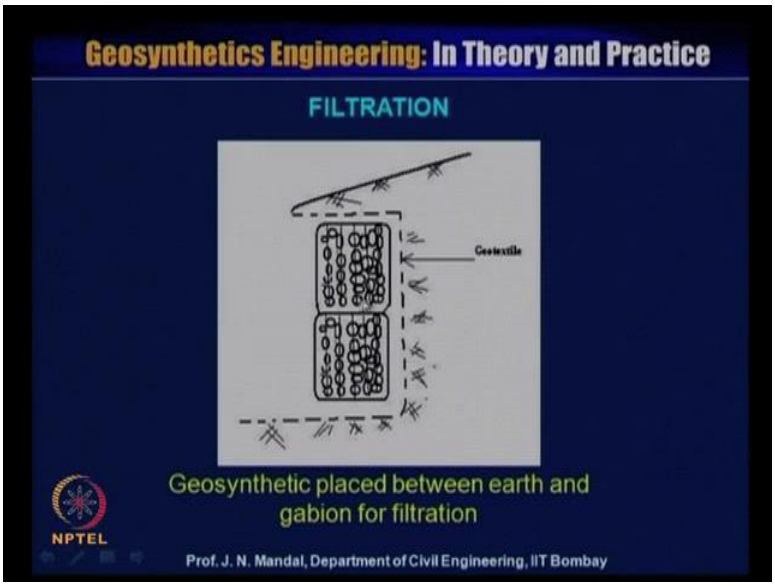

This is the filtration. So, this is the gabion, this is geotextile placed between the earth and the gabion as a filter. Gabion itself is a very good filtration material, gabion you know that one meter, one meter cube of the hexagonal galvanized mild steel set and fill up with the good quality of the aggregate. But sometimes the soil surrounding when it pass through this there is a possibility for clogging or choking or bonding. So, you can place a geotextile material surrounding here which can act as a good filtration. So, geosynthetics can be used as a filtration for such cases.

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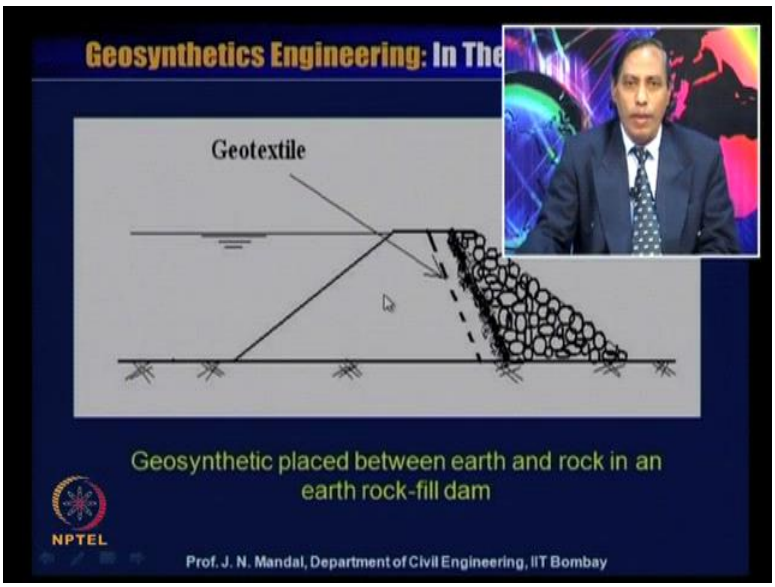

Now, geosynthetics is also placed between the earth and rock in an earth rock fill dam. You can see that here geosynthetics is placed. When the water can flow it can be prevented. So, there is been no clogging or choking here so geosynthetics material act as a filtration.

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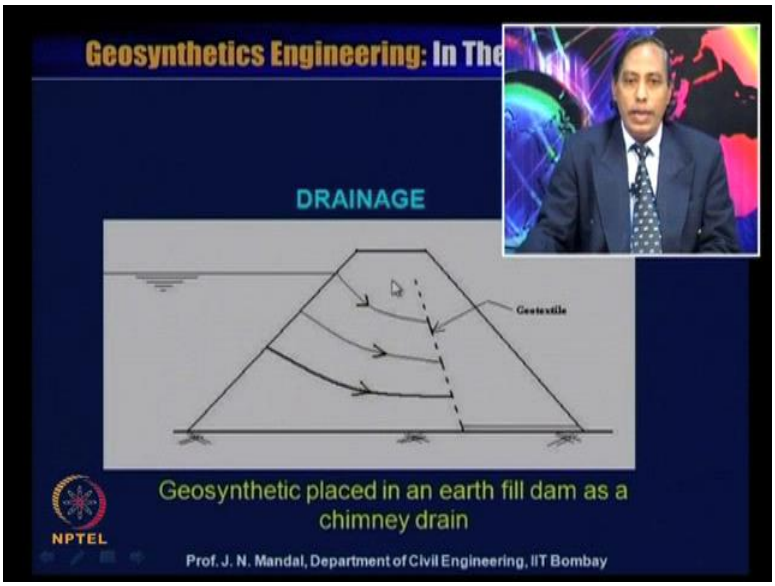

Now, here the geosynthetic material placed in a earth fill dam as a chimney drain, act as a chimney drain. So, this is the drainage. So, geosynthetics, this is the geosynthetics material. So, water can percolate along through this along the plane of the geosynthetics material. That is why it is the drainage. So, geosynthetics placed in a earth fill dam which is a chimney drain.

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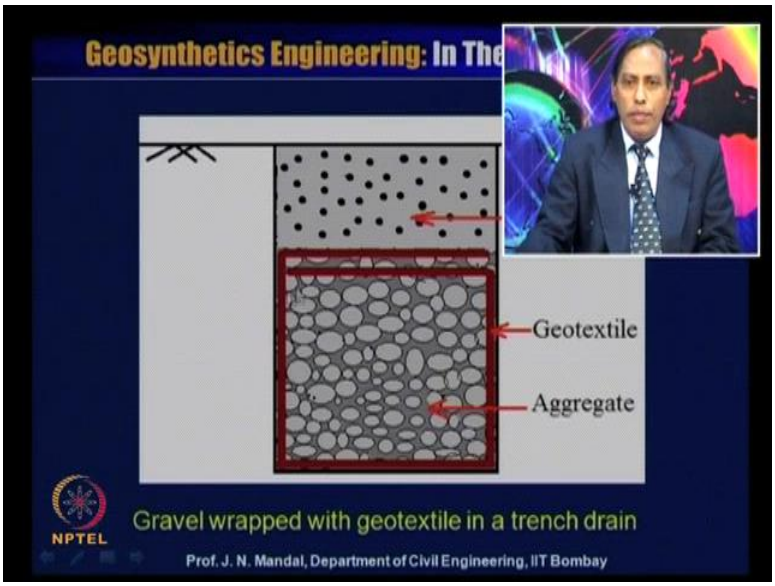

If I see most of the time in the road this is the gravel and wrapped with geotextile in a trench drain and then this is the native soil. So, surrounding soil should not be choked when the geotextile material is there.

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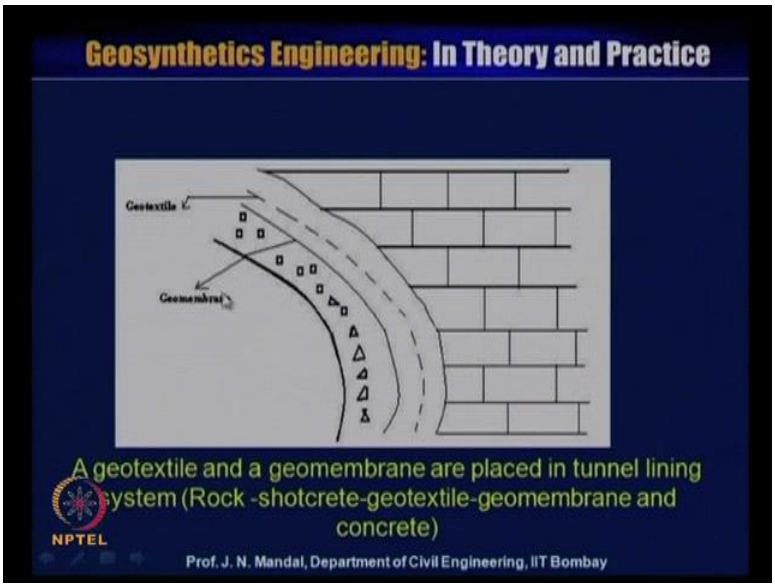

So, it will act as a very good drainage. This a geotextile and a geomembrane material are placed in a tunnel lining system. It is a rock or shotcrete geotextile or geomembrane and the concrete. As I mentioned you earlier that this concrete if it is a angular in shape it can penetrated directly with the geomembrane material and geomembrane material may be

choked. So, that is why we can place that one layer of the geotextile material which will act also as a cushion and can save the geomembrane. And these geomembrane act as a barrier, geotextile act as a filtration and drainage.

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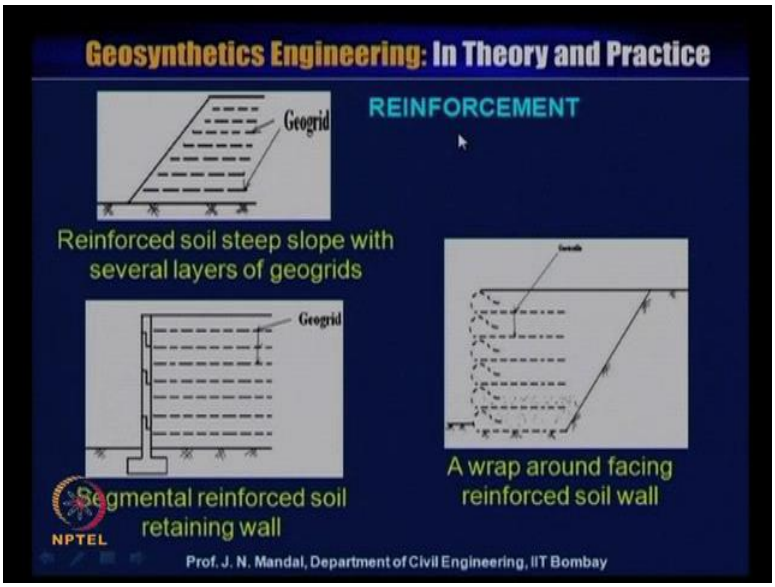

Here is the reinforcement. So, you can see that this is the number of multilayer of the geogrid material. So, we can construct a slope as you like it at any angle you can construct. Up to 70 degree we say it is a slope. So, this is the reinforced steep slope with the several layer of the geogrid material and this is the segmental reinforced soil retaining wall. And this is the reinforcement number of the layer of the reinforcement and this is a kind of the facing element or panel. So, you can construct a reinforced soil retaining wall while geogrid is used.

So, these all are act as a good reinforcement. Even then woven and non-woven geotextile material also act as a reinforcement. This is the wrap around facing reinforced soil wall. You can wrap it like this. I have shown you earlier like this. So, you can construct a wrap around facing reinforced soil wall. So, reinforced soil wall may be made of woven and non-woven geotextile material or the geogrid material for the geosynthetics whether it is a geogrid or the woven nonwoven geotextile material which will also act as a reinforcement.

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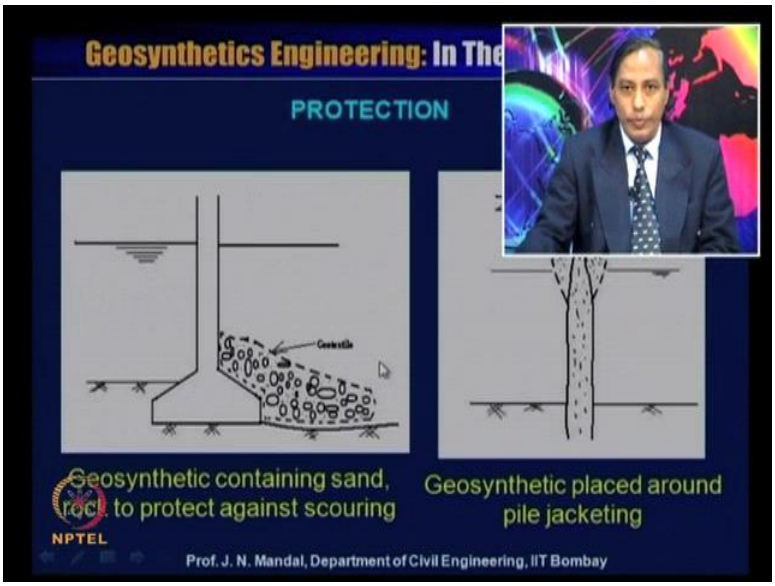

You can have the protection, the geosynthetics containing sand rock to protect against the scouring. Sometimes you can see in the railway bridge where there is a possibility for scouring in this zone and it is eroded and there is a possibility for instability of this structure. So, you can fill up with the good quality of sand or aggregate in a bag and then you can place here in this zone. So, you can save, so you can protect this sphere.

Now, sometimes in the right hand side you can see sometimes the geosynthetics placed around the pile jacket. If this is the pile, because for the fluctuation of the water and most of the time you find there is a formation of the neck. So, this is very danger. So, you can provide a geotextile material wrapped around the neck from the pile or pile jacketing and you can protect this pile for the geosynthetic material act as a protection barrier or containment.

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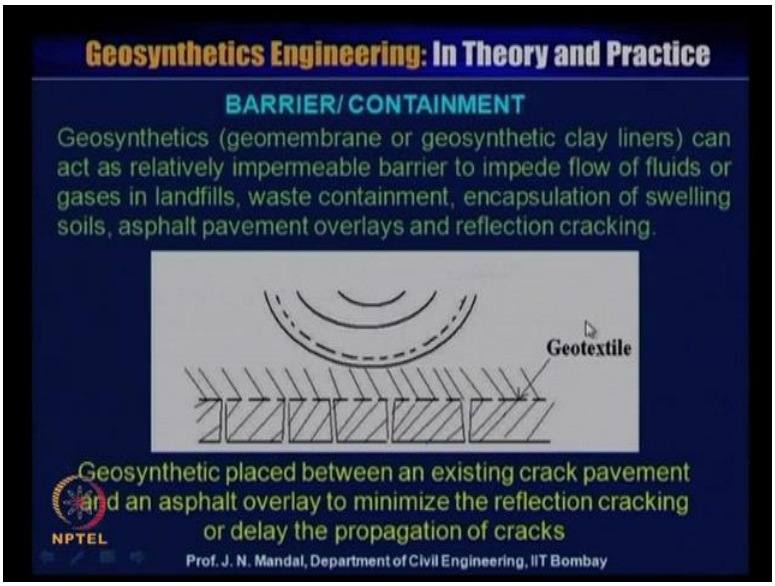

The geosynthetics or the geomembrane or geosynthetic clay liner can act as a relatively impermeable barrier to improve flow of fluid or gases in landfill waste containment encapsulated of swelling soil asphalt pavement overlays and reflection cracking. Here you can see that geosynthetics material placed between an existing crack pavement. This is the crack formation of crack in the pavement and asphalt overlay to minimize the reflection cracking or delay the propagation of the crack.

Most of the time you do not know from where the crack appear. It appears something some below of the subgrade and then it appear on the top and crack is propagating. So, you can fill up with the some coating material, you can place a one layer of the geosynthetics material and then you can place that over as per overlay on the top of these geosynthetics material.

So, when the crack propagate and this will be arrested by the geosynthetics material, where the geosynthetics material act as a barrier or the containment. Or sometimes if we use the non-woven geotextile material, as non-woven geotextile material has a apparent opening size or the equivalent opening size and it can be filled with the bitumen spray or tack coat spray in at a particular speed and time. And then this opening size of the non-woven geotextile material is filled up with bitumen and it will act as a barrier. Also like a impermeable material, and where this material can be meant to prevent the reflection cracking.

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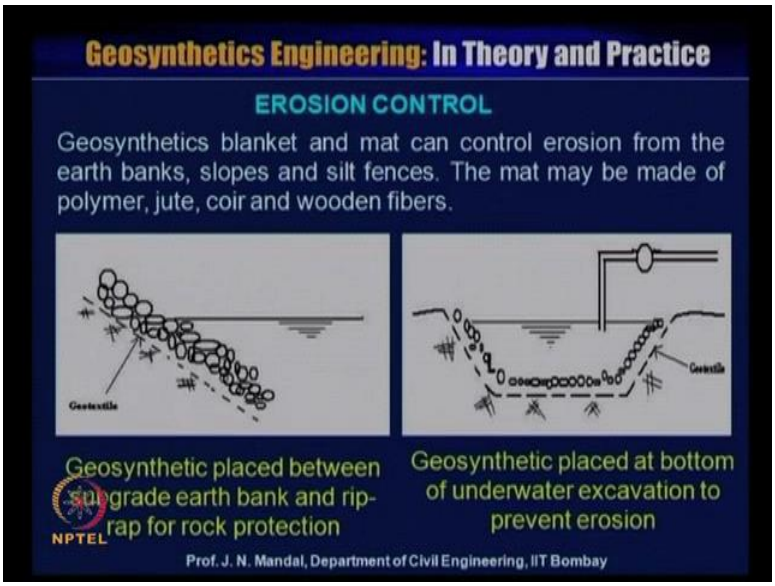

Now, erosion control, geosynthetic blanket and mat can control the erosion from the earth bank slope and silt fences. The mat may be made of polymer, jute, coir or wooden fiber. You can see here geosynthetics is placed between the subgrade, earth bank and the rip-rap or rock protection. You can see geosynthetics placed at the bottom of the underwater excavation to prevent erosion. Where you can see how the geosynthetics can be used these underwater. You can place these geosynthetics material and fill up with the aggregate and you can work out this area. So, geosynthetics material also can be protected for the erosion control here. It can be controlled erosion. Also you can use the geocell here, it can be protected as a erosion control.

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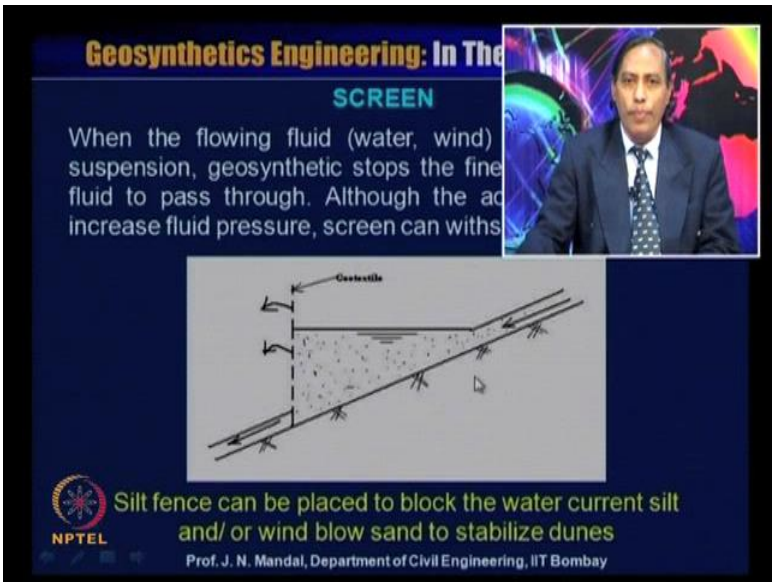

Screen, the silt fence can be placed to block the water current silt and or wind. Blow sand to stabilize the dune. When the flowing fluid water or wind carries particle in suspension geosynthetics stop the fine particle. Here geosynthetic can stop the fine particle and allow fluid to pass through this geosynthetics material. Although, the accumulated particle increase fluid pressure screen can withstand pressure. So, this screen can withstand pressure. So, this suspension can be prevented here. So, geosynthetics material here act as a screen.

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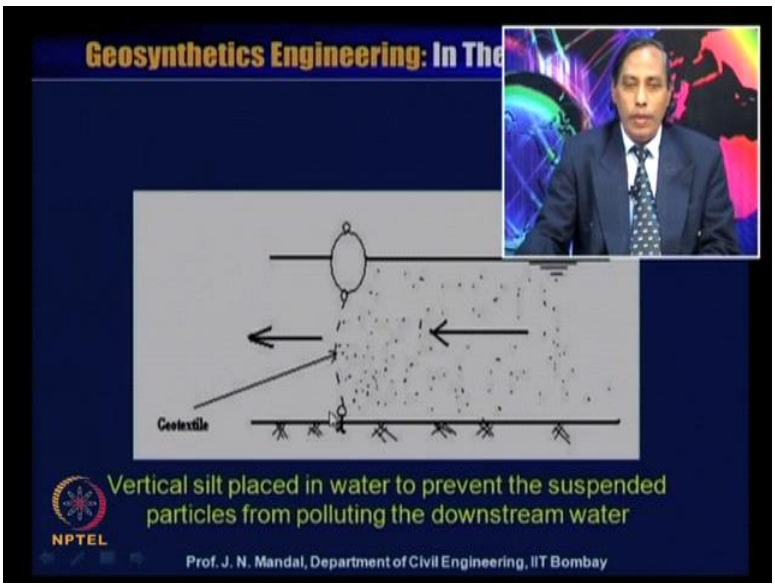

So, in this figure is shown that vertical silt placed in water to prevent the suspended particle from polluting the downstream water. Sometimes you can see in the sea there is a any oil layer contamination which is floating on the top of the sea water and you can place a geosynthetics material. And this is like a balloon and then this all the suspended material or contaminated material can be protected by the geosynthetics material. So, it cannot be propagate on the other side of the sea. So, here vertical slit is placed in water to prevent the suspended particles from polluting the downstream of the water.

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So, how you can see the geosynthetic material it act as some function. So, geosynthetics have several other application. It can be used as a daily cover to the working surface of the municipal solid waste landfill to protect it from the birds, animal and wind. Sometimes what happen in the landfill? Just you dump it and just get away. So, you should cover with certain kind of the geotextile material.

So, if you can cover with the geotextile material then birds or animal, also from the wind can be protected. Also cylindrical shaped, double shaped geosynthetics called as geotextile tube filled with the hydraulic fill can be used for the shoreline protection or to dewater the sludge for water purification. You can see that some kind of the cylindrical shape geosynthetics material and you can fill that geotextile tube with the drainage material or contaminated material or sand. And then if you put the pressure on that then

the water is drained it out and then you can dewater the sludge from the water purification.

So, we will go one of the chapter with the geotextile tube, geotextile container and geotextile bag. So, you will be knowing more about this application and how to design also geotextile tube. Now beauty of this geosynthetics material so far we have studied that it has a separation, filtration, drainage, reinforcement, barrier, sealing etcetera, etcetera. That is many many function, erosion control. So, beauty of this geosynthetic material is that it is not only act as a separation function but at the same time it act as a filtration drainage and reinforcement function. That is the beauty of the geosynthetics material. Now, you can see here that reinforced soil wall or steep slope. The primary function is the reinforcement and secondary function is drainage.

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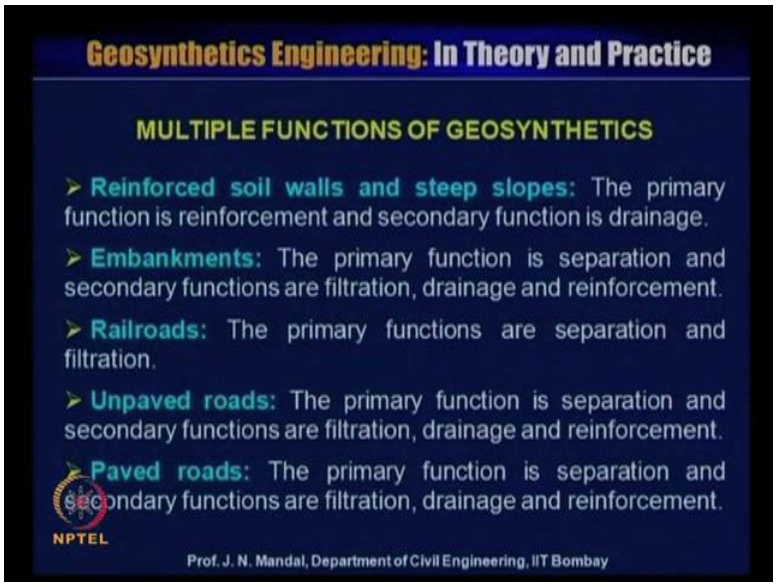

The same material one is acting as a reinforcement as well as it act as a drainage function. When you construct the embankment, the primary function is separation. It separate the finer material to the courser material and secondary function are the filtration, drainage and the reinforcement.

So, remember that what is their primary function and what is their secondary function. So, for the construction embankment, separation is the primary function and the filtration, drainage and reinforcement is the secondary function. For reinforced soil wall and steep slope reinforcement is a primary function, whereas drainage or the filtration is

the secondary function, when railroad construction primary function as separation and the filtration. Unpaved road, primary function is separation and secondary functions are filtration, drainage and reinforcement. Paved road, the primary function is separation and secondary function are filtration, drainage and the reinforcement.

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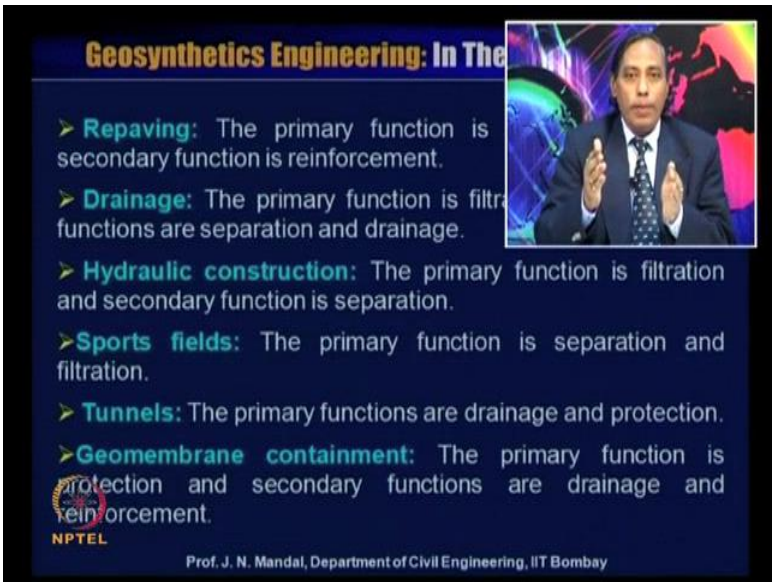

Repaving, the primary function is waterproofing and secondary function is reinforcement. Drainage, primary function is the filtration and secondary functions are separation and drainage. Any hydraulic construction primary function is filtration secondary function is separation. Sports field, the primary function is separation and filtration. Tunnel, the primary function are drainage and protection. Geomembrane containment, the primary function is protection and secondary functions are drainage and the reinforcement.

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So, many design of the geosynthetics material. It is necessary to evaluate the geotextile property by soil exploration thoroughly. Then evaluate the properties of the geosynthetics material. There are physical property, mechanical property, hydraulic property, environmental property. Then determination of the geosynthetics function such as separation, reinforcement, drainage, filtration, protection, containment and erosion control.

And then try trial design and compare with the various alternative method. Analyze the proper model and evaluate their parameter. Develop most shape and cost effective appropriate design. Determine the exact required properties of geosynthetics and their installation technique. Look at the availability of the geosynthetics or modify the design required and monitor the construction site. These are very important that sometimes you are designing but material is not available. So, you have to be careful about the availability of the material and also you have to be careful about the construction site. Whether it has been properly placed or not and which direction it has been placed. So, all this you have to keep it mind.

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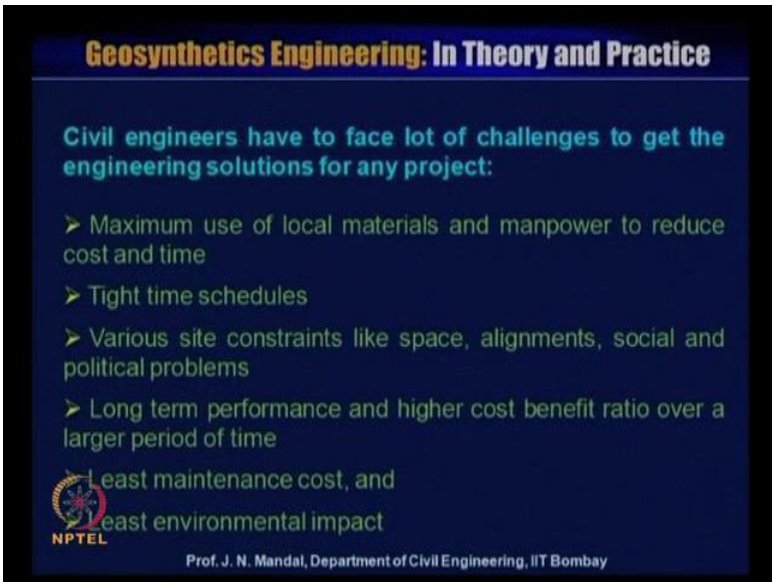

Civil engineer have to face lot of challenges to get the engineering solution for any project. So, we have to use maximum use of local material and manpower to reduce the cost and time, most of the time you can see for any project, there is a tight time schedule. You have to finish within this time. Various site constraint like a space alignment, social and the political problem. You can see when we construct the national highway we face a lot of problem regarding the space, regarding the alignment. There are also lot of social problem, also the political problem.

So, these you have to face. So, these you have to be taken care before the authorizing this any kind of the project to the client. Long term performance and higher cost benefit ratio over a larger period of time. So, you can think that how you can have some long term performance it may the higher cost benefit ratio over a long period of time because you are not to be maintenance. So, that way your least of the maintenance cost and least the environmental impact that is also very important to us.

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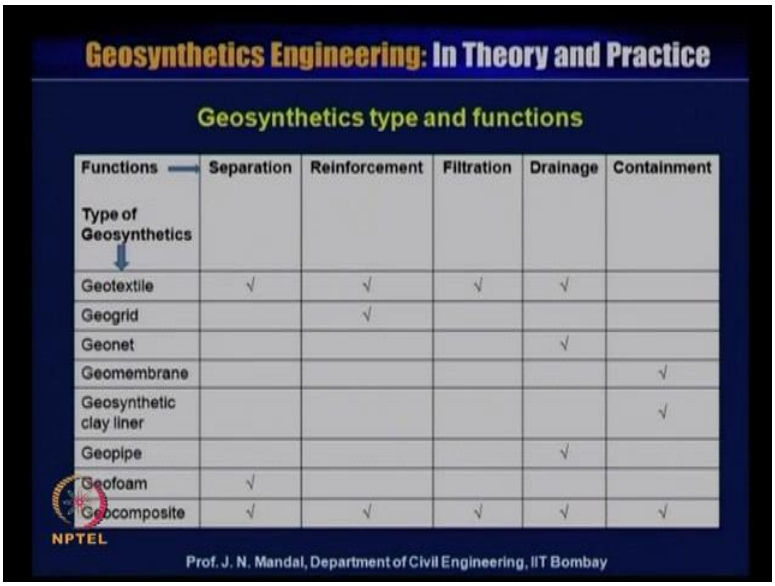

So, in this slide has showing the geosynthetics type and the function. You can see that different types of the geosynthetics material, geotextile, geogrid, geonet, geocomposite, geosynthetic clay liner, geopipe, geofoam and geocomposite. And these are the function separation, reinforcement, filtration, drainage and containment. Here you can see geotextile act as a separation, reinforcement, filtration, drainage. Geogrid as a reinforcement. Geonet as a drainage, geomembrane as a containment or geosynthetic clay liner alternative to geomembrane. So, it it function as a containment. Geopipe, it act as a drainage function. Geofoam act as a separation function and geocomposite its act as all separation, reinforcement, filtration, drainage and the containment.

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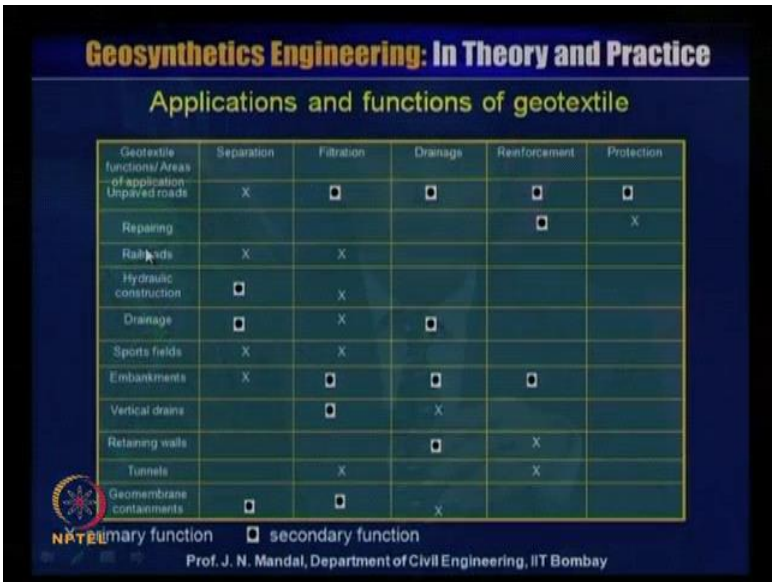

Now you can see that slide that what is the application and the function? This is at the various application. It is a unpaved road, repairing railroad, hydraulic construction, drainage, sports field, embankment, vertical drain, retaining wall, tunnel and geomembrane containment. You can see these are the function separation, filtration, drainage, reinforcement and protection. For unpaved road you can see that this cross shows that this is primary function and this dot shows the secondary function.

So, for unpaved road this primary function is the separation and filtration drainage and the reinforcement and protection is the secondary function. That is why I say the geosynthetics material is not only act as a one function, but act as a multifunction that is the beauty of this material. So, like that you can see that for the repairing or the railroad or separation and filtration function, hydraulic construction, drainage, etcetera. So, for example, this vertical embankment this separation as a function, filtration, drainage and reinforcement is the secondary function. Retaining wall for the primary function is the reinforcement. Secondary function is the drainage. Whereas tunnel, these primary function is the also this reinforcement and also this filtration.

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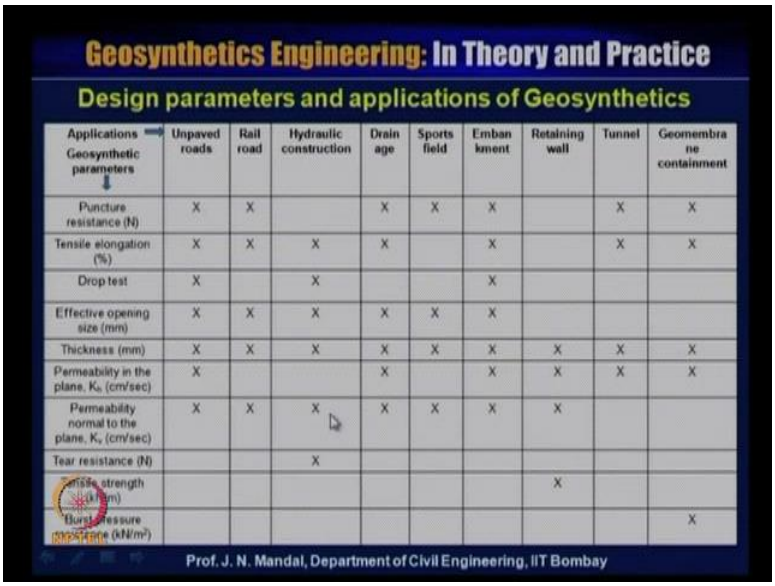

Applications → / Geosynthetic parameters ↓	Unpaved roads	Rail road	Hydraulic construction	Drain age	Sports field	Emban kment	Retaining wall	Tunnel	Geomembra ne containment
Puncture resistance (N)	X	X		X	X	X		X	X
Tensile elongation (%)	X	X	X	X		X		X	X
Drop test	X		X			X			
Effective opening size (mm)	X	X	X	X	X	X			
Thickness (mm)	X	X	X	X	X	X	X	X	X
Permeability in the plane, K_h (cm/sec)	X			X		X	X	X	X
Permeability normal to the plane, K_v (cm/sec)	X	X	X	X	X	X	X		
Tear resistance (N)			X						
Tensile strength (kN/m)							X		
Burst pressure (kN/m²)									X

So, we have to be select that what is primary function what is secondary function? So, one side know that different types of the application. That when application of geosynthetics, unpaved road, retaining wall hydraulic construction, drainage, sports field, embankment, retaining wall tunnel and geomembrane containment. And at the same time you should know what will be the characteristic or the properties of the geosynthetics material.

So, these are the properties, that is we should know what will be the puncture resistance of the geosynthetic tensile strength or elongation drop test, effective opening size or apparent opening size of the geotextile material. What will be the thickness of the geosynthetics material? What will be the permeability that is in plane? What will be the permeability normal to the plane? What will be the tear resistance? What will be the tensile strength of the material? And also you should know the burst pressure.

For puncture strength you require for unpaved road, railroad, drainage, sports field, embankment, tunnel and geomembrane containment. Stabilized tensile strength also required for unpaved road, railroad, hydraulic construction, drainage and also the embankment tunnel and geomembrane containment. Drop test also require for unpaved road hydraulic construction and and embankment. Effective opening size.

You can see this is unpaved road. This is a railroad, hydraulic construction, drainage, sports field and embankment. Thickness is almost in all application and the permeability

in plane is required for the unpaved road. And also drainage, and this embankment and also the retaining wall tunnel and the geomembrane containment. Permeability normal to these, that is unpaved road, railroad, hydraulic construction, drainage, sports field, embankment and retaining wall. Tear resistance is for hydraulic construction. Tensile strength also for the retaining wall. And the burst resistance for the geomembrane containment. So, here we are showing one of the manufacturer list. That is correct choice of the geosynthetics material. Generally the amount of geosynthetics selected depend on the applied load and the soil condition for various project.

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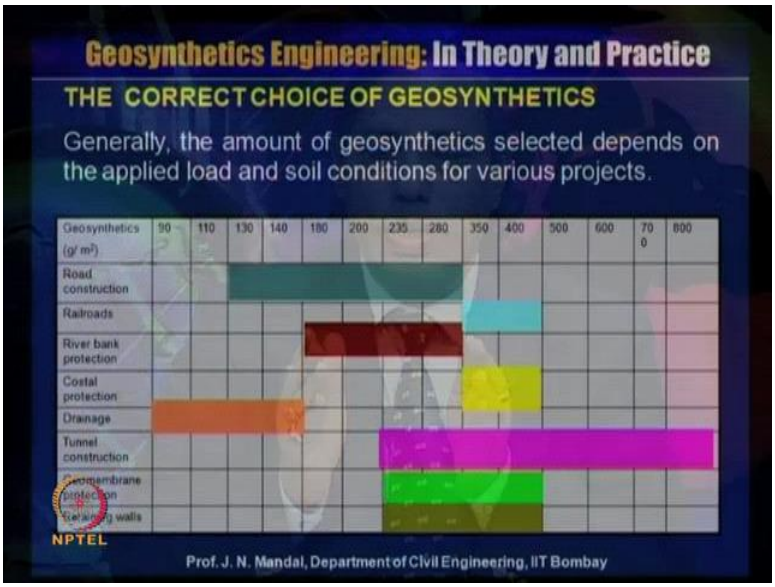

So, when we manufacture the geo, non-woven geosynthetic material. It has a certain weight that is gram per meter square. So, you can see here that different types of the geosynthetics material starting from 90 gram per meter square, 110, 130, 140 180, 200, 235 and so on like this 800 and even then more. And for the road construction you can use within this range. 130 to say let us say 280. This is specifically for a particular manufacturer. For the railroad you see very high weightage. It is 350 to 400. Whereas you can see for tunnel you need very high weight or you need very high strength. You can see starting from 235 to 800 gram per meter square.

So, it depend upon that what will be the type of the application and how you will select the geosynthetics material. For example, for road construction there is a range 130 to 280. You require whether it is a low volume load, medium volume load or high volume

load. And depending upon the load, so you can select what the kind of the geosynthetics material you should select, depending upon the whether it is a low, medium or high volume. So, this picture will give you some idea about that how will you select the proper kind of the material and what will be their proper characteristics.

So, when you will go for the design for the geosynthetics material, so first of all for any project analysis. So, the question comes whether you use the geosynthetics material yes or no? If yes then what you should know? You should determine what will be the geosynthetics function. That means function it may be separation, filtration, drainage, reinforcement, protection and sealing.

You should recall you know that determination of the required safety factor. Then you have to determine the onsite parameter. The onsite parameter means that what will be the soil at that zone. What should be their grain size distribution? What is the shear strength of the soil? What is permeability of the soil? And also you should know what will be the water? What is the rate of flow, condition, stress. Whether it is a static or it is a dynamic.

So, when it is a dynamic then you have to be careful and you have to be take into account in the design accordingly. Now you have to be calculate that what should be the minimum required value and then determine the actual geosynthetics minimum value. So, that means that you should know the geotextile property.

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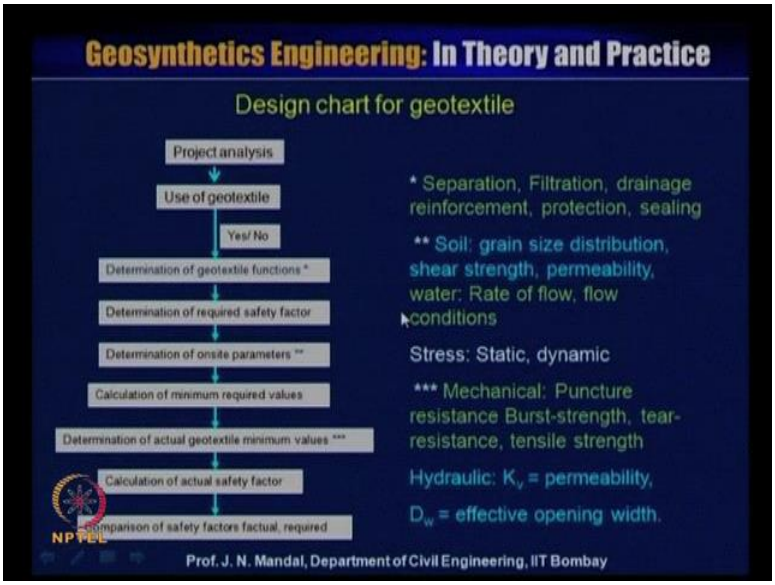

That is, what will be the mechanical property? That is puncture resistance, burst strength, tear resistance and tensile strength. And also you should know what will be the hydraulic characteristic. It may be that coefficient of permeability and also the geosynthetics material has a opening side which we call D w or it called the equivalent opening side. So, this you have to know that what will be the actual geotextile minimum value. Then you have to calculate that what will be the actual safety factor. And then you can compare the safety factor. What is safety factor required or what is safety factor actual? Then you can design it. So far we have discussed the different types of the function. This is very, very important that one should know what should be the functional concept. And we discuss this separation function, filtration function, drainage function, contamination function, erosion control function and how the different types of the function have been used in the different types of the application.

So, this is very useful in our this course geosynthetics engineering in theory and practice. So, when you will design the any kind of the geosynthetics related structure. So, you are to be very careful about their functional concept. What will be the accurate properties of the soil? Detail properties of the soil is very important. And particularly for the erosion control problem and also you should know proper kind of the testing of the geosynthetics material, their mechanical property, their physical property, their environmental property. So, if you know all these. So, you can make a good design. With this I ended up this lecture. Please let us hear from you any question.

Thank you for listening.