Technical Textiles
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Lecture - 17
Geotextiles (Contd.,)

Hello everyone, so, we will now start discussing the properties of geotextiles. So, the properties overall we can classify in 3 categories, intrinsic property of geotextile.

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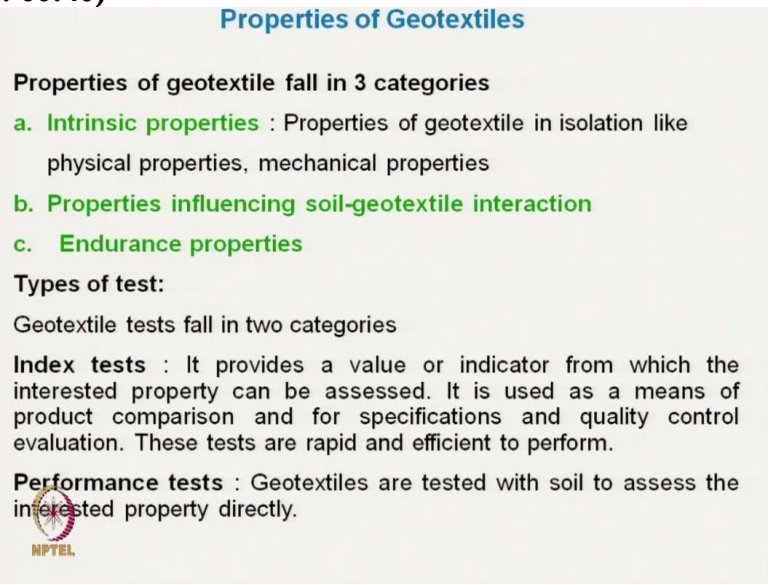

The properties of geotextiles, which are influenced by soil geotextile interactions and endurance properties of geotextiles during use. So, the type of tests are index test so, index test are basically there are 2 types of test, one is index test and other is performance test. The index test is it provides a value and indicator from which the interested property can be assessed, it will give as a value. It is used as a means of product comparison and for specification and quality control.

And this index test as we test using an instrument it is a quicker method and efficiently it can be performed. But as far as performance test is concerned, we have to test in actual condition. The geotextiles are tested with soil to assess the interested properties like reinforcement, filtration. So, this type of tests are not that rapid test this takes time so, the intrinsic properties. So, we will now discuss different types of properties.

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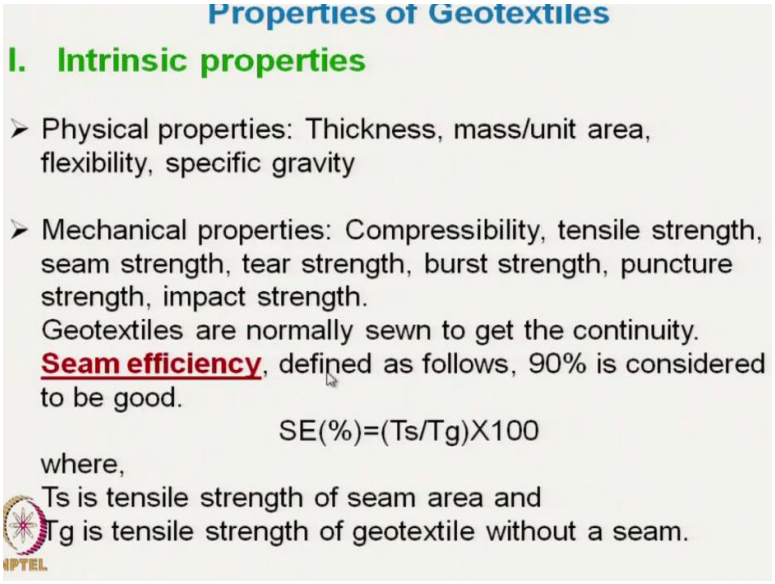

This intrinsic properties are like physical properties, mechanical properties or hydraulic properties, this physical properties are thickness, mass per unit area, flexibility, specific gravity. These are the physical properties. Mechanical properties are tensile strength, seam strength, tear strength, the busting strength related to all the mechanical behavior of geotextiles impact strength. We can calculate seam efficiency by knowing the tensile strength at the seam area and tensile strength of geotextile without seam.

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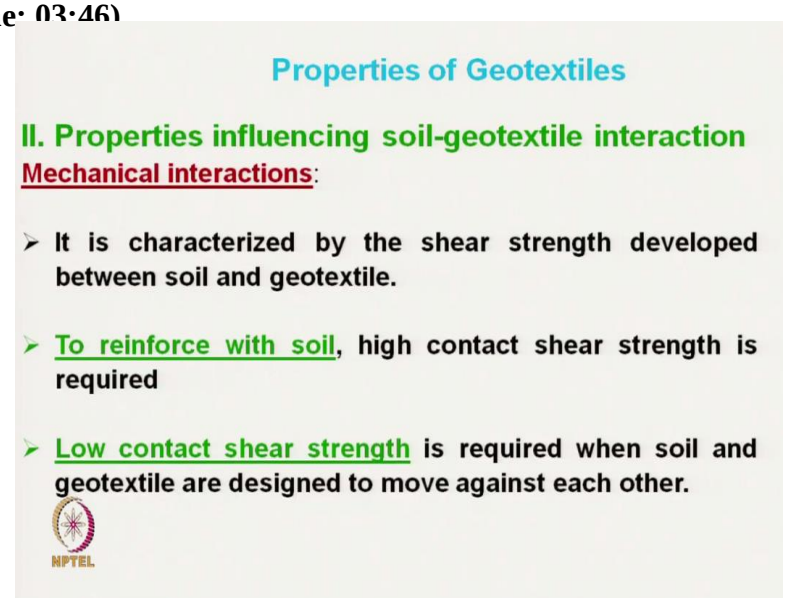

After the intrinsic property next properties are the properties which is influenced by soil geotextile interaction the mechanical interactions are characterized by the shear strength

developed between soil and geotextile. So, this is very important as far as reinforcement application is concerned. So, to reinforce with the soil, high contact shear strength is required.

So, contact shear strength if we can measure depending on the shear strength, we can use for reinforcement. In some applications low contact shear strengths are required when soil and geotextile are designed to move against each other. So, there are different applications. So, depending on that, we can select the fiber or fabrics and the type of soil for the type of soil.

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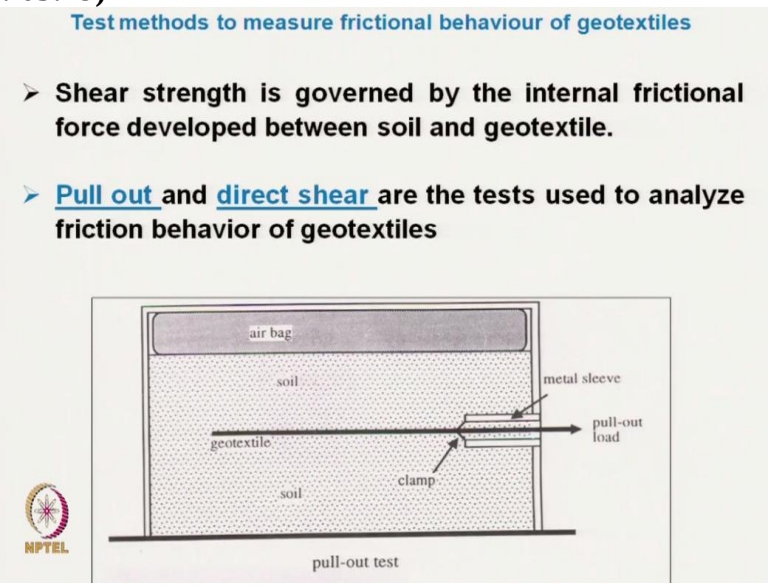

So, this interface mechanical interaction between soil and geotextile can be assessed by shear strength. The shear strength is governed by internal frictional force developed between soil and geotextile and this shear strength between soil and geotextile is measured using 2 techniques. One is pullout test another direct shear test. Geotextile is placed in between soil inside the soil and it is being pulled out depending on the pulling force if we can calculate the shear strength we can see the friction between geotextile and the soil can be measured.

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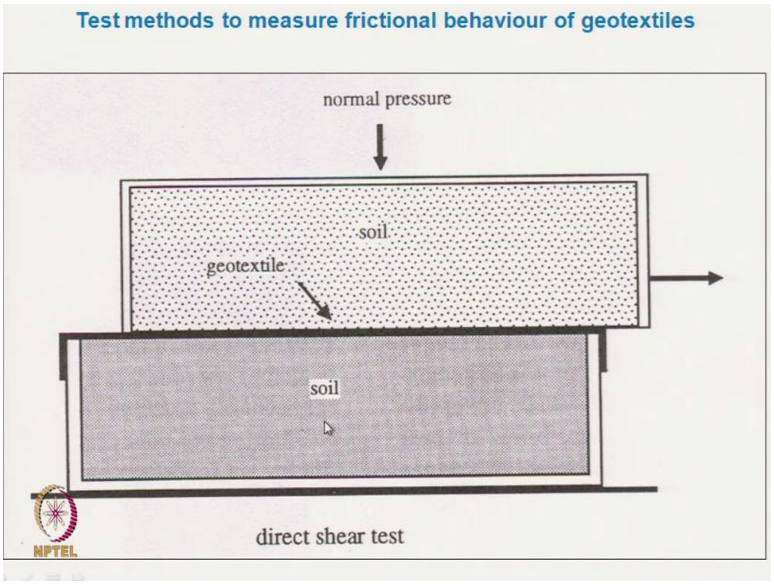

Another way is direct shear test. So, these are the 2 tests by which we can measure the mechanical interaction between geotextile and soil.

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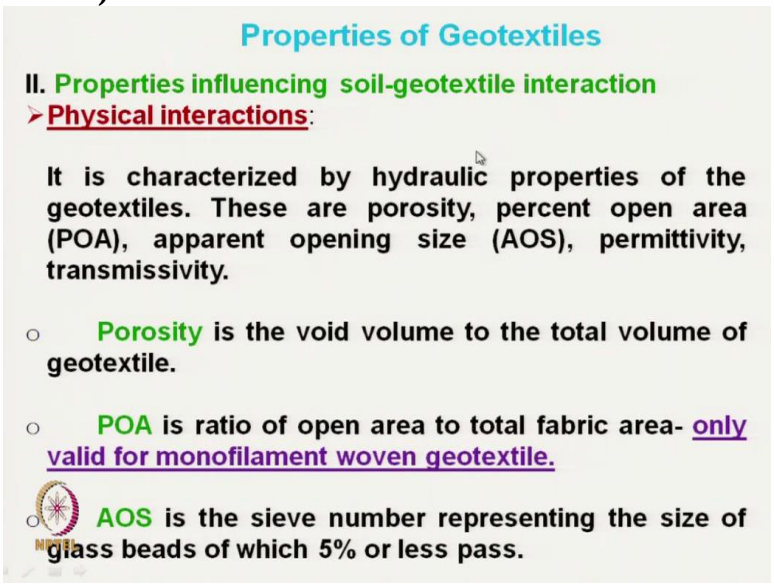

Another parameter related to soil geotextile interaction is a physical interaction where the hydraulic properties are affected, these are percent open area POA, apparent opening size, permittivity, transmissivity. These properties are important for application for a particular soil structure. So, if we know apparent opening size and percent open area, permittivity, transmissivity, we can use for a particular application in particular soil condition ,like porosity is the void content in geotextiles percent open area is basically it is the area.

The ratio of open area to the total area of fabric and this is used only for monofilament open fabric where definite openness is there. Apparent opening size, it is basically used it to get the idea of the pore size and it is measured by sieving, a standard size of glass beads. So, AOS the sieve number representing the size of glass beads of which 5% or less is passed. So, you have standard size of glass beads.

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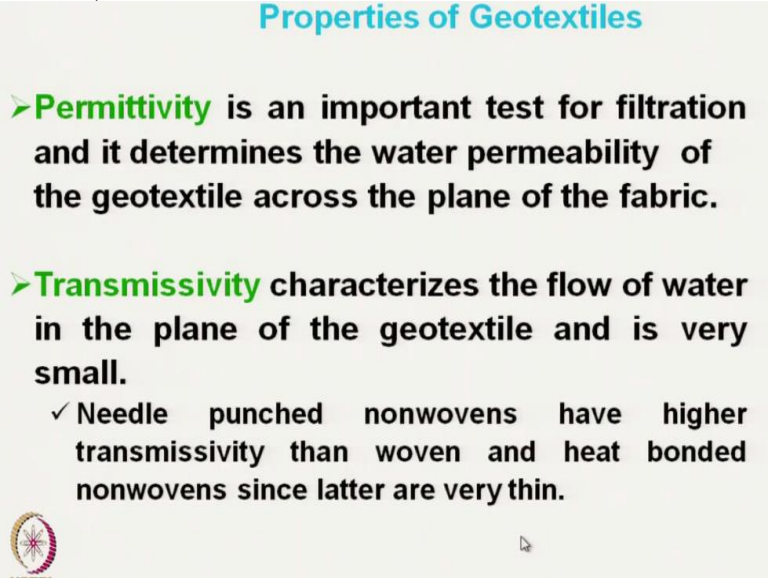

Permittivity is the characteristics which is important for filtration application, the amount of water or fluid pass through across the plane, transmissivity is the characteristics which is used for drainage application. It characterize the flow of water along, the plane needle punched nonwoven have higher transmissivity than woven and heat bonded nonwovens because they are thin in structure. So, this needle punched nonwoven fabrics are therefore used for drainage application.

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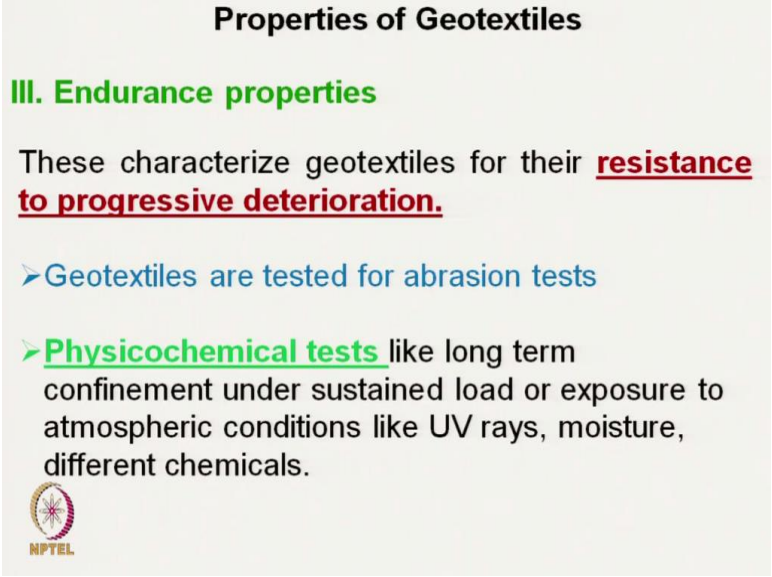

And third type of properties are endurance property these characterize geotextile for their resistance to progressive deterioration because while use we should know the endurance property. Progressively how the structure of geotextile is getting deteriorated that may be due to abrasion maybe UV deterioration maybe moisture deterioration or maybe due to load.

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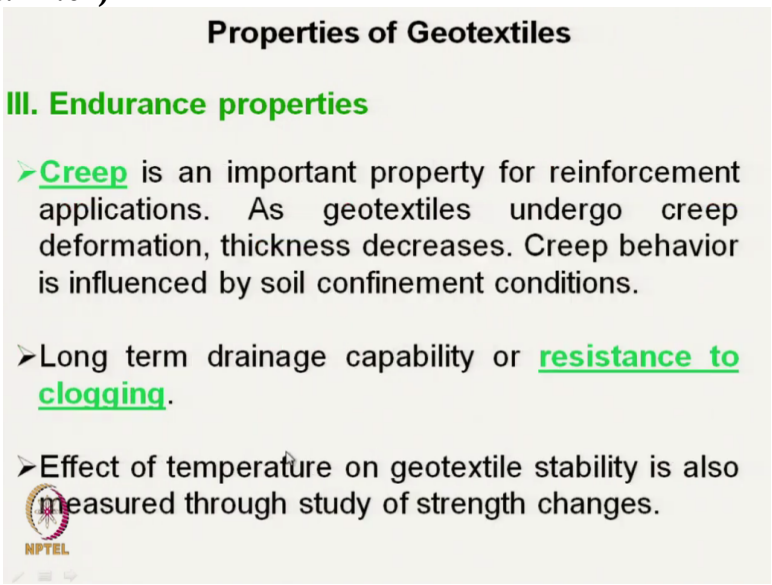

Like mechanical endurance properties are creep. So, it is an important property for reinforcement application as the geotextiles undergo creep deformation, thickness decreases. So, total characteristics of geotextile will change. For filtration and drainage purpose it is a long term drainage capability or resistance to clogging is important because during use the pores of the geotextile may be clogged by soil particle or maybe other deposition so, we must know this

clogging behavior and also during application, the temperature may change. So, we should know the effect of changing temperature on the strength characteristics.

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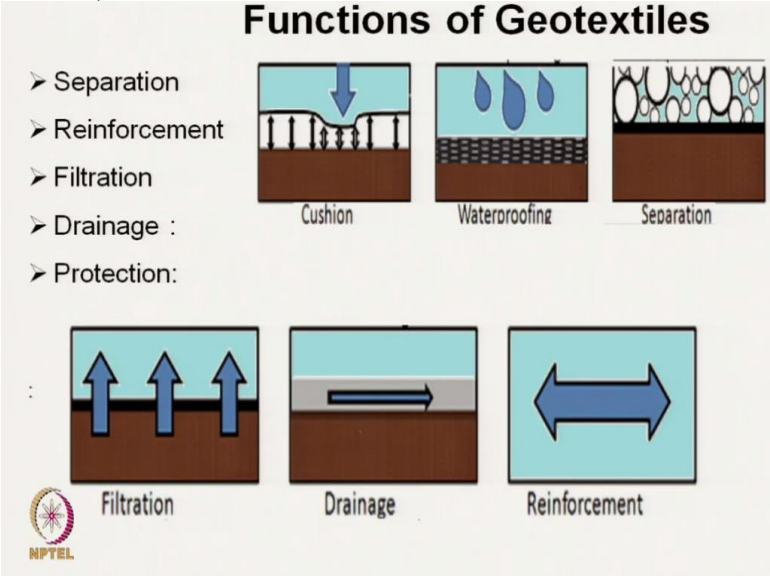

Now we will discuss different functions of geotextiles. Broadly the functions are divided into 5 categories, these are separation this is separation, separation means the geotextile will segregate the soft soil of particle size very low with the larger particles. If we do not separate this soft soil with the stones or gravels the soft soil will penetrate inside this structure and will deteriorate the characteristics. Reinforcement is another function.

It is important function where the soil structure the strength increases, filtration as has already been discussed, it is used to retain or to prevent the soil loss. At the same time it should allow the fluid to pass through, drainage is important so that the water can flow along the plane. So, water accumulation is not there. So, basically strength of soil reduces with the increase in moisture.

So, drainage helps in maintaining the strength of soil structure by distributing the water, it is not allowing the water to accumulate at one place. Another characteristics is that protection, protection of the structure. It is by cushioning. Sometimes we use geotextile for a specific purpose for waterproofing. So, now we will discuss these functions one by one.

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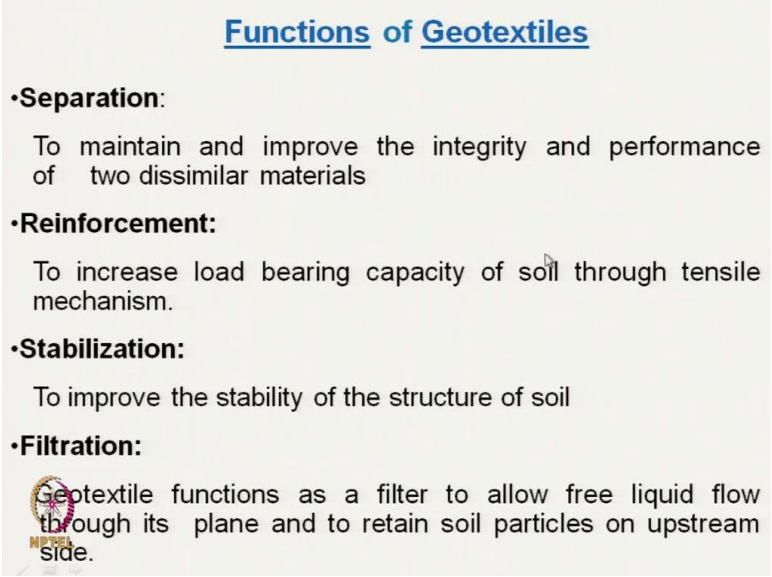

So separation it is to maintain and improve the integrity and performance of 2 dissimilar material. So, once the, these 2 dissimilar materials they mix together, they will not perform their own functions like.

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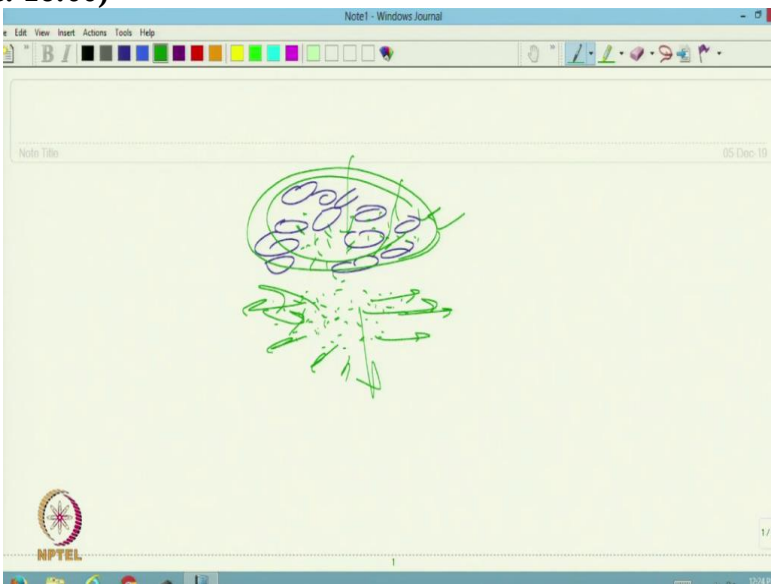

Large size stones in between this and this is a soft soil, with high moisture content this is this structure is very weak. The strength of the structure is done by this and here in this structure the water accumulation should not be there. So, water should pass through. Due to this smaller particles the water accumulation is there, it cannot the water cannot pass through this so, if we do not use if we remove this geotextile.

Then the soft soil will penetrate inside the structure, the soft soil will penetrate inside the structure and this will block their pores and it will be weaken. At the same time the water accumulation will also be there. Reinforcement function is to increase the load bearing capacity of soil through tensile mechanism, stabilization to improve the stability of the structure. Filtration as we know that it allows the free flow of liquid, in this case water through its plane but at the same time it should retain the soil particle.

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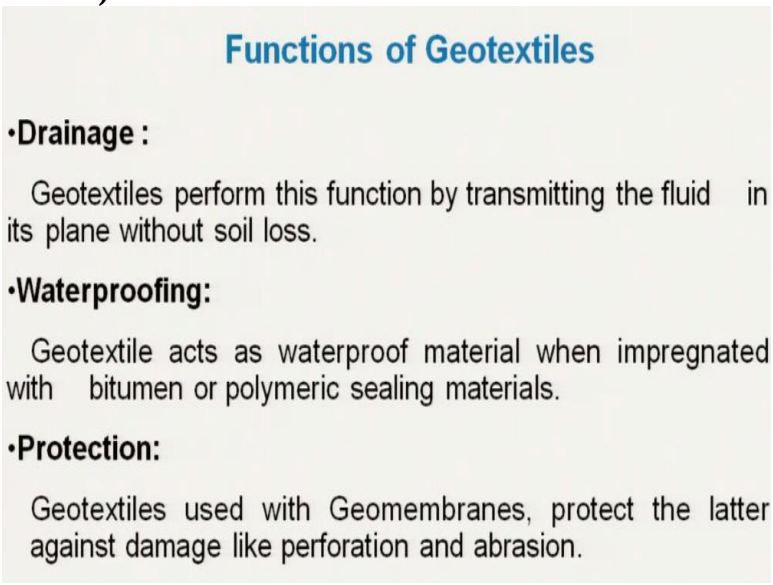

Drainage, geotextile perform this function by transmitting the fluid along its own plane. Waterproofing is required for some specific purpose when the geotextile is impregnated with bitumen or polymeric sealing material. Protection is a function geotextile used for protecting the geomembrane because geomembrane is used for preventing the seepage it should be totally impermeable in case of absence of geotextile, there is chances of geomembrane getting punctured. So, it will not perform its function. So, there geotextiles are used.

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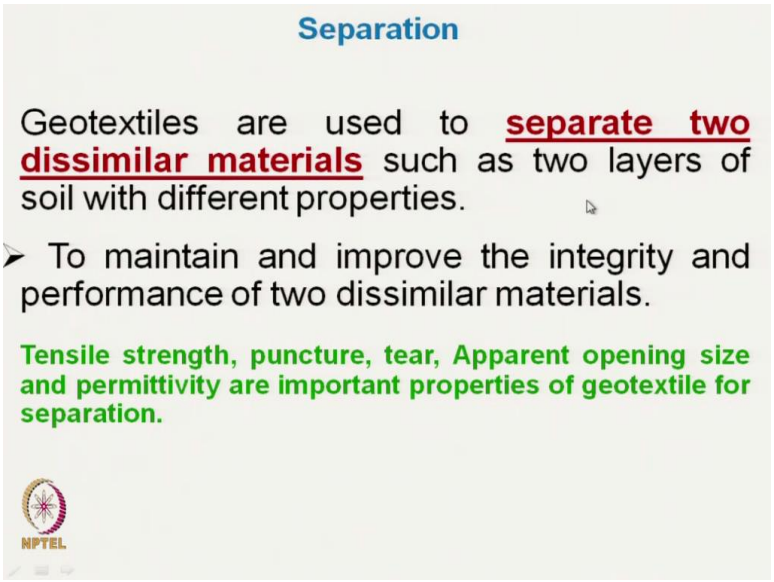

Now, coming to separation. So, geotextiles are used as I have mentioned to separate 2 dissimilar materials, such as 2 layers of soil with different properties, one is a larger size, another is smaller size, it is used to maintain and improve the integrity and performance of 2 dissimilar material. They should not mix together to have better strength. So, for separation purpose we need specific characteristics of geotextiles, it should have higher tensile strength, higher punches strength.

If the geotextile get punctured, then this separation function will not be there, tear strength, apparent opening size is important because otherwise the soft soil the clay particle fine particles will penetrate through the geotextile, we must know the apparent opening size and permittivity. These are the properties we must consider when we use geotextile for separation purpose.

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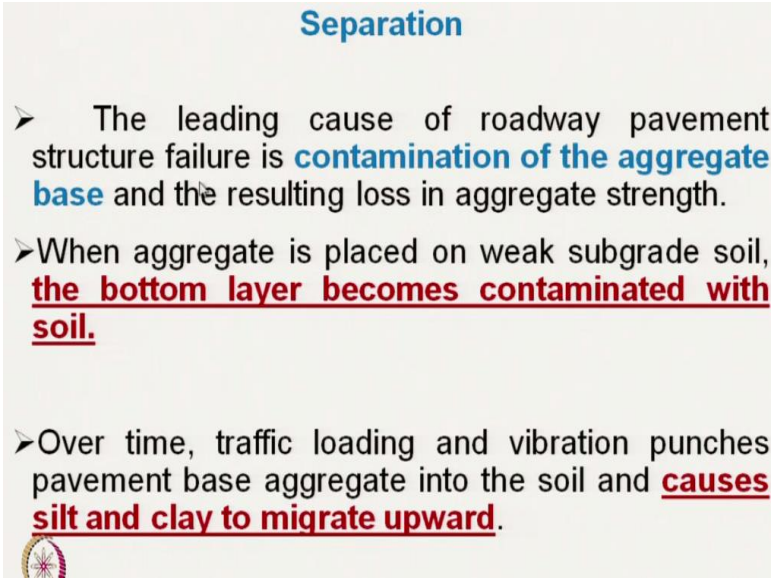

The leading cause of roadway pavement structure failure is contamination of aggregate base and resulting loss of aggregate strength. So, if they are contaminated then the strength will drop. When aggregate is placed on weak sub soil, the bottom layer become contaminated with soil. Soil will penetrate inside the aggregate. To prevent that we must use geotextile.

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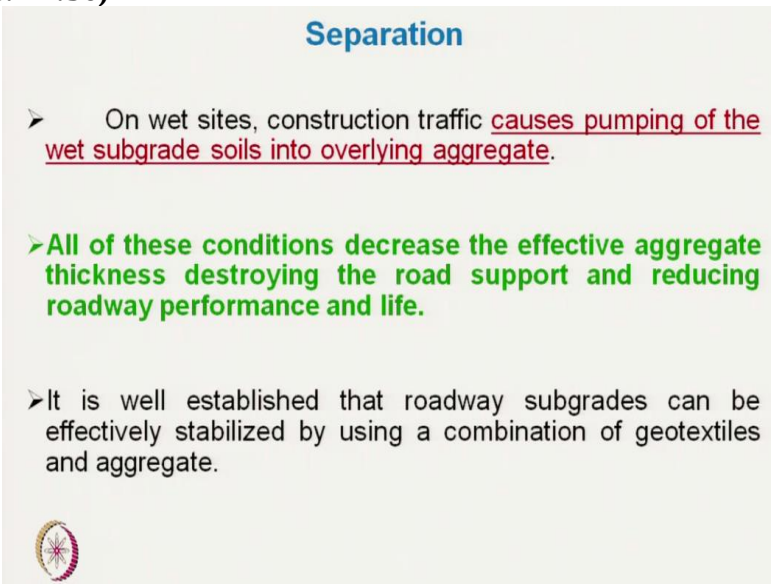

On wet sites construction traffic cause pumping of the wet subgrade soil into overlying aggregate. So, due to the pressure the soft subsoil get pumped into into the aggregate.

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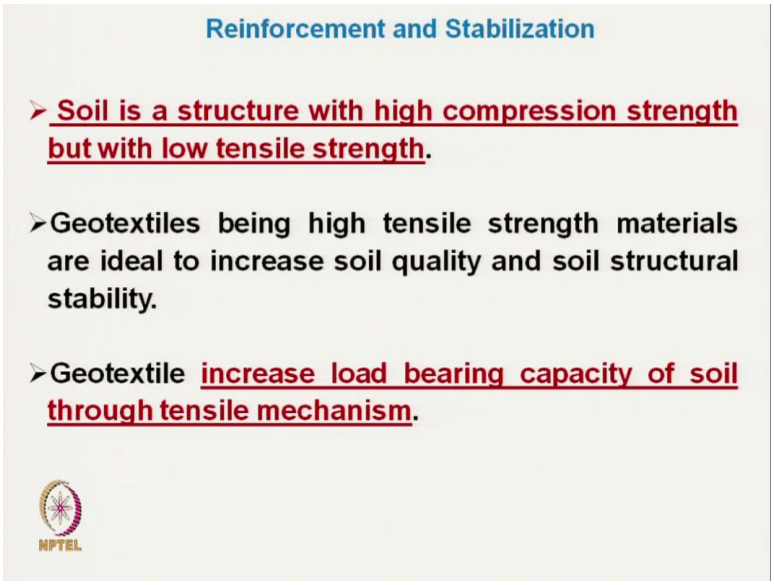

Next performance is that reinforcement and stabilization. So, soil main characteristics of soil is that it has very high compressive strength, but as far as tensile strength is concerned it is very low and tensile strength reduces with increase in moisture. So, geotextile being high tensile strength material are ideal to increase soil quality and soil structure stability. So, geotextile once it is put inside the soil, so, it enhance the strength tensile strength. So, geotextile increase the load bearing capacity of soil through tensile mechanism. So, there are basically that once the load is being put ultimately geotextile tensile strength is important.

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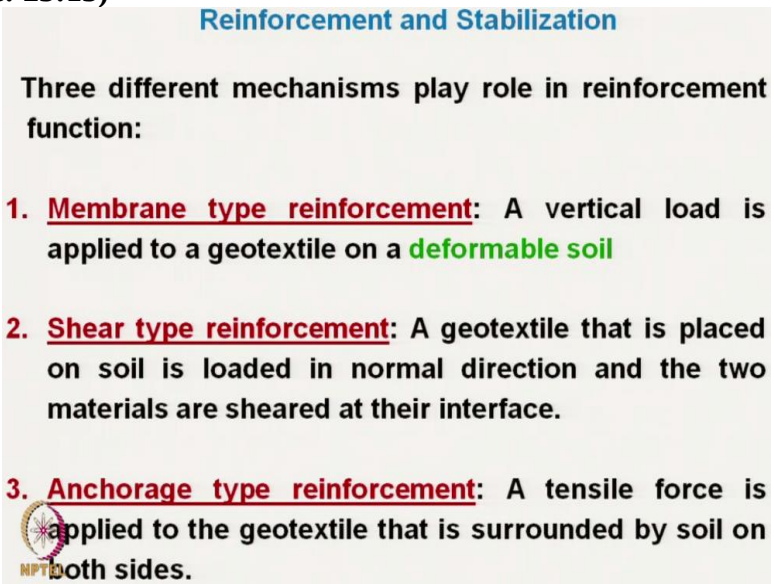

This tensile mechanism tensile strength, it has been transferred to tensile strength by 3 mechanisms the 3 different mechanisms play a role in reinforcement function. First is membrane

type reinforcement where a vertical load is applied to a geotextile on deformable soil. Next is shear type deformation or geotextile that is placed on soil is loaded on normal direction and the 2 materials are sheared at their interface.

And third one is anchor type reinforcement. So, anchorage type reinforcement is that a tensile forces applied to the geotextile that is surrounded by soil on both the sides. The shear type where geotextile is placed on soil that is only on top one side soil over that only geotextile is there.

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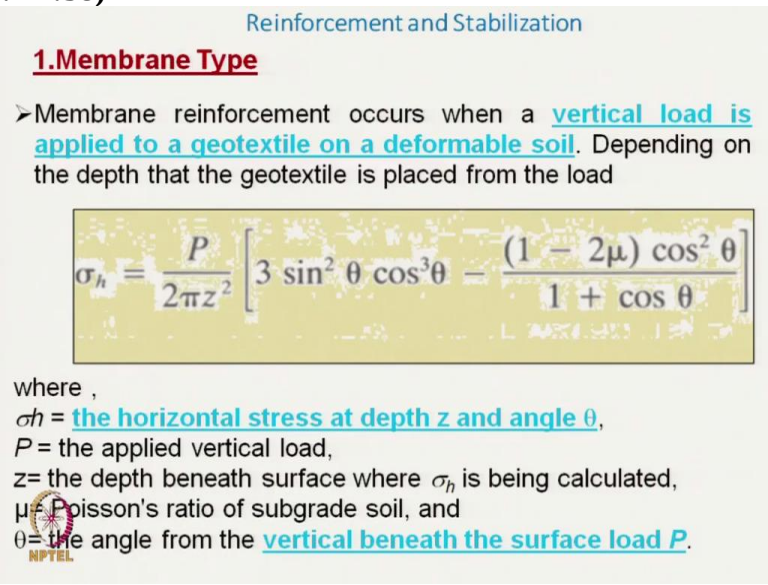

Now, if we see the membrane type geotextile the membrane reinforcement occur when vertical load is applied to geotextile on a deformable soil. Let us see.

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This is soil aggregate, then geotextile then soil particles soil, when vertical load is applied this load will actually act as thus, this will the force will be acting in sideway due to this aggregate and this will act as a tensile deformation. Here there will be tensile deformation, depending on the depth of the geotextile placed the horizontal stress there will be horizontal stress I have as I discussed, horizontal stress is expressed using this equation where, P is the applied vertical load.

On the structure, z is the depth beneath which the geotextile is placed, mu is Poissons ration of subgrade soil and theta is the angle from the vertical beneath the surface where P load is applied. That is the theta. So, once we consider the load exerted on the horizontal stress exerted on the geotextile exactly below the applied load P in that case theta will become 0 theta is 0.

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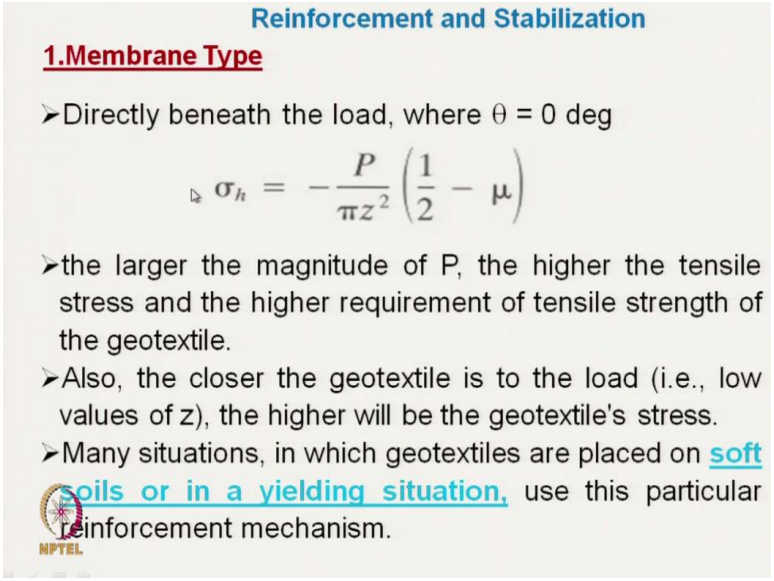

So, this equation will get this form which shows that larger magnitude of P this higher magnitude will result higher stress and z is the depth at which geotextile is laid. So, if we increase the z that means if we place the geotextile in higher depth the load on stress on the geotextile will below. So, the situation where geotextiles are placed on soft soil or yielding situation, this type of reinforcement mechanisms are important. So, where the soils can move sideways this type of membrane type reinforcement is important.

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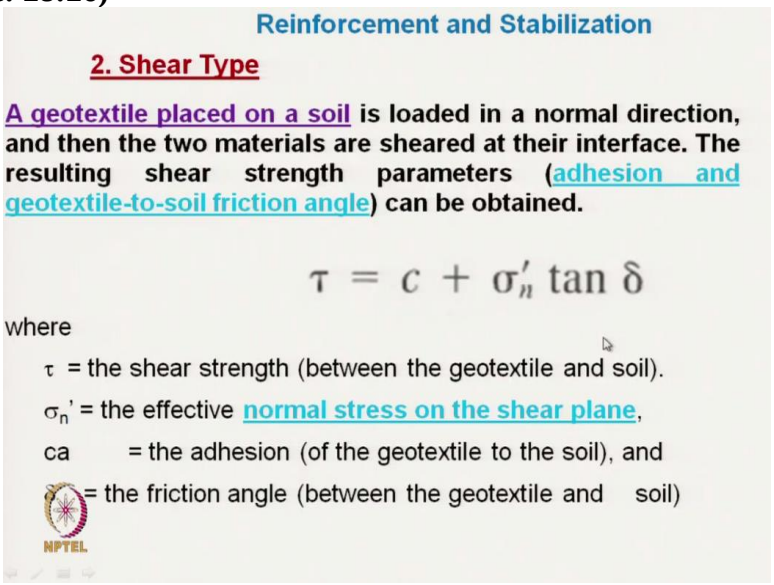

Next is the shear type a geotextile is placed on soil is loaded in a normal direction and then the 2 materials are sheared at their interface. The resulting shear force parameters are, that is shear strength tau and this sigma n is the effective normal stress on the shear plane, ca is the adhesion

shear adhesion is geotextile to soil adhesion and delta is the friction angle. So, from there we can calculate the shear strength between soil and geotextiles.

Now, while measuring the shear strength between soil and geotextile, we must know the soil to soil shear condition. The soil to soil shear condition is important because we must assess whether the application of geotextile actually enhance the shear characteristics or it deteriorates the shear characteristics.

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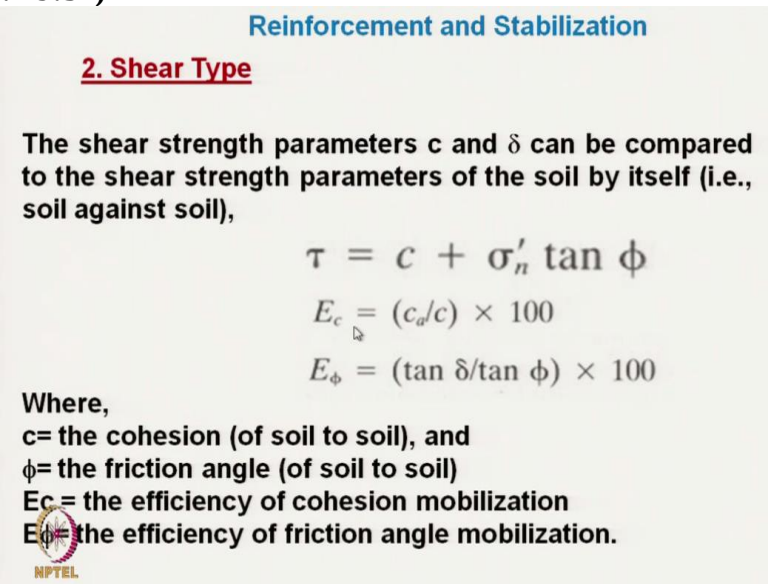

So, this is done by calculating the E c which is efficiency of cohesion mobilization, where C is the cohesion between soil and soil, soil-soil cohesion C and C a is the soil-geotextile cohesion. So, using these characteristics E c and E phi we can get to know the efficiency of using the geotextile.

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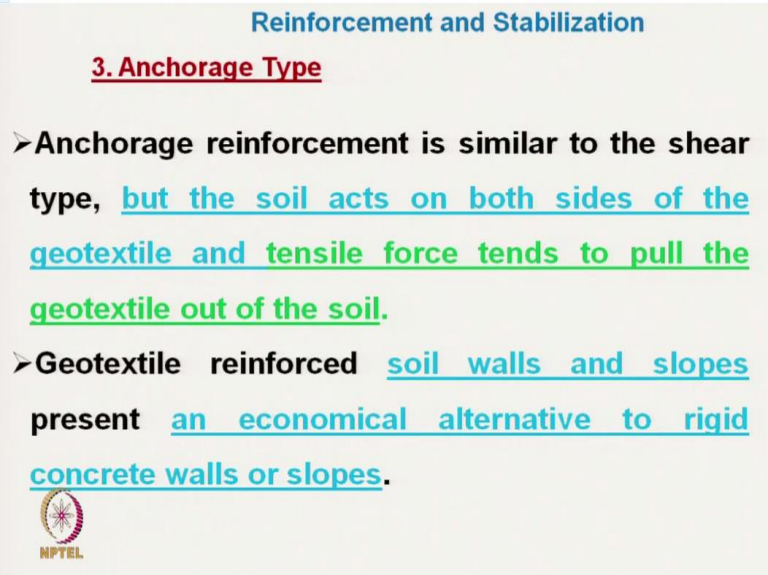

Next is anchorage type, anchorage is the enforcement is similar to shear type but here the difference is that the soil acts on both sides of the geotextile and the tensile force tend to pull the geotextile out of the soil. So, geotechnical reinforced soil wall and slope in this type of applications where anchorage type reinforcements are there, these are the easy cheap alternative of the concrete wall or slopes.

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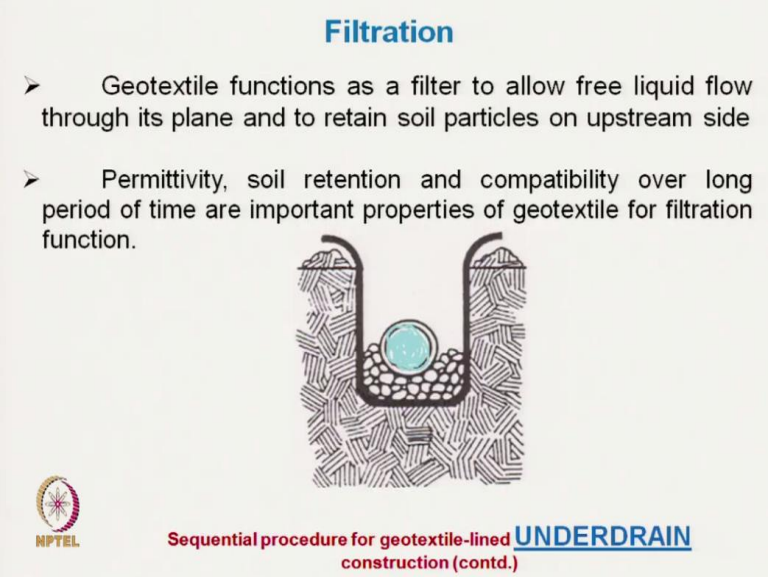

Next function is that filtration. So, here this one is geotextile and that is perforated pipes will be there. Let me discuss here. So in drainage under drain, this is the under drain.

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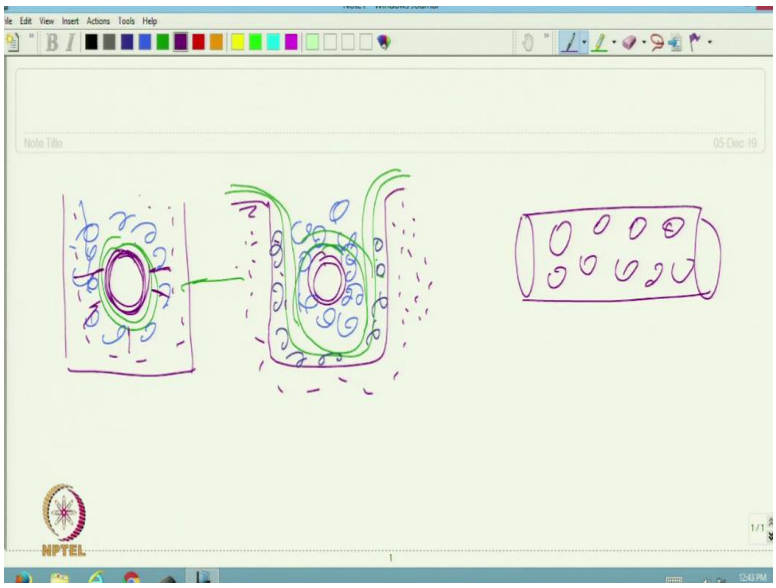

Where this is soil, we use geotextile for filtration and this filtration is required for drainage application. Now, here we may use some time the perforated pipe. So, this is a pipe with large perforations or even without pipe also we can use here this is geotextile is placed here, we can use. So, these are the large stones or gravels here and the pipe is placed here this is a pipe, perforated pipe placed here and then the stones are placed and after that, this geotextile is wrapped around this.

Now finally it will become like this. If we see the structure actually it will be this is the structure. Here we have pipe perforated pipe and around that the geotextile is wrapped and we have say, stones around this and soil. Now, due to filtration characteristics this geotextile will not allow the soil particles to enter inside and clog this pipe and this pipe will maintain the it is the it is openness will be there and this will act as drain. So, this drainage application for this under drain the filtration characteristics of geotextile is important.

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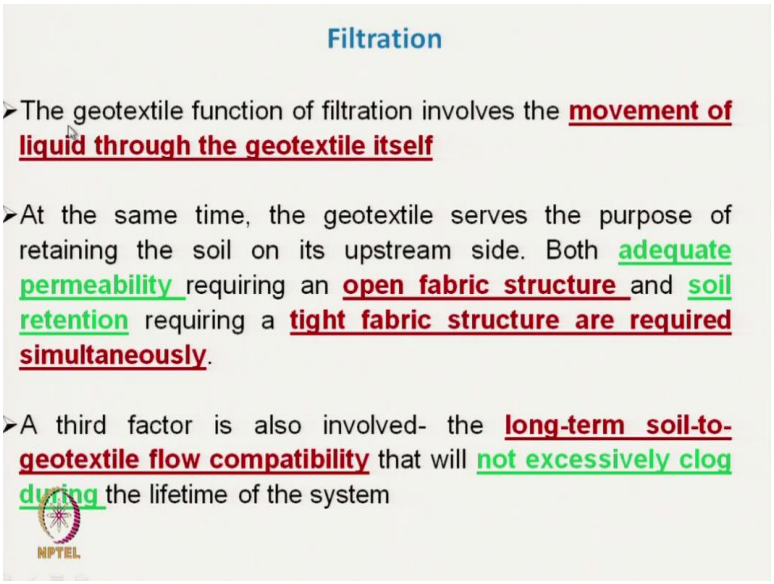

The geotextile function of filtration involves movement of liquid through the geotextile itself. One of the most important characteristics of geotextile to maintain proper filtration behavior is the long term soil to geotextile flow capability, so, there should not be excessive clogging so that it maintains the filtration or drainage behavior.

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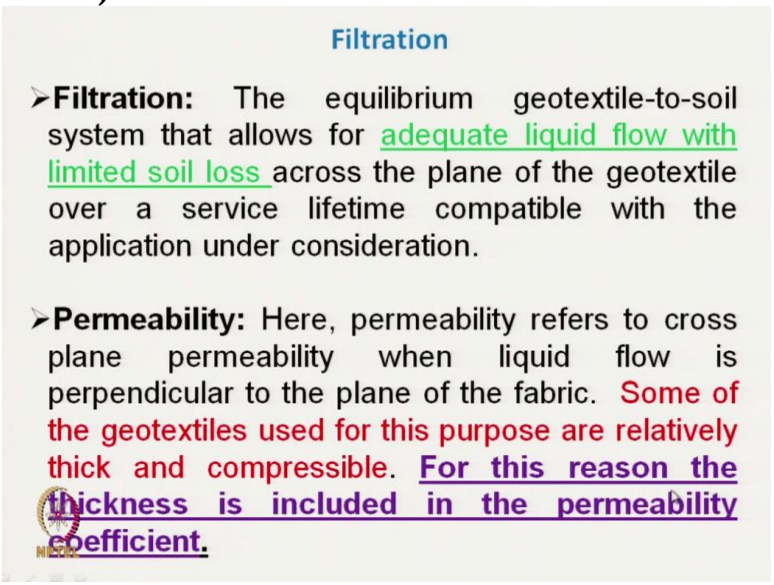

So, filtration the equilibrium geotextile to soil system that allows adequate liquid flow with limited soil loss. So, that I have already mentioned that proper stable structures should be formed to have long term filtration behavior. Permeability is also important, but the only fluid flow rate is important. Here permeability refers to the cross plane permeability, when liquid flow perpendicular to the plane of the fabric is important.

Sometime it is misled by permittivity, some of the geotextiles used for this purpose are relatively thick and compressible. For this reason, the thickness is included in permeability coefficient. So permeability coefficient calculation we include thickness.

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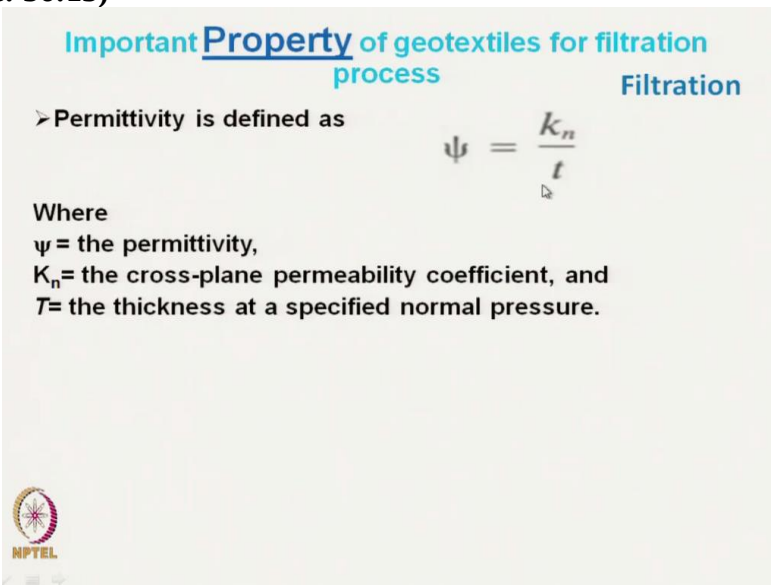

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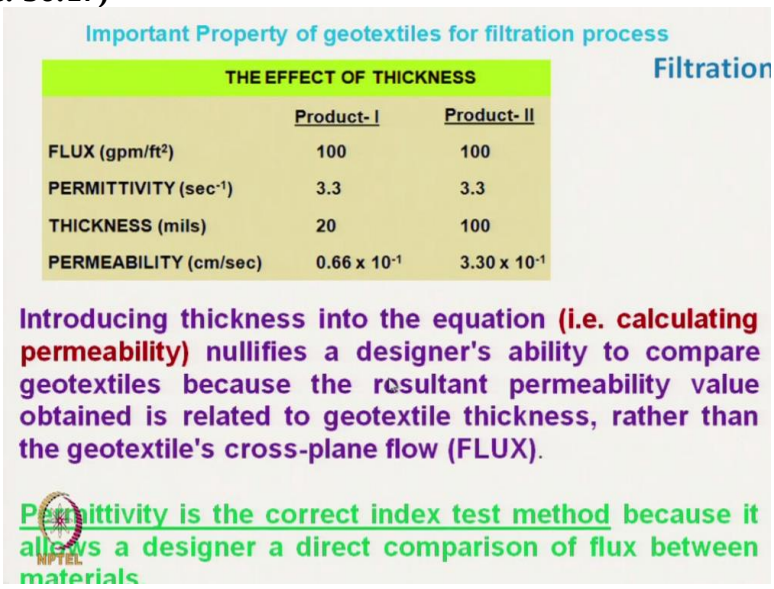

So, this is the permittivity but the introducing thickness into that equation sometime nullifies the designers ability to compare the geotextile because the resultant permeability value obtained is related to geotextile thickness rather than the geotextile cross plane flow. What we need to understand the flow actual flow not the length wise the linear flow per unit time. So, here

permeability is linear flow rate per unit time the unit, actually we know the, we want to know the flux that is 2 products product 1 and product 2 with 100 flux permittivity.

If we see they are same permittivity as the thickness of product 2 is 5 times more than the product 1 that permeability value changes. Therefore, the permittivity is the correct index test method because it allows the designer to know direct actual flux of the material. So, this permittivity value does not change when the flux remains same. This indicates the flux if the permittivity is remain same.

That means it is a fluid flow is same irrespective of the fact their thickness are different. So, these are we can see here permeability are different. So, we cannot compare these 2 products effectively as far as the filtrations are concerned. So, these products are equivalent, but if we see the permeability, they are entirely different.

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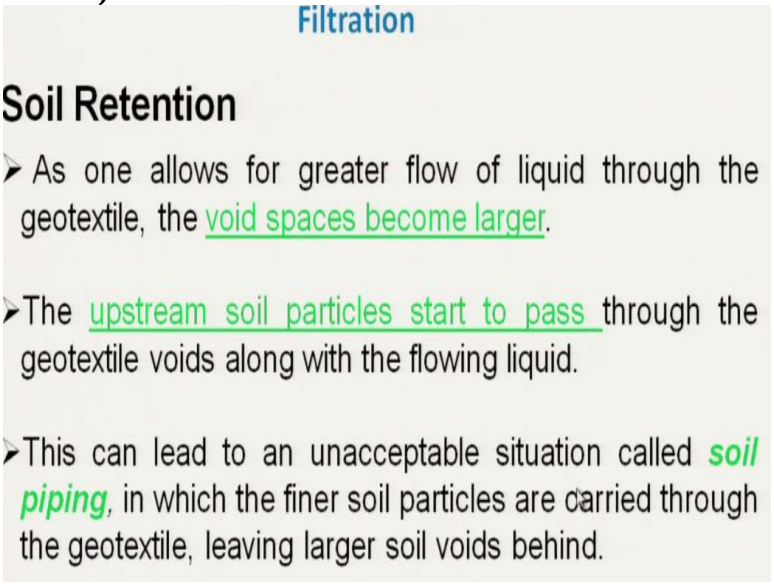

So, soil retention is another important characteristics we should not allow the soil to get lost. So, it is a soil piping we should avoid by adjusting the pore size.

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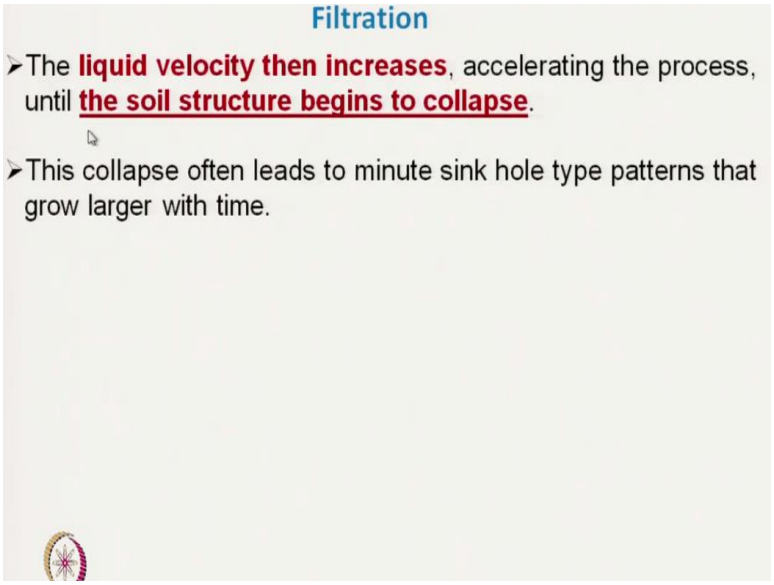

So the liquid velocity as it increases the, it accelerates the collapsing of the soil structure. So, we have to see we have to take into consider consideration the characteristics of the flow.

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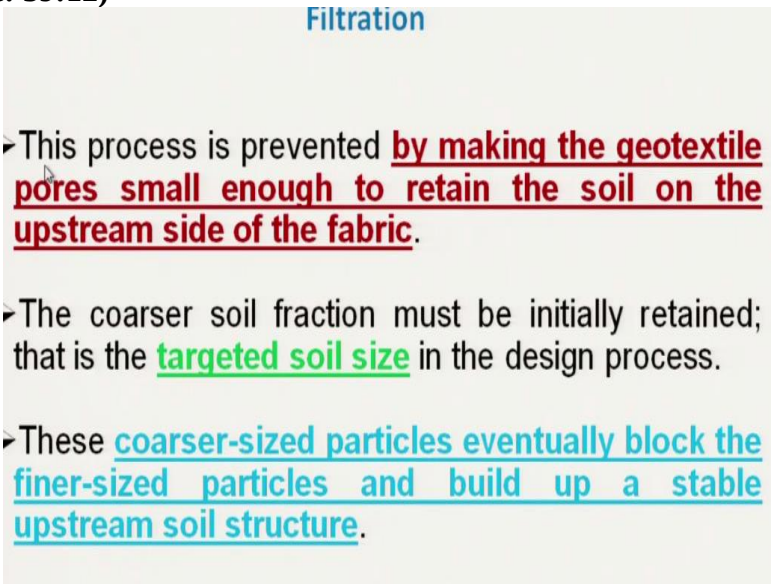

So, this piping this process is prevented by making the geotextile pore smaller enough to retain the soil. So, when the piping takes place it takes mainly in harsh condition in that case as we have mentioned we should design geotextile with lower pore size. The coarser soil, fraction must be initially retained and that is the targeted soil size in the design process so we have to take the coarser soil into consideration for designing like we have mentioned, O90 and D 90 and gradually this coarser particles eventually block finer sized particles and build a stable upstream soil structure that stability is important. So, that is a long term flow capability.

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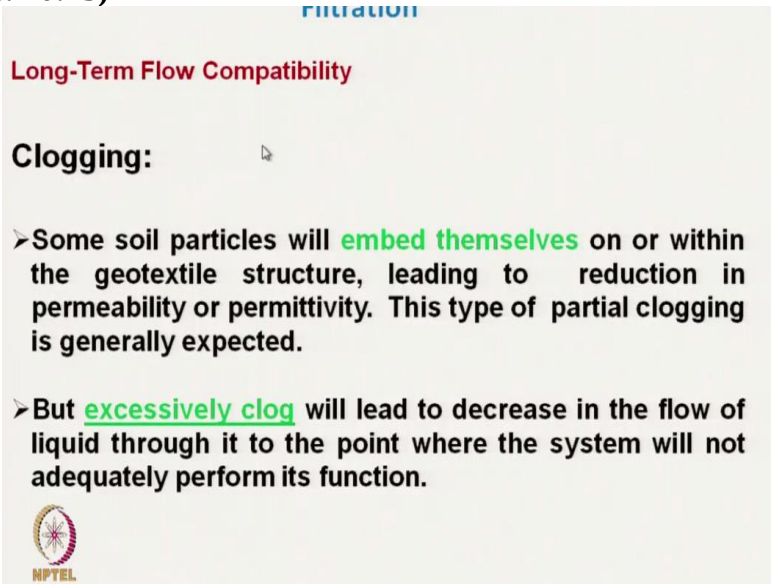

And clogging behavior is important. We should not allow the geotextile to get clogged quickly. If the geotextile clogged quickly, then longtime flow behavior will get deteriorated.

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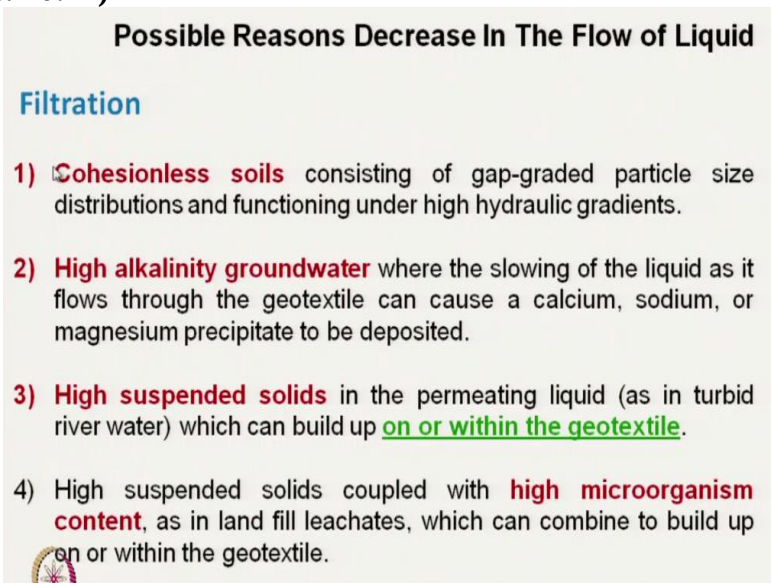

So, these are basically controlled by or maybe they are dependent on the cohesion of soil. So, cohesionless soil consists of gap grade particle size, this gap grade particle size distribution which is when it works under higher hydraulic gradient, results clogging, high alkalinity in groundwater, high suspended solid and high microorganism growth results clogging of the structure.

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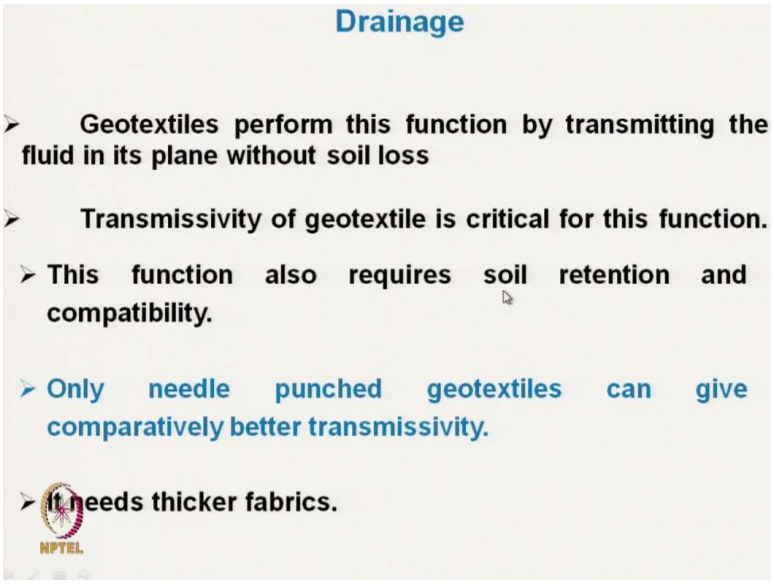

As far as drainage is concerned, the transmission of fluid along the plane is important. So, here only needle punched geotextile can give comparatively better transmissivity because it should transmit water across, along its thickness, transmissivity of say spun bonded heat sealed nonwoven fabric or woven fabric is very low.

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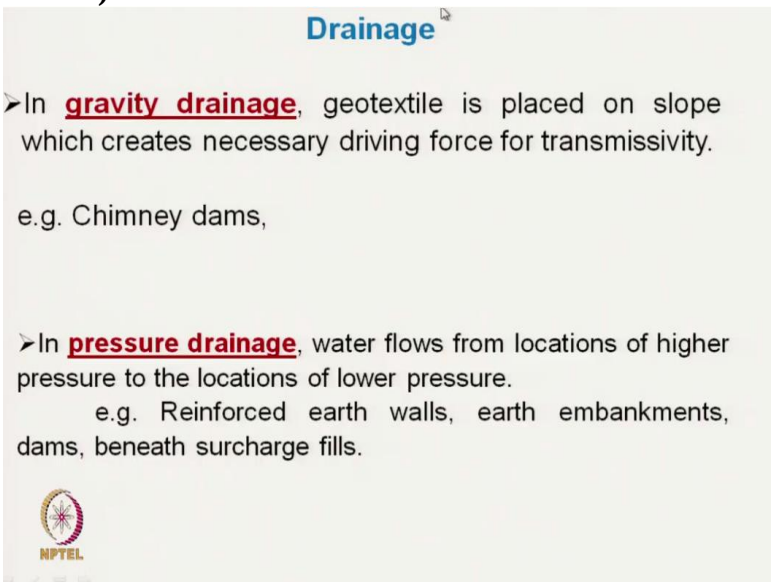

So, drainage applications are of 2 type's gravity drainage where geotextiles are placed in a slope and water flows through the geotextile by gravity, chimney dams is an example. And in pressure drainage water flows from its location at high pressure to the other place where pressure is low, like reinforced earth wall, earth embankment, dams.

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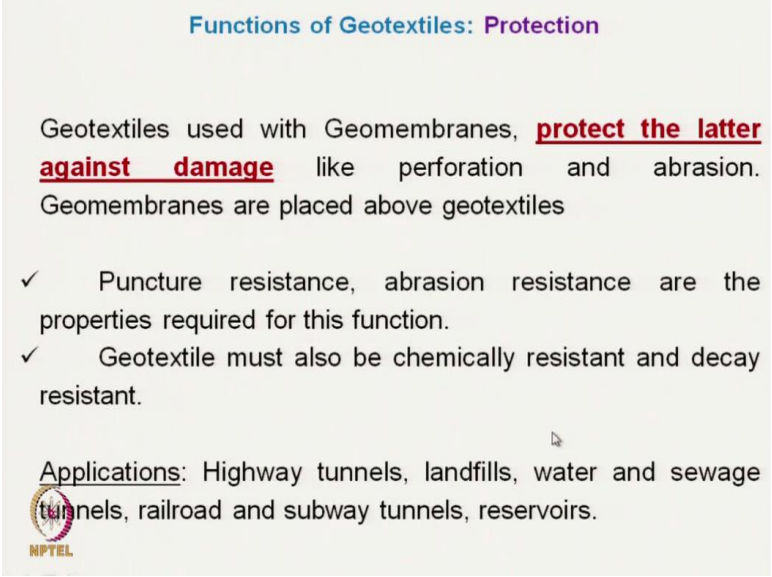

As far as protection function, geotextile used with geomembranes there, it protects the geomembranes, as I have mentioned so puncturing of geomembrane will destroy its function. So in landfill, water and sewage tunnel, rail road, there we can use geotextile for their protection purpose.

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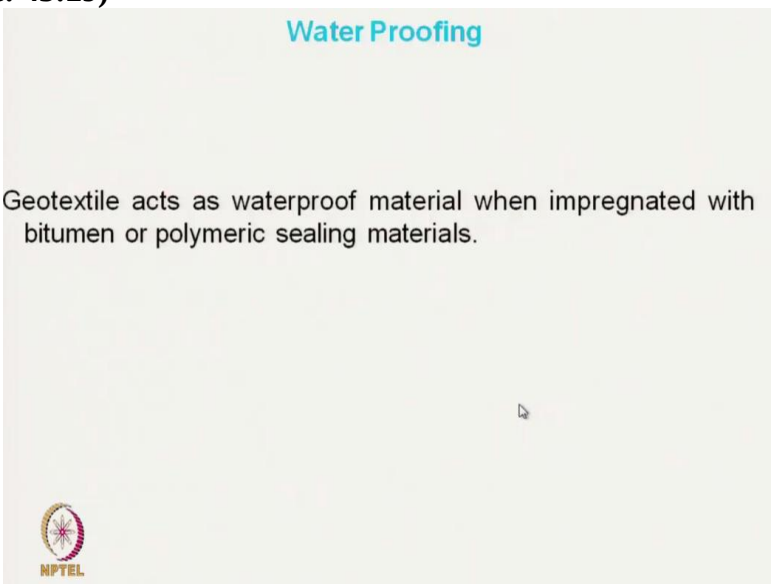

Waterproofing is also used when geotextile acts as waterproof material when impregnated with bitumen or polymeric sealing materials and there are many applications.

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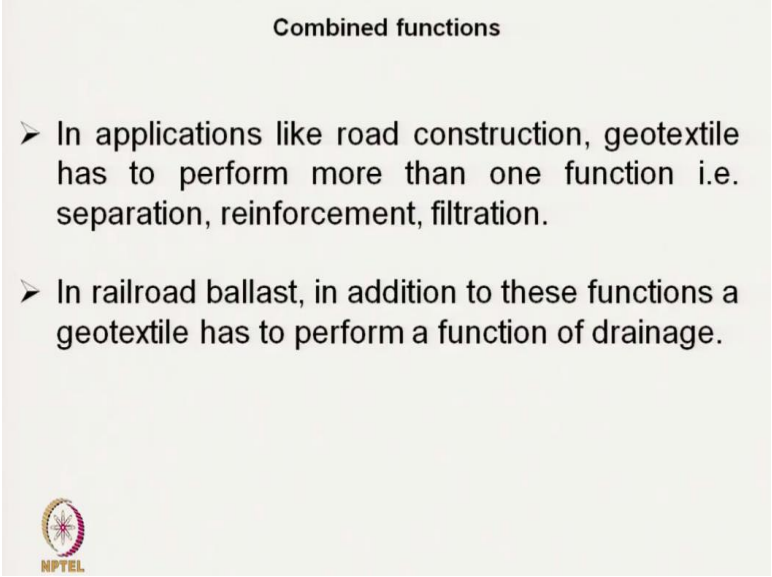

Where combination of all these different functions are important like reinforcement and drainage. This is one example of where in railroad construction we use. So, multiple functions are can be achieved by geotextile single geotextiles.

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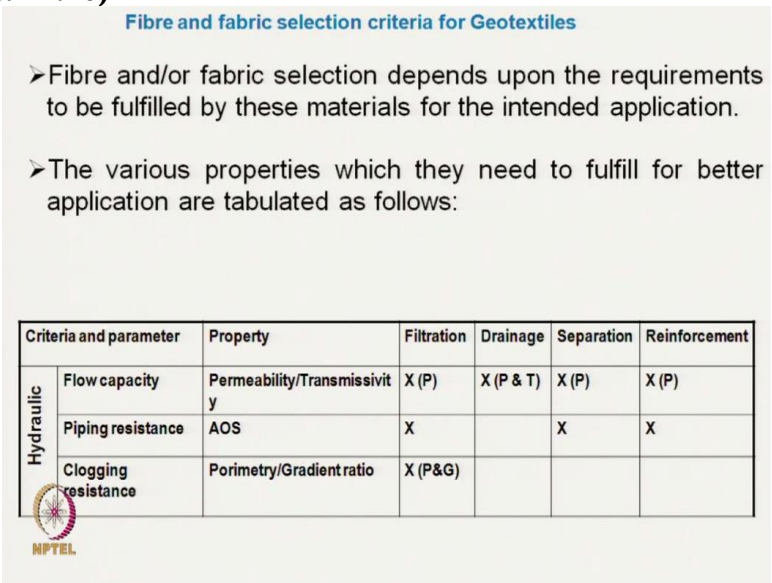

So, this table will show different criteria or different applications where different types of characteristics are important. Hydraulic parameters like clogging resistance, piping resistance. So, these are the parameters important.

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Fibre and fabric selection criteria for Geotextiles

Criteria and parameter		Property	Filtration	Drainage	Separation	Reinforcement
Constructability	Tensile strength	Grab strength	X	X	X	X
	Seam strength	Grab strength	X	X	X	X
	Puncture resistance	Rod puncture	X	X	X	X
	Tear resistance	Trapezoidal tear	X	X	X	X
Longevity	Abrasion resistance	Reciprocating abrasion	X			
	UV stability	UV resistance	X			X
	Soil compatibility	Chemical/biological/wet dry/freeze thaw	X (All)	X (All)		X (C & B)

Tensile strength for construction, tensile strength is important grab strength. So, like in filtration, drainage separation reinforcement, in all these functions we need tensile strength. So, multiple selection criteria is required.

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Design Methods For Geotextiles

- design by cost and availability,
- design by specification, and
- design by function

So, selection of design methods so, there are different criteria of design methods, so design we can do best the cost and availability of the material. Like we want to construct a road and our available fund is limited. So, depending on our available cost, we must design accordingly or available product. So, if the product availability best quality product availability is not there, whatever products are available depending on that we can design we have to design. Design by

specification, so, we will first set the specification then accordingly we will design the geotextile and design by a function if we need a particular function we will design the geotextile.

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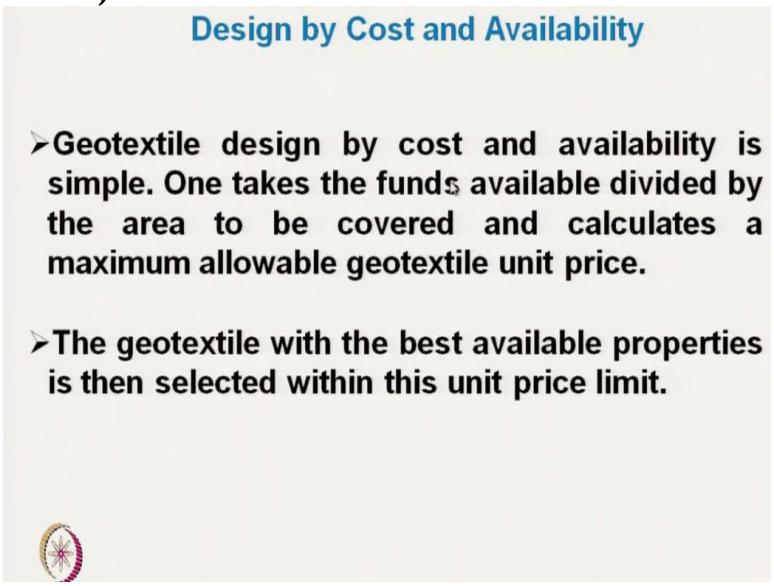

So geotextile design by cost and availability simple one takes the fund available divided by the area of the coverage to calculate the maximum allowable geotextile par unit price. So that is a simple way.

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By specification, geotextile designed by specification is common. It is commonly used and is used almost exclusively when dealing with the public agencies, like road railway track and construction. In this method, several application categories are listed together with critical fabric

properties. So we list that what are the strength required? What are the filtration and characteristics required? And accordingly, we select the fabric. If we know the fabric properties.

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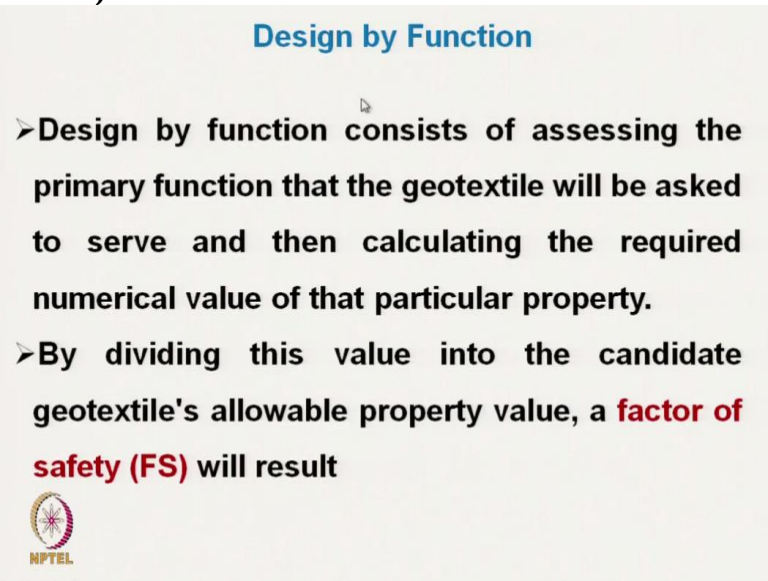

Designed by function, it consists of assessing the primary function of the geotextile with that will be asked to serve and then calculate the required numerical value of the particular property by dividing the value into the candidate geotextile to whatever they do we will use the allowable property can be calculated using the factor of safety. Suppose, we need a certain strength required, like X strength and we have got, we have to select the geotextile with say factor of safety minimum say 10. So the geotextile strength will be 10 X. That is the design by function.

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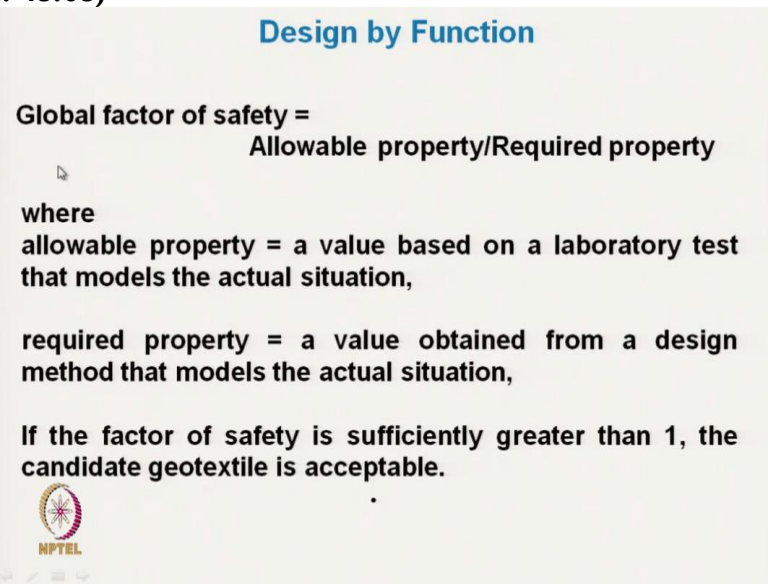

So global factor of safety allowable property by required property. So that is the allowable property of the geotextile and the required property. The value based on the laboratory test that models the actual situation that is allowable property and required property the value obtained from the design method that models the actual situation that is obtained from the design method.

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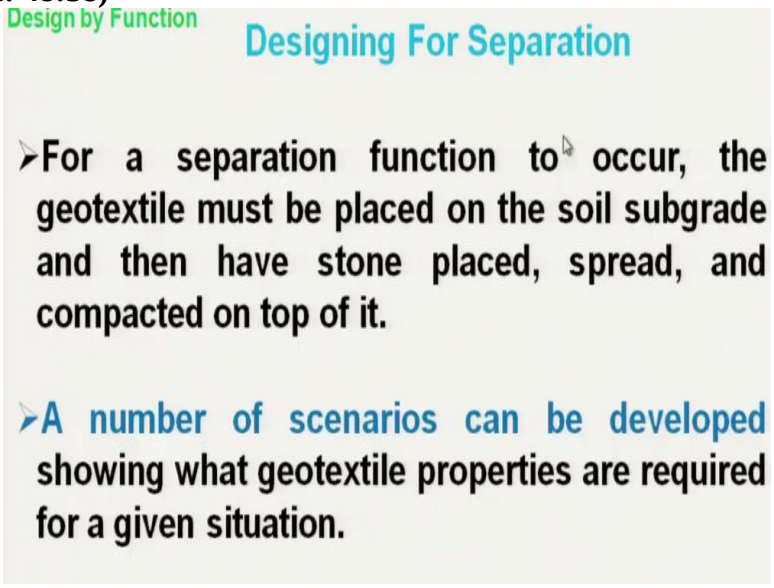

Designing for separation for a separation function to occur, the geotextile must be placed on the soil subgrade and then the stone is placed, spread and compacted on its top. That is the separation function. Here the stone will try to push the geotextile against the soft soil and soft soil will pump inside the will push inside push geotextile up.

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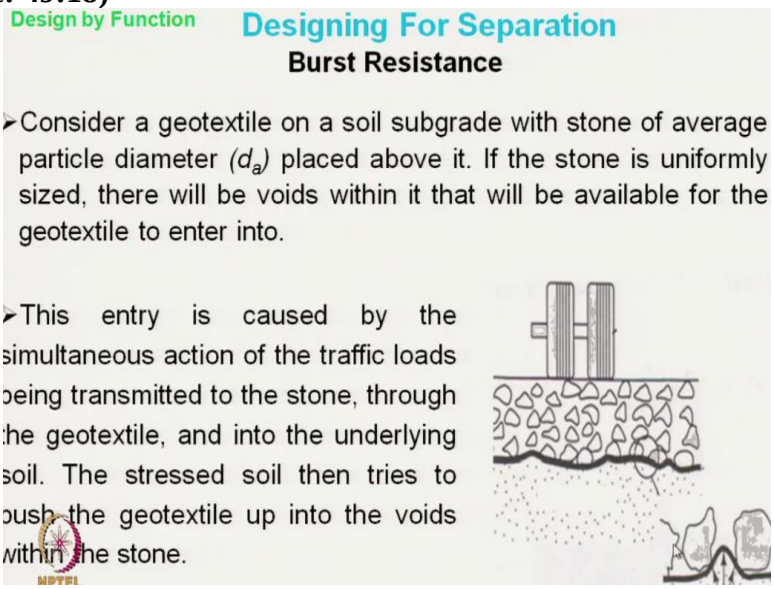

So, this is the situation where for separation function, the bursting strength is important here due to the load the soil the subgrade that this is the stones are pushed inside the subsoil soft soil and depending on the arrangement of this stones, the subsoil will be pushed upward, where the geotextile is acting as separating agent for separation function. This will have some bursting force. So, busting resistance is important. If the bursting strength is low, then there will be damage in the geotextile and this separation function will not be there.

So, for designing of geotextiles for separation function, so, we must take the bursting strength into consideration. So, this is all about the geotextiles in general. In next class, we will discuss the evaluation of geotextiles. So we will discuss in brief as this geotextile testing has been discussed in another course, where the course title is that testing of functional and technical textiles. So, in next class we will briefly discuss the different methods to evaluate geotextiles. Till then thank you.