Technical Textiles
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Lecture - 19
Geotextiles (contd.,)

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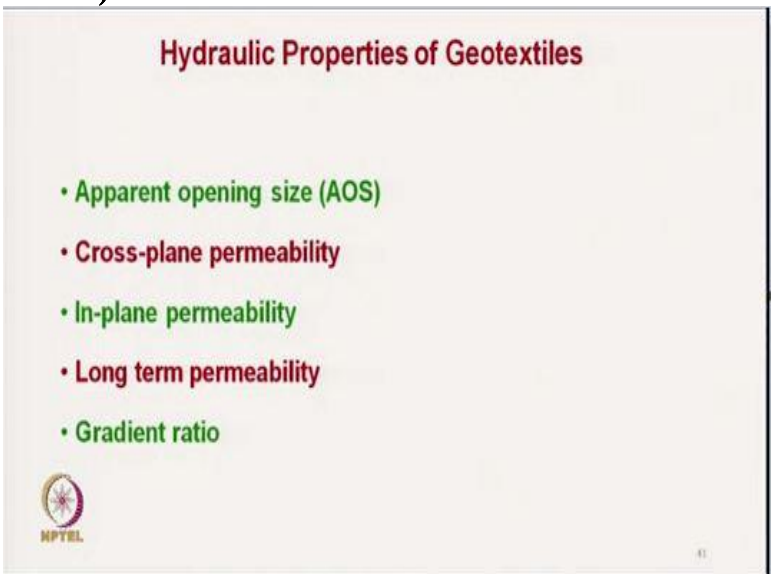

Hello everyone, now I will discuss the hydraulic properties of geotextiles. These hydraulic properties are basically the properties which are related with the water along with the geotextiles. So basically it is a it by this testing we get ideas about the water flow behavior maybe in plane or cross-plane or long term water flow behavior the soil particles gradually clogs the pores of geotextile and that will reduce the permeability characteristics.

So, all these characteristics are hydraulic characteristics of geotextiles. These are evaluated by measuring apparent opening size of geotextiles, what is the pore size or opening size, cross-plane permeability that is the water flow characteristics across the plane which is important for filtration application, in-plane permeability that is the water flow along the plane which is important for drainage application, long term permeability and gradient ratio.

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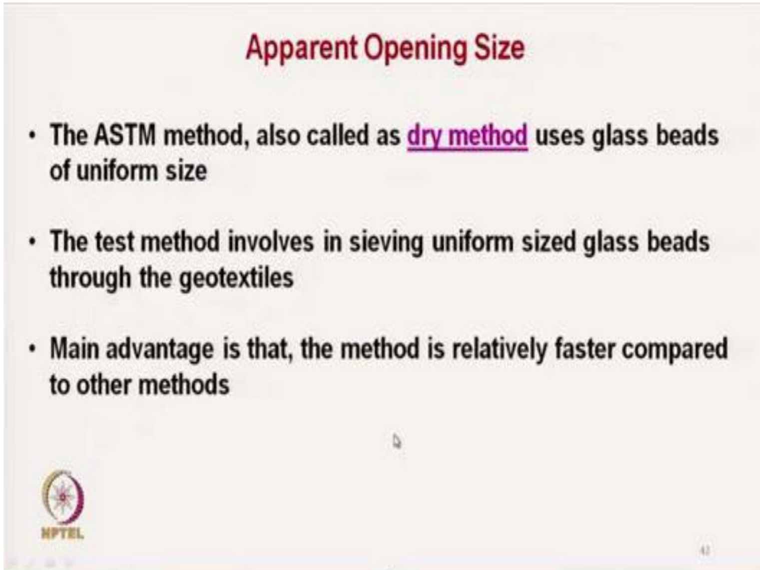

The apparent opening size is measured by dry sieving method the ASTM method also called dry method, where glass beads of uniform size at a certain glass beads of uniform size is used to here the glass beads are sieved through the geotextiles. And basically it is a faster method it has got some drawbacks I will discuss. By this method, we cannot test very thick nonwoven fabrics because the glass beads will get entrapped inside the structure, we can only test the thin geotextile with proper opening.

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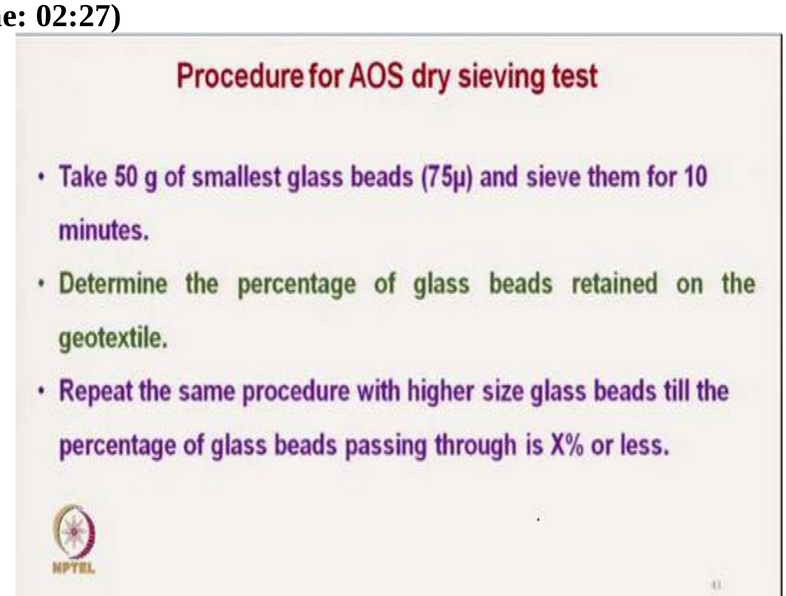

So, as per the standard test method, around 50 gram very smallest size beads are taken and we start with the smallest size that is 75 micron approximately and it is sieved through the geotextile for 10 minutes it is the frame is shaking then determine the percent of glass beads retained on the geotextile and that same process is followed using a little bit larger size till the percent of glass bead present that is passed through the geotextile is X% or less, certain known percent or less that will keep on repeating.

Suppose at 75 micron all the glass beads are passing through the geotextile, so that will not give us the actual idea. So, we have to use the next little bit larger size in this way we will keep on repeating.

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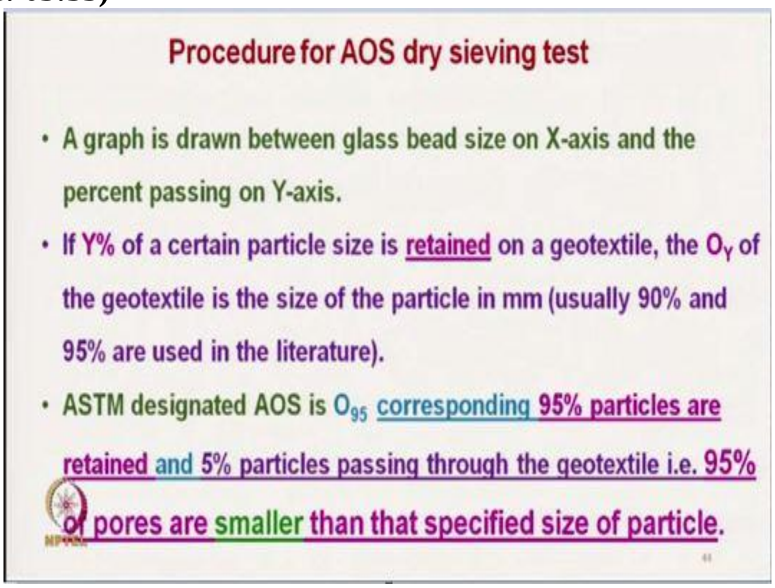

Then we will get a plot between the bead size in X axis and percent passing on Y axis. So, if Y% of certain particle size is retained, we will measure what is the percent retained. That means all the pores are larger than this all the pores are that percent is written at smaller than that size. So, if Y percent of certain particle size is written on geotextile, then O Y of geotextile is the size of the particle in millimeter that is usually 90% we take the Y we take is 90%, 95% are used in the literature O90 we used to take.

As per ASTM apparent opening size is either O95 or O90 we can use. So, O95 means 95% are retained and 5% of the particles are passing through the geotextiles. That means 95% of the pores are smaller than that of specified size of the particles that is the meaning of O95, because 95% particles are retained. So, the amount of particles retained will measure as apparent opening size. So 95% of particles are retained means that means 95% of the pores are smaller than that specific size.

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So, this is the different components, these seams of different sizes here, it is shaking is taking place here.

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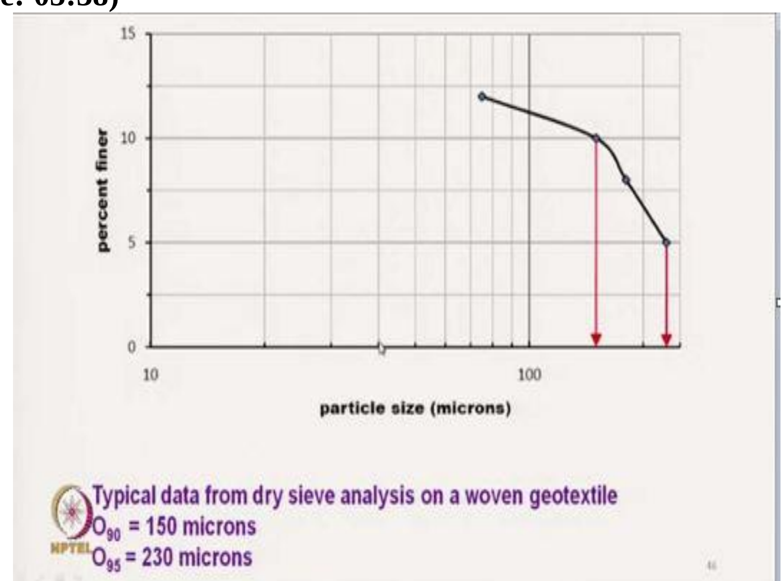

From this plot, we will get the apparent opening size. So for different size particles, we are here in X axis particle size is given. And percent finer, so O95, O90 is 150 micron so, if we take 150 and here it is 230, this is 100, 200, 230 for 230 micron, only 5% is passing, 5% particles are passing through here, the percentage final. This is percent particle passing through this. So, here if it is 5% particles are passing through at this particle size, say 230 particle size.

That means it is an O95 that when 95% of particles are retained. Similarly, at 150 micron, that 10% particles are passing through 90% particles are retained. So, in this way we get idea about the apparent opening size.

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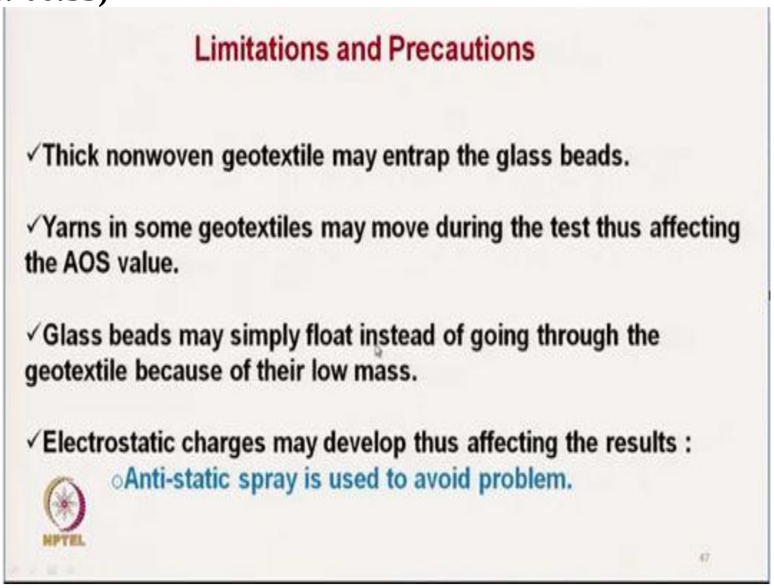

Limitation of this methods. As I have discussed thick nonwoven fabric, we cannot use, if we use woven geotextiles some time yarn may get distorted that affects the apparent opening size value. Glass beads sometime, it is a lighter one it tries to float over the geotextile. And another problem is that if we use the synthetic fibre, it may create the static electricity and that will affect the test result because the glass beads will get attracted by the fibre. So in that case, we use the anti-static spray to avoid this problem to overcome these problems.

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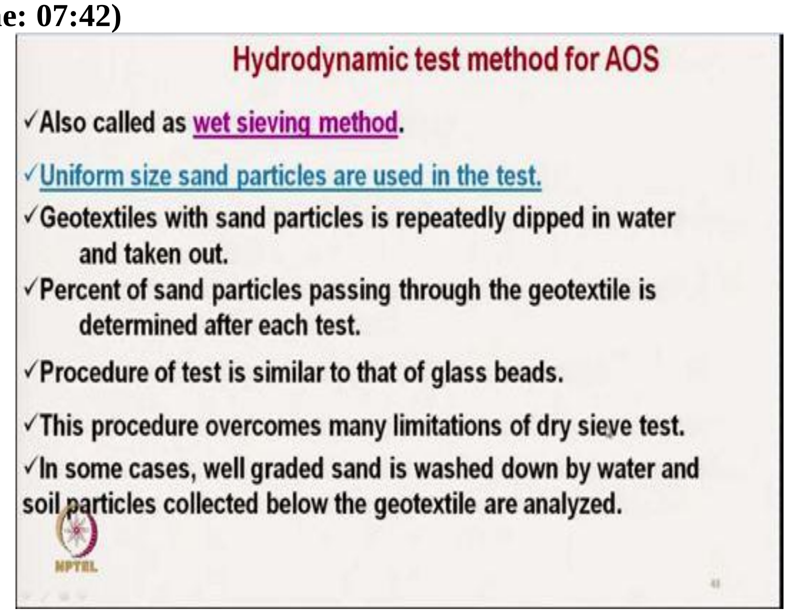

There is another way to measure the apparent opening, that is the hydrodynamic test or we can call it as wet sieving test. The test is almost similar to the dry sieving, but here it is done under water. So, uniform size of sand particles are used in this test. In dry sieving use the glass beads here sand particles are used. Geotextile with sand particles is repeatedly dipped in water and taken out that has been taken out and dipped again.

So, that there is a movement created, percent of sand particle passing through the geotextile is determined after the test. So, this is similar to the dry sieving test, but, this process the, overcomes many limitations of dry sieving process like the static electricity generation process is eliminated.

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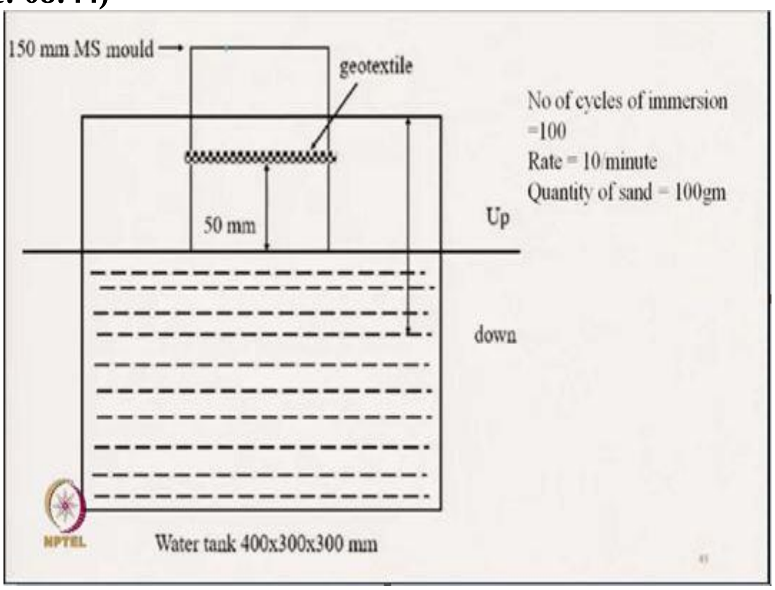

This is the diagram where geotextile and sand particles are kept here and this total frame is moved up and down. So, that the sand particles move through the geotextile, typically number of cycles of immersion 100. After testing we calculate the amount of sand particle passes through the geotextile. Now coming to permeability test. As I mentioned, there are 2 types of permeability test one is cross-plane permeability and another is in-plane permeability.

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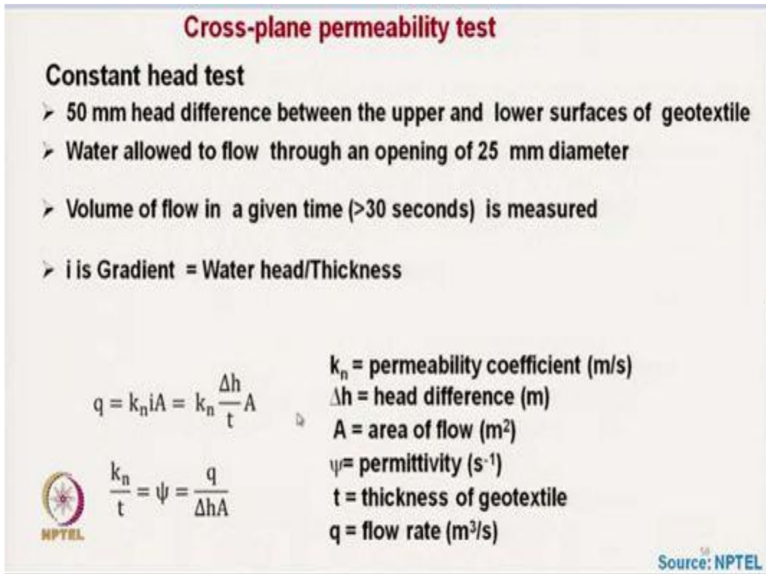

In cross-plane, there are again 2 types one is constant head permeability test and other is falling head permeability test. In constant head 50 millimeter water head difference is created between the upper and lower surface of geotextile, water is allowed to flow through opening of 25 millimeter diameter, volume flow is measured and gradient means water head per unit thickness that is the gradient water gradient. And from there, we can calculate the flow rate, this is the flow rate q and then permeability coefficient we can calculate, also if we divide the permeability coefficient by thickness we will get the permittivity. So, we will get all these data.

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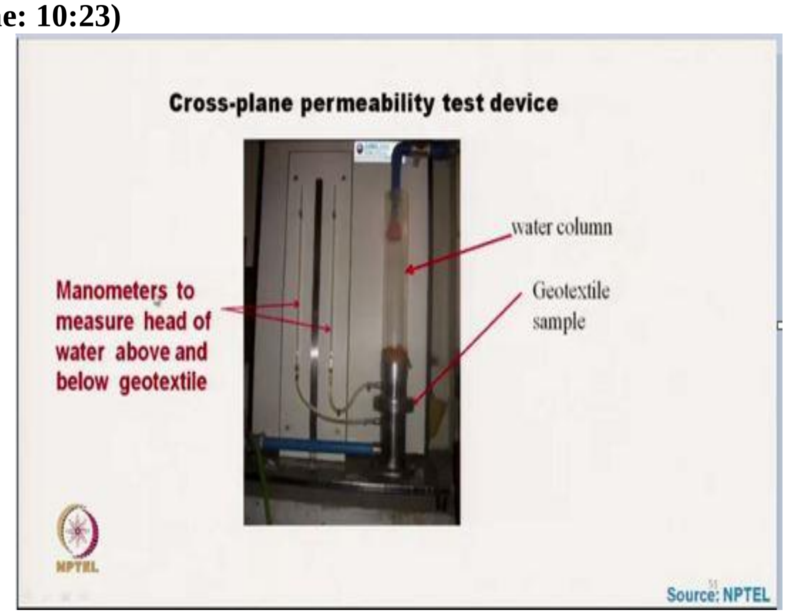

This is the photograph of the test device, here water is fed this is a water inlet water column is there geotextile sample and the water head is measured. So, we can get the certain water head here and we calculate the water flow rate.

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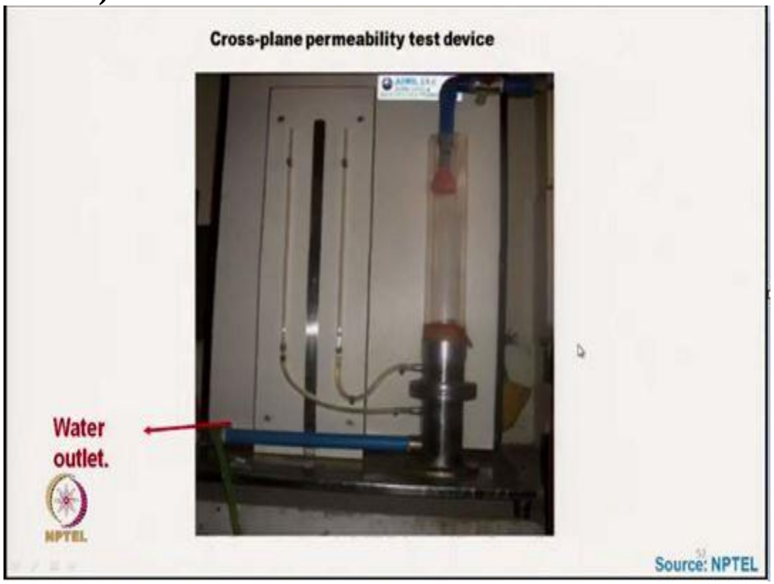

So, this is the water outlet. From the outlet we can calculate the actual flow rate for certain pressure difference.

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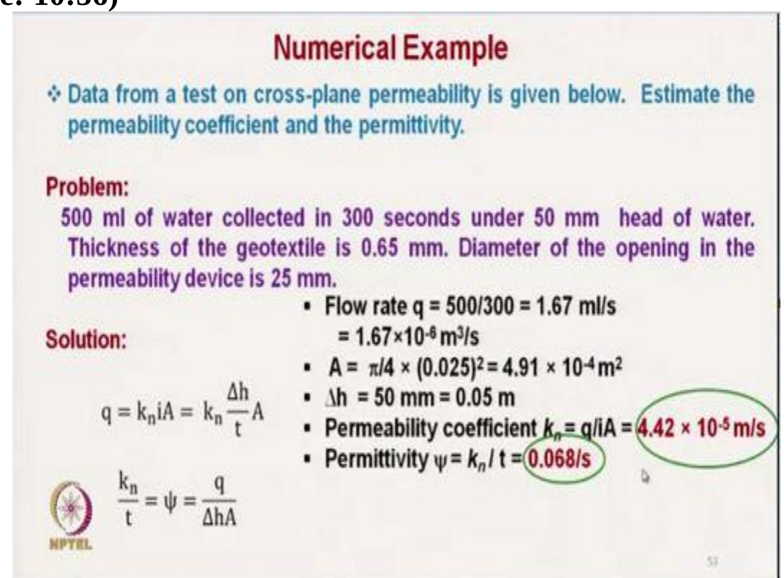

Now, with this numerical example we can calculate the permeability coefficient and permittivity. From this given data, the data 500 ml of water collected in 300 second under 50 millimeter head of water. So, we have constant head, we know the flow rate and thickness of geotextile is known. It is 0.65 millimeter diameter of opening of permittivity device is 25 millimeter.

So, from there we can calculate the flow rate. So, the flow rate is 1.67 milliliter per second, if we convert it to cubic meter per second, it will be 1.67 multiplied by 10 to the power minus 6, area is known cross sectional area. Pressure difference is known, from there we can calculate the permittivity coefficient and then permeability, permeability coefficient is kn and permittivity its value is 0.068 per second.

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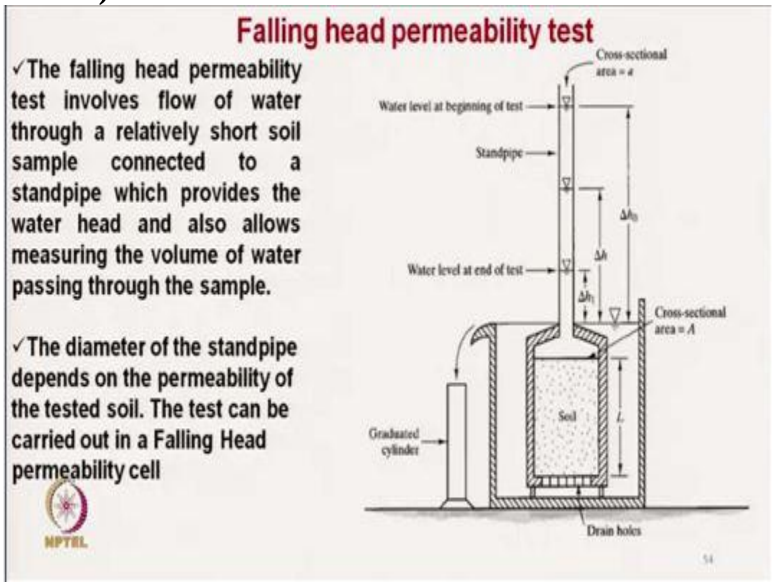

The other method is falling head permeability. In earlier case, what we have seen the water head differences kept constant by feeding by supplying water constantly but here the supply of water is once we do not supply constantly which sometimes which simulates the actual condition and geotextile is placed and with the falling head, we can calculate the permeability and water is collected here in a cylinder.

So, water level initially water level is at this point, height is h 0 and final water level at the end of the test is delta h 1. The falling head permeability test involves flow of water through the relatively short soil sample connected to a standpipe which provides the water head and also allows the measuring the volume of water passing through the sample. So that is how it is measured. The diameter of the stand pipe depends on the permeability of the test soil. So, this water falling head permeability is typically measured for permeability characteristics of soil.

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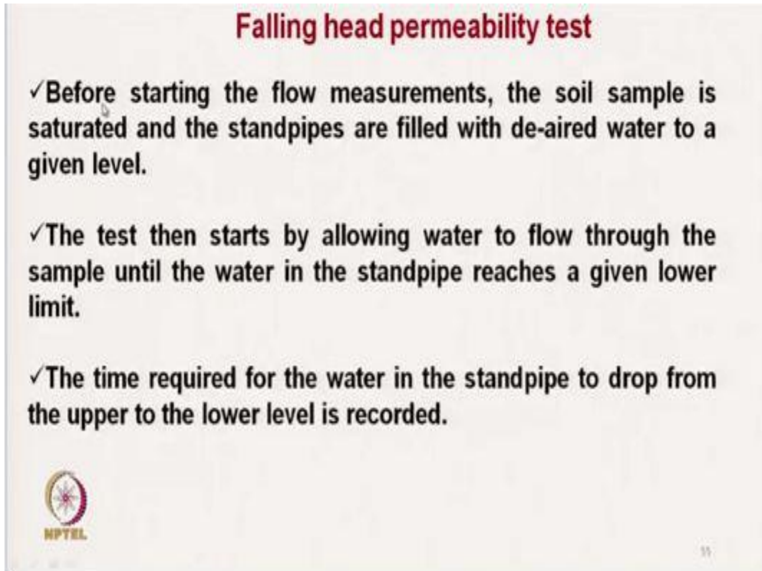

So before starting the flow measurement, the soil sample is saturated and stand pipes are filled with their water. Because if it is not saturated or if it is filled with the void that will actually affect the flow rate. The test is then start by allowing the water to flow through the sample, time required for the water to fall from the top to the lower point is recorded.

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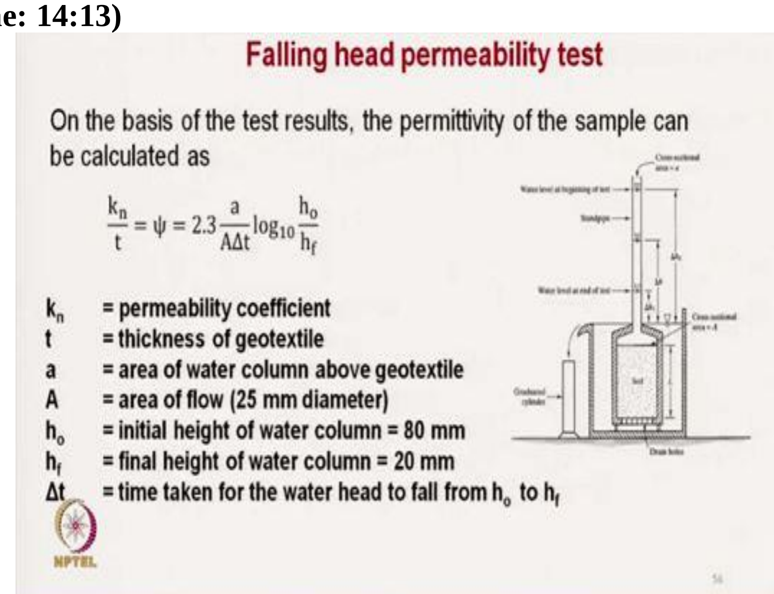

And from there, we calculate the falling head permeability using this formula that is the permeability coefficient and permittivity you can calculate.

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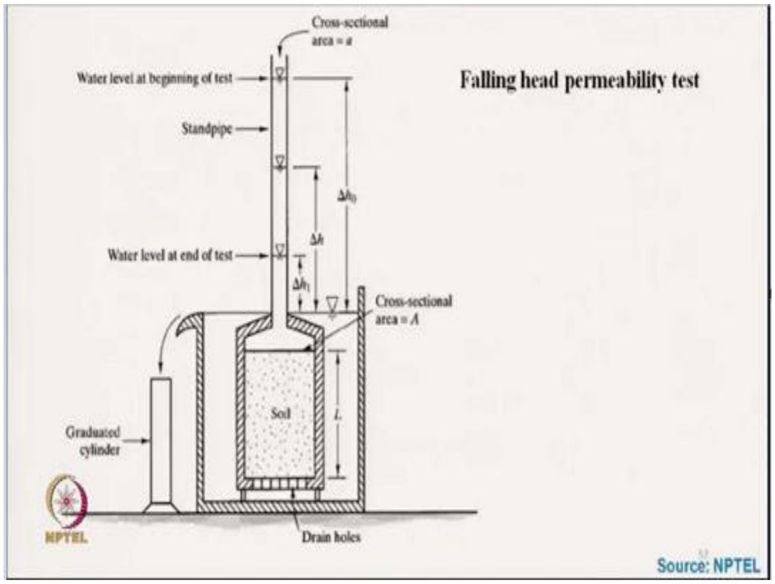

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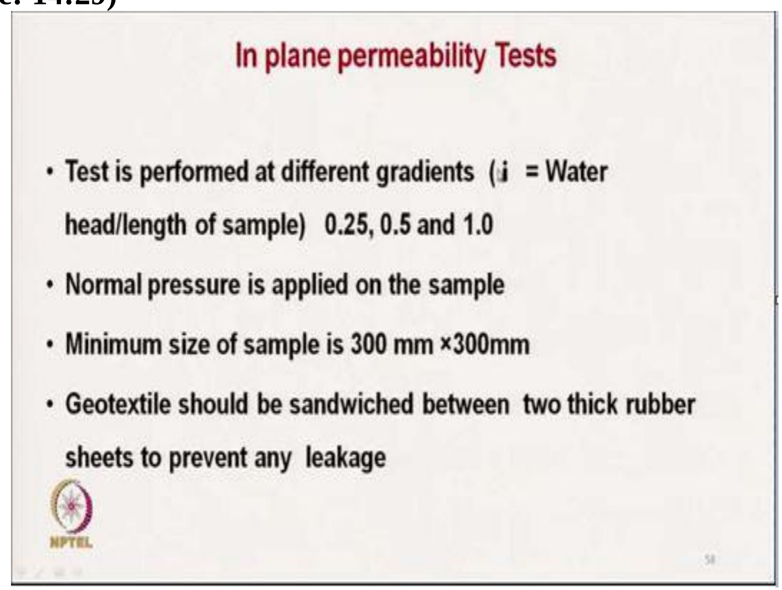

Another characteristics is that, this is a falling head permeability tester, it is an in plane permeability tester where the water is allowed to pass through the plane of the fabric, that is geotextile. Test is performed at different gradient is water head par per length of sample at different water gradient it is used. Here, it is a water head divided by length because in cross-plane it was water head divided by thickness, but here gradient is length. Why it is through length in cross-plane.

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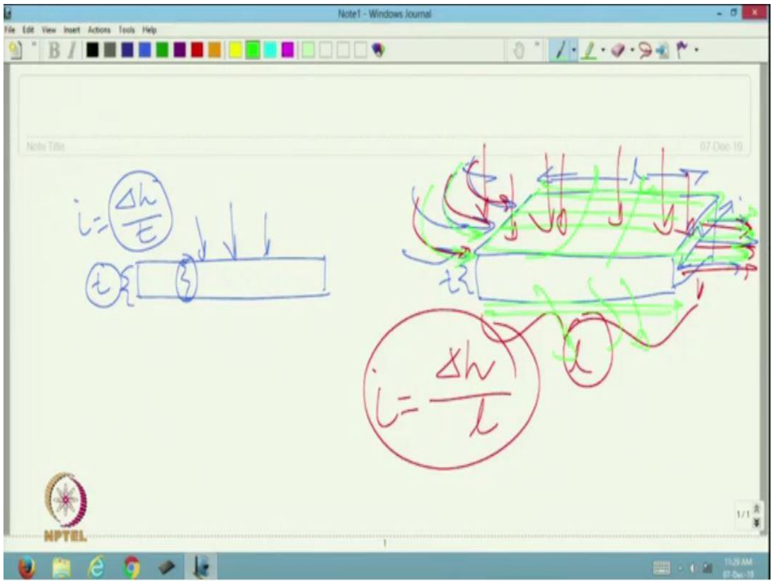

This is the flow and this is the thickness of the fabric. So, water is passing through the material from this point to this point. This is the point, through thickness that is why gradient required is water head divided by thickness, gradient i. But in case of cross-plane the situation is different. This is the specimen, here it is length, width, this is the thickness. Here water is allowed to flow from this point and it is coming out.

This is the water inlet. Through the thickness it is coming and allowed. So it travels this length l. That is why gradient required and the pressure difference from this point to this point, its delta h and traveled l. So, gradient is here in this test, 3 different gradients are taken 0.25, 0.5 and 1. Normal pressure is applied on the sample, because typically in geotextile application, the geotextile when it is placed under the ground, there will be some pressure applied on the normal direction.

So, that is why in this test, we apply certain normal pressure, maximum size is 300 millimeter by 300 millimeter that is a sample size and geotextiles should be sandwiched between 2 thick rubber sheets to prevent any leakage. Here, in this test, we apply certain normal pressure, this normal pressure is known normal pressure is required. So, that the actual it simulates actual condition where normal pressure is applied. In addition to that, this geotextile is covered with rubber sheet impermeable rubber sheet from both the sides.

This is just to ensure that the water which is coming from one side it flows through the plane, along the plane, it should not come out from side, just to prevent the flowing out of water from inside the structure, that is why, the geotextile is sandwiched between 2 thick rubber sheets.

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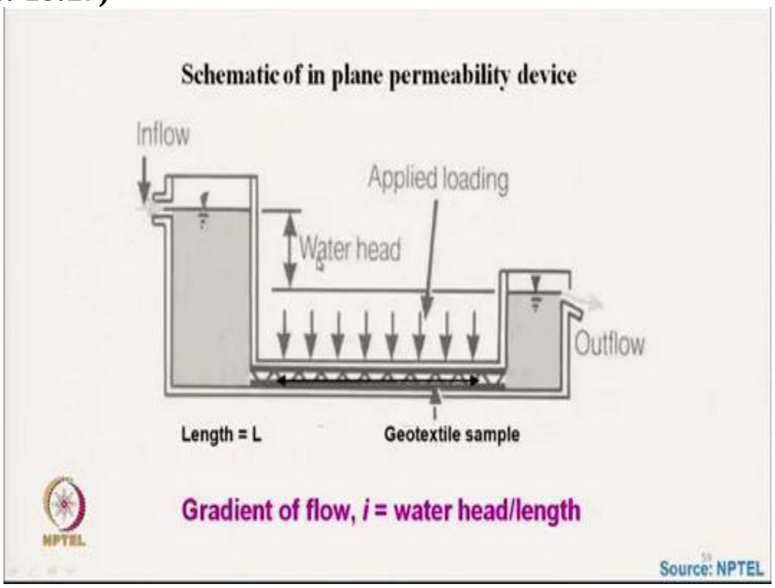

This is the diagram. Here, it is the inflow and this is the outflow and water gradient is created. We know the length and these are the rubber impermeable rubber sheets. It is covered by the impermeable rubber sheets, this is geotextile inside applied load. So from there we can calculate the water head and this water head is constant for a particular test. And we can change the water head by changing the inflow this height. So, here, water is constantly flowing and it allows to overflow so that we can maintain constant head. And from the, this flow rate we can calculate the permeability coefficient and permittivity.

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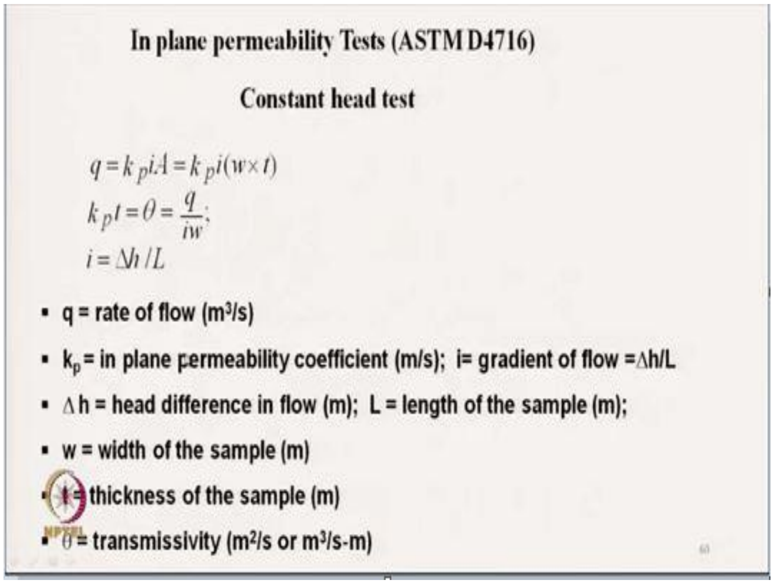

So, q is the flow rate permeability coefficient, we can calculate, this is the k p and water head is known, and from there we can calculate the, this transmissivity. So, this in plane permeability coefficient and transmissivity we can calculate using this formula.

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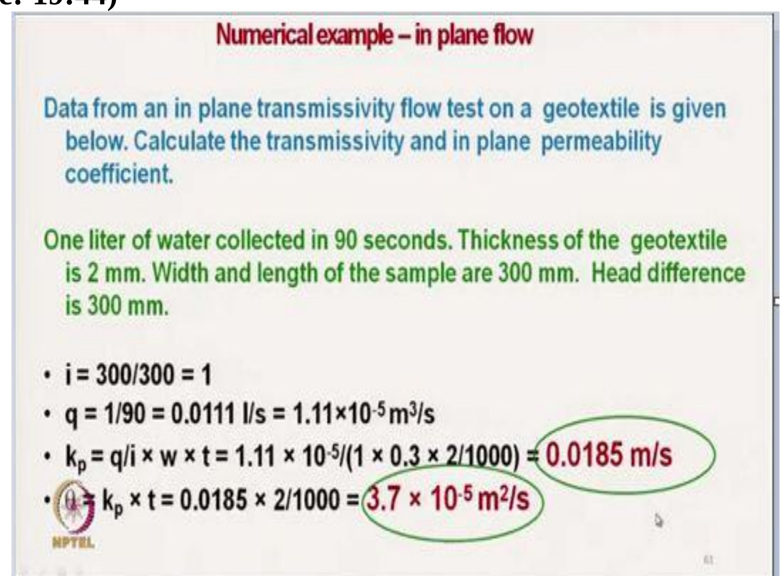

Now, let us try to see one simple numerical, so, this data from this data we can given data we can calculate the transmissivity and in plane permeability coefficient. i is the gradient here, it is a 300, 1 liter of water is collected in 90 second thickness of geotextile is 2 millimeter width and length of the specimen 300 and head difference is 300. So head difference divided by length, it is this is gradient and q is calculated, q is the water flow rate.

And from there we can calculate the transmissivity and in plain permeability. This is the k p value and permittivity value, this in plane the basically this is a transmissivity value 3.7 multiplied by 10 to the power minus 5.

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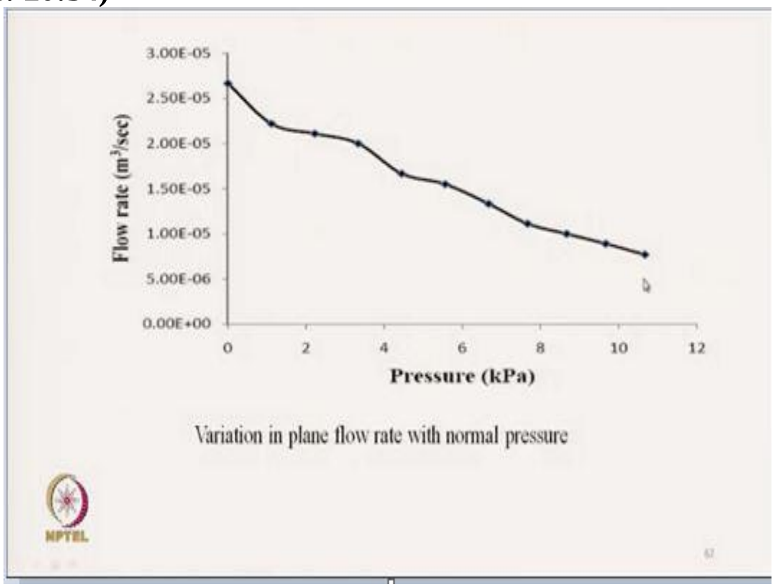

So again, we can calculate the flow rate at different pressure. That is very important. Because at different application how the fabric will perform geotextile will perform that data we can get at different. So, if we change the, let us go back to earlier here if we change the applied pressure at different applied pressure, we can calculate the transmissivity. This data will this graph will help in designing.

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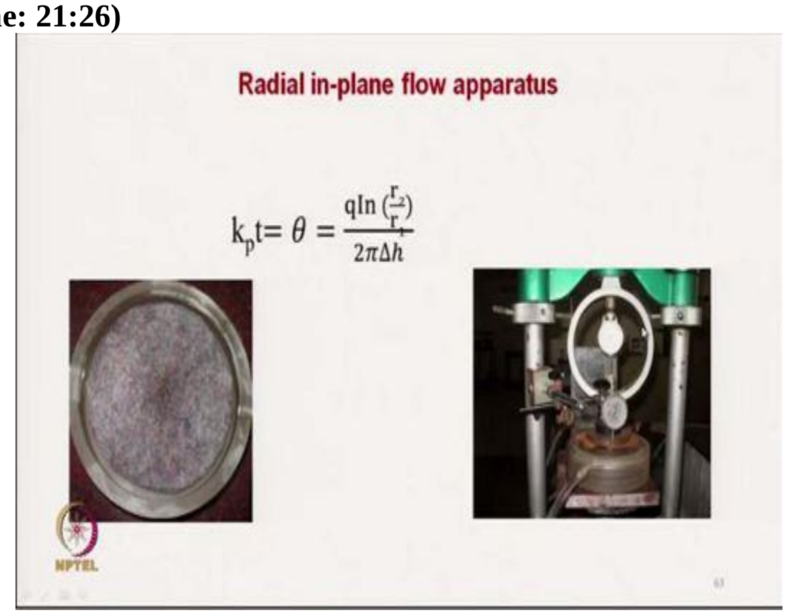

In plane flow parameters, we can also calculate, if the shape of this specimen is circular in that case, it is a radial in plane flow is measured using this formula, where r 1 and r 2 are the radius of the outer radius and inner radius. So, from there we can calculate. Using this formula, we can calculate the in radial flow parameter.

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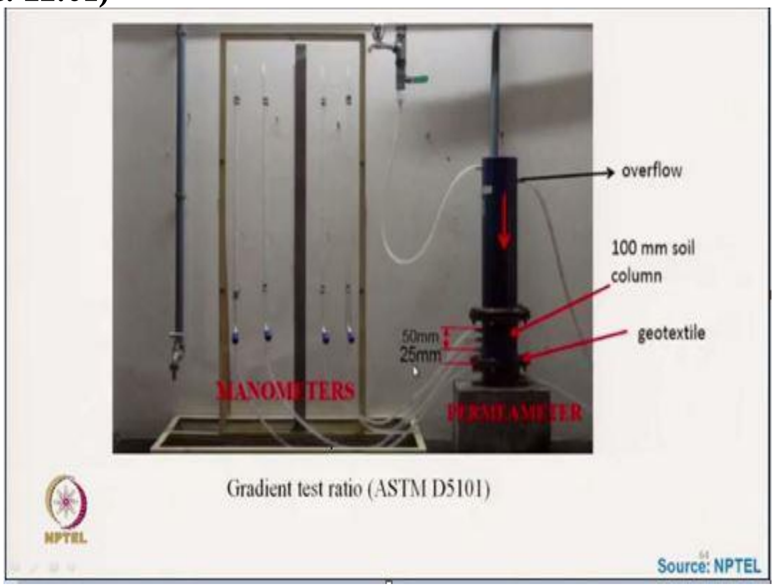

Next test is the gradient ratio test, where the pressure the flow parameter, how the flow of water is affected by introduction of geotextiles that is assessed here.

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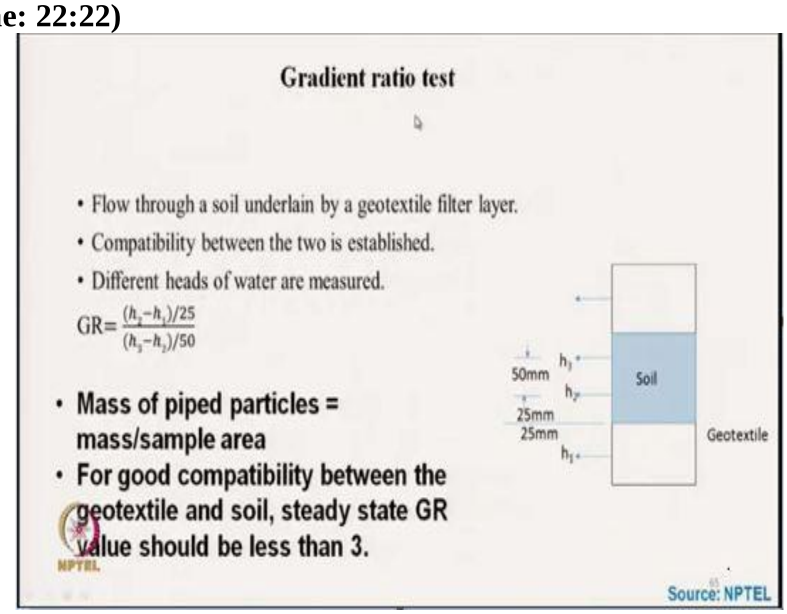

So, gradient ratio is a, it is a flow through soil underdrain by a geotextile filter layer. So, when the geotextile is laid in the soil, so, in that condition here the actual flow is measured. So, this is the technique where the soil as well as geotextiles are placed together. In earlier permeability and transmissibility testing, they are tested in isolation. So, soil and geotextile are put together here, the compatibility between soil and geotextiles are assessed here.

So, if the flow rate is less or gradient ratio, its pressure is high, then we can conclude that the geotextile and the soil is not compatible, we must select a geotextile which is actually compatible with the particular soil. So, difference in heads of soils are of water are measured. Mass of piped particles = mass per sample area that can also be measured here. For good compatibility between the geotextile and soil, the steady state gradient issue value should be less than 3.

If the gradient ratio is more, more than 3 it is increased that means, it shows that the particles are blocking the geotextile and proper flow of the system is reduced. Here in this system, this is the soil flow rate soil with the depth of soil here it is a 50 millimeter and pressure head is calculated that is h1, with h1, and here it is water and water is flowing from this side, this is 50 millimeter. Here it is a 25 millimeter and water is a 25 millimeter. Now, actual head of soil is 50 millimeter here. So that means h 2 - h 1, the actual soil head here it is a 25 millimeter.

So this distance is 25 millimeter. So h 2 - h 1 because at this point there is no soil, but only geotextile. So geotextile and 25 millimeter of soil, in that situation that means h 2 - h 1 / 25. So presence of geotextile and soil is there and h 3 - h 2 it is actually it is a 50 mm, so, h 3 - h 2 here, this height, the water height with the distance of 50 millimeter and if we take the ratio that is actually showing the gradient ratio. Now here if the geotextile is blocking, suppose here geotextile permeability is much less than this soil permeability.

In that case, it is h 2 - h 1 / 25 will be higher than the denominator. So this will basically very high that shows the proper flow of water is not there. Once we apply the geotextile in soil condition, it is normally it is more than normal soil, but with the time it should get stabilized.

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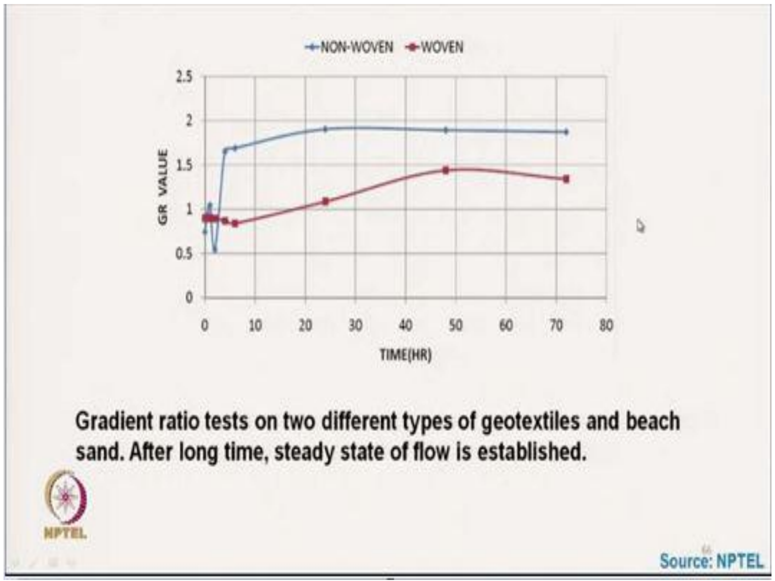

So, this picture shows here initially it is typically around 1 and gradually it increases and this is for woven fabric. And here, it is a nonwoven fabric. So, gradient ratio of nonwoven fabric is little bit higher than woven fabric, but still we use nonwoven fabric prefer nonwoven fabric because its better filters and characteristics. This high gradient ratio, it is due to clogging inside the structure, but after certain time, it gets stabilized. So it is around 2 gradient ratio which is acceptable.

But on the other hand, woven although the gradient ratio is low, but it is not used for drainage or that permeability purpose that cross-plane permeability is not there. So drainage application or filtration application, it is not normally used.

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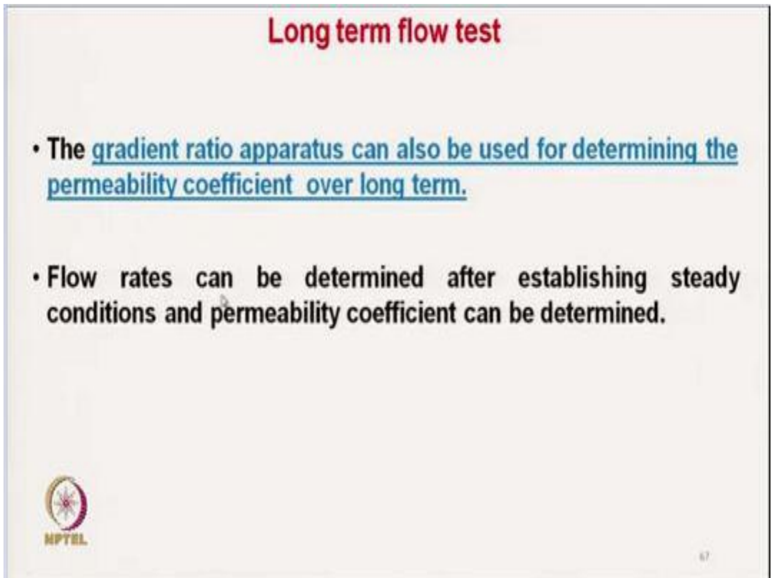

As far as long term flow rate, so, gradient ratio is used. So, flow rate can be determined by establishing steady state condition and permeability coefficient can be determined. So, with the long term at steady state condition the permeability is determined.

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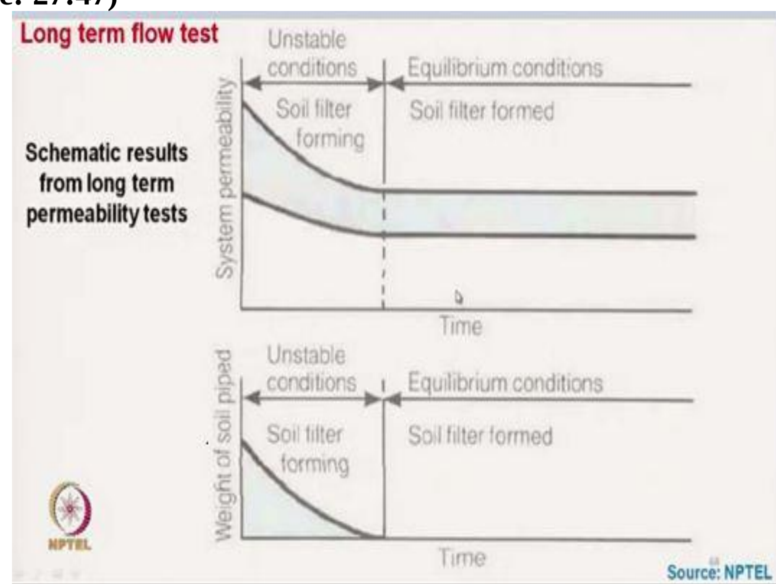

So, this is the schematic diagram. Initially the system permeability reduces gradually because the soil filter formation. So, this is the system permeability, system permeability means the geotextile along with the soil. As I have already mentioned, initially there will be a little bit piping the soil smaller soil particles will come out from the through the geotextile and soil filter formation will be there that is unstable condition.

So, during that unstable condition, the geotextile also being clogged by soil particles which is which penetrates inside, but after a certain time when the proper soil structure is formed in the upstream side then the total system flow rate will be stabilized and that shows by this stability that is a horizontal line shows there is no change in permeability and that is how the long term flow condition is maintained. And this is done using the gradient ratio test also, that is the end of the section geotextile. In next class we will start with another topic on technical textiles. Till then thank you.