Testing of Functional & Technical Textiles
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Lecture – 20
Testing of Geotextiles (contd..)

Hello everyone. So, we will continue with the hydraulic test methods for geotextiles.

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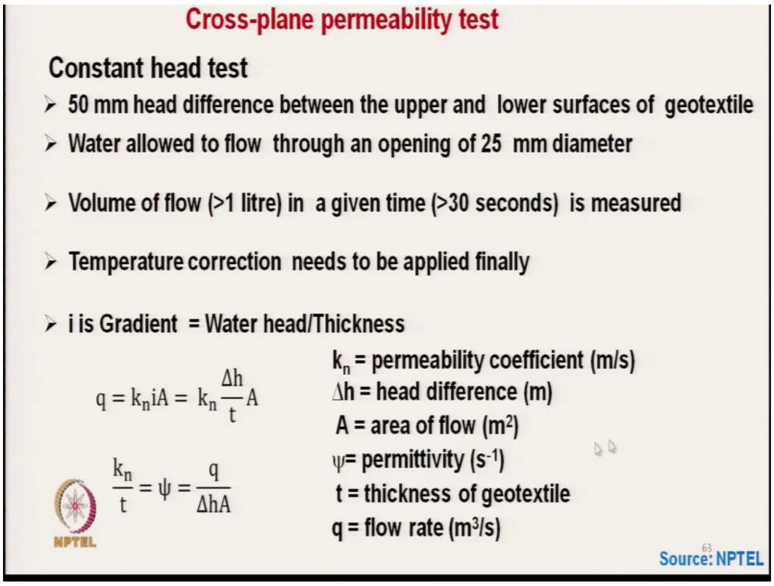

In last class I have discussed the cross plane permeability test using constant head test method, where a constant head difference of 50 millimeter across the geotextile samples were applied. So, we measured the permeability and permittivity under that condition.

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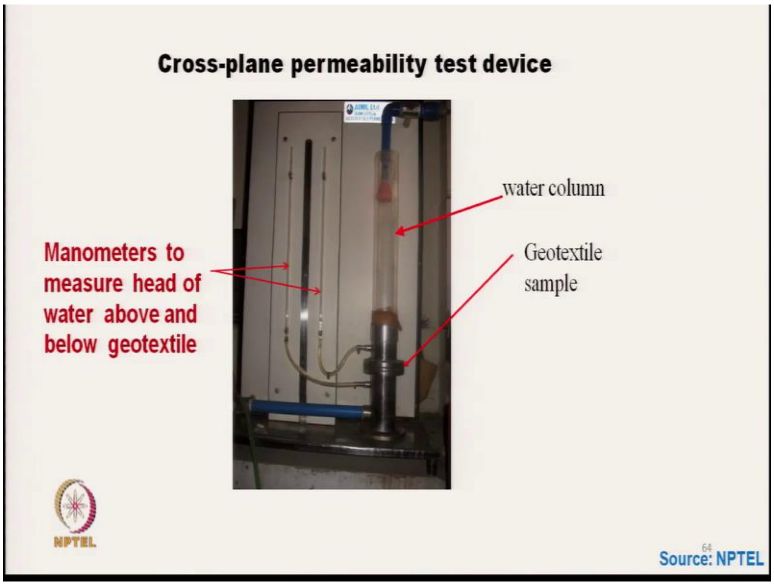

This was the test setup.

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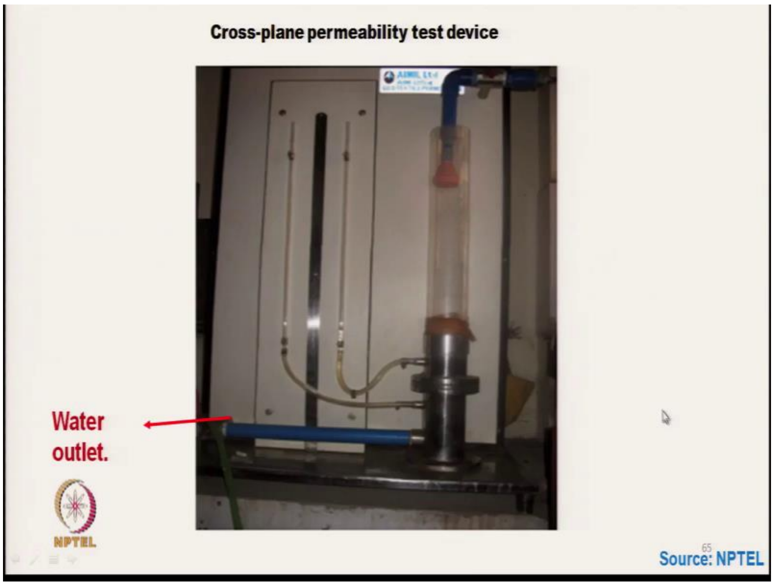

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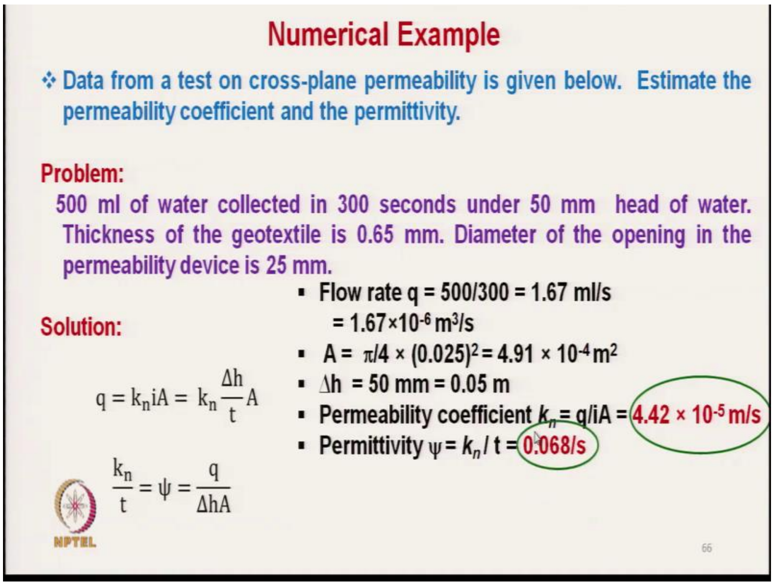

And after that we discussed the numerical analysis giving some known data, we can measure the permeability coefficient and permittivity of geotextiles.

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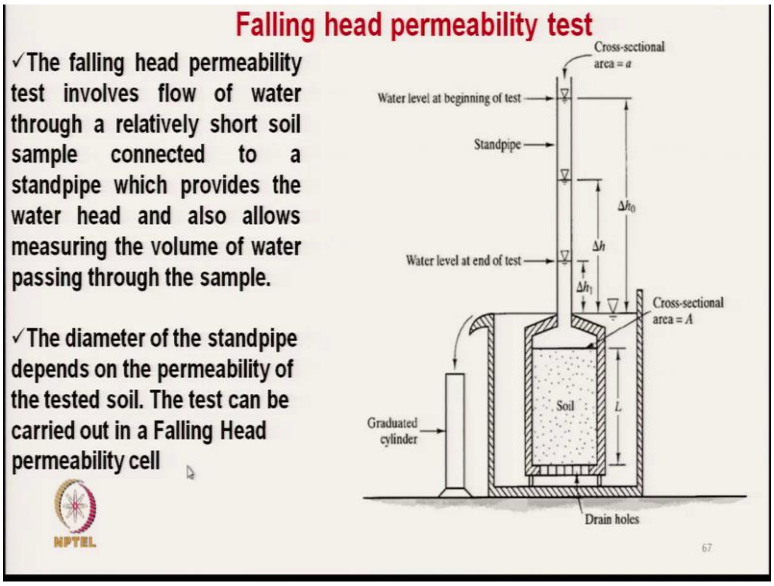

Now, we will continue with the cross plane permeability test, but the method here its a falling head permeability test. This falling head permeability test its very close to actual application condition. In geotextile application many situations are there, where initial the height of water level is maximum and gradually the water when its passing through the geotextile and soil structure, the head of water reduces. Once the water head reduces;

that means, we are not applying constant pressure on geotextile here the total phenomena of permeability is entirely different. So, gradually the pressure reduces and which simulates the actual condition.

Initially, this is the water level Δh_0 and where its a standpipe is there and water level at the end point which is Δh_1. So, at any height at any time, we can also measure Δh. Here graduated cylinder is there with which takes the store the excess water coming out from the system. At the bottom there is a drain hole and falling head permeability test is normally used for soil structure, but we can use this for geotextile also.

The falling head permeability test involve flow of water through a relatively short soil sample connected to a standpipe, which provides the water head and also allows measuring the volume of water passing through the sample, the diameter of the standpipe depends on the permeability of the test soil. So, this falling head permeability test is basically for the soil the test can be carried out in a falling head permeability cell.

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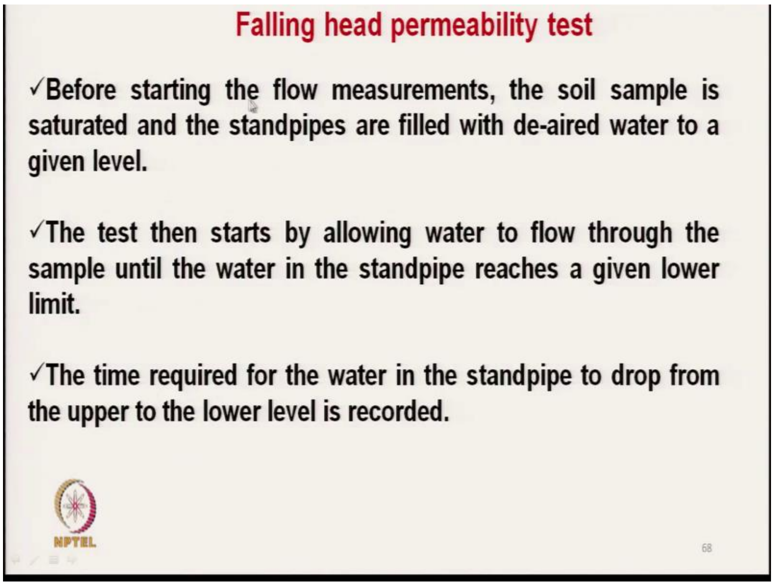

Before starting the flow measurement the soil sample is saturated and the standpipes are filled with de aerated water. So, saturation is required otherwise the quantity of water it will start absorbing and it will give the wrong result the test then starts by allowing the water to flow through the sample unit the water in the standpipe reaches a given lower limit. So, we can note down the time to reach to that point and we can calculate the permeability coefficient of soil.

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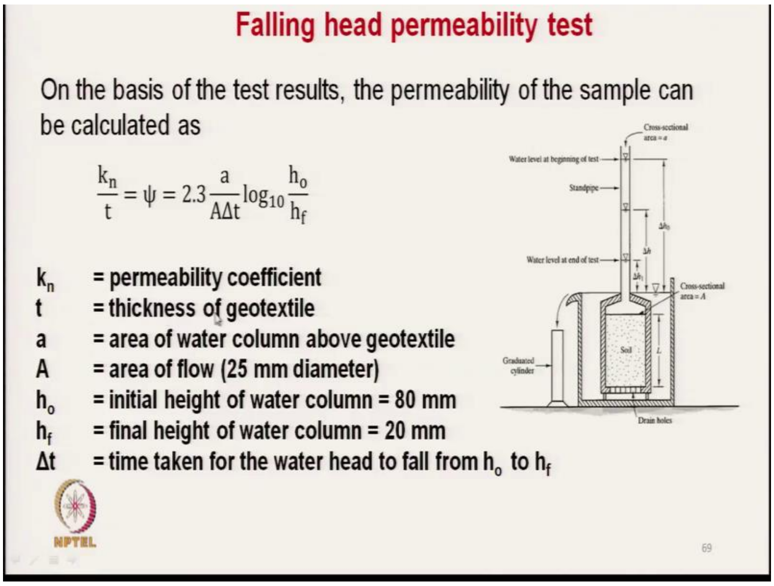

Using this formula

$$\frac{k_n}{t} = \psi = 2.3 \frac{a}{A\Delta t} \log_{10} \frac{h_o}{h_f}$$

where h_0 is the initial height of water column which is typically 80 millimeter and h_f final height is 20 millimeter between this height the time is recorded t, **Δ**t and t is the thickness of the geotextile. So, we can calculate the permeability of the geotextile also. This is the method.

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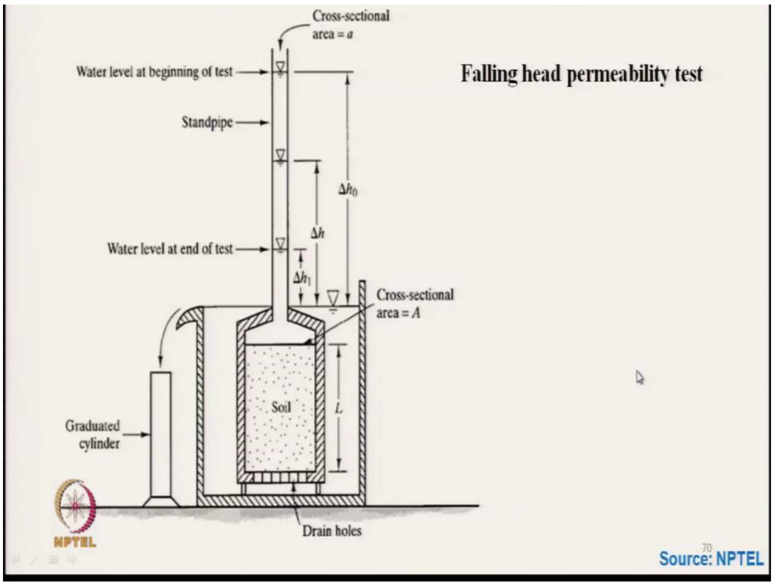

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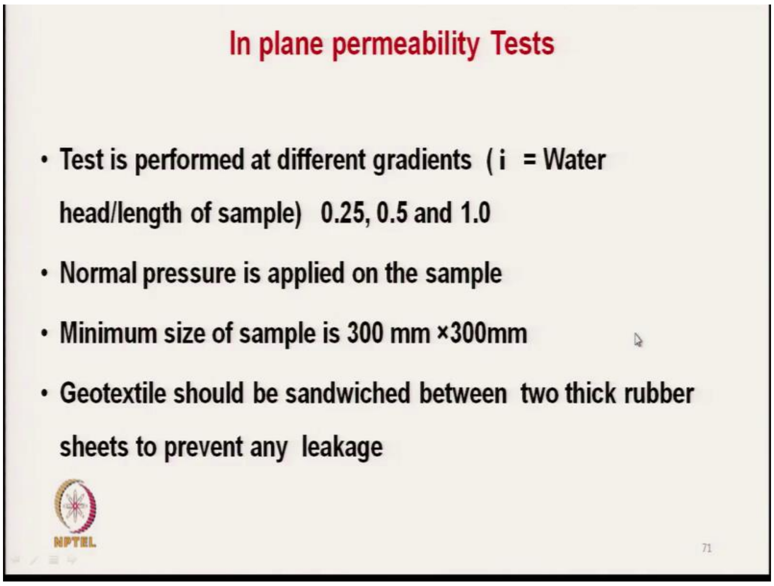

Next method is in plane permeability test. Earlier we have discussed the cross plane permeability now the in plane permeability means where the water flows along the plane of the geotextile; the test is performed at different gradients. So, gradient here is the water head divided by the length of the sample.

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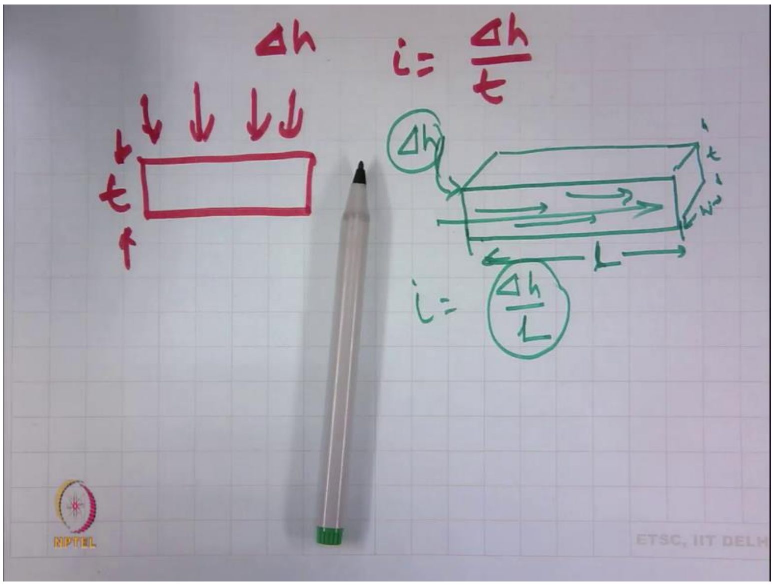

Now, for cross plane this is water is flowing and this is the thickness. So, water head h and thickness. So, that the gradient i in for in case of cross plane, it was **Δ**h/thickness. But in case of in plane where this is the length of the material, here is a thickness say this is the width of the material, length, this is width and this is thickness. In inplane the water flows along the plane. So, the distance travelled is L and for pressure head **Δ**h. So, gradient will be **Δ**h/L not the thickness because the flow length is the length.

So, here we test the in plane permeability with gradient of 0.25 0.5 and 1 at 3 different gradient we test normal pressure is applied on the sample, minimum size of the sample is 300 millimeter by 300 millimeter, geotextile should be sandwiched between two thick rubber sheet to prevent the leakage. Otherwise, if we do not provide the rubber; that means, the channeling of the water will not be proper water will come out from the top and bottom surface to prevent that we have to sandwich the geotextile with the rubber sheet.

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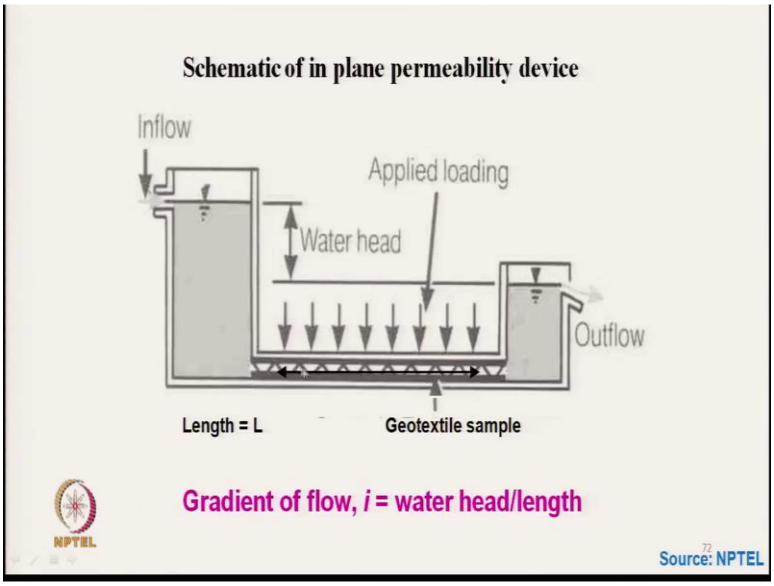

So, this is showing the setup, this one is geotextiles sandwiched with a rubber and the pressure is applied load is there and this is the water head the difference between the inlet and outlet side. So, the height difference at inlet and outlet its showing the water head and gradient of flow i is equal to water head divided by this length of travel.

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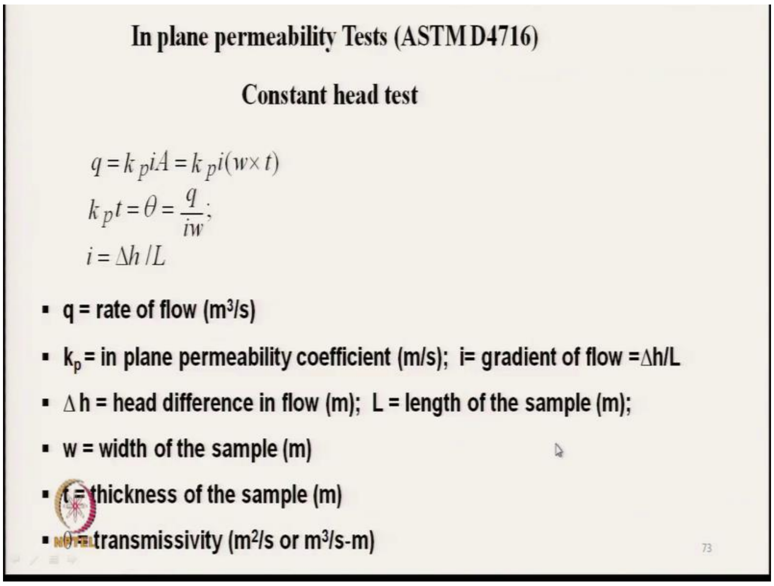

And we can measure the permeability by using similar formula here,

$q = k_p iA = k_p i(w \times t)$

$k_p t = \theta = q/iw$

$i = \Delta h / L$

where q is the rate of flow in cubic meter per second, kp is the in plane permeability coefficient in meter per second, i is gradient of flow as I have mentioned, **Δ**h is head difference this is the head difference L is the length of the specimen, w is width of the sample and t is the thickness. So, if we see the area cross sectional area through which the water flows is the width multiplied by thickness, this is a and theta is the transmissivity.

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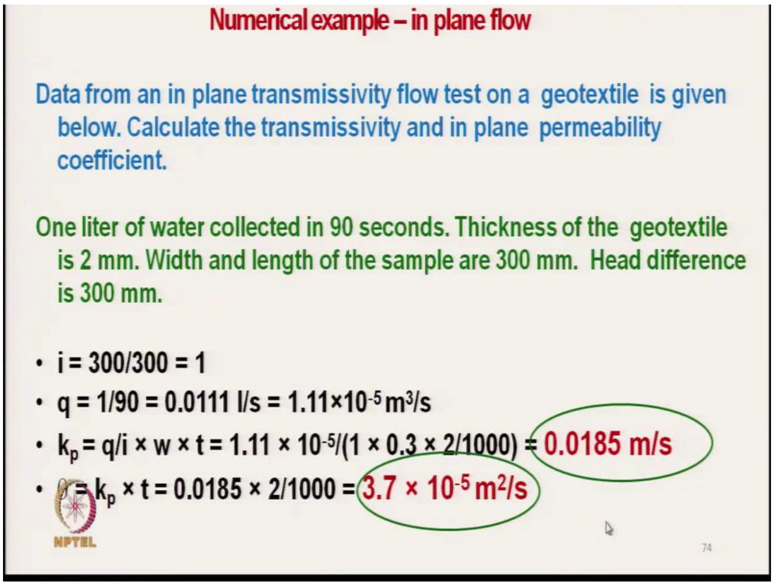

So, using this formula we can calculate. Now, let us see one practical example data from an in plane permeability flow test on a geotextile is given below, calculate the transmissivity and in plane permeability coefficient.

One liter of water collected in 90 seconds. Thickness of the geotextile is 2 mm. Width and length of the sample are 300 mm. Head difference is 300 mm.

- **i = 300/300 = 1**
- **q = 1/90 = 0.0111 l/s = 1.11×10^{-5} m^3/s**
- **k_p = q/i × w × t = 1.11 × 10^{-5}/(1 × 0.3 × 2/1000) = 0.0185 m/s**

- $q = \mathbf{k_p \times t = 0.0185 \times 2/1000 = 3.7 \times 10^{-5}\ m^2/s}$

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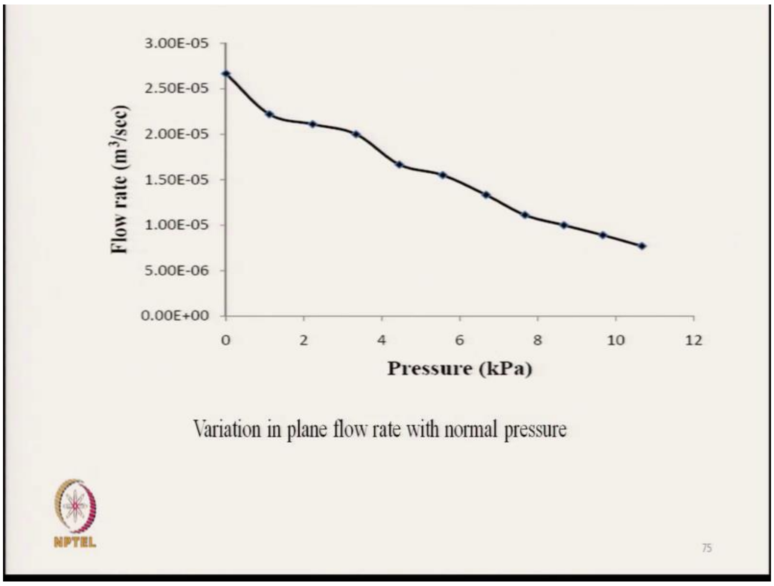

And as we increase the pressure as I have mentioned for compressible geotextile, the pores are being compressed; so, flow rate gets affected. So, with the increasing normal pressure the in plane permeability is actually getting affected, flow rate changes it reduces this has got practical significance. So, accordingly we have to design the geotextiles.

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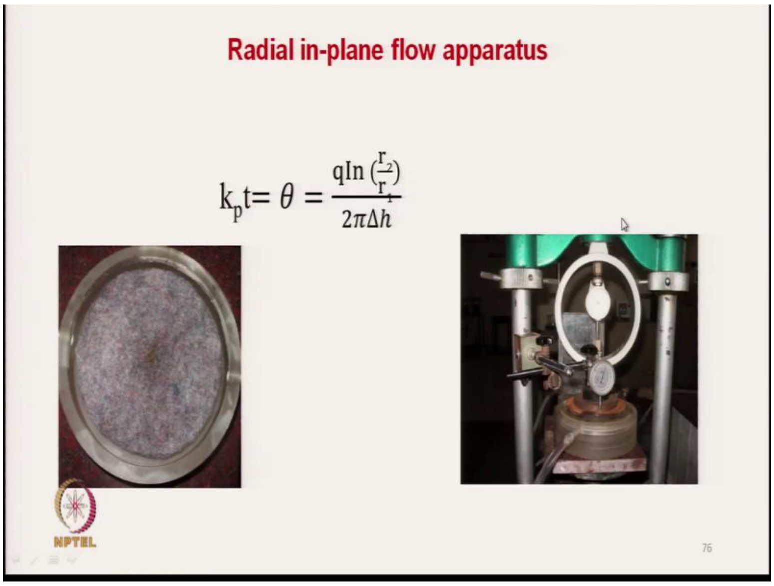
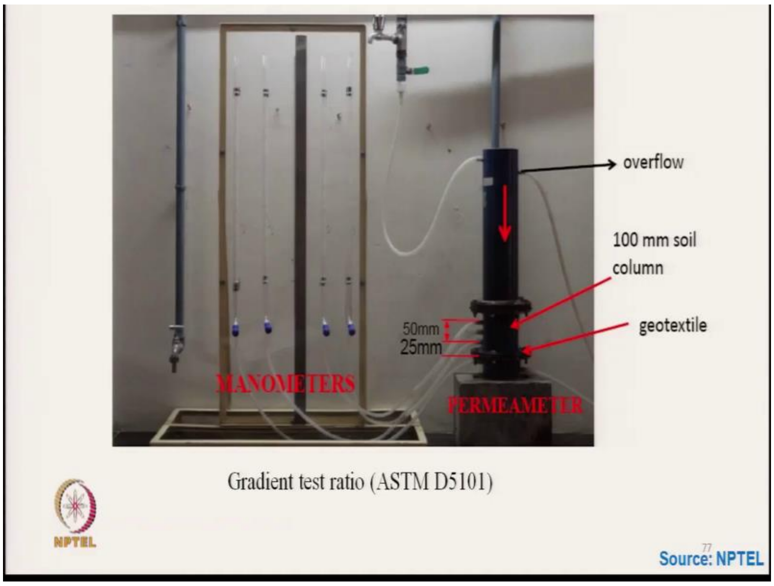


Another method which is used which is radial in plane flow apparatus where the water source is at the centre of the specimen. This is specimen holder it is at the specimen center and we measure the flow radially radial direction and theta is expressed in terms of

$$k_p t = \theta = \frac{q \ln\left(\frac{r_2}{r_1}\right)}{2\pi\Delta h}$$

r 2 and r1 are the inner and outer diameter



Next method is its a called gradient ratio test its as per ASTM D 5101 and this gradient ratio test it shows the long term compatibility of geotextile with the soil as far as the flow condition is concerned. So, if the geotextile is not compatible with the particular soil, in that case there will be sudden increase in pressure then; that means, geotextile will be blocked with the soil structure and soil structure will be totally useless.

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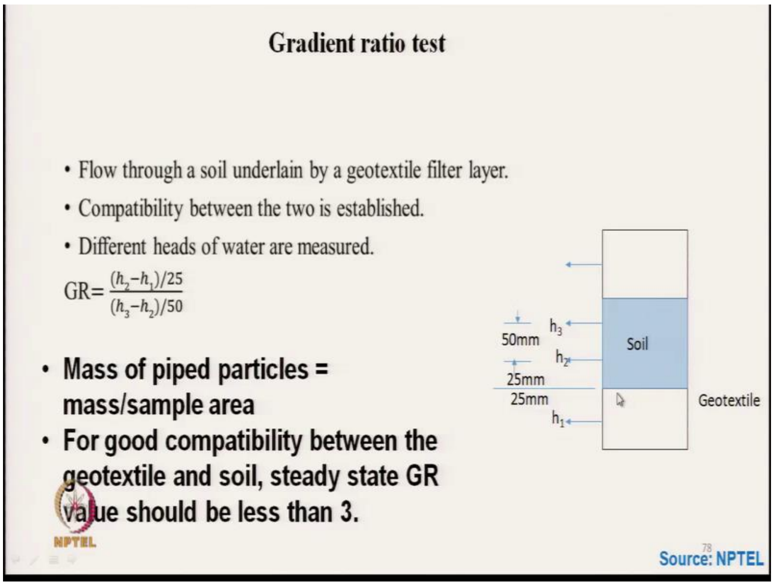

So, here to access this the system is that the soil here the total depth of the soil is 50 millimeter 25 millimeter and another 25. So, total 100 millimeter depth of soil is there and then below that we place the geotextile and here its water.

Now, the flow through a soil underlain by a geotextile filter layer this is the soil underlain is there compatibility between two is established. So, between the soil and geotextile is established, different heads of water are measured. We measure the water head at the bottom of the geotextile at height 25 millimeter from geotextile h2 and from there h3 another 50 millimeter. So, what does it mean? So, h2 and h3 are effectively 50 millimeter of soil structure and here effectively h2 and h1 are 25 millimeter soil and rest is water in between the geotextile is there.

The different heads of water are measured and the ratio is gradient ratio GR, which is

$$GR = \frac{(h_2 - h_1)/25}{(h_3 - h_2)/50}$$

So, mass of piped particles equal to mass per sample area, per unit sample area what is the mass of soil passing through the geotextile that also can be measured. For good compatibility between the geotextile and soil the steady state gradient ratio should be less than 3.

Suppose there is no geotextile and only soil total soil structure is there, in that case we can measure the gradient ratio which will definitely be less than 3 and if we apply geotextile in between the structure, in that case geotextile will definitely try to hinder the water flow and that we are trying to measure here.

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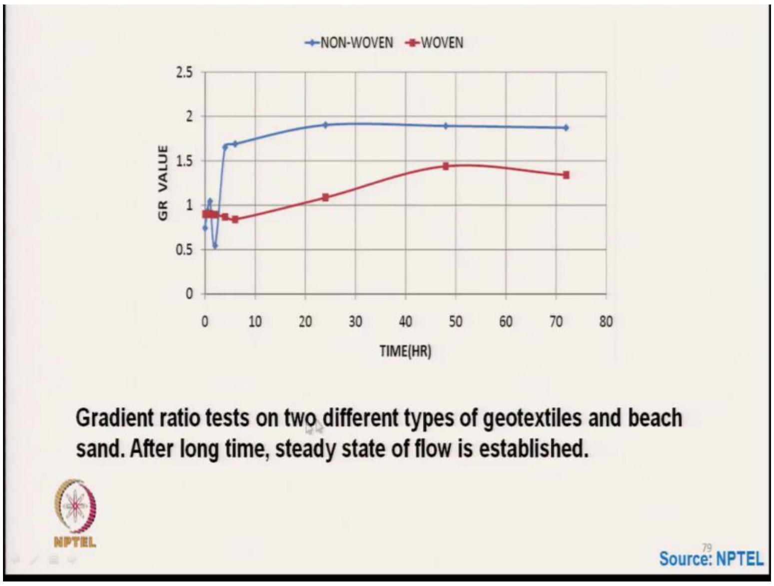

So, gradient ratio here is shown in the y axis and x axis its a time. So, here 2 specimens are used one is woven shown in the red line and non woven its a blue line ok. A gradient ratio test on 2 specimen type objectives of the which with beach sand, so, this is tested using beach sand.

After long time the steady state flow is established. So, initially for non woven it was similar to the woven geotextile, but gradually the gradient ratio value has increased initially because the pores were gradually blocked initially with the soil particle, which actually resulted the higher pressure, but after certain time stabilization took place. So, the value here its less than 2 which is acceptable.

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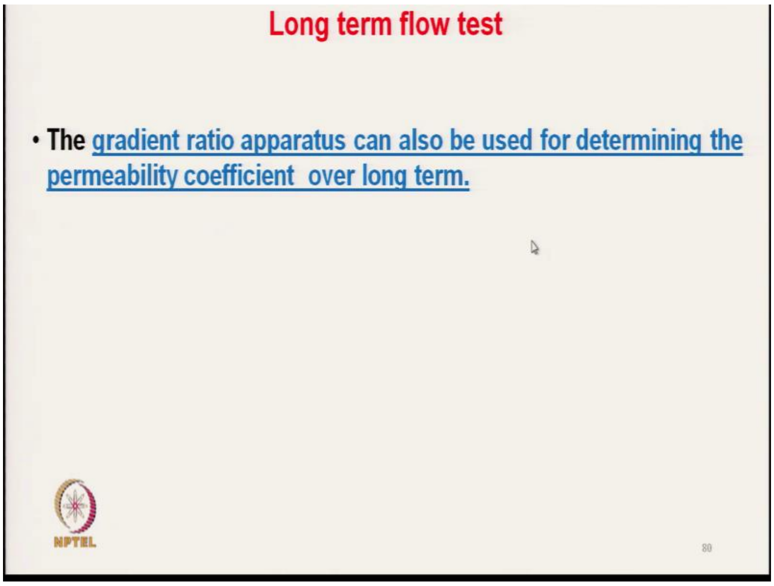

The gradient ratio apparatus can also be used for determining the permeability coefficient over long time. So, after stabilization we can measure the permeability coefficient. Flow rates can be determined after establishing steady state condition permeability coefficient can also be measured. So, initially there will be some piping some blocking of pores, but after certain time steady state flow will be there and this schematic diagram it shows the steady state condition and unsteady state condition.

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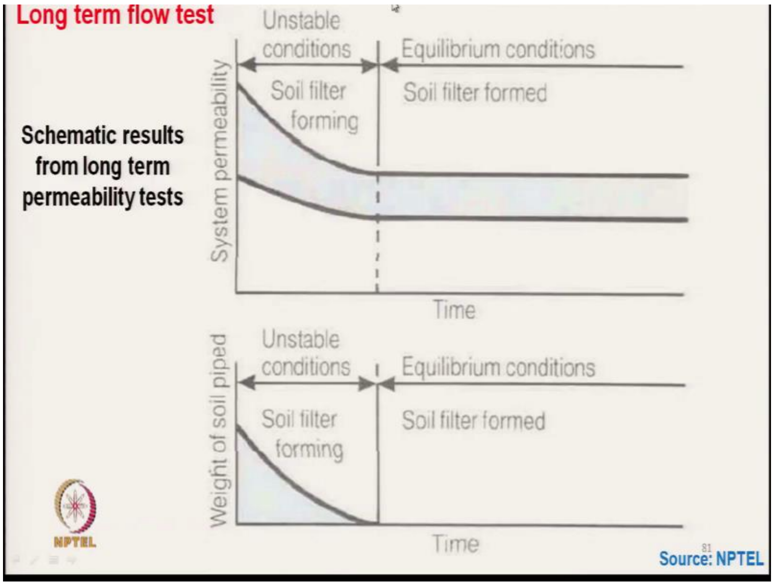

So, initially left side is unstable condition where soil filter formation is taking place. As I had mentioned earlier that typically the diameter of pores of any geotextile is larger than the smaller particle size. The smaller particles will start flowing through the geotextile that is called piping which is shown in the picture below. Initially the piping was high, then gradually the filter formation was taking place some cake formation was taking place and stabilization was there which is shown here. So, there was no piping after certain time and the steady state flow system permeability was reducing gradually.

But once the filter formation is over, proper filter formation took place the steady state flow has reached. So, the flow there is no droppage of flow there is a no reduction of flow. So, it is constant flow is there and the proper formation of filter took place. So, there is no piping taking place, this is the equilibrium condition and this will go on for long time. And from here we can measure the long term flow characteristics of geotextile material. So, we have reached at the end of the session geotextiles and next class we will start a new topic on testing of technical textiles.

Till then thank you.