Soil Mechanics/Geotechnical Engineering I
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Lecture - 13
Permeability and Seepage (Contd.)

Once again welcome to this lecture. We have just completed the various aspects of permeability and seepage related issues and in the mean time we have shown derived different things to particularly for deriving permeability, for calculating equivalent permeability and then flow through the dam structure and all below the dam through soil; obviously, and then I will try to take few problem now that to apply those one by one. So, I will just take the problem number 1, application 1.

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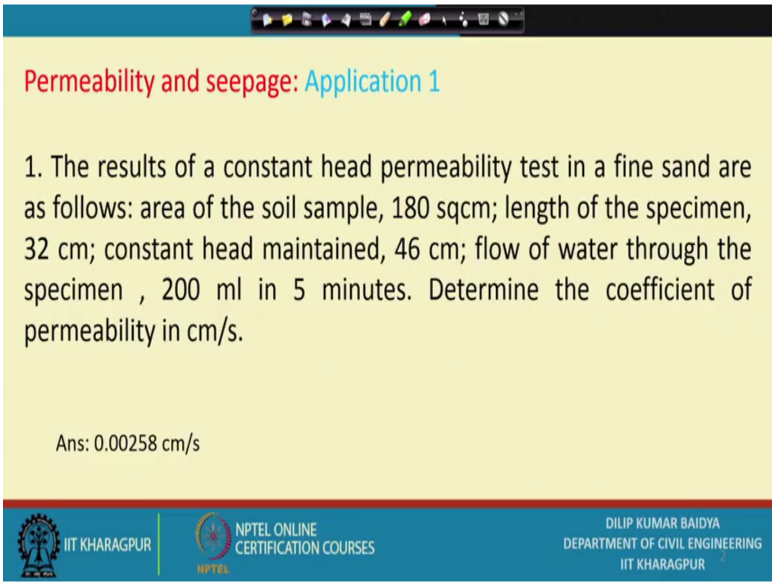

That is the results of a constant head permeability test in a fine sand are as follows. Area of the soil sample 180 square centimetre, length of the specimen 32 centimetre and constant head maintained during the test is 46 centimetre, flow water through the specimen 200 millimetre in 5 minutes. So, based on this given information we have to find out the coefficient of permeability.

So, for this actually what we can do? I have discussed before that.

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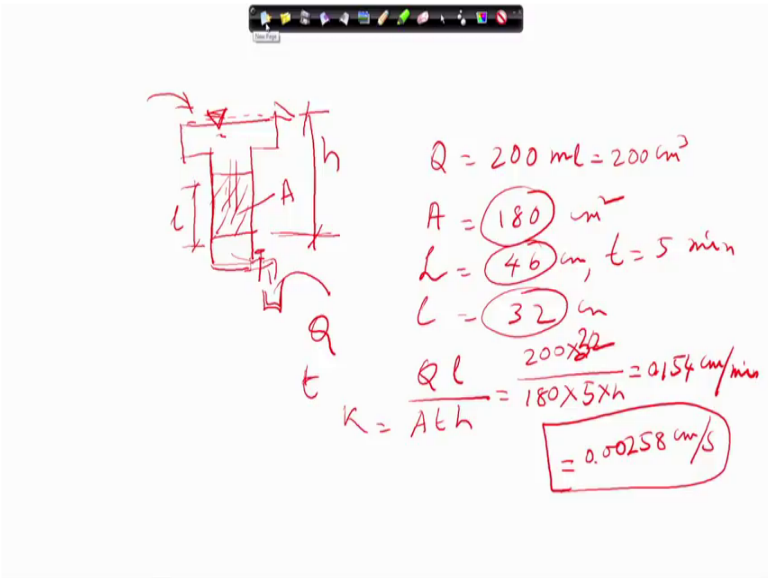

How you do this test? We do the test and suppose this is the soil sample and your quantity of seepage is collecting from here and in this we have different dimension. This is the length of the soil and flow taking place for water actually your head difference, because of which water is flowing through. It is h and your quantity collected suppose Q and cross section area suppose A. Then this is test positive; that means, you are constantly supplying water here and maintaining the height here. So, that more water comes here. It will come out through over flow maintaining this height and this is the sample through which it is continuously water and water then flowing through this and finally coming out here over a particular time t. We have measured the quantity suppose Q.

In that this is the equation. Q actually you have 200 Q is equal to 200 ml equal to 200 centimetre cube. That is capital Q and A area is given 180 centimetre square and h equal to constant h 46 centimetre under which flow is taking place. t equal to 5 minutes and your L is equal to 32 centimetre and our equation governing equation K equal to Q into l by A t into h. So, all those quantity are known here. If I substitute all of them 200 and multiplied by l equal to 32 and divided area is 180 and t is 5 into h.

If I do this, then I will get 1.154 centimeter per minute and which will be equal to 0.00258 centimeter per second. So, this is the thing asked in this; that means, given condition, in a constant head permeability test quantity collected over 5 minutes time 200 ml and the test was conducted on the sample whose cross section area is 180 which centimeter square and length of the sample was 32 centimeter and head difference because of which flow is taking place. That was actually 46 here. All those things are given. I have just substituted and get the value K.

Now, let us go to the second problem that is your Application 2.

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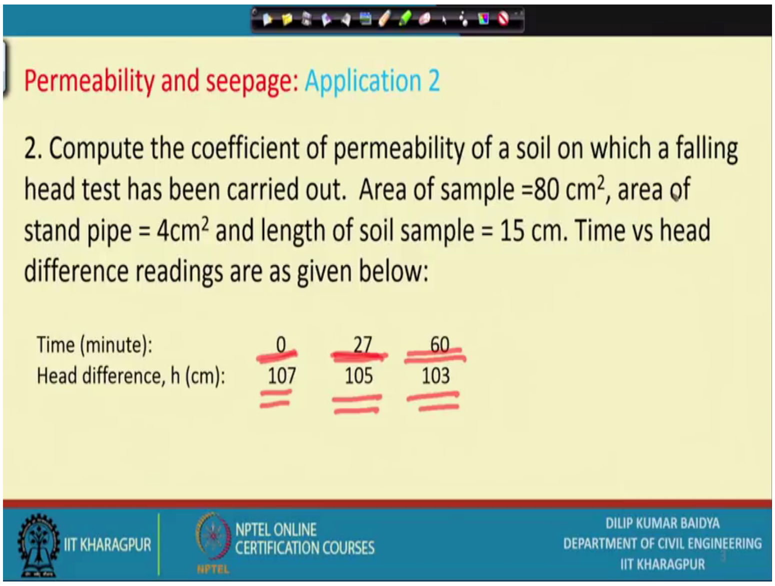

Compute the coefficient of permeability of a soil on which a falling head test has been carried out. Area of sample 80 centimeter square, area of stand pipe for 4 centimeter square and length of soil sample 15 centimeter. Time versus head difference readings are as given below; that means, what is given here, at time 0, head was 107 at 27 minute. After 27 minute, head was 105. After 60 minute is 103.

These are the readings taken. So, based on these readings and based on this given in the information; that means, sample dimension area and length and that water is applied through a stand pipe. That stand pipe cross section area also given and based on these we need to find out the permeability of soil. So, this is a falling head permeability; that means, what the head initially kept at some level and then after some time, because of the flow is taking place, the head is coming down and that taking this observation, how much time taken through drop the head from h1 to h 2? That we considered in calculation.

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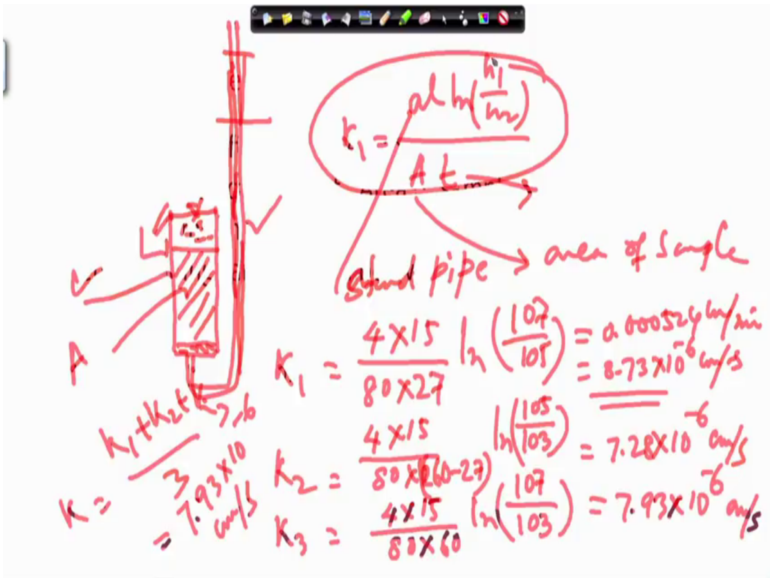

So, if I do that generally are test procedures something like this sample will be there and this is the sample suppose and this may be something and through which there is a stand pipe. Suppose, this should be a uniform section; obviously, is not I have drawn here. Stand pipe is somewhere something like this and water is kept here. This is water and this is suppose water is collected from here. Generally this quantity of water collected not necessary to measure.

Only thing is required to see the head difference. Suppose initially head was somewhere here and after sometime, head has come down here and this is the cross sectional area A. This is the length L and head h1 to h2 there is a time. So, this to be considered and our equation for permeability actually K1 equal to Al, A times l into ln h1 by h2 divided by A t. This is the area of stand pipe. This is stand pipe cross section and this A actually area of sample and this is a time over which the head drop from one h1 to h2. There are 3 combinations we can do. I can consider K1 first. K1 mean; that means, after 27 minutes, there is the head change from one head to another head; that means; so, that if I put, this was 107 to 105.

So, if I put that, the cross section area of stand pipe is 4. Length is given 15 and area of cross section sample is given 80 and time is actually it is 27 minutes and ln 107 by 105. That means, I have 2 times interval is given and 2 different heads are given. I am taking 0 time to 31. So, that I am representing as K1. If I take this one, then it is gives you a value 0.000524 centimeter per minute and if I consider, it will be 8.73 into 10 to the power of minus 6 centimeter per second and previously we have got for sand the value was quite high and it is actually falling head will do (Refer Time 11:12) for fine grained soil where permeability low, this permeability also showing quite low value.

Similarly, I can consider K2. K2 is what actually I consider the observation between 2 and 3; that means, that 27 minutes what is the reading? And your 60 minutes what is the reading this difference of these 2. So, this quantity will be same 4 into 15 divided by 80 into 27 and this will not to be 27. This will become 60 minus 27 and this will be ln. this will be 105 was there at 60 minutes and 27 minute and 60 minutes, 103. This if I do this gives you the K value 7.287 into 10 to the power minus 6 centimeter per second.

And now I can do another that is K3. K3 how I can take? I can take observation 1 at 0 time and at 60 minutes time. This if I do, then it will be 4 into 15 divided by 80 into 60. Now directly at sharp 60 minute time, I am reading and ln will be initially was 107 and finally, it become 103. So, this one I can get another value of permeability K3. That is actually 7.93 into 10 to the power minus 6 centimeter per second.

So, whatever ranges of value I have got 8.7, 7.2 and 7.9 there actually the permeability changes in 10 times or 100 times. Because of that this variation is reasonably within the range and because of that we have got 3 values, but I can finally, recommend the average of this. That K will be equal to K1 plus K2 plus K3 divided by 3. So, if I put that one, that gives you 7.93 into 10 to the power of minus 6 centimeter per second. This is the one. Main application of this here actually using this equation that is al l n h1 by h2 by A t. Where small a is the cross section of the stand pipe and capital A is the cross section area of the sample and t is the time interval over which the head drops from h1 to h2.

And what is h1? What is h2? That too we will observe. If I do that, you will get the value of K. Since there are 3 sets of data observation is given. We can calculate 3 K values and average of these 3 can be reported as recommended value of K.

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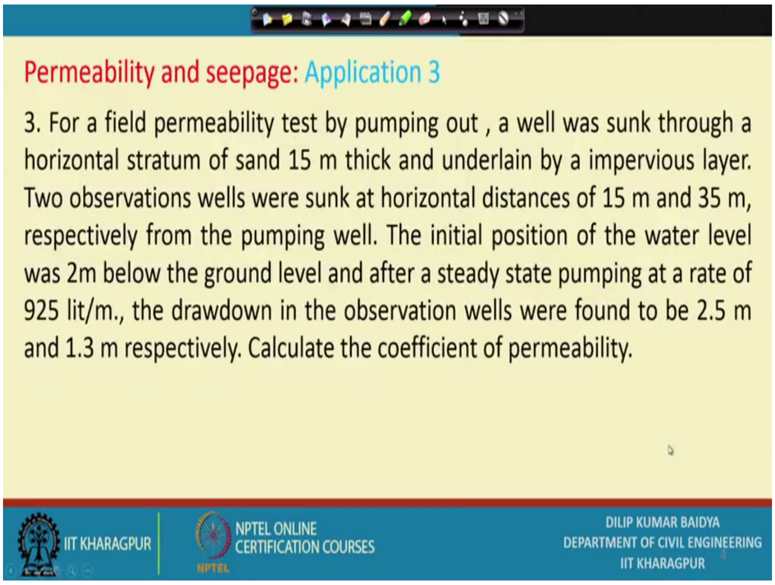

Now, I will go to Application 3. This is actually for a field permeability test by pumping out; that means, the pumping out test is a field test. That will be make a borehole first and through that borehole by using a pump will take out the water and the quantity of water when it become almost constant; that means, steady z and that is one thing to observed and another thing is, at some distance from the main well that will be some observation well and that observation well also you have to see how much is drawdown? It will not be the same as it is in the well. If you go away from the well, you drawdown will be reduced. So, that application is shown given here.

For a field permeability test by pumping out a well was sunk through a horizontal stratum of sand 15 meter thick and underlain by impervious layer. 2 observation wells were sunk at horizontal distance of 15 meter and 35 meter respectively from the pumping well. The initial position of the water level was 2 meter below the ground level; that means, water bearing layer, the sand layer thickness is 15, but water was there only 13 meter and after a steady state pumping at a rate of 925 litters per meter. The drawdown in the observation, wells were found to be 2.5 meter and 1.3 meter respectively. Based on this observation, we have to find out the coefficient of permeability of the soil.

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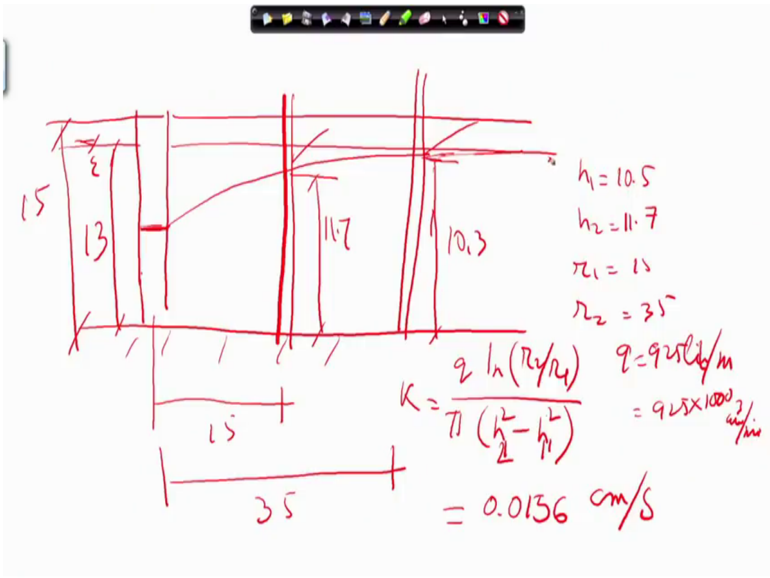

So, generally what is the thing we do, our typical object pumping test schematic diagram is something like this is suppose pump and there may be some impervious layer and this is the ground mark suppose and water layer is somewhere here. This is the water layer and since total is 15. This depth will be 13. Now, observation wells are here one. Another one here this distance of observation well. One is 15 meter, another is 35 meter and when if you do the pumping, then it drawdown will be something like this (Refer time 17:19).

Here drawdown something, here drawdown something else. So, based on the given information this is become 11.7 and this become 10.3 and this is 13. Your h1 equal to 10.5, h2 equal to 11.7, r1 equal to 15, r2 equal to 35 and if you have q equal to 925 liter per minute, equal to 925 into 1000 centimeter cube per minute and if I do that, then our expression is K expression equal to q into l n R2 by R1 pie h2 square minus h2 square minus h1 square.

So, all the values are given. If I substitute in this equation finally, you will get a permeability value equal to 0.0156 centimeter per second.

So, in this problem of course, again I have mentioned while discussing this, I can find out what is the area of influence; that means, why what distance there will might be no drawdown. So, once you get the K and using this I can find out that also. One I will consider at a distance R, the drawdown is zero; that means, observation is one reading is h2 is 13. Using that I can find out the other thing also. Means distance at up to which there is no drawdown or influence area we can say.

So, that was the application 3.

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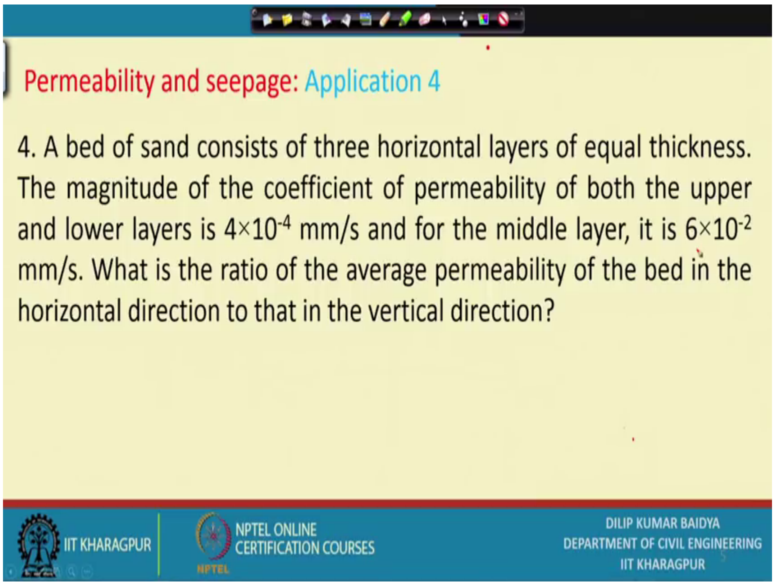

Now, I will take one more problem. That is; Application 4. This is the Application 4 and. Here actually a bed of sand consists of 3 horizontal layers of equal thickness. The magnitude of the coefficient of permeability of both the upper and lower layers is 4 into 10 to the power of minus 4 millimeter per second and for the middle layer it is 6 into 10 to the minus 2; that means, the permeability is high; that means, there will be 2 clear layers and top and bottom where permeability is low and in between 2 layers, there may be a sand layer, where permeability is very high.

Actually 10 to the power of minus 2 and 10 to the power of minus 4 that 100 times. So, in this case when flow is taking place how to calculate actually that we have to use equivalent permeability concept. When you apply equivalent permeability concept in vertical and horizontal direction, it will be different and that is what question is asked. What is the ratio of the average permeability of the bed in the horizontal direction to that in the particle direction? Average equivalent permeability in x direction and y, z direction will not be same. That will be different. That we have shown while discussing the topic now, will show that part in the application here.

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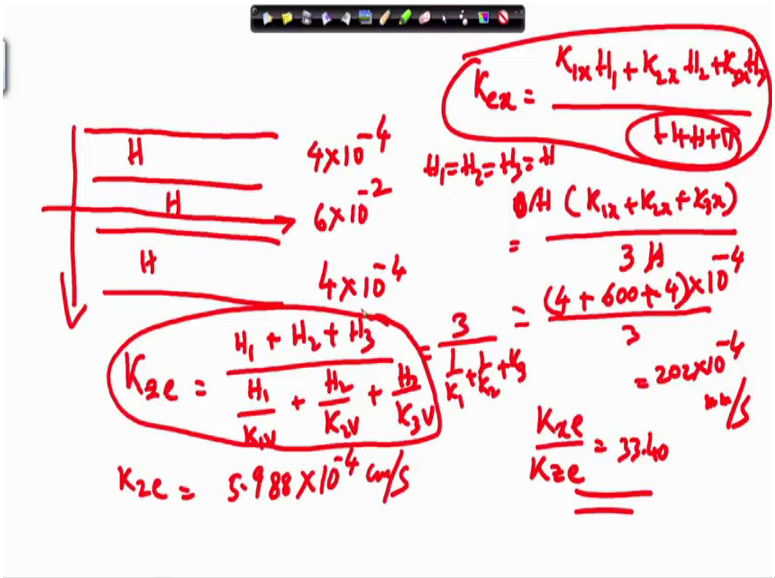

So, suppose there is a 3 layer as it is mentioned. One here, One here, One here and one here, 3 flow can be taking place in this direction and flow can take place in this direction and you can see that the 4 into 10 to the power minus 4. Here 4 into 10 to the power minus 4 here and whereas, here 6 into 10 to the power minus 2 and whatever values is given assuming within that layer it is isotropic; that means, both K x and both the direction it is same.

If I consider that then thickness, all thickness suppose h and h then in horizontal direction we can K e x suppose our formula is K1 x H1 plus K2 x into H2 plus K3 x into H3 divided by H. If I apply this; that means, all H1, H2, H3 is actually same. So, it will be coming H and actually you can say this is H and this H plus H plus H. This total H actually and.

Here actually H1, H2, H3 will be if I consider H1 equal to H2 equal to H3 equal to H. In that case it will be H into K1 x plus K2 x plus K3 x and here actually total thickness of height; that means, H1 plus H2 plus H3. It will be 3H. H is get cancelled. Ultimately it is nothing, but the average of the (Refer Time 24:15) flow is taking place in horizontal direction then equivalent permeability is nothing, but average permeability of the 3 layer. So, if I do that, then you see it will be 4 plus, it will be 600 plus 4 into 10 to the power minus 4 divided by 3 and that become 202 into 10 to the power minus 4 millimeter per second.

And where as in K Z e when it is vertical direction when we consider, there actually it will be H1 plus H2 plus H3 divided by H1 by K1 v plus H2 by K2 v plus H3 by K3 v. Since, they are all equal. This equation can be ultimately converted equal to it becomes ultimately 3 divided by 1 by K1 plus 1 by K2 plus 1 by K3. So, K z e becomes 3 divided by this and if I do this finally, your K Z e becomes 5.98 into 10 to the power minus 4 centimeter per second.

As it is given and now if I do ratio of horizontal K x e divided by K Z e. Then different this ratio will come 33 times. This is another; that means, simply I have to remember when horizontal direction flow this is the equivalent, when vertical direction this is the equivalent equation. This equation you can remember rest of the things are nothing.

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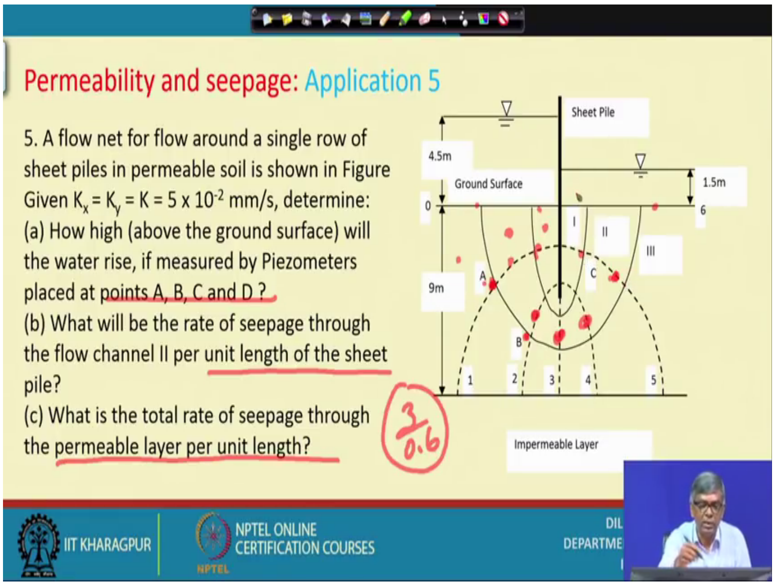

So, I will go to the next application. Question number 5, in these actually you can see the application is given a flow net. Application of flow net around a single row of sheet piles in permeable soil is shown in figure given K x equal K y equal to K equal to 5 into 10 to the power of minus 2 millimeter per second. Determine how high above the ground surface will the water rise, if measured by Piezometers placed at points A, B, C; that means, A, B, C is shown here A, B; that means, at this point and C is at this point what will be the rate of seepage through the flow channel per unit length of the sheet pile? And what is the total rate of seepage through the permeable layer per unit length? So, this is the question. You can see that there is how many flow channels? One flow channel, second flow channel, 3 flow channel, I can consider how many drops? One drop, 2 drops, 3 drops, 4 drops, 5 drops, 6 drops 1, 2, 3, 4, 5, 6, number of drops 1, 2, 3, 4, 5, 6. In these 6, N f is actually 3. These are the observation you can see from this diagram and as it is mentioned that since this is at equipotential line.

This line this point actually one drop only taken place and the head is total actually 4.5 to 1.5; that means, three; that means, how much is the head loss going from to here 3 meter and 3 meter is losing over a 5 drops 1, 2, 3, 4, 5 this is 1 drop, 2 drops, 3 drops, 4 drops, 5 drops, 6 drops. Actually 6 drops actually is there. That mean each will be 3 by 6, 3 by 0.6.

So, that way I can find out if I know that so; that means, in each drop actually this much. It was here 3. Here it will be 3 minus this much. That is the one. If you go to B, then 3 minus 2 times this and when you go to at point C since, again how many 1, 2, 3, 4, 5 drops are there h minus 5 into this is to be calculated so; that means, if I put A here then different. Let us see that how to do the calculation.

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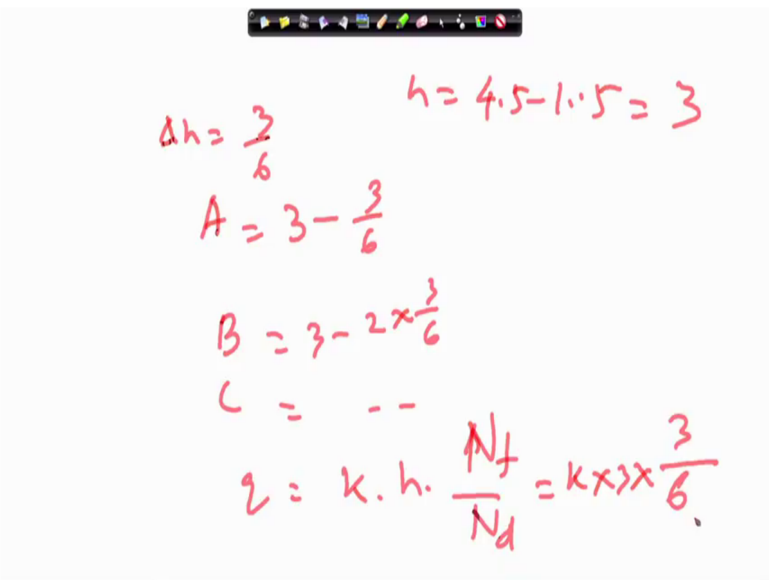

So, here actually del h actually I have done del h equal to 3 by 6. Since 6 drops are there. Whatever value it comes at A will be equal to total head actually equal to 4.5 minus 1.5. So, it is 3 at A. It will be 3 minus 3 by 6 and at it will be B equal to 3 minus 2 into 3 by 6 like that similarly at C also you can find out and also at D point and q will be equal to K into h into N f by N d. K will be given K is given and h actually is 3. K into 3 into N f actually 3 again and N d equal to 6 by doing this calculation one can find out the value of permeability measure. The water how much water is passing through this structure this the 5 application I have done still 1 or 2 may be required. I will do in the later some time. Later may be in the next lecture. So, with this I can conclude permeability and seepage for the time being.

Thank you.