Geology and Soil Mechanics
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Lecture - 18
Permeability - C

Welcome back. Welcome back to the course Geology and Soil Mechanics. So, as we decided in the last lecture that we will be solving few problems on permeability in soil. So, the first problem that is the problem number 9.

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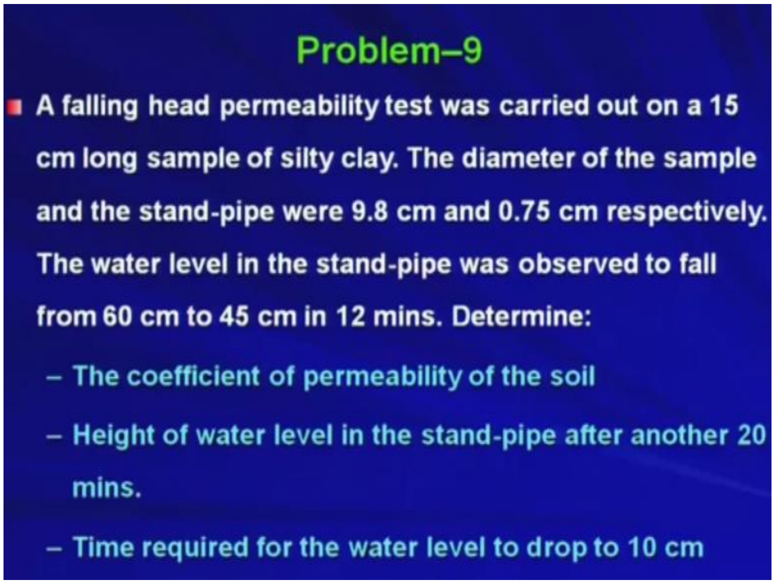

It says that a falling head permeability test was carried out on a 15 cm long sample of silty clay. The diameter of the sample and the standpipe were 9.8 cm and 0.75 cm respectively. The water level in the standpipe was observed to fall from 60 cm to 45 cm in 12 minutes. Determine the following.

First one, the coefficient of permeability of the soil; height of water level in the standpipe after another 20 minutes; and time required for the water level to drop to 10 cm. So, this problem is basically based on the theory which we have covered in falling head permeability laboratory test. So, let us solve this problem. So, we will go to the problem directly.

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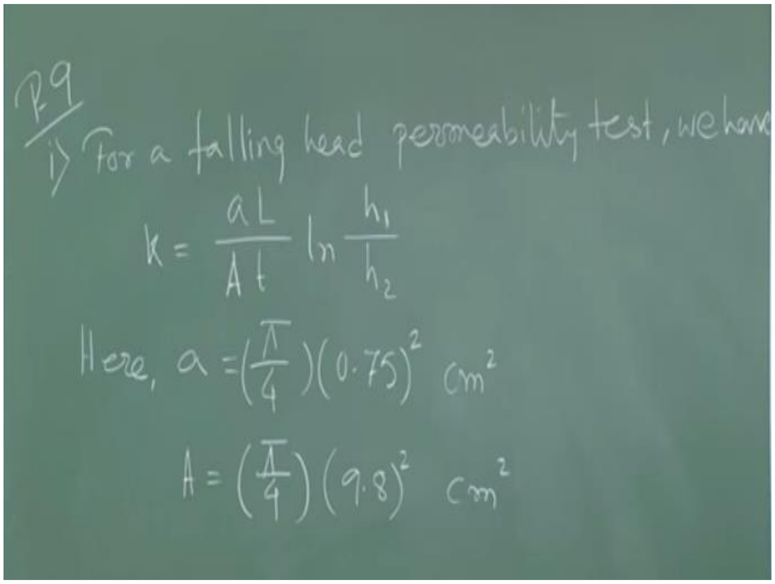

So, this is your problem 9. Now for a falling head permeability test we have so this we know from our theory whatever we have covered in the lecture that is k that is the coefficient of permeability or the hydraulic conductivity that is expressed as a into L; what is a? a is the area, cross sectional area of the standpipe; L is the sample length divided by capital A into t where capital A is the cross sectional area of the soil sample, soil specimen and t is the time into log base e h 1 by h 2.

That is the h 1 is the initial head and h 2 is the final head and that basically this expression is known to us and we have derived this expression and we have seen how we have got his expression. So, there is no issue, we will not further discuss about this equation. So, here in this problem your a that is the cross-sectional area of the standpipe can be obtained as pi by 4 into 0.75 whole square where 0.75 cm is nothing but the diameter of the standpipe as given in the problem.

So, that comes as so we will I will keep that thing as it is so because I do not need to calculate this thing, you will see that why, well. So, capital A that is the cross-sectional area of the soil specimen that comes as 9.8 whole square or 9.8 cm is nothing but the diameter of the soil specimen okay.

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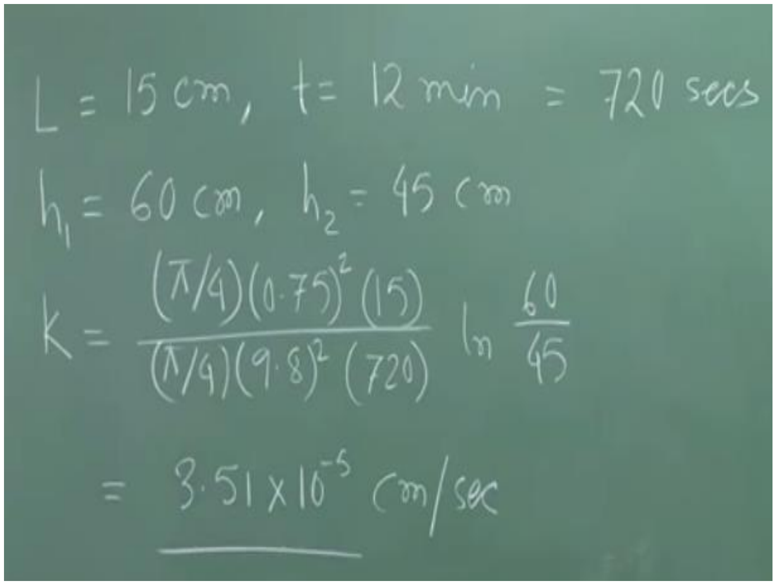

Now what is the L, length of the soil specimen that is given in the problem that is 15 cm and t that is given in 12 min right because it takes 12 minutes from 60 cm head to 45 cm head so that comes as 720 seconds okay in terms of second; h 1 that is the initial head okay from where you are starting or you are initiating the experiment, so that is given as 60 cm and what is the final head you have observed after 12 minutes, that is 45 cm. So, these are the parameters are given in the problem.

So, now we will calculate k as pi by 4 into 0.75 whole square that gives small a into 15 that is L divided by capital A pi by 4 into 9.8 square into 720 ln 60 by 45. So, we did not calculate the area because we will take the advantage over here so they will get cancelled so ultimately, I will get 3.51 into 10 to the power minus 5 cm/sec. So, this is your coefficient of permeability or the hydraulic conductivity right. So, as you have seen so basically, I mean this expression was known to you.

Now basically whatever parameters are given in the problem based on that you have calculated all the things and your permeability is coming 3.51 10 to the power minus 5 and that will be remaining same for the rest of the test I mean whatever you do the test because permeability will not be changing as long as you are considering the same soil sample with same void ratio, same constitutions, and same say your structural behaviour and all those things will be remaining same. So, this permeability will be used for rest of the problem.

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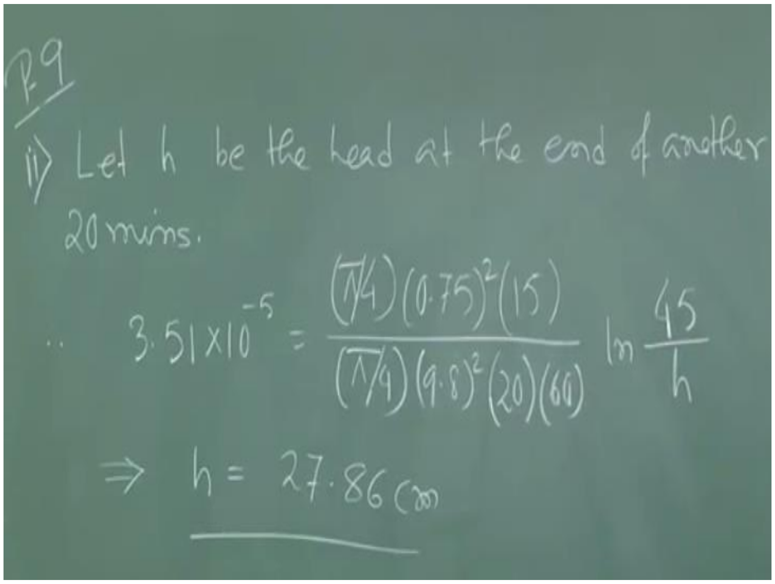

Now in the second part, so it is asked that the height of water level in the standpipe after another 20 minutes that means you have waited till 12 minutes so head was falling from 60 cm to 45 cm and then we are considering another 20 minutes and then we are we want to find out that how much will be the head okay so in the standpipe.

So, let small h be the head at the end of another 20 minutes okay. So, therefore in the previous expression, now you have got the coefficient of permeability so that is not unknown to me. So, 3.51 into 10 to the power minus 5 is equal to pi by 4 into 0.75 whole square into 15, the sample is remaining same so the length of the sample will be 15 cm, divided by pi by 4 9.8 square another 20 minutes right.

So, that means I am expressing that thing in terms of second, so 20 into 60 log base e. Now from this is 45 is your initial head. Now because you have allowed the water to fall from 60 to 45 cm and then you are starting the experiment for another 20 minutes. So, that means your initial head will be your 45, so 45 will be coming as h 1 and this is your final head after 20 minutes okay for another 20 minutes. So, from this if you solve you will be getting h equal to 27.86 cm okay. So, this is the final head after another 20 minutes of the test.

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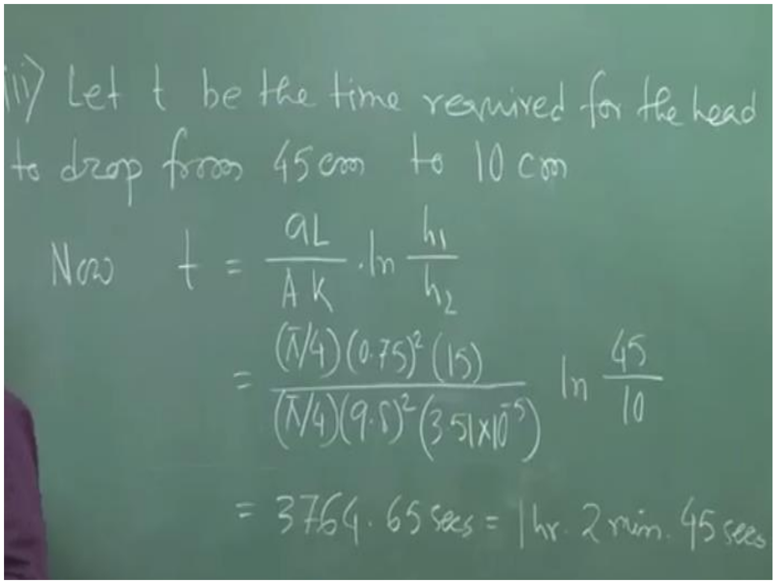

Now we will go to the third part. The third part says it is asking that the time required for the water level to drop to 10 cm. That means you are say suppose you are starting from 54 say cm that is your initial height say in the standpipe. Now you are allowing the water level to fall in the standpipe to fall from 45 cm to some I mean head say that is given as 10 cm. Now how much time is required for that.

Now let us solve that problem. So, let t be the time required for the head to drop from 45 cm that is say initial height I mean it will not be changing say if you start from 60 cm or if you start from 45 cm so I mean accordingly your time will be adjusted because your coefficient of permeability is remaining unchanged. So, to drop from 45 cm to 10 cm okay. So, we can write t equal to aL by Ak into ln h 1 by h 2.

So, this is your expression okay. So, here you know small a, you know capital L that is 15 cm. You know capital A that is pi by 4 into 9.8 square and you know k that is 3.51 into 10 to the power minus 5 into ln 45 that is your h 1 and h 2 is 10. So, you are allowing to fall the water okay up to 10 cm. So, that is coming 3764.65 second which is nothing but 1 hour 2 minutes 45 seconds right.

So, I hope that you have understood the problem so it this problem is good for some warm up kind of thing to understand the behaviour of soil under permeability topic, permeability chapter okay. So, this much of time that is 1 hour 2 minutes 45 seconds is required for the water to fall from 45 cm to 10 cm in the standpipe okay. Now we will go to the next problem. Let us see what the next problem says.

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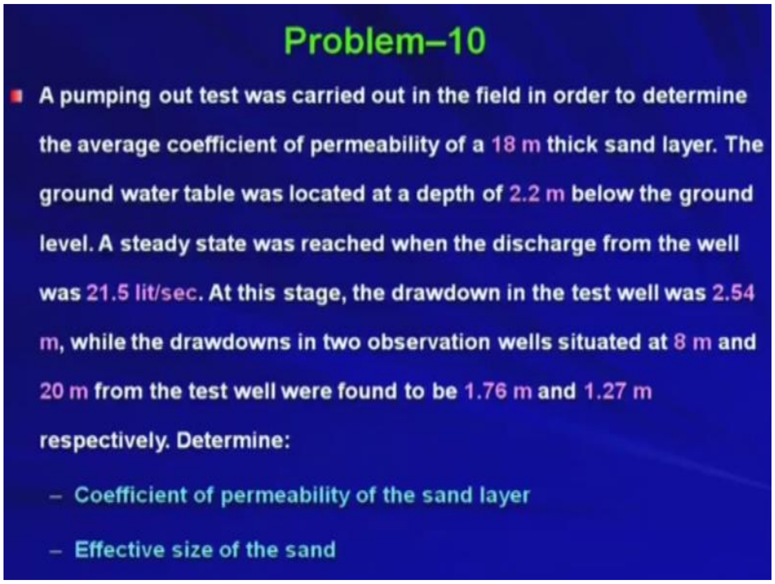

So, that is problem 10. The next problem says that a pumping out test was carried out in the field in order to determine the average coefficient of permeability of a 18 m thick sand layer okay. The ground water table was located at a depth of 2.2 m below the ground level. A steady state was reached when the discharge from the well was 21.5 lit/sec.

At this stage, the drawdown in the test well was 2.54 m while the drawdowns in 2 observations wells situated at 8 m and 20 m from the test well were found to be 1.76 m and 1.27 m respectively. So, determine the following. First one is coefficient of permeability of the sand layer and the second one is effective size of the sand. Effective size means detained. You know from the earlier discussion that effective size is nothing but your detained okay. Now let us solve this problem okay.

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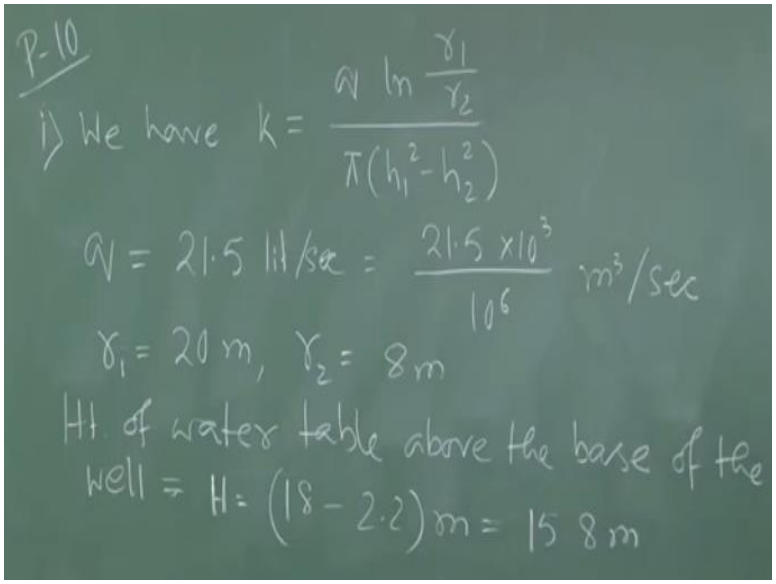

So, the problem 10, the first part basically we are going to calculate the coefficient of permeability. Now we have from our theory whatever we have covered right. So, k was given, could you remember that so q into ln r 1 by r 2 divided by pi into h 1 square by h 2 square. So, that was the expression we derived for the permeability test in the field by pumping from wells. So, if you remember then r 1 is the I mean if you recall or if you refer the previous lecture you will see that r 1 was the radial distance of the observation well 1 okay from the test well.

Similarly, r 2 was the radial distance of the observation well 2 from the test well. Whereas observation well 1 was the furthest well, furthest observation well and observation well 2 was the nearest observation well as with respect to the test well. Now whereas h 1 and h 2 are the heads, water head available at observation well 1 and observation well 2 respectively. So, now we need to find out the different parameters or the magnitude of the different parameters to obtain this coefficient of permeability.

So, first we need to find out q that is the rate of discharge okay rate of flow. So, that is given in the problem, if you recall the problem that is given as 21.5 liter per second which comes around 21.5 into 10 to the power 3 by 10 to the power 6 meter cube per second okay. Now r 1 is how much? That is the radial distance of the observation well 1 from the test well. That is the furthest well. So, that is given as 20 m whereas r 2 is given as 8 m okay.

Now the height of water table above the base of the well is equal to how much? Now what was the depth of the well? The depth of the well was the thickness of the sand layer that is 18 m. Now what is the depth of water table below the ground level? That is 2.2 m. That means a water table is situated at 2.2 m below the ground level. So, that means in the (obser) in the well, whatever, observation well or the test well whatever you consider before pumping out right.

So, the water table above the base of the well will be the total depth of the well that is 18 m minus the depth of the water table below the ground level. So, that will give you the water table available at the wells okay. So, that is given as 18 - 2.2 m. That comes as 15.8 m okay fine. So, that is the water table available at different wells before the pumping okay. Now you started pumping and you considered the steady state is reached okay.

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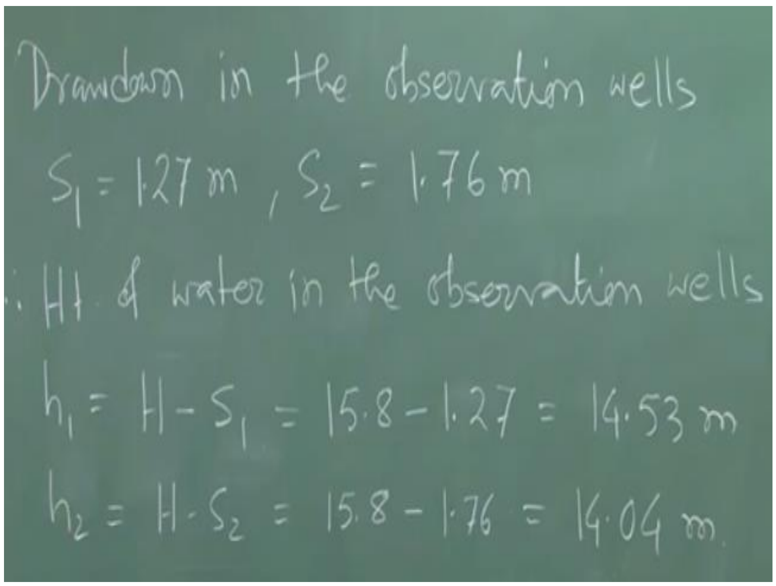

So, the drawdown after pumping out the water, drawdown in the observation wells that is given as S 1 is 1.27 if you refer the problem you will get these values and S 2 is given as 1.76 m right. Therefore, the height of water in the observation wells is given as h 1. Now in this equation we are going to find out this h 1 and h 2. So, h 1 is equal to H that is the total water level or the water height available in the observation well 1 before pumping is started. So, H is the height available. Now you have started the pumping so you have got the drawdown and that is S 1.

So, after I mean when the steady state is reached so this is the water height okay water table level in the observation well 1. So, that comes as 15.58 - 1.27 that comes as 14.53 m. Similarly, we can find out h 2 that is H - S 2 which is equal to 15.8 - 1.76 is equal to 14.04 m okay. Now we will put all these things in the previous expression of coefficient of permeability.

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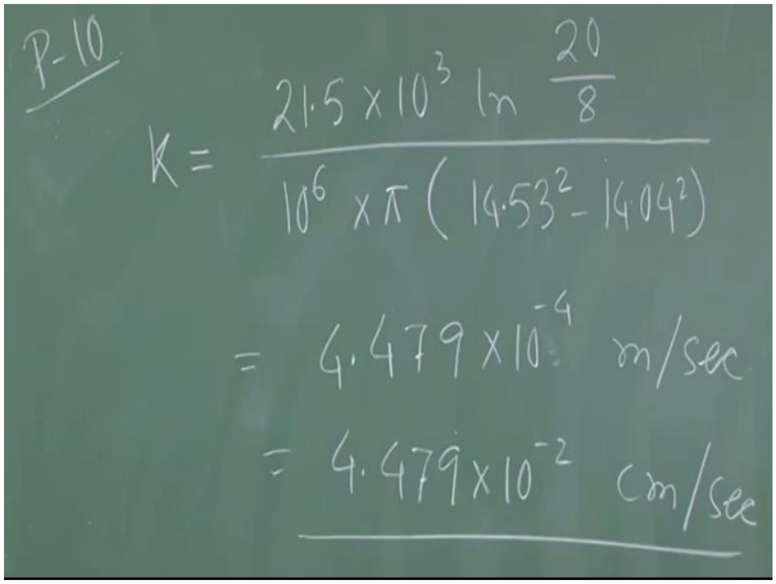

So, K can be obtained as 21.5 into 10 to the power 3 ln 20 by 8 divided by 10 to the power 6, so this is your total rate of flow, into pi into 14.53 whole square minus 14.04 whole square. So, that is h 1 and h 2 as obtained earlier. So, this gives me 4.479 into 10 to the power minus 4 meter per second which is nothing but 4.479 into 10 to the power minus 2 centimeter per second.

So, from your field experiment through the wells you have got the permeability available in the field as 4.479 into 10 to the power minus 2 centimeter per second. I hope that you have understood how we can proceed this kind of problem. Now going to the second part. That is, you need to find out the effective size right.

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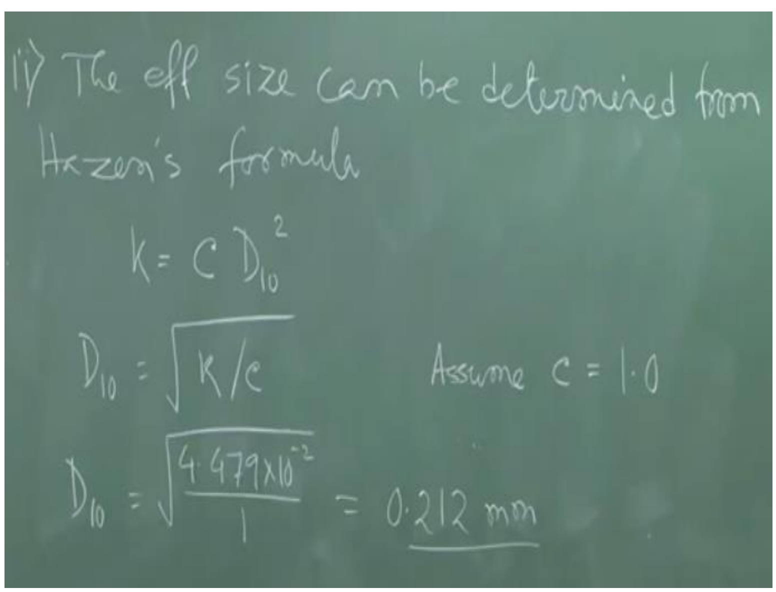

So, in the second part of the problem the effective size can be determined from some empirical relation whatever we have covered that is Hazen's formula okay. So, Hazen's formula was given as K into c some constant into D 10 square where k is in centimeter per second and D 10 will be available or will be calculated in millimeter.

So, your D 10 is nothing but root over K by c. So, let us assume if you recall C was varying from 1 to 1.5 so we are considering c as 1 okay so assume c as 1. So, your D 10 will be 4.479 into 10 to the power minus 2 that should be expressed in centimeter per second divided by 1 which comes around 0.212 mm. So, this is your effective size of the soil sample or the soil in the field. So, you have got this these information's basically. Now you can collect some soil sample from the deposit and you can find out the grain size distribution and from there you can verify that what is the detained value and how much it is coming okay fine.

So, thank you very much. So, I will stop here today. In the next class, we will be taking one more example and then we will be starting some new chapter that is seepage in soil. Thank you.