**Geology and Soil Mechanics**
**Prof. P. Ghosh**
**Department of Civil Engineering**
**Indian Institute of Technology Kanpur**
**Lecture - 27**
**In-situ Stresses - B**

Welcome back. So, in the last lecture we have seen the concept of capillary rise and the effective stress calculation and the pore water pressure calculation in the capillary zone. So, in this lecture we will be taking some numerical problems on the seepage part of the soil whatever we have learnt in last few lectures right. So, the first problem we will be taking on seepage.

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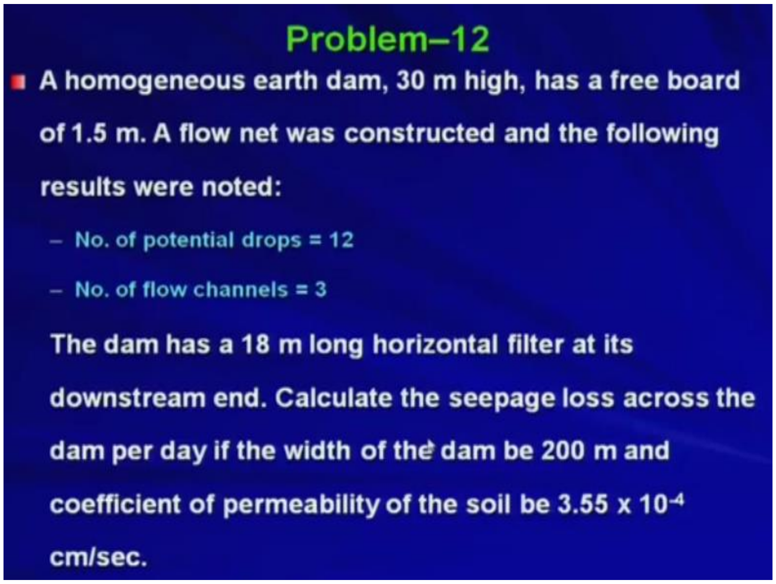


That is, a homogeneous earth dam 30 m high has a free board of 1.5 m okay. A flow net was constructed and the flowing and the following results were noted. So, number of potential drops is equal to 12. Number of flow channels is equal to 3. The dam has a 18 m long horizontal filter at its downstream end. Calculate the seepage loss across the dam per day if the width of the dam be 200 m and coefficient of permeability of the soil be 3.55 into 10 to the power minus 4 cm/sec.

Now the total height of the dam is given as 30 m and the free board is given as 1.5 m. That means so that is the difference between the top water surface or the water level and the top of the dam. So, that is known as free board so that is given as 1.5 m. So, that means the depth of water in the upstream side is 30 m - 1.5 m. So, that is the depth of water available in the upstream side.

So, that is given in the problem and the number of potential drops is given that is 12 and number of flow channels is given as 3 and the dam has 18 m long horizontal filter. So, if the filter is there so we can consider the downstream is completely dry so that means the water level difference between the upstream side and the downstream side is simply is equal to 30 - 1.5 m. So, we will solve the problem now.

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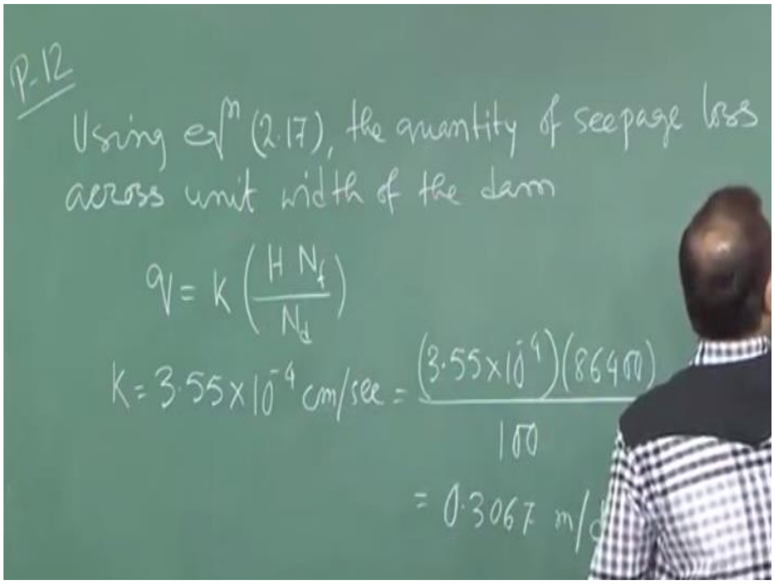


So, let us see how we can solve it. So, using the equation 2.17 if you go back to your lecture okay so in the equation 2.17 whatever equation we have given so that we will be calculating the seepage flow right. So, the quantity so using equation 2.17 as given in the lecture the quantity of seepage loss across unit width of the dam is given by q, can you recall the equation, q is equal to k into H N f by N d right already we have derived this equation for homogeneous isotropic soil so q is nothing but the seepage flow, k is the coefficient of permeability or the hydraulic conductivity okay, H is the depth of water available for this flow, N f is the number of flow I mean number of flow channels and N d is nothing but your number of potential drops right.

So, in this problem it is given K is equal to 3.55 into 10 to the power minus 4 cm/sec which can be expressed as 3.55 into 10 to the power minus 4 into 86400 to make it meter per day divide by 100 it is given as meter per day so that comes as 0.3067 m/day say okay.

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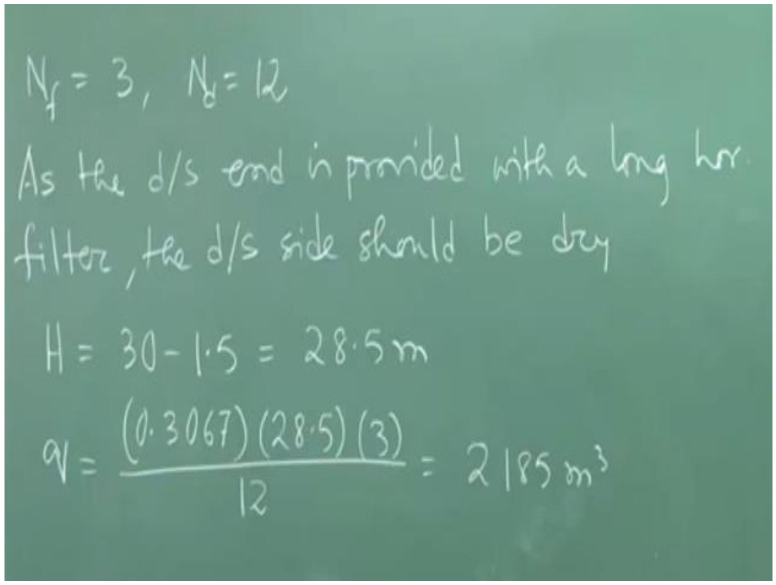


So, N f that is given in the problem as 3 N d is given as 12. So, if you know all those things so as the downstream's end is provided with a long horizontal filter the downstream side should be dry right. So, this is very important. The downstream side should be dry. If the downstream side is dry then what is the magnitude of H. So, magnitude of H is 30 - 1.5. So, this is the head which is causing this seepage flow.

So, downstream side water level is say if you consider that is at 0 then basically this is the head which is available for your seepage flow. So, that is nothing but 30 - 1.5. What is 1.5? That is the free board. That means that is the difference between the top water surface in the upstream side and the top surface of the dam or the top of the dam. So, that gives me 28.5 meter.

So, now if you put that thing in the equation you will get q is equal to 0.3067 that is the permeability into 28.5 that is H into 3 that is N f and 12 that is your potential drop, number of potential drops. So, that comes as 2.185 meter cube. So, this much of water 2.185 meter cube of water is passing through the dam for per unit width of the dam per day right. So, if the width of the dam that is given in the problem what is the width of the dam that is given as 200 meter right.

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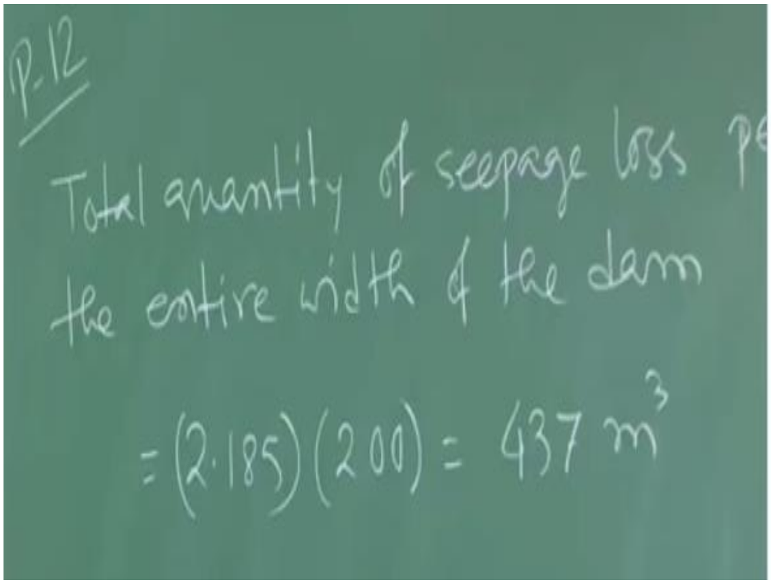


So, total quantity of seepage loss per day across the entire width of the dam is equal to 2.185 that is meter cube per meter width of dam per day. So, that is equal to 2.15 into 200 that is 437 meter cube of water okay will be seeping through the whole dam per day okay so that is the answer of the problem. So, I hope that you have understood that problem. So, now we will take the next problem.

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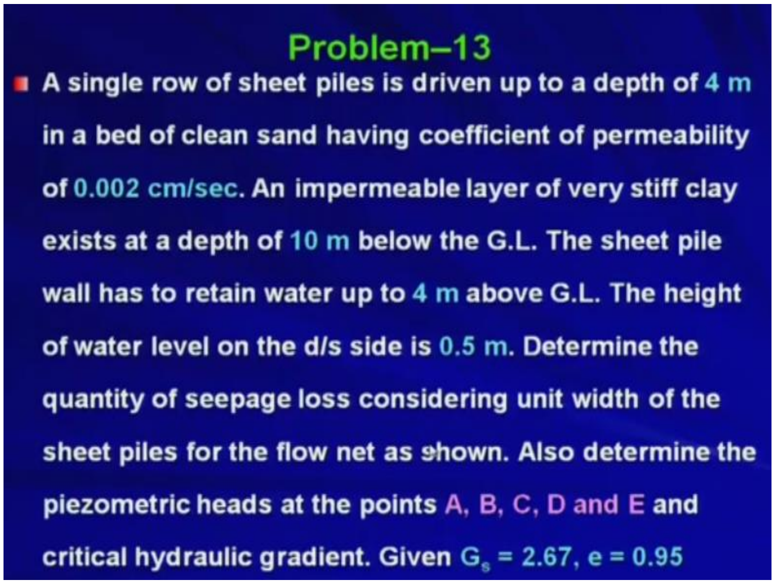


The next problem says that a single row of sheet piles is driven up to a depth of 4 meter in a bed of clean sand having coefficient of permeability of 0.002 cm/sec. An impermeable layer of very stiff clay exists at a depth of 10 m below the ground level. The sheet pile wall has to retain water up to 4 m above ground level. The height of water level on the downstream side is 0.5 m.

Determine the quantity of seepage loss considering unit width of the sheet piles for the flow for the flow net as shown. So, also determine the piezometric heads at the points A, B, C, D, and E and critical hydraulic gradient you have to calculate given G s that is the specific gravity of soil is 2.67 and e that is the void ratio is equal to 0.95.

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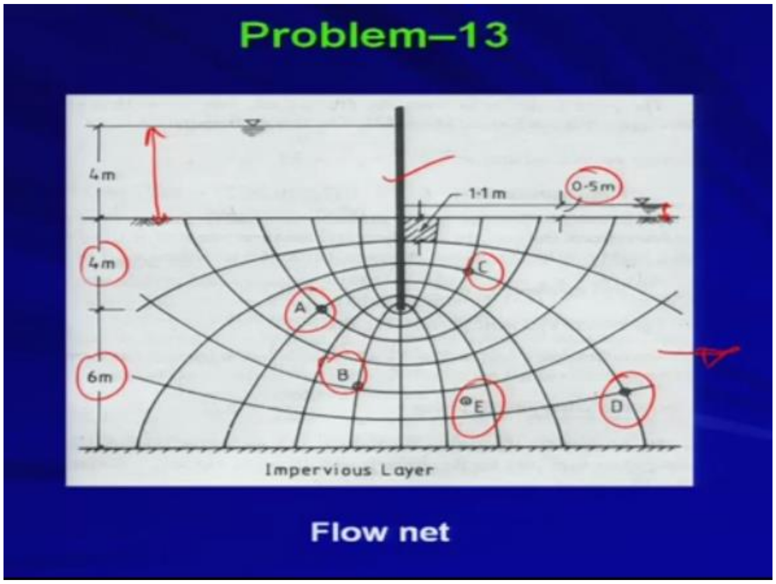


Now the if you look at the flow net and the problem. So, this is the sheet pile okay. So, this is the sheet pile. So, you have the upstream water level depth is 4 m okay and you have the impervious layer from the ground level as say 10 m, 6 + 4, 10 m. Then you have the downstream water level depth is 0.5 m okay and you have to calculate the seepage flow through this say impervious say base okay through this pervious base and you have to calculate the piezometric head at different points okay A, B, C, D, E okay. Let us solve this problem.

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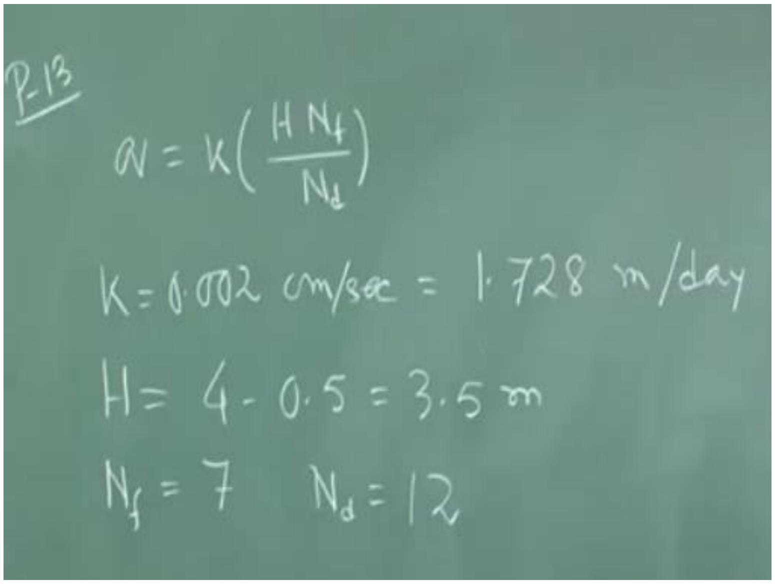


Now already we know the seepage flow is given by q is equal to K into H N f by N d. Now here K is given as 0.002 cm/sec which will be equal to 1.728 m/day very similar to the last problem we can calculate the coefficient of permeability in meter per day. Now what is H? What is the head available for this seepage flow? Can you come back to this figure and can you please tell me what should be the head? Head is nothing but the difference between the upstream water level depth minus the downstream water level depth.

So, upstream water level depth is 4 m and the downstream water level depth is 0.5 m. So, 4 - 0.5 is your H right. So, I hope that you have understood this thing. So, this is nothing but 3.5 m okay. Now from the flow net can you please identify N f and N d okay. So, if you come back to this flow net so can you find out N f. N f is that is the number of flow channels right.

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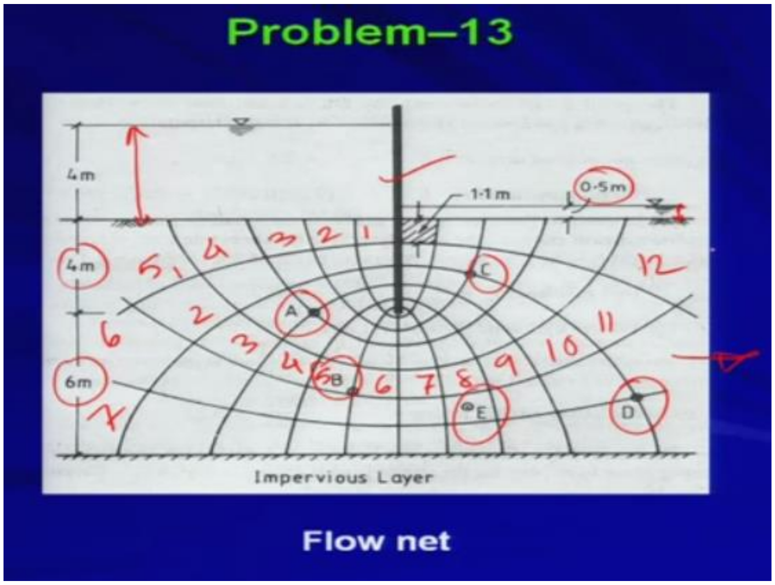


So, how many number of flow channels are there in this problem? So, this is 1, this is 2, this is 3, this is 4, this is 5, this is 6, this is 7. So, there are 7 flow channels. So, I can write N f equal to 7. So, this flow net basically you can construct by following the construction procedure of the flow net. So, as already we have discussed that the flow lines and equipotential lines they must intersect at orthogonally and the flow element that should be approximately equal to square.

So, by following these 2 I mean criteria you can construct the flow net anyway. So, the flow net has been constructed for you. So, from this flow net we can get N f that is the number of flow channel is equal to 7. Now what is the number of potential drops can you please identify how many potential drops are there? So, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12. So, your number of potential drops will be 12.

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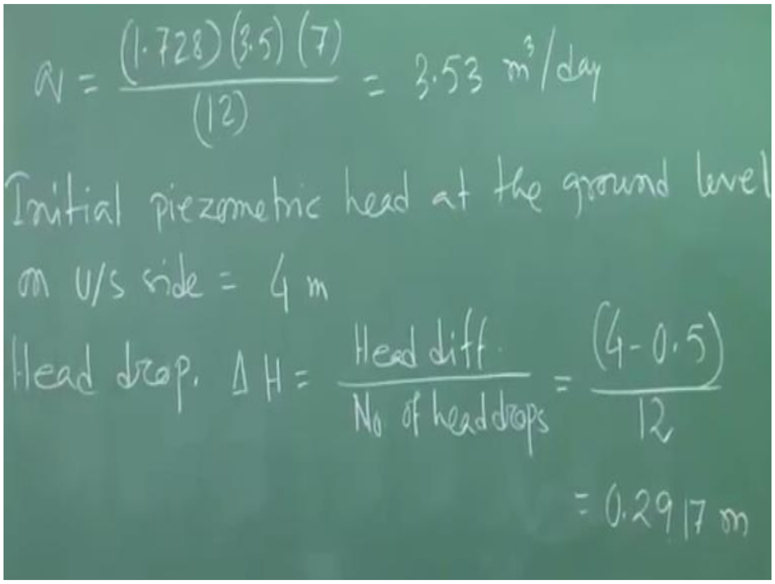


So, if you put that you will be getting q is equal to 1.728 multiplied by 3.5 that is H multiplied by 7 that is N f by N d is equal to 3.53 meter cube per day okay. So, now initial piezometric head at the ground level on upstream side is how much? The initial piezometric head at the ground level on upstream side is nothing but 4 m. If you look at the problem you will be getting that okay.

So, head drop that is say delta H per equipotential drop so basically it is nothing but the head difference by number of head drops. So, what is your head difference 4 - 0.5 right divided by what number of head drops how many number of head drops are there? So, already we have seen in the problem N d is equal to 12. So, that gives me 0.2917 m.

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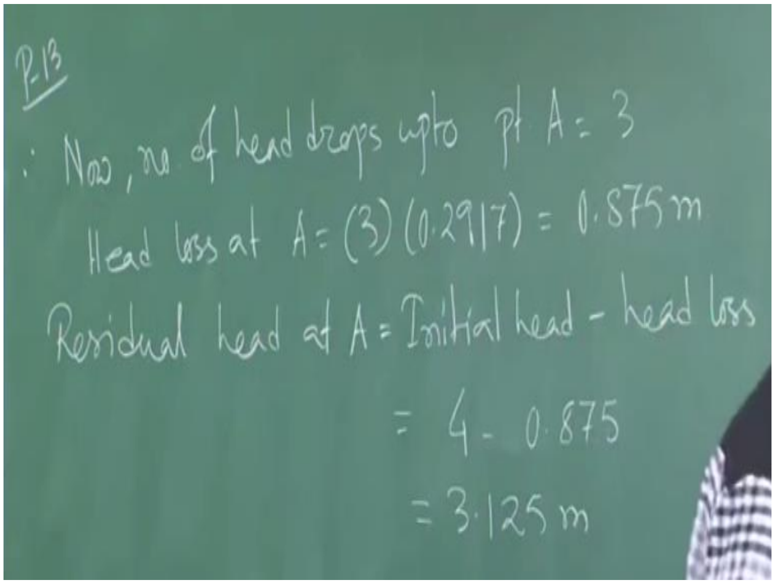

Therefore, number of head drops up to point A is how much? So, if you see number of head drops up to point A so your point A is, here right? So, how many number of head drops is there for up to point A? 1, 2, and 3. So, 3 head drops are there right. So, it is 3. So, head loss at A is equal to 3 into 0.2917 is equal to 0.875 m okay. So, that is the head loss at A. Therefore, residual head at A is equal to initial head minus head loss.

Already we have seen we have derived the expression for this right in the last few lectures when we talked about the seepage analysis. So, what was the initial head? Initial head was 4 m. Now what is the head loss 0.875. Therefore, your residual head at A is 3.125 m right. So, this is the piezometric head at point A right. Similarly, we can calculate for other points B, C, and D.

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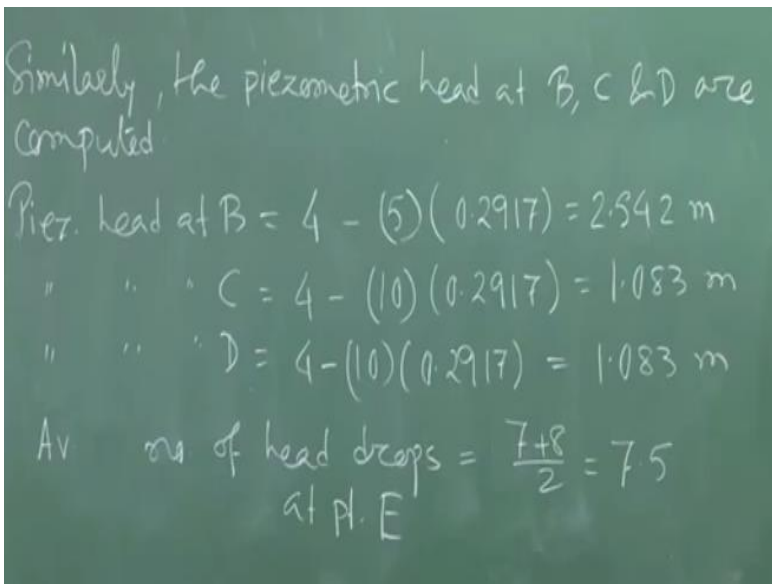


Similarly, the piezometric head at B, C, and D are computed. Piezometric head at B will be how much? What was the initial head? Initial head was 4. So, that is constant. Initial head is 4. Now if you come to point B what was the number of your potential drops? So, if you come to point B lets us see 1, 2, 3, 4, and 5. So, 5 was your number of head drops up to point B. So, 5 into 0.2197 which gives me 2.542 m.

Similarly, at C initial head 4 - 10 if you see up to c what was the number of your head drop that is 10. If you can calculate you can calculate from the flow net. So, 10 into 0.2917 that gives me 1.083. Now if you come to point B what are the number of head drops. So, that will be remaining same as C because C and D both are lying on the same equipotential lines so therefore the number of head drops must be same.

So, that also will be equal to 4 - 10 into 0.2917 equal to 1.083 m okay. Now if you look at point E, point E is in between 2 flow channel, flow lines that is fifth flow line and sixth flow line right. So, E point is in between fifth flow fifth and sixth flow lines and therefore basically we can calculate the piezometric head at point E by taking the average of head drops.

So, that means average of head drop means say just before E you have 7 number of head drops and just after E you have 8 number of head drops so if you take the average of the head drop so at point E average of number of head drops is equal to 7 + 8 by 2 which is coming as 7.5 approximately right. So, 7.5 is your average of number of head drop so average number of head drop at point E is equal to 7 + 8 by 2 is equal to 7.5. So, if I know this I can calculate the piezometric head at point.

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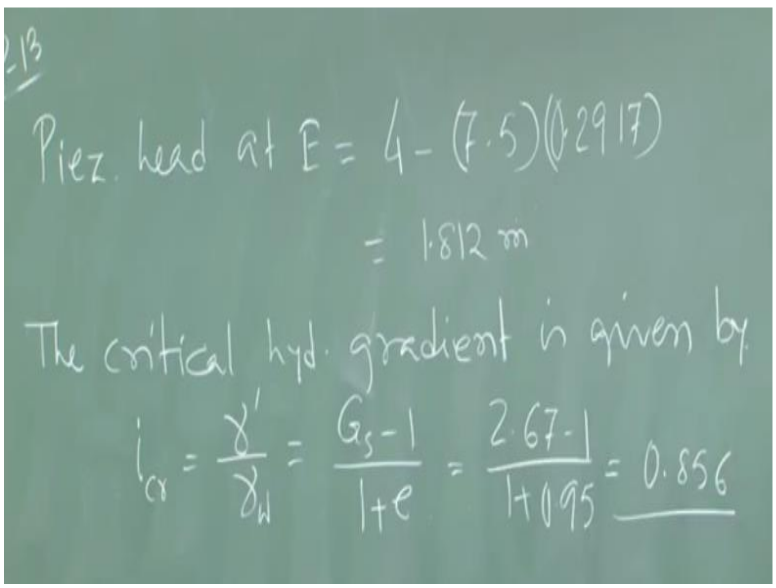


Therefore, piezometric head at E is equal to 4 - 7.5 into 0.2917. So, that gives me 1.812 m okay. So, now we have calculated the piezometric head at all the points A, B, C, D, E. Now we need to calculate the second part of the problem says that what is your critical hydraulic gradient. So, what is your critical hydraulic gradient? Hydraulic gradient is given by as you have seen i cr is equal to gamma prime by gamma w that was the expression right which can be expressed in terms of G s - 1 by 1 + e.

So, you can see from your basic principle basic say definition of this parameters you can express gamma prime by gamma w is equal to G s - 1 by 1 + e which gives me 2.67 - 1 by 1 + 0.95. These are the values given in the problem. So, that comes as 0.856 okay. I hope that you have understood this problem. So, I will stop here today. In the next lecture, we will be taking a couple of problems on the seepage and then we will be taking some other problems in the in-situ stress concept and then we will move on. Thank you very much.