Free Surface Flow
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Lecture 40

Welcome students, today we are going to try to finish this topic on spatially varied flow by solving some problems may be 2 or 3 problems in this last lecture. And then we will proceed to our new module, module 9 that is rapidly varied flow. So, without further to keep you waiting, we start with the problems.

A rectangular channel which has a width of 2 meters and n is equal to 0.014 is laid on a slope So is equal to 0.001. A side weir is required at a section such that it comes into operation when the discharge is 0.6-meter cube per second. diverts 0.15-meter cube per second when the canal discharges 0.9-meter cube per second. design the elements of the side weir. So, there is a rectangular channel whose breadth width is given that is B is equal to 2 meter and n is equal to that is Manning's number 0.014 is laid on a slope, which is So is equal to 0.001.

It says a side weir is required at a section such that it comes into operation and the discharge is 0.6 meters cube per second and diverts 0.15 meters per second when the canal discharge is 0.9-meter cube per second. Design the elements of such a side weir. So, solution is First thing to solve here is finding the normal depth. corresponding to discharge values as Q is given as 0.6 meters cube per second and also

Q is equal to 0.9-meter cube per second. This exercise we have done so many times. So, I have already solved this before, and I think you should be able to do it as well. So, the way to find normal depth is quite simple using Manning's equation. So, this is Q_0, which is first 0.6.

We have to find it. And then, for the table, we use nQ without going into too much detail. If you remember from our normal depth, for that, we need to find y_0/B, and then this is the normal depth. We have done detailed calculations, and this φ comes out to be 0.0418. y_0/B, using these tables, comes out to be 0.165, and therefore, the normal depth is 0.33 meters. In the second case, where the discharge is 0.09, this comes out to be φ, which is one of the parameters in the table to look at, is 0.220 and 0.44 meters.

Uniform flow lectures and problems to calculate these values. First step: find the normal depth corresponding to these two discharges. This we have already written down using my solutions from before. But I have mentioned this table; the reason for mentioning it is when you try to solve it on your own, you can actually match your results from here. So, now continuing the height of the weir crest.

is given as *S* is equal to 2 normal depths. to Q_1. Now, for a discharge of 0.9-meter cube per second, critical depth y_{c1} is equal to 0.9/2.0, $(q^2/g)^{1/3}$, y_C is $(q^2/g)^{1/3}$ and q is *Q/B*. and this comes out to be 0.274 meter.

Now, since *S* is greater than y_{c1} and y_0 is greater than y_{c1}, the flow is type 1. So, in the use of the De Marchi equation y_1 is equal to y_0 is equal to 0.44 V_1 is nothing but $0.9/(1 \times 0.44)$ that is 1.023 meters per second and F_1 is $1.023/\sqrt{9.81 \times 0.44}$ $V/\sqrt{gy}$ that is 0.4924.

And a specific energy E_1 is equal to $0.44 + 1.023^2/2 \times 9.81$ and that is 0.4933 meter and that is equal to E_2. So, specifically, we have calculated V_1, we have calculated Froude number, we have also calculated the specific energy E_1 here now. Now we continue. The discharge over the side weir that is Q_S is how much then the question says it allowed up to 0.15-meter cube per second.

And therefore, when this is the case discharge at the end of the weir Q_2 is equal to how much 0.9 minus because this one already discharged 0.75-meter cube per second. Now, at section 2. E_2 is equal to 0.4933 meter or equal to E_1. Therefore, we can write $y^2 + Q^2/(B^2y^2)^2 \times 2g$ is equal to y^2+0.75^2.

${y_2}^2 \times 4 \times 2 \times 9.81$ and that is equal to 0.4933. And how will the solution if you remember trial and trial and error method is the way to solve this equation. trial and error method we can get y_2 is equal to 0.46 meter.

And what is going to be f_2 then in that case, it is simple, it is $(2\sqrt{(E/y^2 - 1})$ and f_2 will 0.38. Now, De Marchi varied flow function is φM will nothing be 2E, we can see from the slides $(2E - 3s)/(E - s).\sqrt{E-y)/(E-s)}, sin^{-1}\sqrt{E-y)/(E-s)}$. Or first we see $(2E - 3s)/(E - s)$. So, $2 \times 0.4933 - 3 \times s$ is 0.33.

Divided by $0.4933 - 0.33$ equals to minus 0.02082 and φ_{M1} equals to -0.02082. $\sqrt{0.4933 - 0.44 / 0.44 - 0.33} - 3\sin^{-1}\sqrt{0.4933 - 0.44 / 0.44 - 0.33}$ And this value will come out to be -1.840. Similarly, so this $2E - 3s$ is common in this.

So, φ_{M2} will be -0.02082. $\sqrt{0.0333 / 0.13} - 3\sin^{-1}\sqrt{0.0333 / 0.13}$ and this will come to -1.416. C_m will be nothing but 0.611 (1 - 3* into the equations are given in our slides 0.4924 the lecture theory $2 + 0.4924^2$ and C_m finally comes out to be 0.502.

Now, using the equation for length of the weir given by L is equal to $3/2\ B / C_m\ (\varphi_{M2} - \varphi_{M1})$. So, L is equal to $3/2 \times 2.0 / 0.502. -1.416 + 1.840$ and this L comes out to be 2.534-meter length of the side weir. And what is the

Height of the side weir crest. So, the question was to define or determine the elements of the side weir, which we have already done here. So, this gives us a clear idea of how we are going to, you know, solve for different problems related to the side weir where we are going to find the elements. So, another question which is related to this particular question in the above question. Length of the side weir provided is 4.2 meter and meter with.

Side S is equal to 0.33 meter. It is the reverse type of question. Question is: find the discharge over the side weir. And the depth y_2. So the question is, it is a little different. What it says is, in the previous question, if the length is given, we were asked to find the different elements of the side weir. We were given, we were not given S, we were not given L, we were given other conditions like discharge is another thing, then we were asked to calculate S and L. In this question, the things have changed, and what they say is that we are giving you the side S and length L.

Of the side weir. Now, you have to find the discharge over the side weir and the depth. So, there are certain things that we know from before as well. We have calculated already from the previous question: Cm came out to be 0.502, that will not change, and E1 is equal to E2 is equal to 0.4933, also given. Now, y_1. is given as 0.44 meter, that is given, that is not asked to change. And therefore, φ_1 is also units minus 1.840.

This is already given to us. So, we are going to use this particular equation. So, this is the last equation that we used in our previous question. And what was that equation?

L is equal to $3/2\ B/C_m\ (\varphi_{M2}\ -\ \varphi_{M1})$. So, if you see in the revised question, what have we been given? We have been given length L. We know B, which is 2. We knowC_m.

We know M_1 also. Now, we need to find φ_{M2}. So, substitute the above equation the value of φ_{M2} because everything else is known.

So, our length is 4.2 meter is equal to $3/2\ \times\ 2/0.502\ \times \varphi_{M2}$ - of -1.840 or -1.840 So, now we will continue solving this. equation φ_{M2} is coming out to be -1.1372. Now, important is that the value of φ_{M2} is equal to -1.1372 is found using our most widely

used technique that is trial and error. So, you remember this φ_{M2} is a function of y. I will just write φ_M that was I will just write down the equation so that you do not get confused $y - s - 3$ by trial error, we get y_2 as 0.471 meter. So, Q_2 can be written as $By^2\sqrt{(2g(E^2 - y^2\ )})$.

So, again writing down Q_2 is equal to B is 2, y_2 is 0.471 into $\sqrt{2\ *\ 9.81\ *(0.4933\ -\ 0.471)}$ and this Q_2 will come out to be 0.623. meters cube per second. And now Q_3 that is nothing but that is discharge and this is what we have to find out discharge over the weir Q_s is Q_1 minus Q_2. So, Q_s is Q_1 minus Q_2 is equal to 0.90. - 0.623.

So, Q_s comes out to be Q_s comes out to be. So, this was one of the answers that we needed, and this was the other answer that was needed. So, this has been lengthy but a complete question that relates to the SVF and also the side weir. And I think the time is almost up. So, we finish this particular module, which was especially varied flow.

And I will meet you in the next class with our next module, which is rapidly varied flow. Thank you so much.