Free Surface Flow

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Lecture 25

Welcome students to this last lecture of this particular module, which is Module 5: Problems on Uniform Flow. So, today we will be covering 2 to 3 or maybe 4 problems, and then from the next class, we will move on to our next module, which is Gradually Varied Flow. So, without further ado, I think we will start with the problems related to uniform flow. An open channel shape is given. An open channel is V-shaped with each side being inclined at 45 degrees to the vertical. If it carries a discharge of 0.04 cubic meters per second when the depth of flow at the center is 225 *mm*, okay. Now, the question is: Calculate the slope of the channel. One additional information is given, which is assume that Chezy's coefficient *C* is given as 50. So, there are many parameters, variables, and values that are given, and the question here is to find the slope of the channel.

So, the first step, if the figure is not given, is to try to make a rough figure of how the flow conditions look. So, it says the open channel is V-shaped. So, let us draw a V-shape. And then, this is the bed; this slope is 1 in *z*, which is what we have to find out, and this is the water surface. So, what it is saying is that this depth, *y*, is equal to 225 mm, and this angle

Each of these angles is 45 degrees, and this is also 1 in *z*. So, let us write down the data that is given. The data that is given to us is that the shape of the section of the open channel The channel is triangular. The slope of each side of the channel section is equal to 45 degrees to the vertical. The discharge *Q* is also given as 0.04-meter cube per second.

Now, the depth is also given. The depth of flow at the center of the channel section *y* is equal to 225 *mm* or 0.225 meter. *C* is given as 50, and we have to find *S*, which is the bed slope. So, we have to continue the solution. So, you see it is given that tan 45 degrees is equal to *z* by 1, which implies *z* is equal to 45 degrees or *z* is equal to 1.

The second thing is we have to calculate the wetted area of the channel section. So, A is going to be $z(y^2)$ or *z* is 1 into y is (0.225^2) whole square or 0.050625 meter square. So, if we use the principle of continuity, as per the continuity principle, we have what *Q* is equal to *AV*, and *V* is where *V* is the mean Velocity of flow in the channel form. This implies for *V*, we have to do *Q/A* or *Q* is what is given in the problem is 0.04, and what was the area? 0.050625, and that gives us 0.79 meters per second. This is the velocity. So, we have found out the wetted area *A*. Now, the next step is the wetted perimeter. So, wetted perimeter *P* is equal to what? What is *P*? So, *P* is this one.

Plus this one. So, this will be twice the length of one side: $2y\left(z^2+1\right)$ or $2\times 0.225\times\sqrt{1^2+1}$, this is *z*. And this comes out to be 0.6364 meters. Hydraulic radius *R* is equal to *A/P*, and the area is 0.050625 / 0.6364 or 0.07955 mm or 0.08, basically.

So, we have the hydraulic radius now. So, since a hint is already given to us, Chezy's coefficient *C* has been given. So, which formula are we going to apply? Of course, the Chezy's formula. And what is Chezy's formula?

V is equal to $C(RS)^{0.5}$, and v we have already found out. *V* was 0.79 meters per second. *R* we know, *S* we have to find out, and *C* we have been given. So, *V* is 0.79, which is equal to $50\sqrt{RS}$. *R* is 0.07955 into *S*. Therefore, *S* is going to be $0.79^2/(50^2)$*0.07955 or 0.00314. Or, if you want to express it in terms of slope, 1 in 319. So, this is the answer to this particular question.

So, you saw a very simple problem where almost everything was given, and we needed to apply Chezy's formula and find the value of *S*. These are the types of problems that you can expect during your assignments and also maybe during the final exams—a simple one, maybe even a shorter problem with much easier calculations. Another question. So, water is conveyed in a channel of semicircular cross-section with a slope of 1 in 2500.

So, the bed slope is given. We are again given the Chezy coefficient *C*, which has a value of 56. If the radius of the channel is 0.55 meters, the radius is given. What will be the volume flowing per second when the depth of flow is equal to the radius.

So, first, it is told that the channel has a semicircular cross-section, and the bed slope is also given. The Chezy coefficient *C* has also been given, and it is also informed that the radius of the channel is 0.55 meters. It is also told that the depth of flow is equal to the radius. So, the first step will always be drawing a semicircle.

So, basically, drawing a semicircle, and the water is fully filled. This is the radius r, and this is the bed. So, the water is filled, and y is also equal to the radius, which is 0.55 meters. So, start by writing down the data that is given: the radius of the semicircular semicircular channel *r* is equal to 0.55 meters, right? The depth of the flow *y* is equal to the radius, which is equal to 0.55 meters. The bed slope is given in the question: the bed slope of the channel So is equal to 1 in 2500 or 1/2500, and the Chezy coefficient *C* is given as 56. So, this is the data that is already given to us. So, you know, the discharge is given by *AV*, which is the equation of Continuity, alright. What is *A? A* is the wetted area and is equal to $\pi(r^2)/2$, that is $\frac{\pi}{2}\times 0.55^2$ or 0.4754 meter square. And *V* is equal to the mean velocity of flow given by $C(R*S)^{0.5}$. *R* is the hydraulic radius. The hydraulic mean depth, and that is *R*, is given by *A/P*, and *P* is the wetted and which is equal to $\pi\times r$. So, *P* is $\pi\times 0.55$, that is 1.729 meters, or *R* is equal to 0.4754/1.729, which is equal to 0.275 meters. So, this is the hydraulic radius. *Q* is $AC\sqrt{RS}$, or *Q* is equal to *A* is 0.4754, *C* is 56, and the hydraulic radius is 0.275, and the slope is 1 in 2500. And this comes to be 0.279 meters cubed per second, simple.

Now, the second part of the problem is, let us say, in this particular problem, in the previous question. So, basically, the first part answer is this, in the previous question. If the channel had been rectangular in form with the same width of 1.1 meters and the depth of flow of 0.55 meters. What would be the Discharge for the same slope that is 1 in 2500 and the same value of *C* is equal to 56. So, in the first one, it was semicircular. Now, we solved this value of discharge, and now we have been asked to compare in the next problem that if everything else remains the same and if it is rectangular in shape, and the width is now given as 1.1 meters, and the depth of the flow is also equal to 0.55 meters, which was also in the previous case. What would be the discharge of the slope for the same slope and the same value of *C*?

So, quite simple. We again write the data first here. So, first, let us make the figure first. And let this be the water level. This is now given as *y* is equal to 0.55 meters, this width *B* is equal to 1.1, this is the new information that we have; this width is for a rectangular channel.

So, this is how it looks like, and other data, I mean, we will write it down: the bottom width, not the bottom width. of the channel is B is equal to 1.1 meters, depth of flow y is equal to 0.55 meters. Bed slope So is equal to 1 in 2500, same as previous, and Chezy's constant C is also 56. So, same as in the previous question. So, we start with the calculation of the wetted area, that is A, and for a rectangular section, it is nothing but $B * y$, width into depth.

And that is 1.1×0.55, which is equal to 0.605 meter square. Perimeter P is equal to $B + 2y$ or 1.1 + 2×0.55, and that is equal to 1.1 + 1.1, which is 2.2 meters. This is the weighted parameter. Hydraulic radius R is equal to A/P, which is 0.605/2.2, and that is equal to 0.275 meters. Very simple here until this point, and since Chezy's coefficient is given, the same formula applies. So, mean Velocity of flow V is equal to $C\sqrt{RS}$, or V is equal to $C\sqrt{RS}$. C is $56\times\sqrt{0.275\times\frac{1}{2500}}$, and that gives us 0.587 meters per second. That is the So, that is the mean velocity of the flow. And the volume rate of flow Q is $A\times V$, and that is 0.605 ×0.587, which is 0.355 meter cube per second. That is for the rectangular channel. So, it is quite apparent that the two previous questions require some comparison: 0.55y. Whereas, this one is 1.1, and this is also 0.55 meters, same C, same slope. Of the bed, C is equal to 56, and S is equal to 1 in 2500. So, here, this discharge came out to be 0.279 m^3/s.

Whereas, in the case of rectangular, it is 0.*355* m^3/s. So, you see, and you compare the area; the area here was 0.4754 meter square, and the area here was In the area, in this one, it was 0.605. So, this is higher than this, and one of the reasons is that the area that this rectangular section has is more compared to the radius of the, so it has more area than this semicircular.

You see, if this one thing to note is that you see rectangular will be like this. So, the diameter is also 1.1 meter, which is the same as the width of the; however, due to less area, the discharge The discharge capacity of a semicircular channel is less, and the reason is less wetted. Area, all right. So, with this problem, the solution to this problem, we will end this class here, and I will see you in the next class, the next lecture, also the beginning of a new module, which is gradually varied flow.

Thank you so much.