Free Surface Flow
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Lecture 55

Welcome back, students. Today, we are going to solve some more problems on rapidly varied unsteady flow. Maybe we will also touch upon a problem about dam break that was covered in the slides earlier. So, all right. So, let me start writing down the question.

In a tidal river. The depth and velocity of flow are 0.9 m and 1.25 m per second, respectively. So, we have been given the depth and the velocity of the flow in a tidal river. Now, due to tidal action,

a tidal bore of height 1.2 m is observed to travel upstream. Tidal bore means surge. Now, the question is: estimate the height and speed of the bore and the speed of flow after the passage of the bore. So, we have to estimate the height and speed of the bore and the speed of flow after the passage of the bore.

So, we say that let V_w which is directed downstream be the velocity of the bore. So, like always v superimpose a velocity $(-V_w)$ on the system to get the simulated flow ok. How does it look? We draw the simulated steady flow. this is y_1 this is $(V_1 + V_w)$ and this this is the bore which is brought to rest and this is y_2 and this is $(V_2 + V_w)$ and we have given y_1 we have been given 0.9 meter V_1 we also y_1 is given I think V_1 is also given. So, this looks to be a type 3 problem So, we know that here $y1=0.9$ meter and $V_1= 1.25$ meters per second $y_2 = 0.9 + 1.2 = 2.10m$.

height of the tidal bore because Δy is $y_2 - y_1$. So, this we can write 2.10 meter, this is height of the tidal bore. Now, we know the equation So, over the positive surge moving in B. $(V_1 + V_w)^2/gy1 = 1/2 \times y_2/y_1 \times (y_2/y_1 + 1)$ $(1.25 + V_w)^2 = 9.81 \times 0.9/2 \times 2.1/0.9 \times (2.1/0.9 + 1)$ And everything is known on the right-hand side. So, this comes to be 34.335, and we take the positive root. 4.61 meters per second. This is one part of the question.

The second part is by continuity. $By_2(V_2 + V_w) = By_1(V_1 + V_w)$. Then B and B get canceled: $2.1(4.61 + V_2) = 0.9(4.61 + 1.25)$. $V_2 = -2.1$ meters. This means the bore has a velocity of 4.61 meters per second and travels upstream. The river has a velocity of 2.1 meters per second directed upstream after the passage of the bore. So, this is the

complete solution to this problem. Another question: A sluice gate in a wide the channel controls the flow of water. When the flow in the downstream channel was at a depth of 2 meters with a velocity of 4 meters per second. The sluice gate was partially closed.

How? Instantaneously to reduce the discharge to 25 percent of its initial value. Estimate the velocity and depth at the gate as well as the negative wave downstream of the gate, ok. So, we say the sluice gate in a wide channel controls the flow of water. It says that the depth of the flow was 2 meters and the velocity was 4 meters per second. The sluice gate was partially closed instantaneously to reduce the discharge. So, the discharge was reduced to 25 percent.

So, the discharge was reduced to one-fourth of the initial value. Now, estimate the velocity and depth at the gate as well as the surface profile of the negative wave downstream of the gate. So, this is for the negative wave. Let suffix 1 refer to flow conditions before the gate closure and suffix 2 to conditions after the passage of the gate closure. Negative wave. This is the question about the negative wave. So, the prior velocity $V_1 = 4$ meters per second. The old discharge was how much? 4×2, that is 8 cubic meters per second.

So, therefore, new discharge $q = 4 \times 2/4 = 2 \, m^3/s = V_1 y_1$ and we saw many equations. So, we had an equation for the negative wave: $V = V_1 + 2\sqrt{gy} - 2\sqrt{gy_1}$. $V_2 = 4 + 2\sqrt{9.81 y_2} - 2\sqrt{9.81 * 2}$, $V_2 = 6.2642\sqrt{y_2} - 4.8589$. We also know $V_2 y_2 = 2.0$. We will solve this one and we will solve this one. $V_2 = 1.781$ meters per second and $y_2 = 1.123$ meter. So, for the profile substituting for V_1 and y_1 in the previous equation.

So, which equation? The equation for $x = (V_1 + 3\sqrt{9.81 y} - 2\sqrt{9.81 y_1})t$ $x = (4 + 3\sqrt{9.81 y} - 2\sqrt{9.81 \times 2})t$. $x = (9.396\sqrt{y} - 4.859)t$ And this equation represents a parabola concave upwards. and holds good for values of $y = 1.123$ meter to 2.0 meter.

This we have already seen in the slides. another problem. There is a reservoir, a reservoir to a depth of 40 meter undergoes instantaneous ideal So, this is a problem of dam break.

Depth is given 40 meter and the dam break. Question is estimate the depth and discharge intensity at the dam site and the water surface profile of the dam site. wave 3 seconds after the dam break. So, typical problem of type 4 is dam break and we are going to see we dealt very in detail in the theoretical part. So, now, we are going to see the solutions. We know the equations already. So, the water surface profile with positive x in the downstream of the gate axis is given by equation, which we have already seen in the dam break, $(-x) =$

$(3\sqrt{9.81y} - 2\sqrt{9.81 \times 40})t \qquad (-x) = (3\sqrt{gy} - 2\sqrt{9.81 \times y_1})t \; x = 39.62t - 9.396y$ at $x = 0$, $y = y_0 = 39.62/9.396 = 17.78$ meters. velocity at $x = 0$, $V = V_0 = 2/3 \times \sqrt{9.81y} = 2/3 \times \sqrt{9.81 * 40} = 13.21 \; m/s$ So, profile after 3 seconds will be $x = 39.62 \; t - 9.396 * 3 \sqrt{y}$.

So, $x = 39.62 \times 3 - 9.396 \times 3\sqrt{y}$ or $x = 118.86 - 28.188\sqrt{y}$. This will be the water surface profile of the negative wave. 3 seconds after the dam break. So, we have also seen, we have calculated the depth and discharge intensity at the dam site and water surface profile.

So, in today's problem sessions, we have seen type 1 problems, type 2 problems, negative wave, and also the dam break problem. I think this comprehensively covers all the problems that can be tackled in rapidly varied unsteady flow. And I think that will be it for the rapidly varied unsteady flow, both the lectures and also the problem-solving. And I will see you next week with a new module. Thank you so much.