Example Problem Velocity Profile

SPEAKER Rick Huizinga: In this section, we have an example problem where flow is four feet deep, and they give us a turbulent velocity profile. They give us a point velocity at 1.6 feet off of the bed, and that velocity is 3.5 feet per second. They also give us a slope of 0.0003 radians, and that it is fully developed turbulent flow over a rough surface. They ask us to determine what is the velocity at a distance above the bed of 0.5 feet. Well, first of all I'd like to give you a note on the slope. The slope that they give us is 0.0003 radians, and that means that the angle is 0.0003 radians. However, that also means that for a distance of one foot horizontally the bed rises 0.0003 feet. Slope is usually referred to as rise over run, which is actually the tangent of the angle. However, in many cases in open channel, the slope is very small, and therefore the rise over the run, which is actually equal to the tangent of theta, can be approximated as the sine of theta.

So going back to our example problem, we have the velocity distribution equation for rough flow for a rough boundary, 5.75 times U star times the logarithm of 30 Y over K sub-s. And in this case, U star and K sub-s are both unknowns. However, we know that U star is equal to the quantity of the square root of tau zero over rho, and we know that tau zero is equal to gamma times D times the sine of theta. Well, if we set gamma equal to 62.4 pounds per cubic foot and we know that our depth is four feet and we know that the sine of theta is 0.0003, we can then solve for tau zero of 0.0749 pounds per square feet so that U star then can be determined to be 0.1965 feet per second.

We can also determine K sub-s because if we know a velocity at one depth and the velocity profile, we can determine K sub-s. Since they give us the velocity of 3.5 feet per second at a distance above the bed of 1.6 feet, we can plug that into our velocity equation and get that 3.5 is equal to 5.75 times the U star that we determined, 0.1965, times the logarithm of 30 times Y of 1.6 over the value K sub-s. We then simplify and determine that the value of K sub-s is equal to 0.0383 feet. Plugging both of those into our equation then, we can solve for the velocity at a distance above the bed of 0.5 feet. V is equal to 0.575 times U star times the logarithm of 30 Y over K sub-s. When we plug in the values for U sub-star and the value of Y and the value of K

sub-s, we then can determine velocity directly, and we see that the velocity at 0.5 feet above the bed is 2.93 feet per second, which makes perfect sense considering that the velocity at 1.6 feet above the bed is 3.5 feet per second.

And that is the end of the example problem. I hope now that you will take the time to work through the problems at the end of Lesson 5.