EAH 225 HYDRAULICS

(*OPEN CHANNEL FLOW*)

TEST SOLUTIONS (23rd March 2010)

1. If the lake level upstream of the spillway in Figure 1 is 55 m above the channel floor at the base of the spillway just upstream of the hydraulic jump, estimate the depth and velocity there for a flow rate of 1000 m^3/s and a spillway width of 30 m. What is the value of the Froude number? Neglect the approach velocity in the lake and the head losses on the spillway.

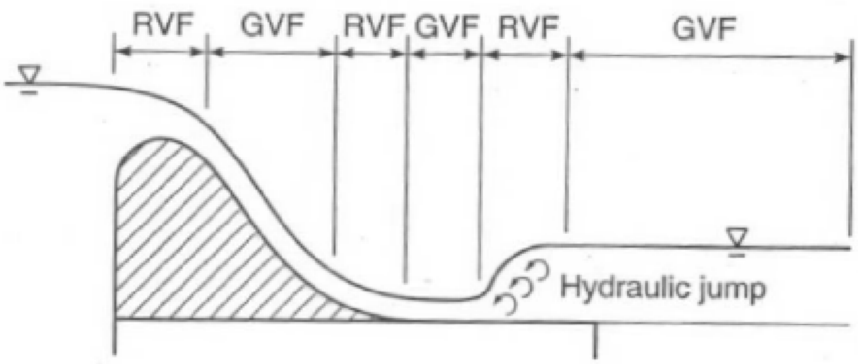

Figure 1

SOLUTION

Writing the energy equation from the water surface upstream of the spillway where the velocity head is negligible to the floor of the stilling basin downstream of the spillway, and neglecting head losses, we have

$$y_1 = y_2 + \frac{q^2}{2gy_2^2}$$

$$55 = y_2 + \frac{(1000/30)^2}{19.62y_2^2} = y_2 + \frac{56.63}{y_2^2}$$

Solving by trial and error, the result is y_2 = 1.024 m and $V_2 = q/y_2$ = 33.33/1.024 = 32.55 m/s. The Froude number becomes

$$\mathbf{F} = \frac{V_2}{\sqrt{gy_2}} = \frac{32.55}{\sqrt{9.81 \times 1.024}} = \mathbf{10.3}$$

2. A horizontal rectangular channel in Figure 2 is 6 m wide with a depth of flow of 3 m has a mean velocity of 1.5 m/s. The channel undergoes a smooth, gradual contraction to a width of 4.5 m. Calculate the depth and velocity in the contracted section. Neglect the head losses.

Figure 2

<u>SOLUTION</u>

Apply the energy equation from the approach section 1 to the contracted section 2 with negligible head losses and assuming a horizontal channel bottom:

$$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{q_2^2}{2gy_2^2}$$

where $q_2 = V_2 y_2 = (6/4.5)q_1$ = (6/4.5)(1.5)(3.0) = 6.0 m^2/s. Substituting and solving, we have

$$3.0+\frac{1.5^2}{19.62}=y_2+\frac{6.0^2}{19.62\times y_2^2}$$

$$y_2+\frac{1.835}{y_2^2}=3.115$$

from which y_2 = 2.90 m by trial and error and $V_2 = q_2/y_2$ = 6.0/2.90 = 2.07 m/s.