Application

Considering the flow upstream of a gate, the gate suddenly closes. The initial flow conditions were: Q = 5000 m^3/s, d = 5 m, B = 100 m. The new discharge is: Q = 3000 m^3/s. Compute the new flow conditions.

Solution

The surge is an advancing wave front (i.e positive surge). Using the quasi-steady flow assumption, the initial flow conditions (upstream of surge) are: d_1 = 5 m, V_1 = 10 m/s, Q_1 = 5000 m^3/s (Fr = 1.43). The flow conditions downstream of the front surge are Q_2 = 3000 m^3/s and B = 100 m.

First iteration: To start the calculations, it may be assumed U = 0 (i.e. stationary surge or hydraulic jump). For the second iteration, a new value of U is selected. For example, U = 2 m/s. Then:

(4-5) $$\frac{d_2}{d_1} = \frac{1}{2} * \left(\sqrt{1 + 8 * Fr_1^{\,2}} - 1 \right)$$

(4-6) $$\frac{Fr_2}{Fr_1} = \frac{2^{3/2}}{\left(\sqrt{1 + 8 * Fr_1^{\,2}} - 1 \right)^{3/2}}$$

$$Fr_2 = \frac{V_2 + U}{\sqrt{g * d_2}}$$

Lastly the continuity equation is checked: is (V_2*d_2*B) equal to Q2 = 3000 m^3/s ?

Calculations are repeated until a suitable value of U satisfy the continuity equation.

Notation : Equation :	U	Fr_1	d_2 Eq. (4.5)	Fr_2 Eq. (4.6)	V_2 Definition of Fr_2	V_2*d_2*B Continuity equation
1st iteration	0.0	1.43	7.91	0.72	6.3	5000
2nd iteration	2	1.71	9.88	0.62	4.1	4024
3rd iteration	3	1.86	10.9	0.58	2.98	240
Solution	3.26	1.89	11.1	0.57	2.70	3000