SLUICE GATE

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It is a special problem of orifice flow is that of the two – dimensional sluice gate, in which jet contraction only on the top of the jet and pressure distribution in the vena contract is hydrostatic. Assuming an ideal fluid, and

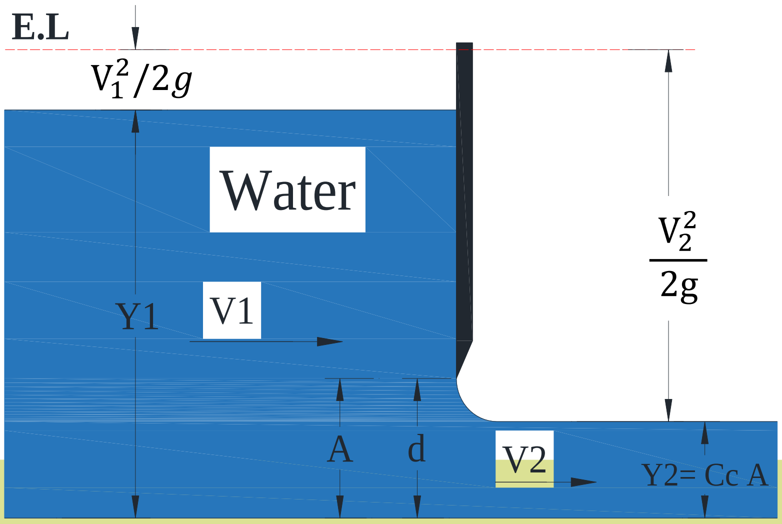
Applying Bernoulli equation between 1 and 2

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2$$

$$\boldsymbol{\frac{V_1^2}{2g} + y_1 = \frac{V_2^2}{2g} + y_2 \quad \dots\dots\dots\dots\dots \quad 1}$$

$$q = \frac{Q}{B} \;;\; y_1 V_1 = y_2 V_2 \qquad \Longrightarrow$$

$$\boldsymbol{V_1 = V_2 \frac{y_2}{y_1} \qquad \dots\dots\dots\dots \quad 2}$$



Substituting equation 2 in 1

$$y_1 - y_2 = \frac{V_2^2 - V_2^2\left(\frac{y_2}{y_1}\right)^2}{2g} \Longrightarrow 2g\,(y_1 - y_2) = V_2^2[1 - \left(\frac{y_2}{y_1}\right)^2]$$

$$V_2^2 = \frac{2g\,(y_1 - y_2)}{[1 - \left(\frac{y_2}{y_1}\right)^2]} \Longrightarrow \boldsymbol{V_2} = \sqrt{\frac{\boldsymbol{2g\,(y_1 - y_2)}}{\left[\boldsymbol{1} - \left(\frac{\boldsymbol{y_2}}{\boldsymbol{y_1}}\right)^2\right]}} \;\ldots\ldots\ldots\ldots\; \boldsymbol{3}\;\; \textit{is the theoritical velocity}$$

The actual velocity is obtained by multiplying the above eq. by Cv

$$\boldsymbol{V_{2actu} = C_V \sqrt{\frac{2g\,(y_1 - y_2)}{\left[1 - \left(\frac{y_2}{y_1}\right)^2\right]}}} \quad ; \quad \boldsymbol{q_{act} = V_{2act}\,A = V_{2act}\,y_2}$$

Flow rate is obtained by multiplying the result by (Cc A).

The flow rate through the sluice is

$$q_{actu} = C_V\, y_2 \sqrt{\frac{2g\,(y_1 - y_2)}{\left[1 - \left(\frac{y_2}{y_1}\right)^2\right]}} \quad \ldots\ldots\ldots\ldots\ldots \quad 4$$

But $\quad y_2 = C_C\, d$

$$\therefore\; q_{actu} = C_V\, C_C\, d \sqrt{\frac{2g\,(y_1 - y_2)}{\left[1 - \left(\frac{y_2}{y_1}\right)^2\right]}} \quad ; \; C_V\, C_C = C_d$$

$$\therefore\; q_{actu} = C_d\, d \sqrt{\frac{2g\,(y_1 - y_2)}{\left[1 - \left(\frac{y_2}{y_1}\right)^2\right]}} \quad \ldots\ldots\ldots\ldots\ldots \quad 5$$

*If the depth y1 becomes large compared to y2 the equation for actual discharge will be

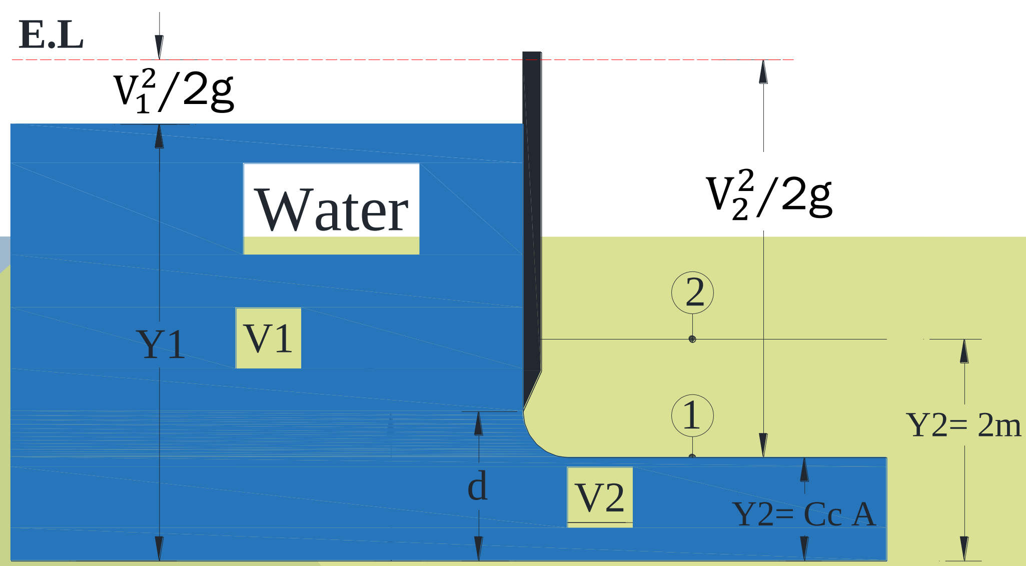
$$q_{actu} = C_d\, d\sqrt{2g\,(y_1 - y_2)}$$

Example: Determine the discharge per unit width of water passing through a sluice gate if the depth of water upstream the gate is 10 m and the opening of the gate is 1 m, then determine the discharge if the gate is submerged and the depth of water downstream the gate is 2 m; Cd = 0.6 ; Cc = 0.61

Solution:

$$y_2 = C_C\, d = 0.61 * 1 = 0.61\, m$$

$$q_{actu} = C_d\, d \sqrt{\frac{2g\,(y_1 - y_2)}{\left[1 - \left(\frac{y_2}{y_1}\right)^2\right]}} = 0.6 * 1 \sqrt{\frac{2g\,(10 - 0.61)}{\left[1 - \left(\frac{0.61}{10}\right)^2\right]}} = 8.1575\ \frac{m^3}{sec\,.m}$$



For submerged case:- Use equation 4

$$q_{actu} = C_V\, y_2 \sqrt{\frac{2g\,(y_1 - y_2)}{\left[1 - \left(\frac{y_2}{y_1}\right)^2\right]}} \quad ;$$

$$C_V = \frac{C_d}{C_C} = \frac{0.6}{0.61} = 0.9836$$

$$q_{actu} = 0.9836 * 2 \sqrt{\frac{2g\,(10 - 2)}{\left[1 - \left(\frac{2}{10}\right)^2\right]}} = 25.15\ \frac{m^3}{sec\,.m}$$

Note: For non-submerged gate use eq. 5 , C_C, C_d
For submerged gate use eq. 4, C_V