Experiment 5

Calibration of Sharp-Crested Weirs

Objectives:

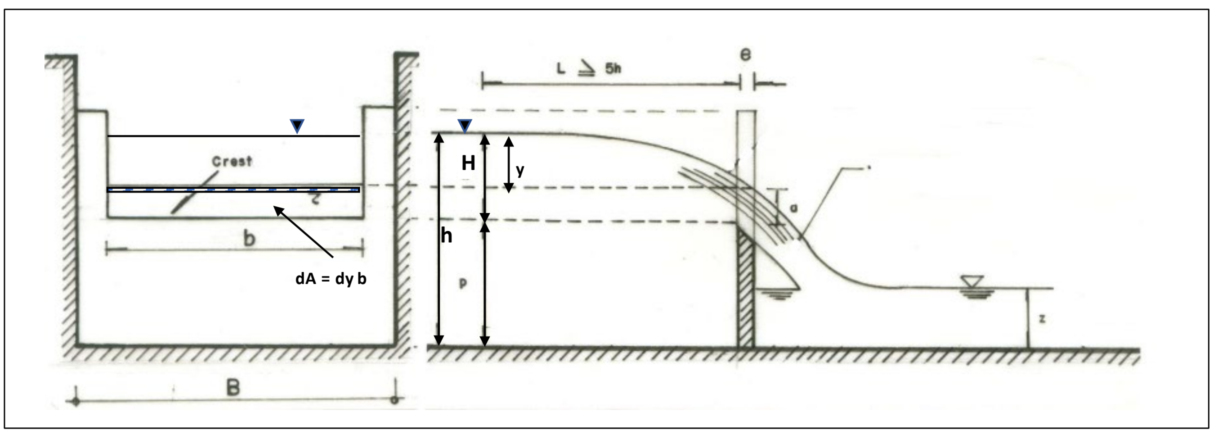
- Verify the discharge equation and estimate discharge coefficients for a rectangular and a V-notch weir.
- Measure flow data that is depend on the flow rate and shape of the weir, and use these data points to modify he equation that results from the theoretical relationships between these variables

Background:

A weir is an overflow structure extending across a stream of a channel and normal to the direction of the flow. They are normally categorized by their shape as either sharp-crested or broad-crested. This laboratory experiment focuses on sharp-crested weirs only. Two different types of weirs will be introduced: The rectangular-notch weir and the V-notch weir.

Theory:

1. **Rectangular-Notch Weir**



Consider the flow through a rectangular notch or sharp-crested weir as shown in Figure 8-1. A horizontal differential element is taken at a depth y below the free surface. The area of the element is given by,

$$dA = b\ dy \quad (5\text{-}1)$$

The velocity through the e lement is given by,

$$v = \sqrt{2gy} \tag{5-2}$$

Therefore, the theoretical discharge through the element is,

$$dQ = b\sqrt{2gy}dy \tag{5-3}$$

Integrating Eq. 8-3 yields the theoretical discharge,

$$Q_t = b\sqrt{2g}\int_0^H y^{\frac{1}{2}}dy \tag{5-4}$$

or,

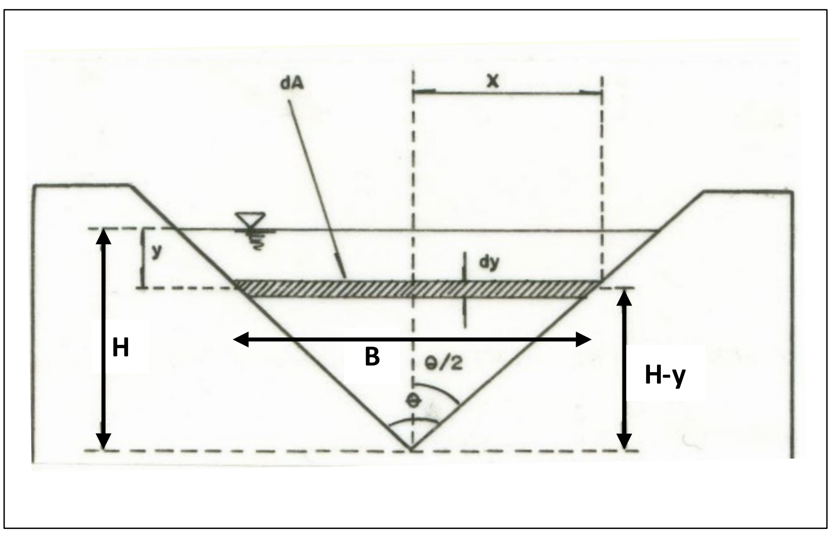
$$Q_t = \frac{2}{3}b\sqrt{2g}H^{3/2} \tag{5-5}$$

The actual discharge is given by,

$$Q_a = C_d\frac{2}{3}b\sqrt{2g}H^{3/2} \tag{5-6}$$

where C_d = the coefficient of discharge.

2. V-Notch Weir



Consider the flow through the triangular notched weir shown in above Figure. Consider an element at depth y. The breadth of the element is given by,

$$B = 2\ (H - y)\ \tan\theta \tag{5-7}$$

and the area of the differential element is then given by,

$$dA = 2\,(H - y)\,\tan\theta\,dy \tag{5-8}$$

while the velocity through the element is given by,

$$v = \sqrt{2gy} \tag{5-9}$$

The discharge through the element is,

$$dQ = 2(H - y)\sqrt{2gy}\,tan\,\theta\,dy \tag{5-10}$$

and the total theoretical discharge is obtained by integrating Eq. 8-10,

$$Q_t = 2\,tan\,\theta\,\sqrt{2g}\int_0^H \left(Hy^{\frac{1}{2}} - y^{\frac{3}{2}}\right)dy \tag{5-11}$$

which yields,

$$Q_t = \frac{8}{15}\tan\theta\sqrt{2g}H^{5/2} \tag{5-12}$$

The actual discharge is given by,

$$Q_a = C_d\frac{8}{15}tan\,\theta\,\sqrt{2g}H^{\frac{5}{2}} \tag{5-13}$$

in which C_d = the *coefficient of discharge*.

θ = 1/2 of the machined angle = 45°

N = 5/2 (triangle), and

$$K = \frac{8}{15}\sqrt{2g}\tan\theta$$

Experimental Procedure

- Measure the width of the weir.
- Turn on the pump and open the control valve until water discharges over the weir plate.
- Close the control valve and turn off the pump and allow water level to drop until water flow over the weir stops.
- Set Vernier height gauge to datum reading (water surface in the channel).
- Position the gauge at about halfway between the plate and the stilling baffle.
- Turn on the pump, open the control valve and adjust it to obtain the head H.

- After the conditions are stable, for each flow rate measure and record H.
- Take readings of volume discharged and time of discharge using the volumetric tank.
- Repeat five times for each weir type.

Data Analysis

Rectangular Weir

In a rectangular weir:

$$Q = \frac{2}{3} * C_d * b * \sqrt{2g} * H^{\frac{3}{2}}$$

Determine discharge coefficient as follows (take measurements for at least 4 different discharges (Q) and 2 to 3 trials to determine each value of Q):

1. Tabulate discharge, head and discharge coefficient.
2. By plotting a graph of the logarithm of the flow rate vs. the logarithm of the depth, compare the theoretical power law and coefficient with those obtained from the graph. Comment on your results.
3. Plot C_d vs Q for each measured Q.
4. Fit a function of the form $Y=cX^{3/2}$ for the data in 2. And from this c and what you know about the weir formula above determine C_d.

Answer in your report: Is C_d constant for this weir?

V-notch Weir

In a V-notch weir:

$$Q = \frac{8}{15} * C_d * \tan\left(\frac{\theta}{2}\right) * \sqrt{2g} * h^{\frac{5}{2}}$$

Determine discharge coefficient as follows (take measurements for at least 4 different discharges (Q) and 2 to 3 trials to determine each value of Q):

1. Tabulate discharge, head and discharge coefficient.
2. By plotting a graph of the logarithm of the flow rate vs. the logarithm of the depth, compare the theoretical power law and coefficient with those obtained from the graph. Comment on your results.
3. Plot C_d vs Q for each measured Q.
4. Fit a function of the form $Y=cX^{5/2}$ for the data in 2. And from this c and what you know about the weir formula above determine C_d.

Answer in your report: Is C_d constant for this weir?

Data Table:

Rect. Weir		Vol (L)	t (s)	V. weir		Vol (L)	t (s)
Q1	trial 1			Q1	trial 1		
	trial 2				trial 2		
	trial 3				trial 3		
h				h			
Q2	trial 1			Q2	trial 1		
	trial 2				trial 2		
	trial 3				trial 3		
h				h			
Q3	trial 1			Q3	trial 1		
	trial 2				trial 2		
	trial 3				trial 3		
h				h			
Q4	trial 1			Q4	trial 1		
	trial 2				trial 2		
	trial 3				trial 3		
h				h			
b				Theta			