Hydraulics Engineering Lec #5: Broad Crested Weirs and Venturi Flumes

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Steady Flow in Open Channels

- Specific Energy and Critical Depth
- Surface Profiles and Backwater Curves in Channels of Uniform sections
- Flow over Humps and through Constrictions
- Hydraulics jump and its practical applications.
- Broad Crested Weirs and Venturi Flumes

Broad Crested Weirs and Venturi Flumes

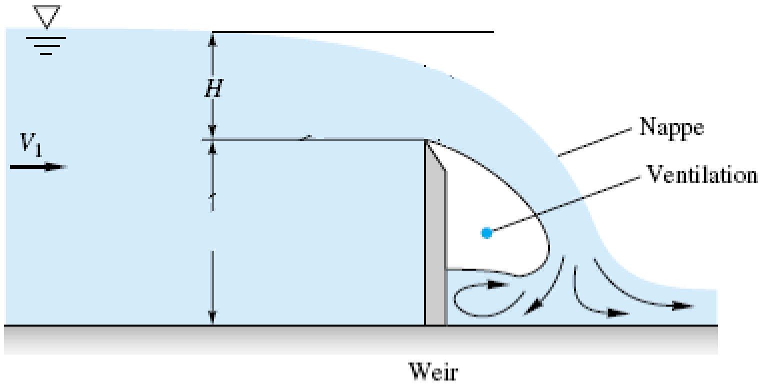
- Flow Measurement in Open Channels
- Temporary Devices
  - Floats
  - Pitot Tube
  - Current meter
  - Salt Velocity Method
  - Radio Active Tracers
- Permanent Devices
  - Sharp Crested Weir/Notch
  - Broad Crested Weir
  - Venture Flume
    - Ordinary Flume
    - Critical Depth Flume

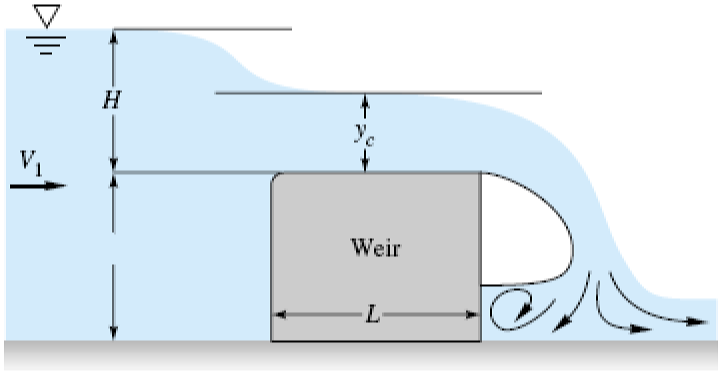
Broad Crested Weirs and Venturi Flumes are extensively used for discharge measurement in open channel.

Broad Crested Weirs and Critical flumes are based and worked on the principle of occurrence of critical depth.

Broad Crested Weir

- A *weir,* of which the ordinary dam is an example, is a channel obstruction over which the flow must deflect. For simple geometries the channel discharge *Q* correlates with gravity and with the blockage height *H* to which the upstream flow is backed up above the weir elevation. Thus a weir is a simple but effective open-channel flow-meter.
- Figure shows two common weirs, sharp-crested and broad-crested, assumed. In both cases the flow upstream is subcritical, accelerates to critical near the top of the weir, and spills over into a supercritical *nappe*. For both weirs the discharge *q* per unit width is proportional to $g^{1/2}H^{3/2}$ but with somewhat different coefficients C_d.





Broad Crested Weir

Applying Energy Equation ignoring h_L

$$H+Z+\frac{V^2}{2g} = Z + y_c + \frac{V_c^2}{2g}$$

For Critical flow $\frac{V_c^2}{2g} = \frac{y_c}{2}$

$$\therefore H+\frac{V^2}{2g} = \frac{2V_c^2}{2g} + \frac{V_c^2}{2g}$$

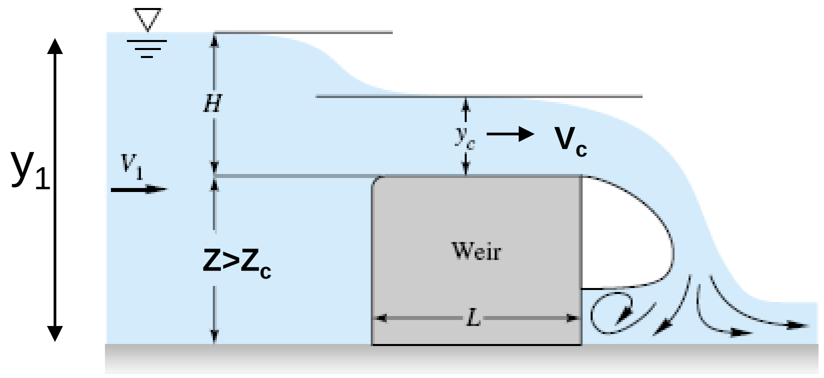
$$V_c = \sqrt{\frac{2}{3} g \left(H + \frac{V_1^2}{2g} \right)}$$

$$Since: Q = By_cV_c = B\frac{V_c^2}{g}V_c = \frac{BV_c^3}{g}$$

$$\therefore Q = \frac{B}{g}\left[\sqrt{\frac{2}{3} g \left(H + \frac{V^2}{2g} \right)}\right]^3$$

$$Q = 1.7B\left(H + \frac{V^2}{2g} \right)^{3/2} \quad in\ SI$$

$$Q = 3.09B\left(H + \frac{V^2}{2g} \right)^{3/2} \quad in\ FPS$$



V = Velocity of approach =Q/By_1

H= Head over the crest

B= Width of Channel

Since $Q_{act} = C_d Q$

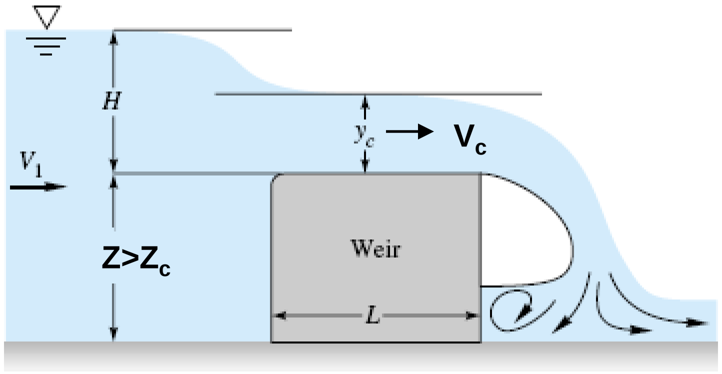
$$\therefore Q_{act} = 1.7C_dB\left(H + \frac{V^2}{2g} \right)^{3/2} \quad in\ SI$$

$$Q_{act} = 3.09C_dB\left(H + \frac{V^2}{2g} \right)^{3/2} \quad in\ FPS$$

Broad Crested Weir

Coefficient of Discharge, C_d also called Weir Discharge Coefficient C_w

- C_w depends upon *Weber number W, Reynolds number R and weir geometry (Z/H, L, surface roughness, sharpness of edges etc).* It has been found that Z/H is the most important. The Weber number W, which accounts for surface tension, is important only at low heads. In the flow of water over weirs the Reynolds number, R is generally high, so viscous effects are generally insignificant. For Broad crested weirs C_w depends on length for. Further, it is considerably sensitive to surface roughness of the crest.



Venturi Flume

Ordinary Flume

- An ordinary flume is the one in which a stream line contraction of width is provided so that the water level at the throat is drawn down but the critical depth doesn't occur.

Continuity Equation

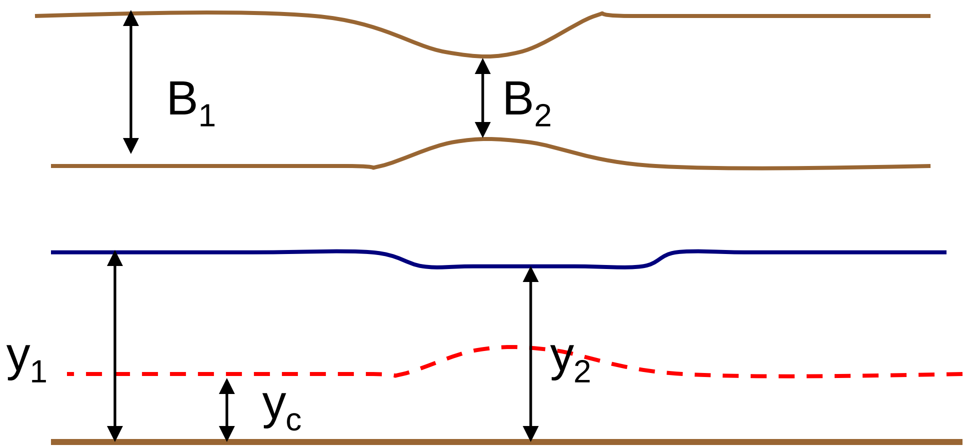
$$B_1 y_1 v_1 = B_2 y_2 v_2$$

Bernoulli's Equation

$$y_1 + \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g}$$

Using both equations, we get

$$Q = B_2 y_2 v_2 = B_2 y_2 \sqrt{\left[\frac{2gH}{1 - \left(\frac{B_2 y_2}{B_1 y_1}\right)^2}\right]}$$



$H = y_2 - y_1$

Venturi Flume

Critical Depth Flume (Standing Wave Flume)

- A critical depth flume is the one in which either the width is contracted to such an extent that critical depth occurs at the throat or more common both a hump/weir in bed & side contractions are provided to attain critical depth with hydraulic jump occurrence at d/s of throat.

Continuity Equation

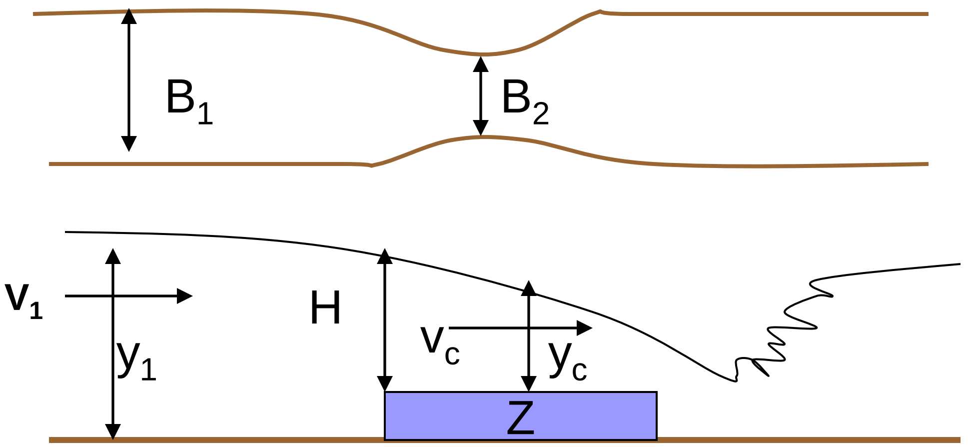
$$Q = B_1 y_1 v_1 = B_2 y_2 v_2$$

Bernoulli's Equation

$$Z + H + \frac{v_1^2}{2g} = Z + y_c + \frac{v_c^2}{2g}$$

Using both equations, we get

$$Q = B_2 y_c v_c$$



Problem: 12.66

- A broad crested weir rises 0.3m above the bottom of channel. With a measured head of 0.6m above the crest, what is rate of discharge per unit width? Allow for velocity of approach.

$Z = 0.3m$

$H = 0.6m$

$y_1 = Z + H$

$q = ???$

As we know that;

$$Q_{act} = 1.7 C_d B \left(H + \frac{V^2}{2g} \right)^{3/2}$$

$$Q_{act} = 1.7 C_d B \left(H + \frac{Q^2}{By2g} \right)^{3/2}$$

Since $B = 1$; using Trial and Error

$Q_{act} = \text{q} = 0.505\ m^3/\text{sec}/m$

Problem: 12.67

- A broad crested weir of height 0.6m in a channel 1.5m wide has a flow over it of 0.27m³/sec. What is water depth just upstream of weir?

$$Z = 0.6m$$

$$H = y_1 - 0.6$$

$$B = 1.5m$$

$$Q = 0.27m^3/\sec$$

$$Cd = 0.62$$

As we know that;

$$Q_{act} = 1.7 C_d B \left(H + \frac{Q^2}{B y_1 2g} \right)^{3/2}$$

$$0.27 = 1.7 x 0.62 x 1.5 \left(y_1 - 0.62 + \frac{0.27^2}{1.5 y_1 2g} \right)^{3/2}$$

Solving above equations reults

$$\mathrm{y}_1 = 0.905m$$

Assignment

- Problem: A venturi flume is placed in a channel 1.83m wide in which the throat width is 1.07m & the floor is effectively horizontal. Calculate the flow when the depth at the throat is 0.84 m with
  - No standing wave beyond the throat
  - Standing wave is produced beyond the throat.

  If the depth at upstream is 0.91m.

- Date of Submission:

Questions