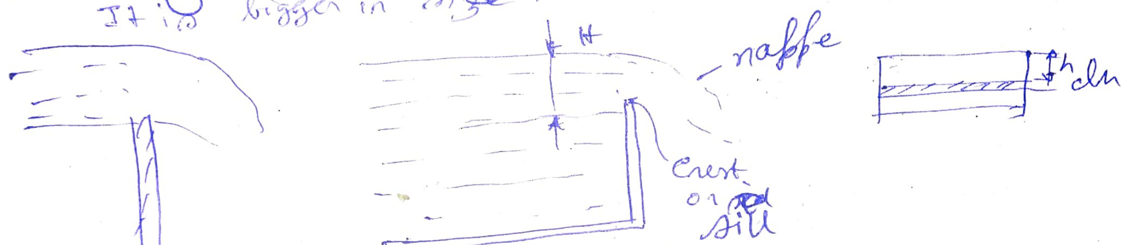
Notches & weirs.

A notch is a device used to measure the flow rate of liquid through a small channel or tank. It is an opening at the side of a tank or small channel such that liquid surface is below the top edge of the opening. It is smaller in size.

Weir is a concrete structure placed in an open channel over which the flow occurs. It is generally in the form of vertical wall, with sharp edges at the top ~~It is of bigger size.~~ running all the way across the open channel. It is bigger in size.



Rectangular notch

Nappe or Vein → The sheet of water flowing through a notch or over a weir is called nappe or vein.

Crest or sill → The bottom edge of a notch or top edge of a weir over which water flows is called sill or crest.

Classification:-

notch According to shape i) Rectangular ii) Triangular iii) Trapezoidal. iv) stepped.

According to effect on the sides of the nappe (a) Notch with end contraction (b) without end contraction.

Weir shape:- i) Rectangular ii) Triangular iii) Trapezoidal weir (Cippoletti weir)

According to shape of crest.

(i) Sharp-crested weir (ii) Broad-crested weir
(iii) Narrow crested weir (iv) Ogee-shaped weir

According to effect on the side of the emerging nappe.

Weir with end contraction
Weir without end contraction.

Discharge over rectangular notch.

Diagram on previous page.

H = head of water over crest.
L = length of notch or weir.

Elementary horizontal strip of dh is considered.

$$dA = L \times dh.$$

Theoretical vel. of water flowing through the strip $= \sqrt{2gh}$.

$$\therefore dQ = C_d \times L \times dh \sqrt{2gh}$$

$$\therefore Q = \int_0^H C_d \cdot L \cdot \sqrt{2gh}\, dh = C_d L \sqrt{2g} \int_0^H h^{1/2}\, dh$$

$$= \frac{2}{3} \cdot C_d \cdot L \sqrt{2g}\, H^{3/2}.$$

Velocity of approach → it is the velocity at which the water approaches the weir or notch before it flows over it.

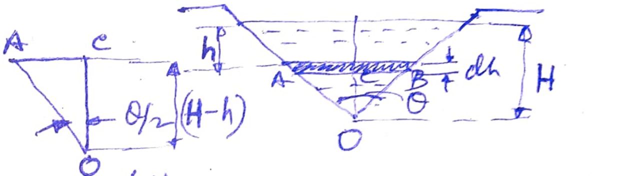
If V_a is the velocity of approach then additional head $h_a = \frac{V_a^2}{2g}$ will act on the water flowing over the notch. Then initial heigh of water over the notch becomes $(H + h_a)$ and final heigh becomes h_a.

V_a is determined by finding the discharge over the notch or weir neglecting velocity of approach.

$$\therefore V_a = \frac{Q}{\text{Area of channel}}.$$

$$Q = \frac{2}{3} C_d \times L \times \sqrt{2g} \left[(H + h_a)^{3/2} - h_a^{3/2} \right]$$

Discharge over a Triangular notch or weir.



(b)

H = head of water above the V-notch.

θ = angle of notch.

$$\tan\frac{\theta}{2} = \frac{AC}{OC} = \frac{AC}{(H-h)}$$

$$AC = (H-h)\tan\frac{\theta}{2}$$

Consider a horizontal strip of water of thickness dh at a depth of h from free surface of water.

width of strip

$$AB = 2AC = 2(H-h)\tan\theta/2$$

Area of strip $dA = 2(H-h)\tan\frac{\theta}{2} \times dh$.

Theoretical vel. of water through strip $= \sqrt{2gh}$

$$\therefore dQ = C_d \times \text{Area} \times \text{vel}$$

$$= C_d \cdot 2(H-h)\tan\frac{\theta}{2}\sqrt{2gh}\, dh.$$

$$= C_d = C_d \cdot 2(H-h)\tan\frac{\theta}{2}\sqrt{2gh}\, dh$$

$$Q = \int_0^H 2 \cdot C_d \tan\frac{\theta}{2}\sqrt{2g}\,(H-h)\sqrt{h}\, dh$$

$$= 2C_d \cdot \tan\frac{\theta}{2}\sqrt{2g}\left[\frac{Hh^{3/2}}{3/2} - \frac{h^{5/2}}{5/2}\right]_0^H$$

$$= 2C_d \cdot \tan\frac{\theta}{2}\sqrt{2g}\left[\frac{2}{3} \cdot H^{5/2} - \frac{2}{5}H^{5/2}\right]$$

$$= 2 \cdot C_d \cdot \tan\frac{\theta}{2}\sqrt{2g} \cdot \frac{4}{15} H^{5/2}$$

$$= \frac{8}{15} C_d \cdot \tan\frac{\theta}{2}\sqrt{2g}\, H^{5/2}.$$

For right angled V-notch if $C_d = 0.6$.

$$\theta = 90^\circ \quad \tan\theta/2 = 1.$$

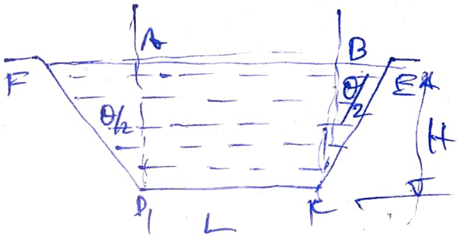
$$Q = 1.417 H^{5/2}$$

Right angles triangular notch has advantage over rectangular notch.

i) Expression simple
ii) More accurate result is obtained for low discharge.
iii) Only one reading i.e. of H is required to compute the Discharge.

Discharge over a trapezoidal notch or weir.

Trapezoidal notch or weir is a combination of a rectangular and a triangular notch or weir.



Total discharge will be sum of two weir.

$$Q = \frac{2}{3} C_{d_1} L \cdot \sqrt{2g} \, H^{3/2} + \frac{8}{15} C_{d_2} \tan\frac{\theta}{2} \sqrt{2g} \, H^{5/2}$$

Effect on discharge over a notch or weir due to error in the measurement of head.

For rectangular weir. $Q = \frac{2}{3} C_d L \sqrt{2g} \, H^{3/2}$

$= k H^{3/2}$

$$\frac{dQ}{dH} = k \cdot \frac{3}{2} H^{1/2}$$

$$\therefore dQ = k \cdot \frac{3}{2} H^{1/2} dH.$$

$$\frac{dQ}{Q} = \frac{k \, 3/2 \, H^{1/2} dH}{k H^{3/2}} = \frac{3}{2} \frac{dH}{H}.$$

$\therefore$ 1% error in head will produce 1.5% error in discharge.

For triangular weir.

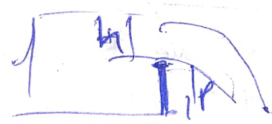
$$Q = \frac{8}{15} C_d \cdot \tan\frac{\theta}{2} \sqrt{2g}\, H^{5/2} = K H^{5/2}$$

$$dQ = K \cdot \frac{5}{2} H^{3/2} dH.$$

$$\frac{dQ}{Q} = \frac{K \cdot \frac{5}{2} H^{3/2} dH}{K H^{5/2}} = \frac{5}{2} \frac{dH}{H}.$$

$\therefore$ 1% error will produce 2.5% error in Q Flow.
on discharge over a weir a notch.

* $C_d = 0.40 + 0.05 \cdot \frac{h}{P}$



This relation is valid upto $\frac{h}{P} > 10$ and so long is weir is ventilated, i.e. atmospheric pressure prevails. on both on top and bottom of the nappe.

Average value of $C_d = 0.62$.

If length of weir is less than approaching stream then end contraction takes place.

Experimental result by Francis

width $= (L - 0.1 \times n H)$ n = no. of contraction.

$$\therefore Q = \frac{2}{3} \cdot C_d (L - 0.1 . n . H) \sqrt{2g}\, H^{3/2}.$$

or

$$Q = \frac{2}{3} C_d \left[L - 0.1 n (H + h_a)\right] \times \left[(H+h_a)^{3/2} - h_a^{3/2}\right]$$