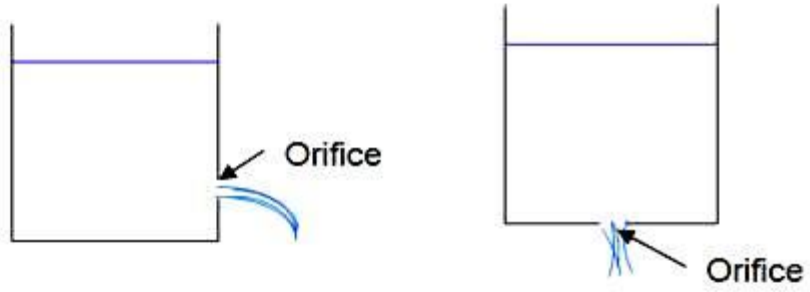
ORIFICE,NOTCHES AND WEIRS

ORIFICE

An opening, in a vessel, through which the **liquid** flows out is known as **orifice**. This hole or opening is called an **orifice**, so long as the level of the **liquid** on the upstream side is above the top of the **orifice**. The typical purpose of an **orifice** is the measurement of discharge.



a. Orifice at the side of vessel wall   b. Orifice at the bottom of vessel

Hydraulic Coefficients

The following four coefficients are known as *hydraulic coefficients* or *orifice coefficients*.

- Coefficient of contraction
- Coefficient of velocity
- Coefficient of discharge
- Coefficient of resistance

Derive the relation between the c_c,c_v and c_d

(1). Co-efficient of contraction (c_c):- it is defined as the ratio of the area of the jet at vena-contracta to the area of the orifice.

It is denoted by symbol c_c.

a = area of orifice

a_c = area of jet at vena-contracta.

$$\text{Then } c_c = \frac{\text{area of jet at vena-contracta}}{\text{area of orifice}}$$

$$C_c = \frac{ac}{a}$$

The value of **c_c** varies from **0.61 to 0.69** depending on shape and size.

In generally, the value of **c_c** may be taken as **0.64**

(2). Co-efficient of velocity (c_v):- it is defined as the ratio between the actual velocity of a jet at vena-contracta to the theoretical velocity of jet.

It is denoted by symbol **c_v**:-

$$C_v = \frac{\textit{actual velocity of jet at vena-contracta}}{\textit{theoretical velocity}}$$

$$C = \frac{v}{\sqrt{2gh}}$$

Where, v = actual velocity

$\sqrt{2gh}$ = theoretical velocity

The value of c_v varies from **0.95 to 0.99** depending on the shape and size. Generally the value of **c_v = 0.98** is taken for sharp-edged orifices.

(3). Co-efficient of discharge (c_d):- it is defined as the ratio of the actual discharge from the orifice.

It is denoted by c_d. if **Q** is actual discharge and Q_{th} is the theoretical discharge

$$C_d = \frac{actual\ velocity \times actual\ area}{theoretical\ velocity \times theoretical\ area}$$

$$C_d = c_v \times c_c$$

The value of c_d varies from 0.61 to 0.65 , generally the value of c_d is taken as 0.62

Classification of Notches:

1. The Rectangular Notch
2. The Triangular Notch or V-Notch
3. The Trapezoidal Notch

Classification of Weirs:

1. Proportional Weir
2. The Cippoletti Weir
3. Submerged Weir:
4. Anicut or Raised Weir or Barrage
5. Broad Crested Weir
6. Ogee Weir
7. Separating Weir

DISCHARGE THROUGH RECTANGULAR NOTCH:

Consider a rectangular notch shown in Fig. 9.2.

Let l = Length of the notch

H = Head of water over the crest of the notch.

Consider an elemental horizontal strip of water of length l and thickness dh, at a depth h below the free surface of water.

Theoretical velocity of water flowing through the elemental strip = $\sqrt{2gh}$

$\therefore$ Theoretical discharge through the elemental strip = $l\,dh\sqrt{2gh}$

$$\therefore \text{Total theoretical discharge} = Q = l\sqrt{2g}\int_0^H h^{1/2}\,dh = \frac{2}{3}l\sqrt{2g}H^{3/2}$$

$$\text{Actual discharge,} = q = \frac{2}{3}C_d l\sqrt{2g}H^{3/2}$$

Where = C_d = Coefficient of discharge.

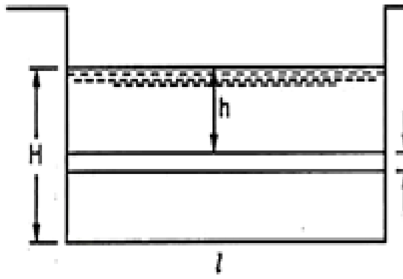


Fig. 9.2.

DISCHARGE THROUGH TRIANGULAR NOTCHES:

Fig. 9.3 shown a triangular notch.

Let H = head of water over the apex

θ = Angle of the notch

Width of the notch at any depth h

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

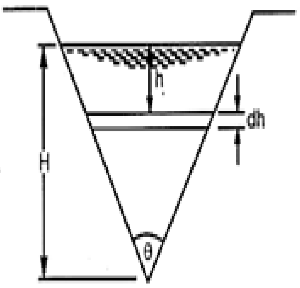


Fig. 9.3.

Consider an elemental horizontal strip of the opening at depth h and having a height dh. The theoretical velocity of flow through the strip $= \sqrt{2gh}$

$\therefore$ Theoretical discharge through the strip

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

$$\text{Total discharge} = Q = \int_0^H 2\sqrt{2g}\tan\frac{\theta}{2}(H-h)h^{1/2}\,dh$$

$$= 2\sqrt{2g}\tan\frac{\theta}{2}\left[H\frac{2}{3}H^{3/2} - \frac{2}{5}H^{5/2}\right] = \frac{8}{15}\sqrt{2g}\tan\frac{\theta}{2}H^{5/2}$$

$$\text{Actual discharge} = q = \frac{8}{15}C_d\sqrt{2g}\tan\frac{\theta}{2}H^{5/2}$$

where C_d = Coefficient of discharge

The vertex angle for a triangular notch may be from 25° to 90°. A vertex angle of 90° is commonly adopted. The coefficient of discharge is found to depend on the vertex angle. At lower heads and lower vertex angles the values of C_d are found to be higher. This may be due to a lesser degree of contraction of the nappe.

$$\text{For a 90° notch } \tan\frac{\theta}{2} = 1$$

$$\text{and the discharge} = q = \frac{8}{15}C_d\sqrt{2g}H^{5/2}$$

Taking $C_d = 0.6$, we have

$$\frac{8}{15}C_d\sqrt{2g} = \frac{8}{15}\times 0.6\sqrt{2\times 9.81} = 1.47$$

and accordingly $q = 1.417\,H^{5/2}$.

References
Fluid Mechanics & Hydraulic Machines - Dr. R.K.Bansal