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Notches

- A notch is a device used for measuring the rate of flow of a liquid through a small channel or a tank.
- It may be define as an opening in the side of a tank or a small channel in such a way that the liquid surface in the tank or a channel is below the top edge of the opening.
- The bottom edge of notch over which the liquid flows is known as **sill or crest.**
- The sheet of liquid flowing over a notch is known as **nappe or vein.**
- A notch is usually made of a metallic plate.
- A notch is used to measure discharge of a small stream or canal.

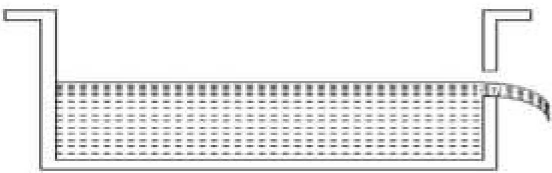
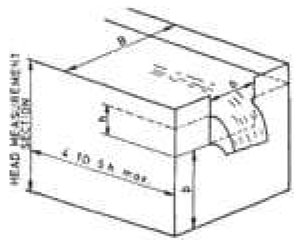
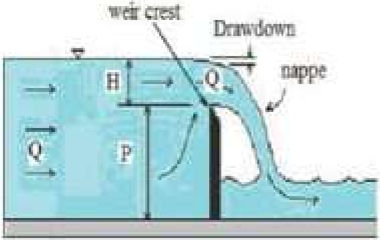


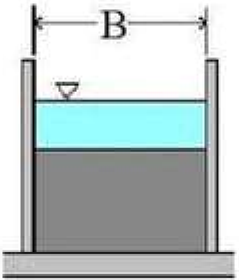
Fig : A Notch



Weirs

- A weir is a concrete or a masonry structure, placed in an open channel over which the flow occurs.
- The weir will cause an increase in the water depth as the water flows over the weir.
- In general, the greater the flow rate, the greater will be the increase in depth of flow.
- The top of a weir over which water flows is known as **crest.**
- A weir is used to measure large discharge of rivers or big canals.
- It is generally in the form of vertical wall, with a sharp edge at the top, running all the way across the open channel.





Difference Between Notch And Weir

NOTCH

- A notch may be defined as an opening provided in one side of a tank or reservoir, with u/s liquid level below the top edge of the opening.
- The bottom edge of notch over which water flows is known as sill or crest.
- A notch is usually made of a metallic plate.
- A notch is used to measure small discharge of small stream or canal.
- Notches are of small size.

WIER

- A weir may be defined as a structure constructed across a river or canal to store water on the upstream side.
- The top of the weir over which water flows is known as crest.
- A weir is made of cement concrete or masonary.
- A weir is used to measure large discharge of rivers and large canals.
- Weirs are of bigger size.

The conditions of flow, in the case of a weir, are practically the same as those of a rectangular notch. That is why, a notch is, sometimes, called as a weir and vice versa

Classification of Notches

The notches are classified as;

- According to the shape of the opening:

  1. Rectangular Notch

  2. Triangular Notch

  3. Trapezoidal Notch

  4. Stepped Notch

- According to the effect of the sides of the nappe:

  1. Notch with end contraction

  2. Notch without end contraction or suppressed notch

Classification of Weir

Weir are classified according to the shape of the opening the shape of the crest, the effect of the sides on the nappe.

According to the shape of the opening:

1. Rectangular weir
2. Triangular weir
3. Trapezoidal weir

According to the shape of the crest:

1. Sharp-crested weir
2. Broad-crested weir
3. Narrow-crested weir
4. Ogee-shaped weir

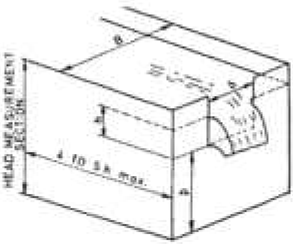
According to the effect of sides on the emerging nappe:

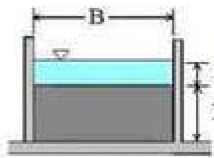
1. Weir with end contraction
2. Weir without end contraction

Discharge Over a Rectangular Notch or Weir

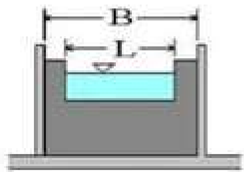
The expression for discharge over a rectangular notch or weir is the same.

- Used to control water upstream and downstream of weir
- Typically have higher discharge values
- Two main types:
- A suppressed rectangular weir is one for which the weir extends across the entire channel, so that the length of the weir, L, is the same as the width of the channel.
- Contracted weir -has notch cut into it, adding to the head loss A contracted rectangular weir is one for which the weir extends across only part of the channel, so that the length of the weir, L, is different from as the width of the channel.





suppressed rectangular weir (L = B)



Contracted Rectangular Weir

Empirical formula for discharge over rectangular weirs (IS 9108.1979 Liquid flow measurement in open Channels using thin plate weirs)

Rectangular and suppressed weirs have the same general discharge equation (below), but differing weir lengths that the water flows over

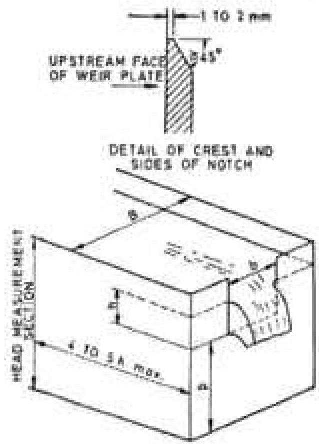
9.7.1 *Rehbock Formula (1929)* — The Rehbock formula in the form proposed in 1929 is of the effective-head variety:

$$Q = C_e \frac{2}{3} \sqrt{2g}\, b\, h_e^{3/2}$$

in which

$$C_e = 0{\cdot}602 + 0{\cdot}083\, h/p$$

$$h_e = h + 0{\cdot}001\,2$$



Where:

- Q (m^3/s) = the volumetric flow rate over the weir
- *Ce* = discharge coefficient usually ranging from 0.60 to 0.62
- h (m) = head over the weir(from the weir crest to the upstream water surface)
- p (m) = height of the weir plate
- b (m) = width of the contracted notch (rectangular), or the width of the channel (suppressed)
- g = acceleration of gravity (9.81 m/s^2)

Discharge Over a Rectangular Notch or Weir

$$Q = C_e \frac{2}{3} \sqrt{2g}\, b\, h_e^{3/2}$$

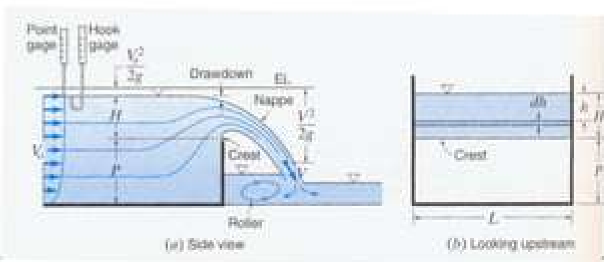
in which

$$C_e = 0{\cdot}602 + 0{\cdot}083\, h/p \qquad \ldots(17)$$

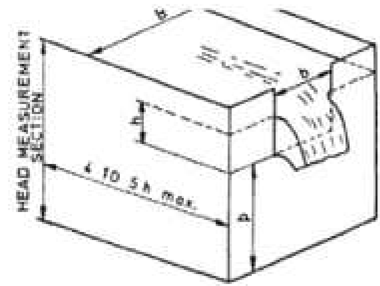
$$h_e = h + 0{\cdot}001\,2 \qquad \ldots(18)$$

Practical limitations applicable to the use of the Rehbock formula are:

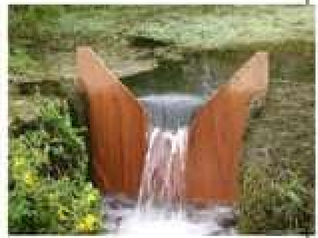
a) h/p shall be not greater than 1·0;
b) h shall be between 0·03 and 0·75 m;
c) b shall be not less than 0·30 m; and
d) p shall be not less than 0·10 m.



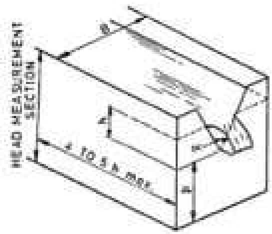
(a) Side view (b) Looking upstream



Discharge Over a Triangular Notch or Weir



- ✓ Triangular or V-notched weirs measure low discharges more accurately than horizontal weirs.
- ✓ The V-notch is most commonly a 90° opening with the sides of the notch inclined 45° with the vertical.
- ✓ It requires only readings of H, to find discharge.
- ✓ The equation of Discharge over a triangular notch



$$Q = \frac{8}{15}\sqrt{2g}\,C_e \tan\left(\frac{\theta}{2}\right) h_e^{5/2}$$
$$h_e = h_u + K_h$$

Where:

- Q (m^3/s) is flow over V-Notch weir
- *Ce* discharge coefficient
- *Kh* is an experimentally determined quantity, in metres, which compensates for the combined effects of viscosity and surface tension , can be found using the graphs given by IS Code
- *hu*(m) is the head flowing through the notch
- θ(degrees) is the notch angle , g is the acceleration of gravity(9.81 m/s^2)

Discharge over a Trapezoidal notch or Weir

- A trapezoidal notch/weir is a combination of a rectangular notch and two triangular notches as shown in figure.
- The advantage of this weir is that no correction for end contraction is required. A disadvantage is that measurement accuracy is inherently less than that obtainable with a rectangular suppressed or V-notch weir.
- The trapezoidal notch/ Weir is commonly used in irrigation systems.
- Discharge over a trapezoidal notch will be the sum of the discharge of rectangular notch and triangular notches.
- Discharge over Trapezoidal notch = Qrectangular + Qtriangular

$$Q = 2/3 . Cd . L . \sqrt{(2g)} . H^{(3/2)} + 8/15 . Cd . \sqrt{(2g)} . \tan(\theta/2) . H^{(5/21)}$$

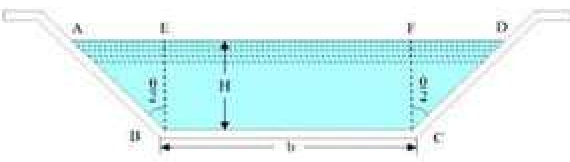
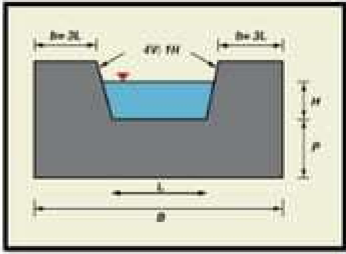


Fig : Trapezoidal Notch



Discharge over a Stepped Notch

- A stepped notch is a combination of rectangular notches as shown in figure.
- It is thus obvious that the discharge over such a notch will be the sum of the discharges over the different rectangular notches.
- Discharge over stepped notch = Discharge over Rectangular notches at different levels

$$Q = 2/3.Cd.\ b1.\sqrt{(2g)}.H1^{(3/2)} + 2/3.Cd.\ b2.\sqrt{(2g)}.H2^{(3/2)}$$

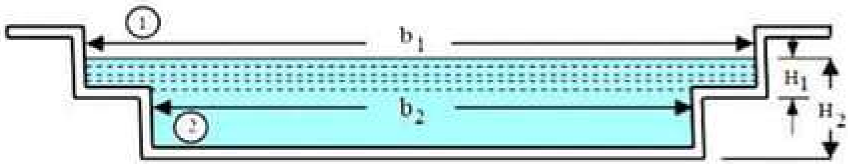


Fig : Stepped Notch

Discharge over a Sharp crested Weir

- A weir with a sharp upstream corner or edge such that the water springs clear of the crest is a sharp crested weir.
- Sharp-crested weirs are typically constructed by placing a **thin**, rust resistant metal plate, with a notch in the top of it, perpendicular to the flow of water (concrete and timber can also be used to construct).
- The flow surfaces at the top and bottom of the nappe are exposed to the air and at atmospheric pressure
- Sharp-crested weirs are usually used for smaller rivers and canals.
- The equation of Discharge over a sharp-crested weir

$$Q = \tfrac{2}{3} \cdot C_d \cdot L \cdot \sqrt{2g} \cdot H^{3/2}$$

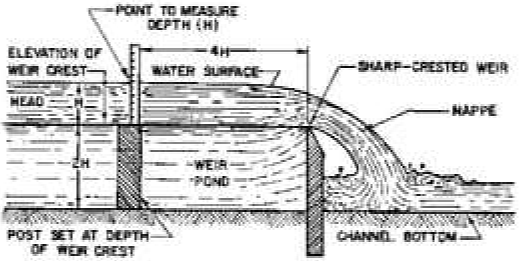
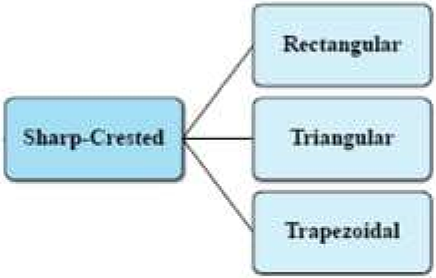
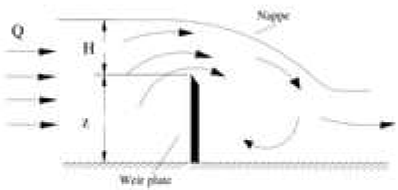


FIGURE I.—PROFILE OF A SHARP-CRESTED WEIR



Discharge over a Sharp crested Weir

- The main forces governing flow over a weir are gravity and inertia.
- The gravity accelerates the fluid from its free surface elevation upstream of the weir to a larger velocity as it flows down the hill formed by the nappe.
- Although viscous and surface tension effects are usually of secondary importance, such effects cannot be entirely neglected.
- Generally, appropriate experimentally determined coefficients such as *Francis, Bazin's* and *Rehbock's formulae* are used to account for these effects.



Francis Formula

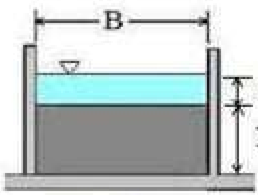
- Francis on the basis of his experiments established that end contraction decreases the effective length of the crest of weir and hence decreases the discharge.
- Each end contraction reduces the crest length by 0.1 x H, where H is the head over the weir.
- For rectangular sharp crested weir there are two end contractions only and hence effective length, **L = (L – 0.2 H)**

$$Q = (2/3)\ Cd\ \sqrt{2g}\ L\ (H)3/2$$

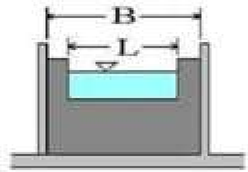
$$Q = 1.84\ (L - 0.2\ H)$$

- If end contractions are suppressed, then

$$H = 1.84\ L\ H3/2$$



suppressed rectangular weir (L = B)



Contracted Rectangular Weir

Bazin's Formula

- Bazin proposed the following formula for the discharge over a rectangular weir as,

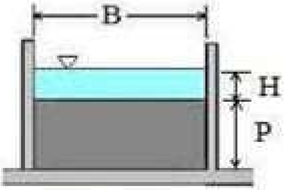
$$Q = m\, L\, \sqrt{2g}\, H3/2$$

where, m = (2/3). Cd = 4.05 + (0.003/H)

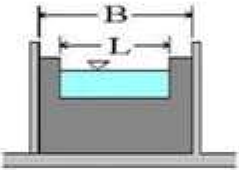
- If velocity of approach is considered, then

$$Q = m1\, L\, \sqrt{2g}\, [(H1+ha)\ 3/2 - ha3/2]$$

where, m1 = 0.405 + 0.003 / (H + ha)



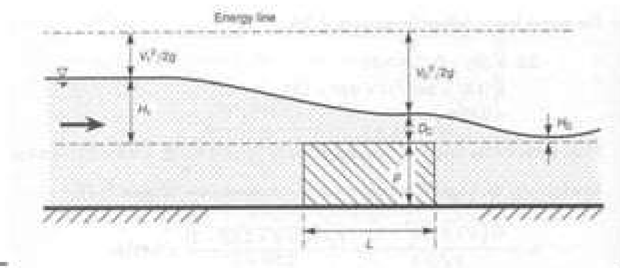
suppressed rectangular weir (L = B)



Contracted Rectangular Weir

Discharge over a Broad crested Weir

- A weir having a wide crest is known as broad crested weir.
- Let, H = height of water above the crest and L = length of the crest
- If 2L > H, the weir is called broad crested weir
- If 2L < H, the weir is called narrow crested weir
- Broad crested weirs are robust structures that are generally constructed from reinforced concrete and which usually span the full width of the channel.
- They are used for flow measurement and water level regulation in small to medium sized rivers and canals.
- Additionally, by virtue of being a critical depth meter, the broad crested weir has the advantage that it operates effectively with higher downstream water levels than a sharp crested weir.



Advantages Of Broad Crested Weir

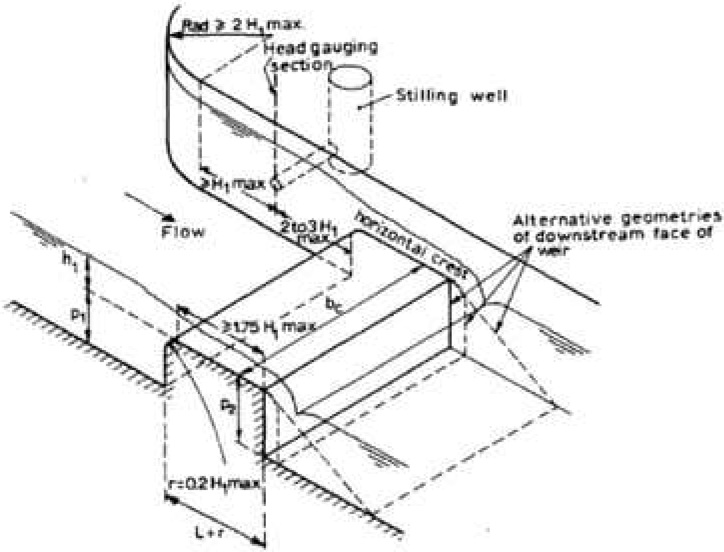
- Cost effective installation due to ease of design and construction
- Relatively small head loss across the structure
- **Sturdy** and capable of measuring discharge in small to medium channels
- Theoretical calibration possible based on post-construction dimensions
- Capable of passing floating debris

Dis-Advantages Of Broad Crested Weir

Some disadvantages of using broad-crested weirs for flow measurement and regulation:

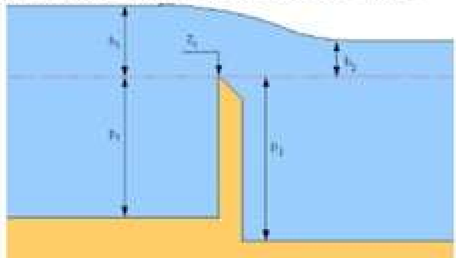
- May interfere with fish passage and disrupt ecological equilibrium
- Sediment deposition occurs on the upstream side of the structure, leading to lower sediment flow downstream and higher water levels upstream
- The channel immediately upstream of the weir is prone to sediment deposition , which in turn can compromise the accuracy of the rating curve
- Head loss occurs across the weir (especially when there is a hydraulic jump) lowering the energy of the flow

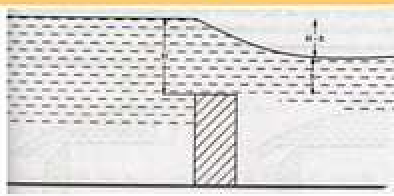
Rectangular Broad Crested Weir



Submerged or Drowned Weir

- When the water level on the d/s side of a weir is above the crest of the weir, then the weir is called to be submerged or drowned weir.
- The total discharge, over the weir is obtained by the dividing the weir into two parts.
- The portion between u/s and d/s water surface may be treated as free weir and portion between d/s water surface and crest of weir as drowned weir.





$Q1$= discharge through upper portion

$Q = \frac{2}{3} C_d . L . \sqrt{(2g)} . (H-h)^{(3/2)}$

$Q2$ = discharge through drowned portion

$Q2 = Cd2 *$ area of flow * velocity of flow

$Q2 = Cd2 * (L*h) * \sqrt{(2g(H-h))}$

Total discharge

$Q = Q1+Q2$

$Q = \frac{2}{3} C_d . L . \sqrt{(2g)} . (H-h)^{(3/2)} + Cd2 * (L*h) * \sqrt{(2g(H-h))}$

Ogee Weir

- Uncontrolled Ogee Weir/ spillway profiles are traditionally constructed to match the lower nappe surface produced by flow over a fully ventilated sharp-crested weir.
- Is is generally used as a spillway of a dam.
- The main advantage of providing such a shape is that the flowing sheet of water remains in contact with the surface of the weir and thereby preventing negative pressure being developed on the downstream side.

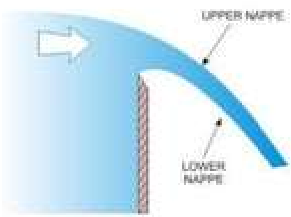


FIGURE 6. Outflow from a free-falling weir, properly ventilated from below

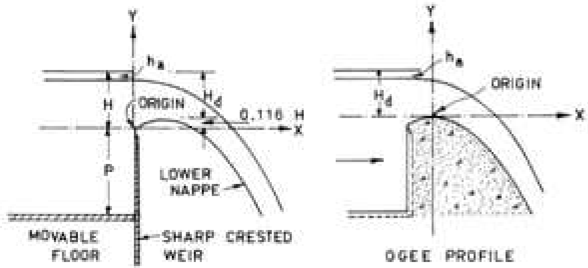


Figure 1 Principle of derivation of crest profile

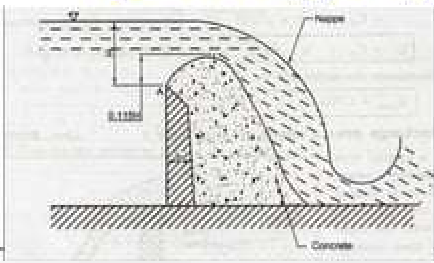
Discharge over a Ogee Weir

- United States Bureau of Reclamation (**USBR**) (1948) and many other researchers have measured lower nappe profiles and have developed design criteria for ogee crest geometry.

- A properly designed and constructed ogee crest shape will result in a discharge coefficient of 3.90 at design head, while atmospheric pressure is maintained on the spillway surface.

- The discharge for an Ogee weir is same as that of rectangular weir, and it is given by,

$$Q = \tfrac{2}{3} \cdot C_d \cdot L \cdot \sqrt{2g} \cdot H^{(3/2)}$$



Conclusion

- Some drawbacks of using weirs as diversion structures are that they interrupt the natural channel processes such as sediment flow, potentially disturbing the equilibrium of a river system.

- Head loss also inevitably occurs over these flow diversion structures, lowering the total energy of the flow.

- Benefits and costs associated with weir placement as well as the necessity of flow control should be evaluated before implementation.

- The many types of sharp- and broad crested weir designs possible offer a spread of tools capable of measuring and adjusting flow in a variety of situations.

Conclusion

- Sharp-crested and broad-crested weirs are common overflow structures used to alter the flow characteristics of a channel in order to more easily determine the volumetric flow rate or regulate flows.
- Flood control and general water management policies and practices are often designed using such data.
- Weirs also aid in making rivers more navigable and controlling flooding.
- Water flow data can also be useful for environmental impact studies, specifically in determining how the weir or other structures would affect the ecosystem of a stream or river.
- Irrigation and other water use needs programs also benefit from this kind of data


Thank You