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Subject: Hydraulics Engineering

Semester: 6th

Section : B

Assignment: 01, 02, 03

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Date : 30-June-2020

Assignment : 01

Question no: 01

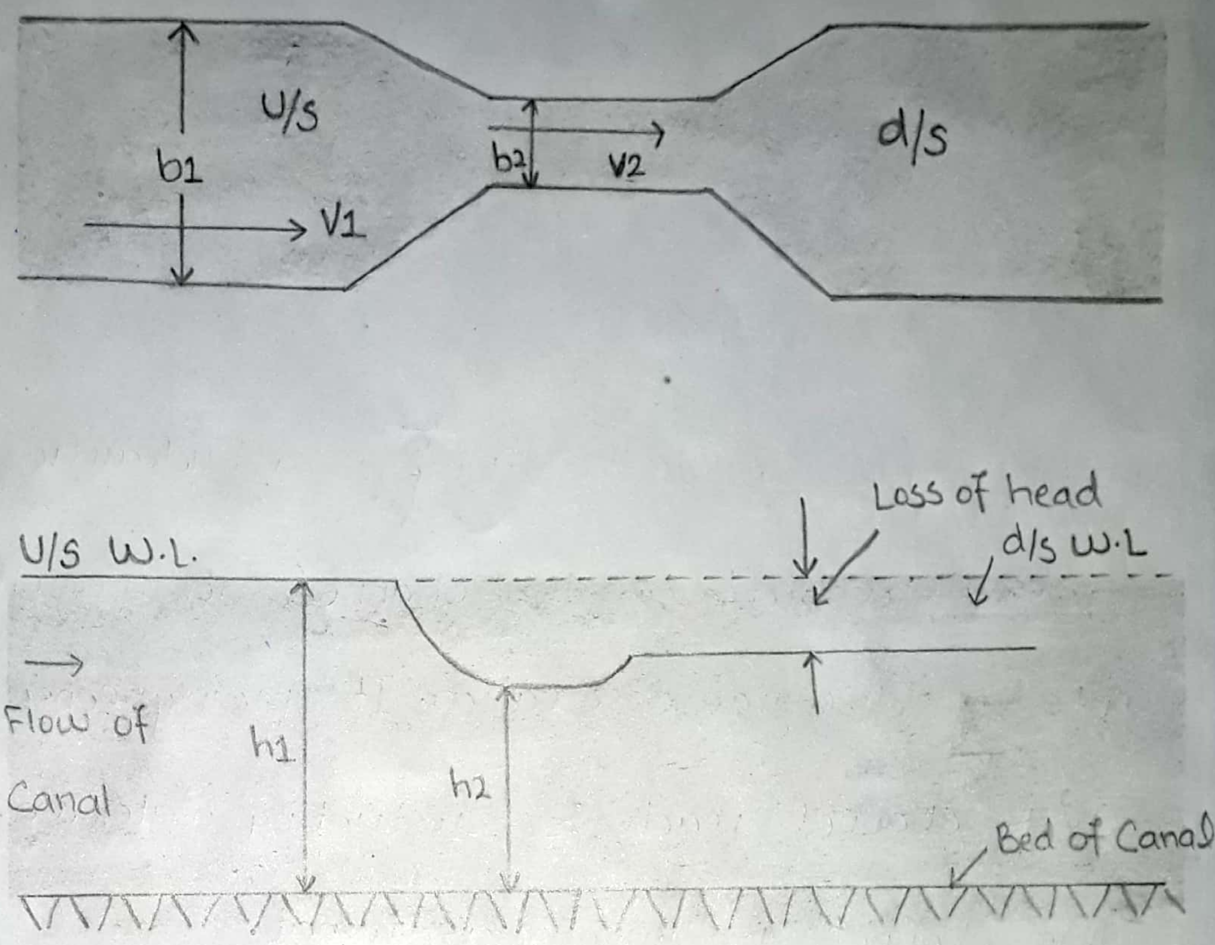
what is venturi flume? Explain with detail?

Ans: Venturi Flume: Venturi flume is a hydraulic Structure constructed in the channel for measurements of discharge observation. It mainly consist of Short channel reach for restricting water way. This channel is known as throat.

* Due to decrease in water way at the throat the velocity and the discharge per unit increases, due to which the reduction in depth of the flow occurs at the throat. The discharge of the channel is obtained by taking observations of the readings on upstream and inside the throat.

* The discharge of the channel is determined by formula:

$$Q = \frac{a_1 \cdot a_2 \sqrt{2g \cdot (h_1 - h_2)}}{\sqrt{a_1^2 - a_2^2}}$$



Venturi Flume

Advantages of flumes:

(i). Minimal drop in pressure.

(ii). Enables measurement in a large range of flow.

(iii). The flowrate in flumes is usually high enough to prevent Sedimentation, they are therefore Self cleaning.

(iv). Provides a reliable measurement in free flow and Submerged flow conditions.

Disadvantages of Flomes:

(i). Installation is usually expensive.

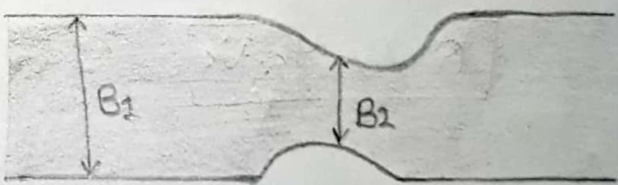
(ii). Installation requires extreme careful work.

(iii). Requires a secure watertight base.

(iv). Flow at entrance must be evenly disturbed, with little turbulence, to produce accurate measurements.

Types of flomes:

(i) Ordinary Flome: An ordinary flume is the one in which a streamline contraction of width is provided so that the water level at the throat is drawn down but the critical depth doesn't occur.

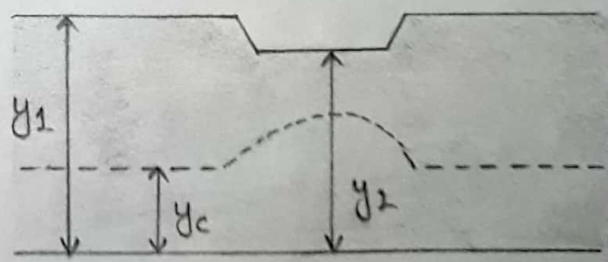


* Continuity Equation:

$$B_1 \cdot y_1 \cdot V_1 = B_2 \cdot y_2 \cdot V_2$$

* Bernoulli's Equation:

$$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g}$$



* Using both Equations we get:

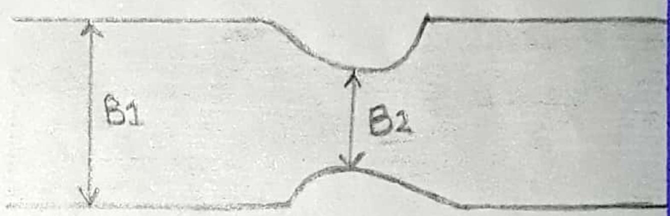
$H = y_2 - y_1$

$$Q = B_2 \cdot y_2 \cdot V_2 = B_2 \cdot y_2 \cdot \sqrt{\left[\frac{2gH}{1-\left(\frac{B_2 \cdot y_2}{B_1 \cdot y_1}\right)^2}\right]}.$$

(ii) Standing Wave Flume: A Standing wave 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 hompl weir in bed and side contractions are provided to attain critical depth with hydraulic jump, occurance at downstream of throat.

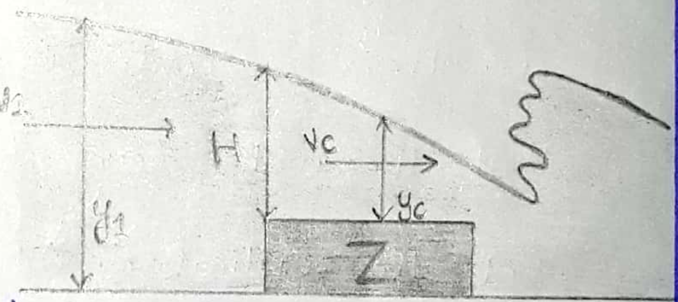
* Continuity Equation:

$$Q = B_1 \cdot y_1 \cdot V_1 = B_2 \cdot y_2 \cdot V_2$$



* Bernoulli's Equation:

$$Z + H + \frac{V_1^2}{2g} = Z + y_c + \frac{V_c^2}{2g}$$



* Using both equations we get:

$$\boxed{Q = B_2 \cdot y_c \cdot V_c}$$

Question no: 02

A 3m wide channel carries a total discharge of $12 m^3/sec$. Calculate

(a): The Critical depth.

(b): The minimum Specific energy.

(c): The alternate depth when $E = 4m$.

Given Data: Channel width $= b = 3m$

Total Dischauge $= Q = 12 m^3/sec$

Solution: (i):- The Critical depth:

$$y_c = \left(\frac{q^2}{g}\right)^{1/3}$$

$$y_c = \left(\frac{4^2}{9.81}\right)^{1/3}$$

$$\boxed{y_c = 1.177m}$$

$Q = q \cdot b$

$q = Q/b = 12/3$

$$\boxed{q = 4 m^2/sec}$$

(ii):- Emin or Minimum Sp. Energy:

$$E_{min} = y_c + \frac{v^2}{2g}$$

$$E_{min} = 1.177 + \frac{(3.398)^2}{(2 * 9.81)}$$

$$\boxed{E_{min} = 1.766m}$$

$A.V = q \cdot b$

$y \cdot \cancel{b} \cdot v = q \cdot \cancel{b}$

$v = q/y$

$v = \frac{4}{1.177}$

$$\boxed{v = 3.398 m/s}$$

(iii) :- Alternate depth = ?

* As $E > E_c$, there are two possible depths for a given Specific energy

$$E = h + \frac{v^2}{2g} \quad \text{or} \quad \boxed{E = h + \frac{q^2}{2gh^2}}$$

* Substituting values in meter-second units:

$$4 = h + \frac{0.8155}{h^2}$$

⇒ for the Subcritical solution, the first term associated with potential energy dominates, so rearrange as:

$$h = 4 - \frac{0.8155}{h^2}$$

$$\boxed{h = 3.948m}$$

⇒ for the Supercritical Solution, the second term associated with kinetic energy dominates so rearrange as:

$$h = \sqrt{\frac{0.8155}{4-h}}$$

$$\boxed{h = 0.4814m}$$

* So hence depths are 3.95m and 0.481m.

Assignment : 02

Problem: 01

Water flows at a depth of 10cm with a velocity of 6m/s in a rectangular Channel. Is it the Subcritical or Supercritical Flow? what is the alternate depth?

Given Data: Depth of water = y = 10cm or 0.1m

velocity = V = 6m/s

Required: (i) Flow Type = ?

(ii) Alternate depth = y_A = ?

Solution: (i) Using Froude Number:

$$F_r = \sqrt{\frac{V^2}{gL}} = \frac{V}{\sqrt{g \cdot y}}$$

$$F_r = \frac{6}{\sqrt{9.81 * 0.1}}$$

$$\boxed{F_r = 6.06} > 1 \Rightarrow \text{SuperCritical Flow}$$

(ii) Using Specific Energy Equation:

$$E = y + \frac{V^2}{2g}$$

$$E = 0.1 + \frac{6^2}{2*9.81}$$

$$\boxed{E = 1.934m}$$

$$E = y + \frac{V^2}{2g}$$

$$1.934 = y + \frac{6^2}{2*9.81}$$

$y_A = 1.945m$

Problem: 02 water flows with a velocity of 2m/s and at a depth of 3m in a rectangular channel. what is ------------------?

Given Data:
* Velocity = V = 2m/s
* Depth = y = 3m
* Change in Elevation = ΔZ_1 = 60cm or 0.6m (upstep)
* Change in Elevation = ΔZ_2 = 15cm or 0.15m (Down Step)

Required: (i) change in depth and water Surface elevation=?

(ii) change in depth and change in elevation=?

(iii) Max. Size of upstep before upstream depth=?

Solution:

(i):-

* $E_1 = y_1 + \frac{V_1^2}{2g}$

$E_1 = 3 + \frac{(2)^2}{(2 \times 9.81)}$

$E_1 = 3.20m$

* $E_2 = E_1 - \Delta Z_1$

$E_2 = 3.20 - 0.6$

$E_2 = 2.60m$

* Now finding y_2 value using Sp. energy equation:

* $E_2 = y_2 + \frac{q^2}{2gy_2^2}$

$$2.60 = y_2 + \frac{(6^2)}{(2*9.81)(y_2^2)}$$

$y_2 = 2.24m$

* $\Delta y = y_2 - y_1$

$\Delta y = 2.24 - 3$

$\Delta y = -0.76m$ So water Surface drops 0.16m.

(ii):-

* For a downward step of 15cm we have:

$E_2 = E_1 - \Delta z$

$E_2 = 3.20 - (-0.15)$

$E_2 = 3.35m$

* Similarly we got y_2 value from Sp. energy equation.

$y_2 = 3.17m$

* $\Delta y = y_2 - y_1$

$\Delta y = 3.17 - 3$

$\Delta y = 0.17m$ So water surface rises 0.02m (iii):-

* The maximum upstep possible affecting upstream water surface (before):

$$y_2 = y_c$$

$$y_c = \sqrt[3]{\frac{q^2}{g}}$$

$$y_c = \sqrt[3]{\frac{(6)^2}{9.81}}$$

$$\boxed{y_c = 1.54m}$$

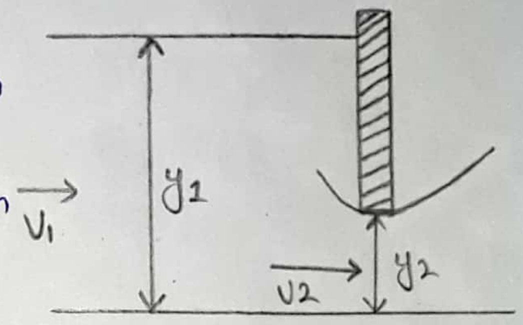
Assignment : 03

Problem:01) A water passing from the sluice gate in Dam having- ?

Given Data: Upstream depth $= y_1 = 3.6m$

Downstream depth $= y_2 = 0.9m$

Width of sluice gate $= b = 3.9m$



Required: ⓐ Dischaige (Q).

ⓑ Froud Number Upstream and downstream.

Solution: Specific energy at point is equal $E_1 = E_2$

$$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g} \longrightarrow (1)$$

Also by dischaige formula,

$$Q = A_1 V_1 = A_2 V_2$$

$$b \cdot y_1 \cdot V_1 = b \cdot y_2 \cdot V_2$$

$$y_1 \cdot V_1 = y_2 \cdot V_2$$

$$\boxed{V_2 = y_1/y_2 * V_1}$$ → Now putting values

$$V_2 = \frac{3.6}{0.9} * V_1$$

$$\boxed{V_2 = 4V_1} \longrightarrow (2)$$

⇒ Putting value of U_2 in equation B

$$y_1 + \frac{U_1^2}{2g} = y_2 + \frac{U_2^2}{2g}$$

$$3.6 + \frac{U_1^2}{2g} = 0.9 + \frac{(4U_1)^2}{2g}$$

$$3.6 + \frac{U_1^2}{2g} = 0.9 + \frac{16U_1^2}{2g}$$

$$3.6 + \frac{U_1^2}{2g} = 0.9 + \frac{16U_1^2}{2g}$$

$$\frac{U_1^2}{2g} - \frac{16U_1^2}{2g} = 0.9 - 3.6$$

$$\frac{U_1^2 - 16U_1^2}{2g} = -2.7$$

$$\frac{-15U_1^2}{2g} = -2.7$$

$$\sqrt{U_1^2} = \sqrt{\frac{2.7 * 2(9.81)}{15}}$$

$$\boxed{U_1 = 1.879 \text{ m/s}}$$

⇒ Putting values in equation 02,

$$U_2 = 4U_1$$

$$U_2 = 4(1.879)$$

$$\boxed{U_2 = 7.516 \text{ m/s}}$$

(a) Discharge (Q):-

$$Q_1 = A_1 \cdot U_1$$

$$Q_1 = b \cdot y_1 \cdot U_1 = (3.9) \cdot (3.6) \cdot (1.879)$$

$$\boxed{Q_1 = 26.38\ m^3/sec}$$

$$Q_2 = A_2 \cdot U_2$$

$$Q_2 = b \cdot y_2 \cdot U_2$$

$$Q_2 = (3.9) \cdot (0.9) \cdot (7.516)$$

$$\boxed{Q_2 = 26.38\ m^3/sec}$$

hence $Q = Q_1 = Q_2 = 26.38\ m^3/sec$

(b) Froud number at upstream side:-

$$Fr_1 = \frac{U_1}{\sqrt{g \cdot y_1}} = \frac{1.879}{\sqrt{(9.81)(3.6)}}$$

$\boxed{Fr_1 = 0.31} < 1 \Rightarrow$ it is Subcritical flow.

Froud number at downstream side:-

$$Fr_2 = \frac{U_2}{\sqrt{g \cdot y_2}} = \frac{7.516}{\sqrt{9.81 * 0.9}}$$

$\boxed{Fr_2 = 2.52} > 1 \Rightarrow$ it is Supercritical Flow.