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Subject Hydraulic Engineering

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Assignment # 1

1) What is venture flume? Explain with detail

Ans Venturi flume:-

A venturi flume is a critical-flow open flume with a constricted flow which causes a drop in the hydraulic grade line, creating depth.

It is used in flow measurement of very large flow rates, usually given in millions of cubic units. A venturi meter would normally measure in millimeters, whereas a venturi flume measures in meters.

Measurement of discharge with venturi flumes requires two measurements, one upstream and one at the throat (narrowest) cross section) If the flow passes in a subcritical state through the flume. If the flumes are designed in such in a way as to form a hydraulic jump on the downstream side of the structure These flumes are called 'standing wave flumes.

2) Example

A 3-m 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 $E = 4m$

$b = 3m$

$Q = 12 m^3/sec$

a) Discharge per unit width:

$$q = \frac{Q}{b} = \frac{12}{3} = 4 m^2 s^{-1}$$

Then, for a rectangular channel:

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{4^2}{9.81}\right)^{1/3} = 1.177m$$

critical depth $= 1.18m$

b) For a rectangular channel

$$E_c = \frac{3}{2} y_c = \frac{3}{2} \times 1.177 = 1.766 m$$

minimum specific energy $= 1.77m$

c) As $E > E_c$, there are two possible depths for a given specific energy.

$$E = h + \frac{V^2}{2g} \quad \text{where } V = \frac{Q}{A} = \frac{q}{h} \text{ (for rectangular channel)}$$

$$\Rightarrow E = h + \frac{q^2}{2gh^2}$$

Substituting values in metre-second units

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

For the subcritical (slow, deep) solution the first term, associated with potential energy dominates so rearrange as

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

Iteration (from, e.g., $h = 4$) gives $h = 3.948$m

For the supercritical (fast, shallow) solution, the second term, associated with kinetic energy.

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

Iteration (from e.g., $h = 0$) gives $h = 0 = 0.4814$m

alternate depths are 3.95m and 0.481m.

Assignment #2

Problem # 1

Water flow at a depth - - - - -

- - - - - alternate depth?

Solution:-

Check Froud number

$$Fr = \frac{V}{\sqrt{gy}} = \frac{6m/s}{\sqrt{9.81/s^2 \cdot 0.1m}} = 6.06 > 1$$

so the flow is supercritical

$$E = y + \frac{V^2}{2g} = 0.1m + \frac{(6m/s)^2}{2.981\,m/s^2} = 1.935m$$

solving for the alternate depth for an

$E = 1.935\,m$ yields $y_{alt} = 1.93m$.

Problem # 2

water flows with a velocity of 2m/s - -

- - - - at a depth of 3m in a rectangular

channel - - - - - - - - - - -

Solution:-

$$E_1 = y_1 + \frac{V_1^2}{2g} = 3m + \frac{(2m/s)^2}{2.981m/s^2} = 3.20m$$

$$E_2 = E_1 - \Delta_2 = 3.20m - 0.60m = 2.60m$$

Also

$$E_2 = y_2 + \frac{q^2}{2gy_2^2} = y_2 + \frac{(6m^3/s/m)^2}{2.981m/s^2 \cdot y_2^2} = 2.60m$$

so $y_2 = 2.24m$. $\Delta y = y_2 - y_- = -0.76m$ so water surface drops 0.16m

For a downward step of 15cm we have

$$E_2 = E_1 - \Delta z = 3.20m - (-0.15m) = 3.35m$$

giving $y_2 = 3.17m$ and $\Delta y = y_2 - y_1 = 0.17$ m so water surface rises 0.02m.

The maximum upstep possible before affecting upstream water surface is

$$y_2 = y_c$$

$$y_c = \sqrt[3]{\frac{q^2}{g}} = \sqrt{\frac{(6m^3/s/m)^2}{9.81m/s^2}} = 1.54m$$

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Assignment # 3

Given data:

$y_1 = 3.6m$, $y_2 = 0.9m$

$b = 3.9m$

Sol:-

As we know that

$$E_1 = E_2$$

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

Also

$$Q = A_1V_1 = A_2V_2$$

$$b_1 y_1 . V_1 = b_2 y_2 V_2 \qquad (b = b_1 = b_2)$$

$$\cancel{b} . y_1 . V_1 = \cancel{b}_1 \, y_2 . V_2$$

$$y_1 . V_1 = y_2 . V_2$$

$$V_2 = \frac{y'}{y_2} \times V_1$$

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

$$\boxed{V_2 = 4V_1} \quad — (2)$$

Putting in eq ①

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

$$3.6 + \frac{V_1^2}{2g} = 0.9 + \frac{(4V_1)^2}{2g}$$

$$3.6 + \frac{V_1^2}{2g} = 0.9 + \frac{16V_1^2}{2g}$$

$$\frac{V_1^2}{2g} - \frac{16V_1^2}{2g} = 0.9 - 3.6$$

$$\frac{V_1^2 - 16V_1^2}{2g} = -2.7$$

$$\frac{\cancel{-}15V_1^2}{2g} = \cancel{-}2.7$$

$$\sqrt{V_1^2} = \sqrt{\frac{2.7 \times 2(9.81)}{15}}$$

$$\boxed{V_1 = 1.879 \text{ m/sec}}$$ → putting in ② we get

$$V_2 = 4V_1$$

$$V_2 = 4(1.879) \Rightarrow \boxed{V_2 = 7.516 \text{ m/sec}}$$

⇒ As

$$Q_1 = A_1V_1 = by_1 \cdot V_1$$

$$= 3.9 \times 3.6 \times 1.879$$

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

$$\Rightarrow Q_2 = A_2 V_2 = b \cdot y_2 \cdot V_2$$

$$= 3.9 \times 0.9 \times 7.516$$

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

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

(1) Froud Number → At upstream side

$$F_{r_1} = \frac{V_1}{\sqrt{g y_1}} = \frac{1.879}{\sqrt{9.81 \times 3.6}} = 0.31$$

sub-critical flow

(2) Froud Number → At Downstream side

$$F_{r_2} = \frac{V_2}{\sqrt{g y_2}} = \frac{7.516}{\sqrt{9.81 \times 0.9}} = 2.52$$

Super-critical flow.