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Section

A

Semester

6th

Subject

Hydraulic Engineering

Submitted to

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Question # 01

Venture Flume :- A Venture flume is a critical open flume with a constricted flow which causes a drop in the hydraulic grade line, creating a critical 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 millimeter, where as a Venturi flume measure in meter.
- ⇒ Measurement of discharge with Venturi flumes requires two measurements, one upstream and one at the throat, if the flow passes in a subcritical state through the flume.
- ⇒ If the flume are designed so as to pass the flow from sub critical to supercritical state while passing through at the flume, a single measurement at the throat is sufficient for computation of discharge. To ensure the occurrence of critical depth at the throat, the flume are usually designed in such way as to form the structure.

Question # 02

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

- * The critical depth.
- * The minimum specific energy
- * The alternate depth where $E = 4\text{m}$

Given Data

Wide of channel = $b = 3\text{m}$

Discharge = $Q = 12 \text{ m}^3/\text{sec}$

Solution:-① Critical depth

⇒ Discharge per unit width

$$q = Q/b = \frac{12}{3}$$

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

For Rectangular channel.

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

$$h_c = 1.18 \text{ m}$$

(b) Minimum Specific Energy (E_c) = ?

For Rectangular channel

$$E_c = \frac{3}{2} h_c = \frac{3}{2} \times 1.18$$

$$E_c = 1.77 \text{ m}$$

(c) The Alternate depth $E = 4 \text{ m}$

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

$$E = h + \frac{v^2}{2g} \quad \text{where} \quad v = \frac{Q}{A} = \frac{q}{h}$$

(For rectangular channel)

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

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

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

For the subcritical solution the first term, associated with potential energy dominates

⇒ Iteration (from $h=4$) gives $h = 3.948\text{m}$

For the subcritical (Fast, shallow) solution, the second term associated with kinetic energy dominates. Rearrange as

So

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

⇒ Iteration (from $h=0$) gives $h = 0.4814\text{m}$

So Alternate depth are 3.95m & 0.4814m

Assignment #02

Question - 01 :- Water flows at a depth of 10 cm with a velocity of 6 m/s in a rectangular channel. Is the flow subcritical or supercritical? What is the alternate depth?

Solution :- First of all we find the Froude Number to find the flow.

As we know that

$$Fr = \frac{V}{\sqrt{gy}} = \frac{6 \text{ m/s}}{\sqrt{9.81 \times 0.1}}$$

$$Fr = 6.06 > 1$$

So the flow is supercritical.

Alternate Depth :-

As we know that

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

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

$$= 1.935 \text{ m}$$

The alternate depth for $E = 1.935 \text{ m}$

fields

$$y_{\text{alt}} = 1.93 \text{ m}$$

Question - 2 :

Water flow with a velocity of 2 m/s and at a depth of 3 m in a rectangular channel. What is the change in depth and in water surface elevation produced by a gradual upward change in bottom elevation (upstep) of 60 cm? What would be the depth and elevation changes if there were a gradual down step of 15 cm? What is maximum size of upstep that could exist before upstream depth changes would result? Neglect head losses.

Given Data :-

$$\text{Velocity} = V_1 = 2 \text{ m/s}$$

$$\text{depth} = y_1 = 3 \text{ m}$$

$$\text{Elevation } \Delta z = 60 \text{ cm} = 0.6 \text{ m}$$

$$\text{down step} = 15 \text{ cm} = 0.15 \text{ m}$$

Solution :-

As we know that

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

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

$$E_1 = 3.20 \text{ m}$$

Now

$$E_2 = E_1 - \Delta z$$

$$E_2 = 3.2 - 0.6$$

$$E_2 = 2.60 \text{ m}$$

Also

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

$$2.60 = y_2 + \frac{b^2}{2 \times 9.81 \cdot y_2^2}$$

$$y_2 = 2.24 \text{ m}$$

$$\Delta y = y_2 - y_1$$

$$\Delta y = 2.24 - 3$$

$$\Delta y = -0.76 \text{ m}$$

So water surface ~~rise~~ drop = 0.16 m

* For a downward step of 15 cm or 0.15 m we have

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

$$E_2 = 3.35 \text{ m}$$

~~Answer~~

$$\text{Now } y_2 = 3.17 \text{ m}$$

$$\therefore \Delta y = y_2 - y_1 = 3.17 - 3$$

$$\boxed{\Delta y = 0.17 \text{ m}}$$

So water surface rises 0.17 m

- * The maximum upstep possible before affecting upstream water surface level is for

$$y_2 = y_c$$

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

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

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

Question:

A water passing from the slice gate in Dam having a depth of water at upstream side is 3.6m after passing through sluice gate the water curve shows that depth of water at downstream side is 0.9m. the width of slice gate 3.9m.

Determine * Discharge * Froude Number and downstream.

Given Data :-

Depth of water at upstream side $y_1 = 3.6\text{m}$

Depth of water at downstream side $y_2 = 0.9\text{m}$

width of sluice gate $b = 3.9\text{m}$

Solution:-

As we know that

specific energy on both stream are same

$$\text{So } E_1 = E_2$$

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

Also by discharge formula

$$Q = A_1 V_1 = A_2 V_2$$

$$b_1 y_1 V_1 = b_2 y_2 V_2$$

$$y_1 V_1 = y_2 V_2$$

$$b = b_1 = b_2$$

$$V_2 = \frac{y_1}{y_2} \times V_1$$

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

$$\boxed{V_2 = 4V_1} \rightarrow \textcircled{2}$$

Putting the value of V_2 in eq (1)

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

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

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

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

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

$$-15V_1^2 = -2.7 \times 2g$$

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

$$\boxed{V_1 = 1.878 \text{ m/sec}}$$

Putting the value of v_1 in eq (a)

$$V_2 = 4V_1$$

$$V_2 = 4(1.879)$$

$$V_2 = 7.516 \text{ m/sec}$$

Also

$$Q_1 = A_1 V_1$$

$$Q_1 = b_1 y_1 V_1 = 3.5 \times 3.6 \times 1.879$$

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

$$Q_2 = A_2 V_2$$

$$Q_2 = b_2 y_2 V_2 = 3.5 \times 0.9 \times 7.516$$

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

$$Q = Q_1 = Q_2 = 26.38 \text{ m}^3/\text{sec}$$

Froude Number At upstream side :-

By formula

$$Fr_1 = \frac{V_1}{\sqrt{g y_1}} = \frac{1.879}{\sqrt{9.81 \times 3.6}}$$

$$Fr_1 = 0.31 < 1$$

It is sub critical flow

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Froude Number At downstream side ::

$$Fr_2 = \frac{V_2}{\sqrt{g y_2}}$$

$$Fr_2 = \frac{7.516}{\sqrt{9.81 \times 0.8}}$$

$$Fr_2 = 9.52$$

$$Fr_2 > 1$$

It is super-critical flow.