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Sec: B

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 a critical depth.

It is used in flow measurement at very large flow rates usually given in millions of meter would normally measure in mm where as in meters.

Measurement of discharge with venturi flumes requires two measurement one upstream and one at the throat - if the flow

passes in subcritical state though the flume -
If the flumes are designed so as to pass the flow from subcritical to supercritical state while passing through the plane, a single measurement at the throat is sufficient for computation of discharge. To ensure the occurrence of critical depth at the throat the flumes are such away

Example:

A 3m wide channels carries a total discharge of $12\text{m}^3\text{s}^{-1}$ calculate

- The critical depth
- The minimum specific Energy
- The alternate depth when $E = 4\text{m}$

$$b = 3\text{m}$$

$$Q = 12\text{m}^3\text{s}^{-1}$$

A:

Discharge per unit width

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

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

Answer.

$$\text{Critical depth} = 1.18\text{m}$$

B.

For a rectangle channels

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

Answer.

Minimum specific Energy
= 1.177 m

C:

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 a rectangle channel

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

Substituting value in meta
Second units -

For the subcritical (slow, deep)
the first term associated
with P.E $h = 4$ 0.8155
 h^2

$$g = 3.45 \text{ ft}$$

PROBLEM: 4.22

Water flows 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:

Check Froude number

$$Fr = \frac{V}{\sqrt{gy}} = \frac{6 \text{ m/s}}{\sqrt{9.81 \text{ m/s}^2 \cdot 0.1 \text{ m}}} = 1.935 \text{ m}$$

So the flow is supercritical

$$E = y + \frac{v^2}{2g} = 0.1 \text{ m} + \frac{(6 \text{ m/s})^2}{2 \cdot 9.81 \text{ m/s}^2} = 1.935 \text{ m}$$

solving for alternate depth
for an $E = 1.935\text{m}$ yields
 $y_{alt} = 1.93\text{m}$

PROBLE - 4.36

Water flows with velocity of 2 m/s and at a depth of 3 m in a rectangular channel. What is the change in depth in water surface elevation produced up word change in bottom elevation of 60 cm ? What would be the depth and elevation change if there were a gradual downstep of 15 cm ? What is the maximum size of setup that could exist before upstream depth changes would result? Neglect head losses.

Solution.

$$E_1 = y_1 + \frac{v_1^2}{2g} = 3\text{m} + \frac{2\text{m/s}^2}{2 \cdot 9.81\text{m/s}^2}$$
$$= 3.20\text{m}$$

$$E_2 = E_1 - \Delta z = 3.20\text{m} - 0.60\text{m} = 2.60\text{m}$$

$$E_2 = y_2 + \frac{q^2}{2gy_2^3} = y_2 + \frac{(6\text{m}^3/\text{s})^2}{2 \cdot 9.81\text{m/s}^2}$$
$$= 2.60\text{m}$$

So $y_2 = 2.24\text{m}$ $\Delta y = y_2 - y_1 = -0.76\text{m}$
So water surface drops 0.76m
for a downward step
of 15cm we have

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

giving $y_2 = 3.19\text{m}$ and $\Delta y = y_2 - y_1$
 $= 0.19\text{m}$ so water
surface raises 0.19m .

The maximum upstep possible

before affecting upstream
water ~~sup~~ surface levels
is for

$$y_d = y_c$$

$$y_c = 3 \sqrt{\frac{q_d}{g}} = 3 \sqrt{\frac{(6 \text{ m}^3/\text{s m})^2}{9.81 \text{ m/s}^2}}$$

$$= 1.54 \text{ m}$$

PROBLEM 1

A water passing from
the soft slope gate in
Dam - - - - -

→ GIVEN Data:

$$y_1 = 3.8 \text{ m}$$

$$y_2 = 0.9 \text{ m}$$

$$b = 3.9 \text{ m}$$

Solution:

We know that

$$E_1 = E_2$$

$$y_1 + \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g}$$

→ Also

$$Q = A_1 v_1 = A_2 v_2$$

$$b_1 y_1 v_1 = b_2 y_2 v_2$$

$$b y_1 v_1 = b y_2 v_2$$

$$b = b_1 = b_2$$

$$y_1 v_1 = y_2 v_2$$

$$v_2 = \frac{y_1}{y_2} \times v_1$$

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

$$V_2 = 4V_1$$

\Rightarrow Put eq (1)

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

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

$$\Rightarrow V_1 = 1.879 \text{ m/sec}$$

put in eq (2)

$$\Rightarrow V_2 = 4V_1$$

$$\Rightarrow Q = A_1 V_1 = B y_1 V_1$$

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

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

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

$$\Rightarrow 3.9 \times 3.6^{0.9} \times 7.516$$

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

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

1) Froude Number \rightarrow At downstream

$$Fr_1 = \frac{V_1}{\sqrt{g y_1}} = \frac{1.879}{\sqrt{9.81 \times 3.6}} = 0.316$$

subcritical
flow

2) Froude Number At downstream
side

$$Fr_2 = \frac{V_2}{\sqrt{g y_2}} = \frac{7.516}{\sqrt{9.81 \times 0.9}}$$

$= 2.59$ super critical
flow