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QNo1

A Let Suppose a rectangular Channel, discharges 7854 liter/sec of Water into a 8m wide apron with zero slop. Mean velocity is 7854 -220ft/sec

Calculate

1. Height of hydraulic jump
2. Power absorbed due to hydraulic jump

Ans Given Data

Channel Width $b = 8m$

Discharge $Q = 7854$ litre/sec

Mean Velocity $V = 7854 - 220$

$V = 7634$ Ft/sec

$$V = \frac{7634}{3.28}$$

$V = 2327.43$ m/sec

1. Height of Hydraulic Jump :-

$$q = \frac{Q}{b}$$

$$= \frac{7.854}{8} \Rightarrow q = 0.98175 \ m^2/sec$$

$\Rightarrow$ Critical Depth :-

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

$$= \left(\frac{0.98175^2}{9.81}\right)^{1/3}$$

$$y_c = 0.465 \ m$$

Critical Velocity :-

As we know that

$$q = Vy \Rightarrow V = \frac{q}{y}$$

$$V_c = \frac{q}{y_c}$$

$$V_c = \frac{0.981}{0.465} \qquad V_c = 2.10 \ m/sec$$

Depth of Water on upstream Side :-

By using Discharge formula,

$$Q = AV$$

$$Q = (b \times y) \times V$$

$$y = \frac{Q}{V.b}$$

$$\Rightarrow y_1 = \frac{Q}{V_1.b}$$

$$y_1 = \frac{7.854}{2327.43 \times 8}$$

$$y_1 = 0.000421 \text{ m}$$

$$y_2 = \frac{-y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2y_1(V_1)^2}{g}}$$

$$y_2 = \frac{-0.000421}{2} + \sqrt{\frac{(0.000421)^2}{4} + \frac{2 \; 0.000421 \times 2327.43^2}{9.81}}$$

$$y_2 = 21.55 \text{ m}$$

$$\Delta y = y_2 - y_1$$

$$\Delta y = 21.55 - 0.000421$$

$$\Delta y = 21.549\,m$$

(ii) $\Delta E = E_1 - E_2$

As we know that

$$Q_1 = Q_2$$

$$A_1V_1 = A_2V_2$$

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

$$V_2 = 0.000421 \times \frac{(2327.43)}{21.55}$$

$$V_2 = 0.045\,m/sec$$

$$\Delta E = E_1 - E_2 = \left(y_1 + \frac{V_1^2}{2g}\right) - \left(y_2 + \frac{V_2^2}{2g}\right)$$

$$= \left(0.000421 + \frac{(2327.43)^2}{2\times 9.81}\right) - \left(21.55 + \frac{F(0.045)^2}{2(9.81)}\right.$$

$$E_1 - E_2 = 254.437\ m$$

→ Power absorbed:

$$\Delta P = \rho g Q\,(E_1 - E_2)$$

$$\Delta P = 1000 \times 9.81 \times 7.854\,(254.437)$$

$$\Delta P = 1960379\ W$$

B. A sluice gate controls the flow in a channel of width 4m. If the discharge is 7854 ft^3/sec and the upstream and downstream water depth is 2.9m and 1.1m respectively calculate the downstream velocity. Also state the type of flow at upstream and downstream side using any equation.

Sol:- Given Data

width $b = 4m$

Discharge $Q = 7854 \; ft^3/sec$

$$= \frac{7854}{(3.28)^3} = 222.57 \; m^3/sec$$

Height of upstream side = 2.9m

Height of downstream side = 1.1m

Let Specific Energy at upstream and downstream side

$$E_1 = E_2$$

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

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As we know that

$$Q = A_1 V_1 = A_2 V_2$$

$$b y_1 V_1 = b y_2 V_2 \qquad \because b = b_1 = b$$

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

$$V_2 = \frac{2.9}{1.1} V_1$$

$$V_2 = 2.634 V_1 \longrightarrow (2)$$

Put the value of eq (2) in eq (1)

$$2.9 + \frac{V_1^2}{2 \times 9.81} = 1.1 + \frac{(2.634 V_1)^2}{2 \times 9.81}$$

$$2.9 - 1.1 = \frac{6.938 V_1^2}{19.62} - \frac{V_1^2}{19.62}$$

$$1.8 = \frac{6.938 V_1^2 - V_1^2}{19.62}$$

$$1.8 \times 19.62 = 5.938 V_1^2$$

$$V_1^2 = \sqrt{\frac{1.8 \times 1962}{5.938}}$$

$$\boxed{V_1 = 2.44\ m/sec}$$

Now put the value of V_1 in eq ①

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

$$2.9 + \frac{(2.44)^2}{2g} = 1.1 + \frac{V_2^2}{2g}$$

$$2.9 - 1.1 = \frac{V_2^2}{2g} - \frac{5.95}{2g}$$

$$1.8 = \frac{V_2^2 - 5.95}{2g}$$

$$1.8 \times 2g = V_2^2 - \cancel{5.95}\ 5.95$$

$$1.8 \times 2 \times 9.81 = V_2^2 - 5.95$$

$$\sqrt{V_2^2} = \sqrt{41.266}$$

$$\boxed{V_2 = 6.42\ m/sec}$$

Using Froud No to determine type of flow

Upstream side

$$Fr_1 = \frac{V_1}{\sqrt{gy_1}}$$

$$= \frac{2.44}{\sqrt{9.81 \times 2.9}}$$

$$= 0.457 < 1$$ (subcritical flow)

Down Stream

$$Fr_2 = \frac{V_2}{\sqrt{gy_2}}$$

$$= \frac{6.42}{\sqrt{9.81 \times 1.1}}$$

$$= 1.95 > 1$$

Super critical flow.

QNo2

A What is the minimum height of broad crested weir if it is to function critical depth on the crest.
If water flows along a rectangular channel at a depth of 1.8m with a discharge of 7854 ft^3/sec. the channel width is 66ft.

Sol:- Given Data:

Depth of Channel = 1.8m

Discharge = 7854 ft^3/sec

$$= \frac{7854}{3.28^3}$$

$$= 222.57 \; m^3/sec$$

Width of channel = 66ft

$$= \frac{66}{3.28} = 20.12m$$

Required data:

Minimum height (P) of weir

$Q = AV$

$V = \frac{Q}{A} = \frac{Q}{by} = \frac{222.57}{20.12 \times 1.8}$

$= 6.14 \ m/sec$

As we know

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

$q = \frac{Q}{b}$

$= \left(\frac{(11.06)^2}{9.81}\right)^{1/3}$

$q = \frac{222.57}{20.12}$

$q = 11.062$

$y_c = 2.29 \ m$

Also $V = \sqrt{gy}$

$V_c = \sqrt{g y_c}$

$= \sqrt{9.81 \times 2.29}$

$V_c = 4.73 \ m/sec$

Now

According to specific energy

$$E_1 = E_2$$

$$y_1 + \frac{V_1^2}{2g} = \frac{V_c^2}{2g} + y_c + P$$

$$1.8 + \frac{6.14^2}{2 \times 9.81} = \frac{4.73^2}{2 \times 9.81} + 2.29 + P$$

$$P = 0.29m$$

B An orifice in one side of large tank is rectangular in shape. 2.8 m broad and 1.5m deep. The water level on one side of the orifice is 5 meters above its top edge. The water level on the other side of the orifice is 0.6 m below its top edge. calculate the discharge through the orifice if coefficient of discharge is
$C_d = 0.7854$

Sol:: Given data:

Breadth = 2.8m

Depth = 1.5m

Water level on one side (above its top edge $H_1 = 5m$

Water level on other side = 5m + 1.5
$H_2 = 6.5m$

cd = 0.7854

H = 5.6m

Discharge Q = ?

Discharge through Submerged Portion

$Q_1 = cd \times b \times (H_2 - H_1) \times \sqrt{2gh}$

$Q_1 = 0.7854 \times 2.8 (6.5 - 5.6) \times \sqrt{2 \times 9.81 \times 5.6}$

$Q_1 = 20.75 \ m^3/sec$

Discharge of free Portion

$$Q_2 = \frac{2}{3} cd \times b\sqrt{2g} \times [H^{3/2} - H_1^{3/2}]$$

$$Q_2 = \frac{2}{3}(0.7854) \times 2.8\sqrt{2\times 9.81}\,[5.6^{3/2} - 5^{3/2}]$$

$$Q_2 = 13.32 \ m^3/sec$$

Total Discharge

$$Q = Q_1 + Q_2$$

$$Q = 20.75 + 13.32$$

$$Q = 34.07 \ m^3/sec$$

QNO3

A The diameter of a water pipe on suddenly enlarged from R-200mm to R+3000 mm the rate of flow through is 0.95 m^3/sec and the pressure in larger pipe is R+800 N/m^2

Calculate

1. The loss of Head due to sudden enlargement
2. The power lost due to sudden enlargement
3. The pressure in the smaller pipe

Sol:- Given Data:

$d_1 = R - 200mm$

$d_1 = 7854 - 200 = 7654\ mm$

$d_2 = R + 3000mm$

$d_2 = 7854 + 3000 = 10854\ mm$

Flowrate $Q = 0.95\ m^3/sec$

Solution: The Loss of Head due to Sudden enlargement.

$$d_1 = 7654 = 7.654\,m$$

$$A_1 = \frac{\pi}{4}(7.654)^2$$

$$A_1 = 45.99\,m^2$$

$$d_2 = 10854 = 10.854\,m$$

$$A_2 = \frac{\pi}{4}(10.854)^2$$

$$A_2 = 92.49\,m^2$$

As $\Rightarrow$ $Q = AV$

$$V_1 = \frac{Q_1}{A_1}$$

$$V_1 = \frac{0.95}{45.99}$$

$$V_1 = 0.020\ m/sec$$

$$\Rightarrow V_2 = \frac{Q}{A_2}$$

$$V_2 = \frac{0.95}{92.49}$$

$$V_2 = 0.010 \ m/sec$$

① By formula of Sudden Enlargement

$$h_e = \left(1 - \frac{A_1}{A_2}\right)^2 \times \frac{(V_1 - V_2)^2}{2g}$$

$$h_e = \left(1 - \frac{45.99}{92.49}\right)^2 \times \frac{(0.020 - 0.010)^2}{2 \times 9.81}$$

$$h_e = 0.2527 \times (5.09 \times 10^{-6}$$

$$h_e = 1.286 \times 10^{-6} m$$

$$h_e = 0.00000128 \ m$$

② Power loss due to Sudden enlargement

$$P = \rho g Q h_e$$

$P = (1000)(9.81)(0.95)(1.286 \times 10^{-6})$

$P = 0.01198\ W$

(c) The Pressure in Smaller pipe

By using Bernoulli's equation

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_L$$

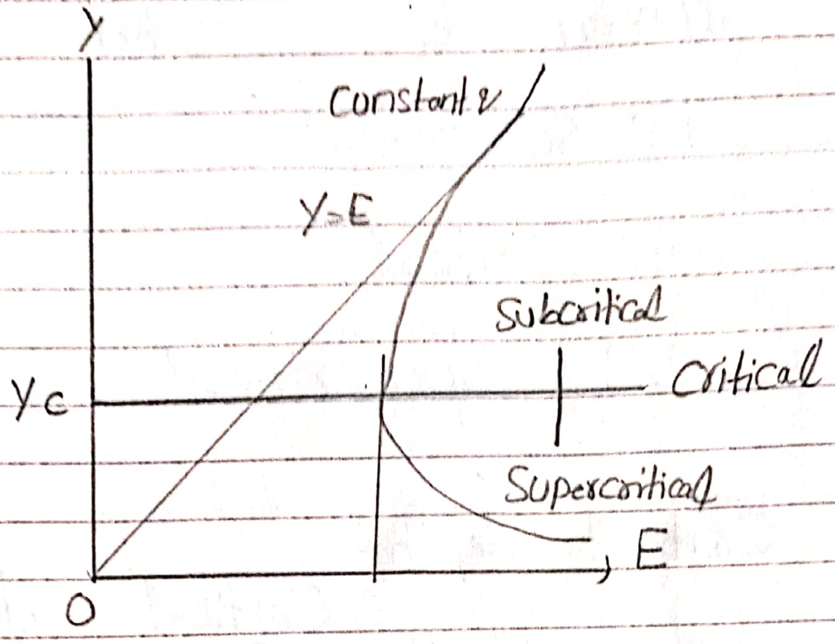
$$\frac{P_1}{(1000)(9.81)} + \frac{(0.020)^2}{2 \times 9.81} = \frac{8654}{1000 \times 9.81} + \frac{(0.010)^2}{2 \times 9.81} + 1.286 \times 10^{-6}$$

$$\Rightarrow \frac{P_1}{9810} + 0.0000203 = 0.8821 + 5.09 \times 10^{-6} + 1.286 \times 10^{-6}$$

$$\frac{P_1}{9810} =$$

$P_1 = 8652.86\ N/m^2$

(B)



What does this blue curve indicates How it is obtained. Explain the above figure from each and every point of view.

Ans First we define Specific Energy as

" Specific Energy is a parameter that can be used to clarify the meaning of Super critical, Subcritical and Critical flow in an open channel ".

The above graph is plot between depth flow (y) and Specific energy. It is made from three degree polynomial equation which shows us the different specific

Energy for the depth flow which may be either

i) Subcritical

ii) Critical

iii) Super critical

Critical depth:-

Critical depth is the depth corresponding to minimum specific energy

→ $y > yc$, $E > E_{min}$ (Subcritical)

→ $y = yc$, $E = E_{min}$ (Critical flow)

→ $y < yc$, $E < E_{min}$ (Super critical)