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Submitted
to

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Subject

Hydraulic Engineering

Semester

6th

Section

B

Q: No: 01:

Part a): Let suppose a rectangular channel discharges Q litre/sec of water into a $8m$ wide apron with zero slope. Mean velocity is $Q-220$ ft/sec

calculate

- 1- Height of Hydraulic jump (in unit of meter)
- 2- Power absorbed due to Hydraulic jump (in unit of kW)

Ans:

Given Data:

Channel width = $b = 8m$

Discharge = $Q = 7883$ lit/sec = 7.883 m³/sec

Mean velocity = $v = Q-220 = 7883-220$

$v = 7663$ ft/sec

$v = 2336.28$ m/sec

1) As we know

$Q = vb$

$v = Q/b = \frac{7.883}{8} = 0.9853$ m²/sec

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

$y_c = \left(\frac{0.9853^2}{9.81}\right)^{1/3} \Rightarrow \boxed{y_c = 0.462m}$

As it is rectangular section

$$Q = vb \text{ --- (1)}$$

$$Q = Av \text{ --- (2)}$$

Equating (1) & (2)

$$vb = Av$$

$$vb = ybV$$

$$v = yV$$

$$V_c = v/y_c = \frac{0.9853}{0.4162} = 2.32 \text{ m/sec}$$

$\therefore V > V_c$ (super critical flow)

Height of hydraulic jump on the upstream side.

As

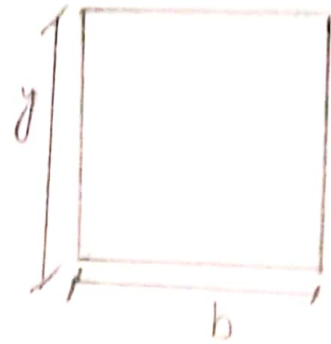
$$Q = Av$$

$$Q = byV$$

$$y_1 = \frac{Q}{v_1 b}$$

$$y_1 = \frac{7.883}{23.2628 \times 8} = 0.00041$$

$$y_1 = 0.0004 \text{ m}$$



$$y_2 = \frac{-y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2y_1|v_1|^2}{g}}$$

$$y_2 = \frac{-0.00041}{2} + \sqrt{\frac{(0.00041)^2}{4} + \frac{2(0.00041)(2336.28)^2}{9.81}}$$

$$y_2 = 21.09 \text{ m}$$

$$\Delta y = y_2 - y_1$$

$$\Delta y = 21.09 - 0.00041 = 21.089$$

$$\Delta y = 21.089 \text{ m}$$

(ii):

$$\Delta E = E_1 - E_2$$

As we know that

$$Q_1 = Q_2$$

$$A_1 v_1 = A_2 v_2$$

$$b y_1 v_1 = b y_2 v_2 \quad \therefore b_1 - b_2 = b$$

$$v_2 = y_1 v_1 / y_2$$

$$v_2 = \frac{0.00041(2336.28)}{21.09} = 0.0441 \text{ m/sec}$$

$$v_2 = 0.0441 \text{ m/sec}$$

$$\Delta E = E_1 - E_2 = \left(y_1 + \frac{v_1^2}{2g} \right) - \left(y_2 + \frac{v_2^2}{2g} \right)$$

$$= \left(0.00021 + \frac{(2336.28)^2}{2 \times 9.81} \right) - \left(21.09 + \frac{(0.044)^2}{2 \times 9.81} \right)$$

$$E_1 - E_2 = 2781721.84 \text{ m}$$

→ Power absorbed:

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

$$\Delta P = 1000 \times 9.81 \times 7.883 (2781721.84) = 2.15 \times 10^{10} \text{ W}$$

$$\Delta P = 21551880.71 \text{ W}$$

Q No.: 01

Part b:

A sluice gate controls the flow in a channel of width 4m. if the discharge is $R \text{ ft}^3/\text{sec}$ and the up stream and downstream water depth is 2.9m and 1.1m respectively calculate the downstream velocity.

Also state the type of flow at up stream and downstream side using any equation.

Sol: Given Data:

$$b = 4 \text{ m}$$

$$Q = 7883 \text{ ft}^3/\text{sec} = \frac{7883}{(3.28)^3} = 223.39 \text{ m}^3/\text{sec}$$

$$y_1 = 2.9 \text{ m}$$

$$y_2 = 1.1 \text{ m}$$

Let Specific Energy at upstream & downstream side

$$E_1 = E_2$$

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

As we know that

$$Q = A_1 V_1 = A_2 V_2$$

$$b y_1 V_1 = b y_2 V_2 \quad \therefore b_2 = b_1 = b$$

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

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

$$\boxed{V_2 = 2.634 V_1} \quad \text{--- (2)}$$

~~Put~~ Put the value of eqn (2) in eqn (1)

(6)

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$$2.9 + \frac{v_1^2}{2 \times 9.81} = 1.1 + \frac{(2.634v_1)^2}{2 \times 9.81}$$

$$2.9 - 1.1 = \frac{6.938 v_1^2}{19.62} - \frac{v_1^2}{19.62}$$

$$1.8 = \frac{6.938 v_1^2 - v_1^2}{19.62}$$

$$1.8 \times 19.62 = 5.938 v_1^2$$

$$v_1^2 = \sqrt{\frac{1.8 \times 19.62}{5.938}}$$

$$v_1 = 2.414 \text{ m/sec}$$

Now put the value of "v₁" in eq (1)

$$J_1 + \frac{v_1^2}{2g} = J_2 + \frac{v_2^2}{2g} \quad (\text{Putting } v_1)$$

$$2.9 + \frac{(2.414)^2}{2g} = 1.1 + \frac{v_2^2}{2g}$$

$$2.9 - 1.1 = \frac{v_2^2}{2g} - \frac{5.95}{2g}$$

$$1.8 = \frac{v_2^2 - 5.95}{2g}$$

$$1.8 \times 2g = v_2^2 - 5.95$$

$$1.8 \times 2 \times 9.81 = v_2^2 - 5.95$$

$$\sqrt{v_2^2} = \sqrt{41.266}$$

$$v_2 = 6.42 \text{ m/sec}$$

Using Froud No to determine type of flow
UP stream side.

$$Fr_1 = \frac{v_1}{\sqrt{gy_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = 0.457 < 1$$

(sub critical 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

Q: No: 02

Part: A :

What is the Minimum height (In unit of meter) 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 $R \text{ ft}^3/\text{sec}$ the channel width is 66 ft.

Sol: Given Data:

$$y = 1.8 \text{ m}$$

$$b = 66' = \frac{66}{3.28} = 20.12 \text{ m}$$

$$Q = \frac{7883}{3.28^3} = 223.39 \text{ m}^3/\text{sec}$$

Required data:

Minimum height (P) of weir.

$$Q = AV$$

$$V = \frac{Q}{A} = \frac{Q}{by} = \frac{223.39}{20.12 \times 1.8} = 6.16 \text{ m/sec}$$

As we know

$$y_c = \left(\frac{Q^2}{g} \right)^{\frac{1}{3}} = \left(\frac{(11.10)^2}{9.81} \right)^{\frac{1}{3}}$$

$$y_c = 2.32 \text{ m}$$

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

$$v = \frac{223.39}{20.12}$$

$$v = 11.10 \text{ m/s}$$

Also $v = \sqrt{gy}$

$$v_c = \sqrt{gy_c} = \sqrt{9.81 \times 2.32}$$

$$v_c = 4.77 \text{ m/sec}$$

Now; According to specific energy

$$E_1 = E_2$$

$$y_1 + \frac{v_1^2}{2g} = \frac{v_c^2}{2g} + y_c + P$$

$$1.8 + \frac{6.16^2}{2 \times 9.81} = \frac{4.77^2}{2 \times 9.81} + 2.32 + P$$

$$P = 3.73 - 3.47$$

$$P = 0.26 \text{ m}$$

Q: No: 2

Part: b:

An orifice in one side of large tank is rectangular in shape 2.8m 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 0.6m below its top edge. Calculate the discharge through the orifice if coefficient of discharge is $C_d = 0.8$.

Sol: Given data:

$$b = 2.8 \text{ m}$$

$$d = 1.5 \text{ m}$$

$$H_1 = 5 \text{ m}$$

$$H_2 = 5 + 1.5 = 6.5 \text{ m}$$

$$H = 5 + 0.6 = 5.6 \text{ m}$$

$$C_d = 0.7883$$

Required data:

$$Q = ?$$

Discharge through submerged portion

$$Q_1 = C_d \times b \times (H_2 - H) \times \sqrt{2gH}$$

$$Q_1 = 0.7883 \times 2.8 \times (6.5 - 5.6) \times \sqrt{2 \times 9.81 \times 5.6}$$

$$Q_1 = 20.82 \text{ m}^3/\text{sec}$$

Discharge of free portion

$$Q_2 = \frac{2}{3} C_d \times b \sqrt{2g} [H_2^{3/2} - H_1^{3/2}]$$

$$Q_2 = \frac{2}{3} (0.7883) \times 2.8 \sqrt{2 \times 9.81} [5.6^{3/2} - 5^{3/2}]$$

$$Q_2 = 13.502 \text{ m}^3/\text{sec}$$

Total Discharge

$$Q = Q_1 + Q_2$$

$$Q = 20.82 + 13.502$$

$$Q = 34.322 \text{ m}^3/\text{sec}$$

Q: No: 03

Part A:

The diameter of a water pipe is suddenly enlarged from $R=200\text{ mm}$ to $R+300\text{ mm}$ the rate of flow through is $0.95\text{ m}^3/\text{sec}$ and the pressure in the larger pipe is $R+800\text{ N/m}^2$

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 (if the pipe is horizontal)

Sol: Given data:

$$P_2 = R + 800 = 7883 + 800 = 8683\text{ N/m}^2$$

$$d_1 = R - 200 = 7883 - 200 = 7683\text{ mm} = 7.683\text{ m}$$

$$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4} (7.683)^2 = 46.36\text{ m}^2$$

$$d_2 = R + 3000 = 7883 + 3000 = 10883\text{ mm}$$

$$d_2 = 10.883\text{ m}$$

$$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4} (10.883)^2 = 93.022$$

$$A_2 = 93.022$$

$$Q = 0.95 \text{ m}^3/\text{sec}$$

$$\therefore Q = AV$$

$$V = \frac{Q}{A}$$

$$V_1 = \frac{Q_1}{A_1} = \frac{0.95}{46.36} = \boxed{0.020 \text{ m/sec}}$$

$$V_2 = \frac{Q_2}{A_2} = \frac{0.95}{93.022} = 0.010 \text{ m/sec}$$

$$\boxed{V_2 = 0.010 \text{ m/sec}}$$

1

Head loss due to sudden enlargement

$$h_e = \left(1 - \frac{A_1}{A_2}\right)^2 \frac{(V_1 - V_2)^2}{2g} = \left(1 - \frac{46.36}{93.022}\right)^2 \frac{(0.020 - 0.010)^2}{2 \times 9.81}$$

$$h_e = 1.28 \times 10^{-6} \text{ m}$$

$$h_e = 0.00000128 \times 10^6 \text{ m}$$

$$\boxed{h_e = 0.00000128 \text{ m}}$$

2)

Power lost due to sudden enlargement

$$P = \rho g Q h_e$$

$$P = 1000 \times 9.81 \times 0.95 \times 1.28 \times 10^{-6}$$

$$\boxed{P = 0.011 \text{ W}}$$

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3) Pressure in the smallest pipe

Apply Bernoulli's eqn

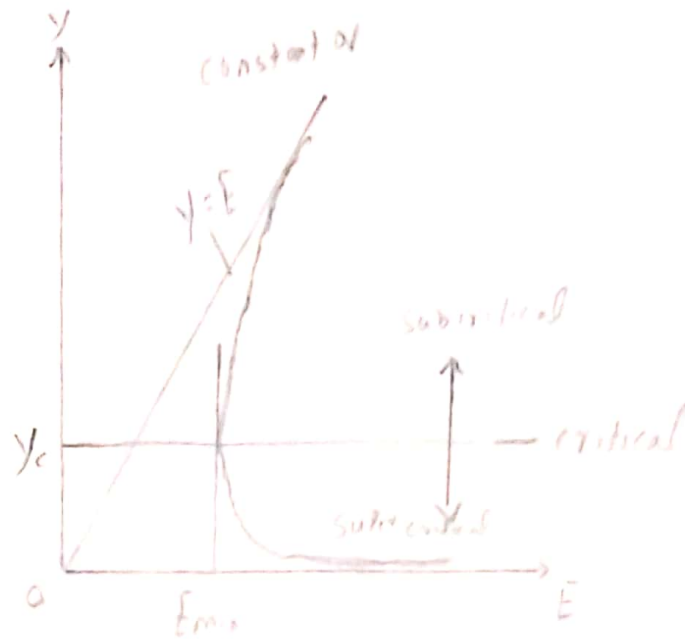
$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_e$$

$$\frac{8683}{1000 \times 9.81} + \frac{(0.020)^2}{2 \times 9.81} = \frac{P_2}{1000 \times 9.81} + \frac{(0.010)^2}{2 \times 9.81} + 1.28 \times 10^{-6}$$

~~P₂ = 8681.78~~

$$P_2 = 8681.78 \text{ N/m}^2$$

Q: No: 03

Part: b

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

Ans: The above graph is plot between depth flow (y) and specific energy (E). 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) supercritical

Specific energy is used to clarify the meaning of the above terms in an open channel.

How is this ACHIEVED?

Total energy = Potential Energy + kinetic energy

$$TE = mgh + \frac{1}{2}mv^2$$

$$\therefore W = mg$$

$$m = W/g$$

$$= WR + \frac{1}{2} \frac{W}{g} v^2$$

ignoring "W" weight of water

$$TE = y + \frac{v^2}{2g} \quad \text{--- (1)}$$

As we know that

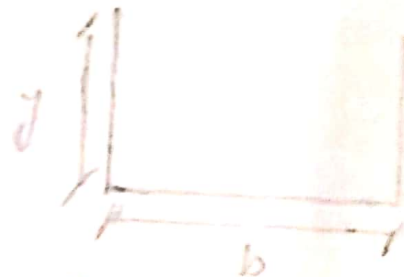
$$Q = VA$$

$$v = \frac{Q}{A}$$

$$v^2 = \frac{Q^2}{A^2} \quad \text{squaring both side}$$

Put v^2 in eq (1)

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



Let's suppose the channel is Rectangular

$$A = y \times b \quad \text{--- (2)}$$

$$Q = vb \quad \text{--- (3)}$$

Putting value of (2) & (3) in eq (1)

$$E = y + \frac{Q^2}{y^3 b^3 2g} \quad (\text{pulling } \textcircled{x})$$

$$E = y + \frac{v^2}{y^2 2g} \rightarrow \text{pulling } \textcircled{y}$$

$$E - y = \frac{v^2}{y^2 2g}$$

$$(E - y) y^2 = \frac{v^2}{2g}$$

$$(E - y) y^2 = \text{constant}$$

As "v" and "g" are constants

* critical depth is the flow depth corresponding to minimum specific energy

$$y > y_c \Rightarrow \text{subcritical flow.}$$

$$y = y_c \Rightarrow \text{critical flow.}$$

$$y < y_c \Rightarrow \text{supercritical.}$$