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Section B

Semester 6^{th}

Subject Hydraulic Engineering

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Question No 1
(A) Let suppose a rectangular channel discharge Q lit/sec of water into a 8m wide apron with zero slope. Mean velocity is Q-220 lit/sec calculate.
1. Height of hydraulic jump (In unit of Meter)
2. Power absorbed due to hydraulic jump (In unit of KW)

Given data:- Channel width $= b = 8m$
Discharge $Q = 7868$ lit/sec
$= 7.868 \; m^3/sec$

Mean velocity $\Rightarrow v = Q - 200$
$= 7868 - 200$
$= 7668$ lt/sec
$= 2337.8 \; m/sec$

As we know that

$$Q = qb \Rightarrow q = Q/b$$

$$= \frac{7.868}{8} = 0.984 \; m^2/sec$$

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{0.984^2}{9.81}\right)^{1/3} = 0.462 \, m$$

As the channel is rectangular

$Q = qb \rightarrow ①$ $Q = AV \longrightarrow ②$

$qb = AV \Longrightarrow qb = y/v$

$q = yv \Longrightarrow v_c = q/y = \frac{0.984}{0.462}$

$v_c = 2.129\ m/sec$

$\therefore\ v > v_c$ (Super Critical Flow)

Height of hydralic Jump on the upstream side

As $Q = AV$ $Q = byv$

$y_1 = \frac{Q}{v_1 b_1} \Longrightarrow \frac{7.868}{2337.8 \times 8} = 0.000421m$

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

$$= \frac{-0.00042}{2} + \sqrt{\frac{0.00042}{4} + \frac{2(0.000421)(2337.81)}{9.81}}$$

$y_2 = 21.714\ m$

$\Delta y = y_2 - y_1 = 21.714 - 0.000421$

$\Delta y = 21.713\ m$

$\because \Delta E = E_1 - E_2$

As we know that

$Q_1 = Q_2$

$A_1 V_1 = A_2 V_2 \qquad \because b_1 = b_2 = b$

$\Rightarrow \cancel{b}_1 y V_1 = \cancel{b} y_2 V_2$

$V_2 = \frac{y_1 V_1}{y_2} \Rightarrow \frac{0.000421 \times 2337.8}{21.714}$

$V_2 = 0.045 \text{ m/sec}$

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

$= \left(0.00421 + \frac{2337.8^2}{2(9.81)}\right) - \left(21.714 + \frac{0.045^2}{2(9.81)}\right)$

$= (0.000421 + 278.558.04) - (21.714)$

$= 278558.04 - 21.714$

$= 278536.33 \text{ m}$

$\Rightarrow$ Power absorbed

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

$\Delta P = 1000 \times 9.81 \times 7.868 \times 278536.33$

$\Delta P = 2.1498 \times 10^{10}$ W

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Question No 1 (B)

A sluice gate controls the flow in channel of width 4m. If the discharge is R ft³/sec and the upstream and down stream 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.

Given data :-

$$b = 4m$$

$$Q = 7868 \ ft^3/sec = \frac{7868}{(3.28)^3}$$

$$Q = 222.953 \ m^3/sec$$

$$Y_1 = 2.9m$$

$$Y_2 = 1.1m$$

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

$$Q = A_1 V_1 = A_2 V_2$$

$$b y_1 V_1 = b y_2 V_2$$

$$V_2 = \frac{Y_1 Y_2}{Y_2}$$

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

$$\boxed{V_2 = 2.636 V_1}$$

Put the values in eq (2) & eq (1)

$$2.9 + \frac{V_1^2}{2 \times 9.81} = 1.1 + \frac{(2.63 V_1)^2}{2 \times 9.81}$$

$$2.9 - 1.1 = \frac{6.948 V_1^2}{19.62} - \frac{V_1^2}{19.62}$$

$$1.8 = \frac{6.948 V_1^2 - V_1^2}{19.82}$$

$$1.8 \times 19.62 = 6.948 V_1^2 - V_1^2$$

$$35.316 = 5.948 V_1^2$$

$$\sqrt{V_1^2} = \sqrt{\frac{35.316}{5.948}}$$

$$\boxed{V_1 = 2.4366}$$

Now put the values of "V_1" in eq (1)

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

$$2.9 + \frac{2.4366^2}{2g} = 1.1 + \frac{V_2^2}{2g}$$

$$2.9 + \frac{5.937}{2g} = 1.1 + \frac{V_2^2}{2g}$$

$$2.9 - 1.1 = \frac{V_2^2}{2g} - \frac{5.937}{2g}$$

$$1.8 = \frac{V_2^2 - 5.937}{2g}$$

$$1.8 \times 2 \times 9.81 = V_2^2 - 5.937$$

$$35.316 = V_2^2 - 5.937$$

$$V_2^2 = 35.316 + 5.937$$

$$\sqrt{V_2^2} = \sqrt{41.253}$$

$$\boxed{V_2 = 6.4228 \ m/sec}$$

Using Froud No to determine type of Flow

Upstream Side :-

$$F_{r_1} = \frac{V_1}{\sqrt{g y_1}} = \frac{2.4366}{\sqrt{9.81 \times 2.9}} = 0.4568 > 1$$

Sub Critical Flow

Down stream side :-

$$Fr_2 = \frac{V_2}{\sqrt{gy_2}} = \frac{6.4228}{\sqrt{9.81 \times 1.1}} = 1.955 > 1$$

(Super critical flow)

Question No 2 "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 1.8 m with a discharge of R ft^3/sec the channel width is 66 ft.

Given data :-

$y = 1.8m$

$b = 66' \Rightarrow \frac{66}{3.28} = 20.12$

$Q = \frac{7868}{3.28^3} \Rightarrow 223.016\ m^3/sec$

Required data :-

Minimum height (P) of weir

$Q = AV \quad V = \frac{Q}{A} = \frac{Q}{by} = \frac{223.016}{(20.12)(1.8)}$

$V_1 = 6.157\ m/sec$

As we know that

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{11.08}{9.81}\right)^{1/3}$$

$\because q = \frac{Q}{b}$
$= 11.08\ m^2/sec$

$y_c = 2.22\ m$

Also $v = \sqrt{gy} \Rightarrow \sqrt{gy_c}$

$$V_c = \sqrt{9.81 \times 2.22}$$

$$V_c = 4.67\ m/sec$$

Now according to specific Energy

$$E_1 = E_2$$

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

$$1.8 + \frac{6.157^2}{2(9.8)} = \frac{4.67^2}{2(9.81)} + 2.22 + P$$

$$3.73 = 3.33 + P$$

$$P = 0.398\ m$$

Question No 2 "B"

An orifice is in one side of large tank is rectangular in shape. 2.8m board and 1.5m deep. The water level on one of the orifice is 5 meter 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 efficient of discharge is

cd = 0.R

Given data :-

$b = 2.8m$

$d = 1.5m$

$H_1 = 5m$

$H_2 = 5 + 1.5 = 6.5m$

$H = 5 + 0.6 = 5.6m$

$Cd = 0.7868$

Required data :-

$Q = ?$

Discharge through submerged portion

$Q_1 = Cd \times b \times (H_2 - H) \times \sqrt{2gh}$

$= 0.7868 \times 2.8 \times (6.5) - (5.6) \times \sqrt{2 \times 9.81 \times 5.6}$

$= 20.778 \ m^3/sec$

⇒ Discharge of free portion

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

$= 2/3 \times 0.7868 \times 2.8 \times \sqrt{2 \times 9.81} \times [5.6^{3/2} - 5^{3/2}]$

$Q_2 = 13.47 \ m^3/sec$

Total discharge

$$Q = Q_1 + Q_2$$

$$Q = 34.25 \ m^3/sec$$

Question No. 3 "A"

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

(1) The loss of Head due to sudden ëlargement.

(2) The power last due to sudden enlargement.

(3) The pressure in the smaller pipe (If the pipe is horizontal)

Given data :-

$$P_1 = R + 800 = 7868 + 800 = 8668 \ N/m^2$$

$$d_1 = R - 200 = 7868 - 200 = 7668 \ mm$$

$$= 7.668 \ m$$

$$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4}(7.668)^2 = 46.156 \ m^2$$

$$d_2 = R + 3000 \Rightarrow 7868 + 3000 = 10868 \ mm$$

$$= 10.87 \ m$$

$A_2 = \frac{\pi}{4} d_2^2 = \pi/4 (10.87)^2 = 92.75 m^2$

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

$\because Q = AV = V_2 = Q/A = \frac{0.95}{46.156}$

$V_2 = 0.011 \, m/sec$

⇒ Head loss due to Sudden ëlargement

$h_L = \left[1 - A_1/A_2\right]^2 \left(\frac{V_1 - V_2}{2g}\right)^2$

$= \left\{1 - \frac{46.156}{92.75}\right\}^2 \left(\frac{0.02 - 0.011}{2 \times 9.81}\right)^2$

$h_L = 6.4 \times 10^{-7} m$

⇒ Power loss due to sudden enlargement

$P = \rho g Q h_L$

$= 1000 \times 9.81 \times 0.95 \times 6.4 \times 10^{-7}$

$P = 0.00605 \, w$

3 ⟹ Pressure in the smallest pipe

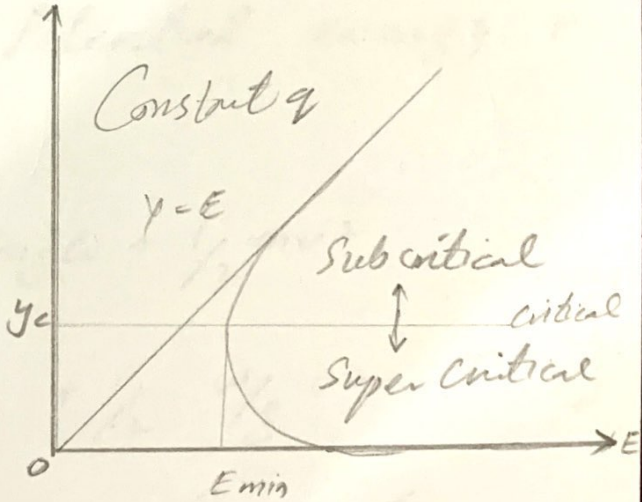
apply Bernoullis equation

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

$$= \frac{8668}{1000 \times 9.81} + \frac{(46.156)^2}{2(9.81)} = \frac{P_2}{1000 \times 9.81} + \frac{(46.156)^2}{2 \times 9.81} + 1.37 \times 10^{-6}$$

$$\boxed{P_2 = 8668.14 \ N/m^2}$$

Question No 3 "B"



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

Answer:- The above graph is plot 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.

Critical, Sub critical or Super Critical

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

Total energy = Potential energy + Kinetic energy

$$T.E = mgh + \frac{1}{2}mv^2 \qquad \because w = mg$$

$$= wh + \frac{1}{2}\frac{w}{g}v^2 \qquad m = \frac{w}{g}$$

ignoring "w" weight of water

$$T.E = h + \frac{v^2}{2g} \longrightarrow ①$$

As we know

$$Q = VA$$

$$V = Q/A$$

Taking Sq on b/s

$V^2 = Q^2/A$

Put V^2 in eq ①

$$E = Y + \frac{Q^2}{A^2 2g} \quad eq — ②$$

Let suppose the channel is rectangular

$A = Y \times b \longrightarrow (x)$

$Q = qb \longrightarrow (y)$

Putting values of (x) and (Y) in (2)

$$E = Y + \frac{Q^2}{Y^2 b^2 2g} \quad (\text{Putting } x)$$

$$E = Y + \frac{q^2}{Y^2 2g} \quad (\text{Putting } y)$$

$$E - Y = \frac{q^2}{Y^2 2g} \Longrightarrow Y^2 (E - Y) = \frac{q^2}{2g}$$

$(E - Y) \, Y^2 = \text{Constant}$

As "q" and "g" are constant

Critical depth is the flow depth corresponding to minimum specific energy.

$Y > Y_c \Rightarrow$ Sub Critical flow.

$Y = Y_c \Rightarrow$ Critical flow.

$Y = Y_c \Rightarrow$ Super Critical flow.