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Sec :- A

Subject :- Hydralic Engineering

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MID TERM EXAM

Q1) A) let suppose a rectangular channel, discharge R liter/sec of water into a 8m wide apron with zero sign - Mean velocity is R-220ft/sec. Calculate:

1) Height of Hydralic jump (In unit of Meter
2) Power absorbed due to hydralic pump (In unit of K.W

Ans:- "<u>Given data</u>:-"

channel width = b = 8m

Discharge = Q = 7826 ltr/sec = 7.826 m^3/sec

Mean velocity = V = R-220 = 7826 - 220

= 7606 ft/sec

= ~~2325~~ m/sec

= 2318.90 m/sec

i) As we know

$$Q = q.b$$

$$q = Q/b = \frac{7.826}{8} = 0.978 \; m^2/sec$$

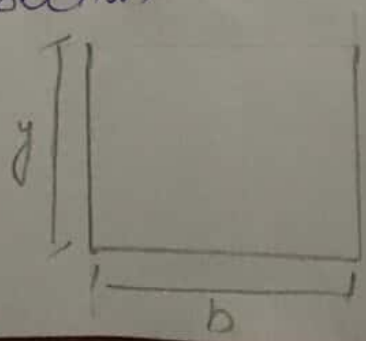
$$\rightarrow y_c = \left(\frac{q^2}{g}\right)^{1/3}$$

$$= \left(\frac{0.978^2}{9.81}\right)^{1/3} = \boxed{0.4602m}$$

As it is a rectangular section

$$Q = q.b \quad \text{--- (1)}$$

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



Equating eq 1 & 2

$$qb = AV$$

$$qb = ybV$$

$$q = yv$$

$$V_c = q/y_c = \frac{0.978}{0.4602} = 2.125 \ m/sec$$

$\therefore \ V > V_2$ (supercritical flow)

Height of hydralic jump on the upstream side

As

$$Q = AV$$

$$Q = byV$$

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

$$y_1 = \frac{7.826}{(2318.90)(8)} = 0.0004 m$$

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

$$y_2 = \frac{-0.004}{2} + \sqrt{\frac{(0.004)^2}{4} + \frac{2(0.004)(2318.90)^2}{9.81}}$$

$$\boxed{y_2 = 20.94 m}$$

$\Delta y = y_2 - y_1$

$= 20.94$

$\Delta y = \cancel{1.419} - 0.0004\,m$

$\boxed{\Delta y = \cancel{1.4186} \; 20.93m}$

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

As we know that

$Q_1 = Q_2$

$A_1 V_1 = A_2 V_2$

$by_1 V_1 = by_2 V_2 \qquad (\because b_1 = b_2 = b)$

$V_2 = y_1 V_1 / y_2$

$$V_2 = \frac{0.004 \times (2318.90)}{\cancel{1.419}\; 20.94}$$

$\boxed{V_2 = 0.\cancel{6}44\ m/sec}$

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

$$= \left(0.0004 + \frac{2318.90}{2 \times 9.81}\right) - \left(1.419 + \frac{\overset{0.044}{\cancel{6.6513}}}{2 \times 9.81}\right)$$

$E_1 - E_2 = 118.19 - 1.42$

$E_1 - E_2 = 116.77\,m$

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→ Power absorbed:

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

$$\Delta P = 1000 \times 9.81 \times 7.826\,(116.77)$$

$$\boxed{\Delta P = 8962487.02\,kW}$$

B) A sluice gate controls the flow in a channel of width 4m. If the discharge is R ft³/sec and the upstream and downstream water depth is 2.9m & 1.1m respectively. Calculate the downstream velocity. Also state the type of flow at upstream & downstream side using any equation

Given data:-

$$b = 4m$$

$$Q = 7826\ ft^3/sec = \frac{7826}{(3.28)^3} = 221.77\,m^3/sec$$

$$y_1 = 2.9m$$

$$y_2 = 1.1m$$

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

$$Q = A_1 V_1 = A_2 V_2$$

$b_1 y_1 V_1 = b y_2 V_2$ $\quad (\because b_2 = b_1 = b_1)$

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

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

$\boxed{V_2 = 2.636 V_1}$ — 2

put value eq 2 in eq 1, we get

$2.9 + \frac{V_1^2}{2 \times 9.81} = 1.1 + \frac{(2.636 V_1)^2}{2 \times 9.81}$

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

$1.8 = \frac{6.948 V_1^2 - V_1^2}{19.62}$

$1.8 \times 19.62 = 5.948 V_1^2$

$V_1^2 = \sqrt{\frac{1.8 \times 19.62}{5.948}}$

$\boxed{V_1 = 2.436 \text{ m/sec}}$

Now put the value of "V1" in eq 1

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

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$$2.9+\frac{(2.43)^2}{2g} = 1.1 + \frac{(2.636V_1)^2}{2g}$$

$$2.9-1.1 = \frac{(2.636V_1)^2}{2g} - \frac{(2.43)^2}{2g}$$

$$1.8 = \frac{6.94V_1^2}{2g} - \frac{5.9}{2g}$$

$$1.8 = 0.35V_1^2 - 0.30$$

$$V_1^2 = 6$$

$$\sqrt{V_1^2} = \sqrt{6}$$

$$\boxed{V_1 = 2.45 \text{ m/sec}}$$

Now putting the value of "V_1" in eq (1)

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

$$2.9+\frac{(2.43)^2}{2g} = 1.1 + \frac{V_2^2}{2g}$$

$$1.8 = V_2^2 - \frac{5.9}{2g} = V_2^2 - 0.30$$

$$\frac{1.8}{6.36} = V_2^2$$

$$\boxed{V_2 = 6.41 \text{ m/sec}}$$

using froud no to determine type of flow.

"Upstream Side:-" $Fr_1 = \frac{V_1}{\sqrt{gy_1}} = \frac{2.43}{\sqrt{9.81 \times 2.9}} = 0.45 < 1$

(Subcritical flow)

"Downstream side:-"

$$Fr_2 = \frac{V_2}{\sqrt{gy_2}} = \frac{6.41}{\sqrt{9.81 \times 1.1}} = 1.95 > 1$$

(Super critical flow)

Q2 A) What is the minimum height of broad crested weir if it is to function critical depth on the crest. If water flow along a rectangular channel at a depth of 1.8m with a discharge of R ft^3/sec. the channel width is 66ft.

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Given data :-

$y = 1.8m$

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

$Q = \frac{7826}{3.28^3} = 221.77\,m^3/sec$

Required:- Minimum height (P) of weir

$Q = AV$

$V = \frac{Q}{A} = \frac{Q}{by} = \frac{221.77}{20.12 \times 1.8} = 6.12\,m/sec$

As we know

$y_c = (q^2/g)^{1/3}$.

$= \left(\frac{11.02^2}{9.81}\right)^{1/3}$

$\left[\because q = Q/b = \frac{221.77}{20.12} = 11.02\,m^3/sec\right]$

$\boxed{y_c = 2.31m}$

Also $V = \sqrt{gy}$

$V_c = \sqrt{gy_c} = \sqrt{9.81 \times 2.31} \; \boxed{= 4.76\,m/sec}$

Now according to specific energy

$$E_1 = E_2$$

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

$$1.8 + \frac{(6.12)^2}{2 \times 9.81} = \frac{(4.76)^2}{2 \times 9.81} + 2.31 + P$$

$$3.70 = 3.46 + P$$

$$P = 3.70 - 3.48$$

$$\boxed{P = 0.22\,m}$$

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 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 coefficient of discharge is Cd = 0.R.

Sol: Given data:-

$$b = 2.8m$$
$$d = 1.5m$$
$$H_1 = 5m$$
$$H_2 = 5 + 1.5 = 6.5m$$
$$H = 5 + 0.6 = 5.6m$$
$$Cd = 0.7826$$

Required: $Q = ?$

As we know,

Discharge through submerged portion

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

$$= 0.7826 \times 2.8 \times (6.5 - 5.6) \times \sqrt{2 \times 9.81 \times 5.6}$$

$$1.97 \times \sqrt{2 \times 9.81 \times 5.6}$$

$$\boxed{Q_1 = 20.64 \ m^3/sec}$$

Discharge of free portion

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

$$Q_2 = \frac{2}{3}(0.7826) \times 2.8 \sqrt{2 \times 9.81} \left[5.6^{3/2} - 5^{3/2} \right]$$

$$\boxed{Q_2 = 13.4 \ m^3/sec}$$

Total Discharge

$$Q = Q_1 + Q_2$$

$$Q = 20.64 + 13.4$$

$$\boxed{Q = 34.04 \ m^3/sec}$$

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(Q3A) The diameter of water pipe is suddenly enlarged from R-200 mm to R+3000 mm. The rate of flow through is 0.95 m³/sec and the large pipe is R+800 N/m²

Calculate;

1) The loss of Head due to sudden enlargement.
2) The power loss due to sudden enlargement.
3) The pressure in the smaller pipe (If the pipe is horizontal).

"Given data:-"

$$P_1 = R+800 = 7826+800 = 8626 \text{ N/m}^2$$

$$d_1 = R-200 = 7826-200 = 7626 \text{ mm}$$
$$= 7.626 \text{m}$$

$$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4}(7.626)^2 = 45.67 \text{ m}^2$$

$$d_2 = R+3000 = 7826+3000$$
$$= 10826 \text{mm} = 10.836 \text{ m}$$

$$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4}(10.836)^2 = 92.22 \text{ m}^2$$

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

$$\therefore Q = AV$$

$$V = Q/A$$

$$V_1 = \frac{Q_1}{A_1} = \frac{0.95}{45.67} = 0.02 \text{ m/sec}$$

$$V_2 = \frac{Q_2}{A_2} = \frac{0.95}{92.22} = 0.01 \, m/sec$$

1) Head loss due to sudden enlargement:

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

$$h_e = \left(1 - \frac{45.67}{92.22}\right)^2 \frac{(0.02 - 0.01)^2}{2 \times 9.81}$$

$$\boxed{h_e = 0.00000127 \, m}$$

2) Power lost due to sudden enlargement:

$$P = \rho g Q h_e$$

$$P = 1000 \times 9.81 \times 0.95 \times 0.00000127$$

$$\boxed{P = 0.0118 \, W}$$

3) Pressure in the smallest pipe:-

Apply Bernoulli equation

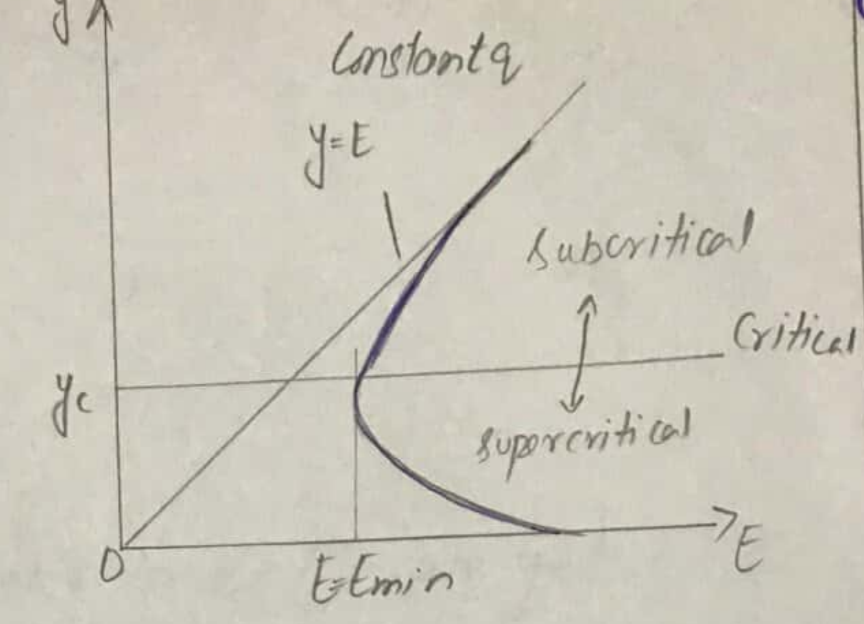
$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_e$$

$$= \frac{8626}{1000 \times 9.81} + \frac{(0.02)^2}{2 \times 9.81} = \frac{P_2}{1000 \times 9.81} + \frac{(0.01)^2}{2 \times 9.81} + 1.27 \times 10^{-6}$$

$$P_2 = (0.879 - 6.36 \times 10^{-6}) \times 9810$$

$$\boxed{P_2 = 8622.92 \, N/m^2}$$

B)



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

Ans: This graph is plotted between depth flow (y) and specific energy (E) - It is made from 3 degree polynomial equation which show us the different specific energy for the depth flow which may be either subcritical, critical or super critical -

How it is obtained?

As we know that

Total Energy = Potential Energy + Kinectic Energy

$$T.E = mgh + \frac{1}{2}mv^2 \qquad \left[\begin{array}{l} W = mg \\ m = W/g \end{array}\right.$$

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

ignore weight of water (W)

$$\boxed{T.E = h + \frac{V^2}{2g}} \quad \text{--- (1)}$$

As we know

$Q = VA$

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

Squaring b.s

$V^2 = \frac{Q^2}{A^2}$ put v^2 in eq (1), we get

$$\boxed{E = y + \frac{Q^2}{A^2 2g}} \quad \text{--- (2)}$$

Suppose the channel is Rectangular

$A = y \times b$ — (i)

$Q = q b$ — (ii)

putting value of (i) & (ii) in eq (2)

$E = y + \frac{Q^2}{y^2 b^2 \cdot 2g}$ putting (i)

$E = y + \frac{q^2}{y^2 2g}$ — putting (ii)

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

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

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

→ Critical depth is the flow depth Corresponding to minimum specfic energy

$y > y_c$ = Subcritical flow

$y = y_c$ = Critical flow

$y < y_c$ = Super critical flow.