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Subject	Hydraulic ENGINEERING.

Q1a Given data

Channel width = b = 8m

Discharge = Q = 7648 liter/sec

$Q = 7.648\ m^3/sec$

Mean velocity = V_1 = 7648 − 220

= 7428 ft/sec

= 2264.6 m/sec

Sol) Hieght of hydraulic Jump

$Q = q \cdot b$

$q = \frac{Q}{b} = \frac{7.648}{8}$

$q = 0.956\ m^2/sec$

* critical depth (y_c)

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

$y_c = \left(\frac{(0.956)^2}{9.81}\right)^{1/3}$

$y_c = 0.453\ m$

* critical velocity V_c:-

$q = y \cdot v$

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

$V_c = \frac{0.956}{0.453}$

$V_c = 2.110\ m/sec$

$V_1 > V_c \Rightarrow$ Hence Super critical flow

★ Depth of water on upstream side:-

$Q = AV \Rightarrow Q = b \cdot y \cdot v$

$y = \frac{Q}{V \cdot b} \Rightarrow y_1 = \frac{Q}{V_c \cdot b}$

$y_1 = \frac{7.648}{(2.110)(8)}$

$y_1 = 0.46m$

$Y_2 = \frac{-y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2y_1 \cdot V_c^2}{g}}$

$= \frac{-0.46}{2} + \sqrt{\frac{(0.46)^2}{4} + \frac{2(0.46)(2.110)^2}{9.81}}$

$y_2 = 0.58m$

★ Depth Difference ΔY:-

$\Delta y = y_2 - y_1$

$= 0.58 - 0.46$

$= 0.12m$

★ Now find V_2:-

As we know that

$\Delta E = E_1 - E_2$

$Q_1 = Q_2$

$A_1 V_1 = A_2 V_2$

$b \cdot y_1 \cdot V_1 = b \cdot y_2 \cdot V_2$

$V^2 = \frac{y \cdot V_1}{y_2}$

$V^2 = \frac{(0.46)(2264.6)}{0.58}$

$V^2 = 1796.06 m/sec$

* Difference in Specific Energy ΔE:-

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

$$= \left(0.46 + \frac{(2264.6)^2}{2(9.81)}\right) - \left(0.58 + \frac{(1796.06)^2}{2(9.81)}\right)$$

$$E_1 - E_2 = 96971.42$$

* Power in Dissipated in hydraulic jump:

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

$$= (1000)(9.81)(7.648)(9697.42)$$

$$= 727567166.64 \text{ KW}.$$

Q No 1

b) Given data.

$b = 4m$

$Q = 7648 \ ft^3/sec = \frac{7648}{(3.28)^3} = 216.73 \ m^3/sec$

$y_1 = 2.9m$

$y_2 = 1.1m$

Sol → Let specific energy at upstream & down stream 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.

$$Q = A_1V_1 = A_2V_2$$

$$\cancel{b} y_1 V_1 = \cancel{b} y_2 V_2$$

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

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

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

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

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

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

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

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

$$\sqrt{V_1^2} = \sqrt{\frac{1.8 \times 19.62}{5.938}}$$

$V_1 = 2.44$ m/sec

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

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

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

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

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

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

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

$V_2 = 6.42$ m/se

Using frood No to determine type of flow up stream sic

$$Fr_1 = \frac{V_1}{\sqrt{gy_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = 0.45 \not> < 1$$

(sub critical flow)

<u>Down stream</u>

$$Fr_2 = \frac{V_2}{\sqrt{gy_2}} = \frac{6.42}{\sqrt{9.81 \times 1.1}} = 1.95 > 1$$

super critical flow

(Q2A)

Given data

Depth of channel = 1.8m

Discharge = 7648 ft^3/sec

$Q \Rightarrow 216.5\, m^3/sec$ ~~Tons~~

width of channel = $\frac{66 ft}{3.281} = 20.1m$

weir height = ?

Sol ⇒

$$V_1 = \frac{Q}{A} = \frac{Q}{by}$$

$$V_1 = \frac{216.5}{20.1 \times 1.8}$$

$$V_1 = 5.9 m/sec$$

⇒ Critical Depth

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

Also $q = Q/b = \frac{216.5}{20.1} = 10.77\, m^2/sec$

$$y_c = \left(\frac{(10.77)^2}{9.81}\right)^{1/3} = 2.27m$$

Also

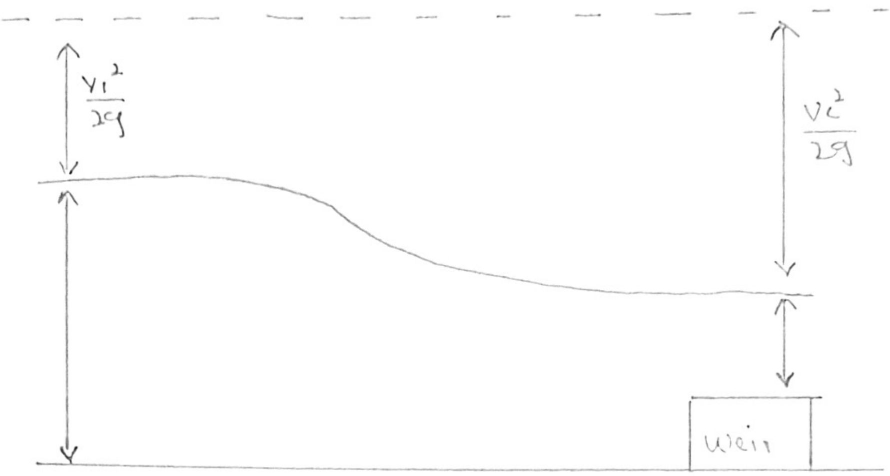
$$V = \sqrt{gy}$$

$$V_c = \sqrt{g y_c}$$

$$V_c = \sqrt{9.81 \times 2.27}$$

$$V_c = 4.71 m/sec$$

From the figure



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

$$= \frac{(5.9)^2}{2(9.81)} + 1.8 = \frac{(4.71)^2}{2(9.81)} + 2.27 + P$$

$$P = 0.17 \text{ m}$$

Q2) B

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 = 7m

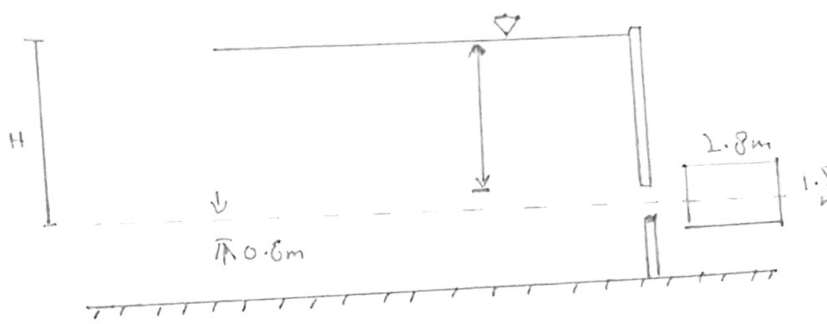
Similarly

$H = 5 + 0.6$

$H = 5.6$

$C_d = 0.76$

Discharge = (Q) = ?



Sol

As by formula

=> Discharge through submerged portion

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

$= 0.76 \times 2.8 \times (7 - 5.6) \times \sqrt{2(9.81)(5.6)}$

$= 31.22\ m^3/sec$

=> Discharge through Free Portion.

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

$= \frac{2}{3}(0.76) \times 2.8\sqrt{2 \times 9.81} \times \left[(5.6)^{3/2} - (5)^{3/2}\right]$

$= 13.01\ m^3/sec$

=> Total discharge $Q = Q_1 + Q_2$

$= 31.22 + 13.01$

$= 44.23\ m^3/sec.$

Q3 A

Given data

$d_1 = R - 200$

$= 7648 - 200 \Rightarrow 7448$

$d_2 = 7648 + 3000 \Rightarrow 10648.$

Flow rate $= 0.95 m^3/sec$

Pressure in larger pipe $= R + 800 \ N/m^2$

$= 7648 + 800$

$= 8448 \ N/m^2$

Sol.

$d_1 = 7448 = \cancel{7.448m} \ 7.448m$

$A_1 = \frac{\pi}{4}(7.448)^2 = 43.5 \ m^2$

$d_2 = 10648 \Rightarrow 10.648 \ m$

$A_2 = \frac{\pi}{4}(10.648)^2 = 89.04 m^2$

As, $Q = AV$

$V = Q/A \Rightarrow V_1 = Q/A_1$

$$V_1 = \frac{0.95}{43.5} = 0.021 \ m/sec$$

Similarly

$V_2 = Q/A_2$

$$V_2 = \frac{0.95}{89.04} = 0.010 \ m/sec$$

By formula of sudden Enlargement :-

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

$$= \left(1 - \frac{43.5}{89.04}\right)^2 \times \left(\frac{0.021 - 0.010}{2 \times 9.81}\right)^2$$

$h_e = 0.000000082222 = 8.2 \times 10^{-8}$

b) Power loss due to sudden Enlargement:-

$P = \rho g Q h_e$

$= (1000)(9.81)(0.95)(8.2 \times 10^{-9})$

7.6×10^{-6} W

c) Pressure in the smaller pipe:

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

$$\frac{P_1}{(1000)(9.81)} + \frac{0.021^2}{2(9.81)} = \frac{8448}{1000(9.81)} + \frac{(0.010)^2}{2(9.81)} + 8.2 \times 10^{-9}$$

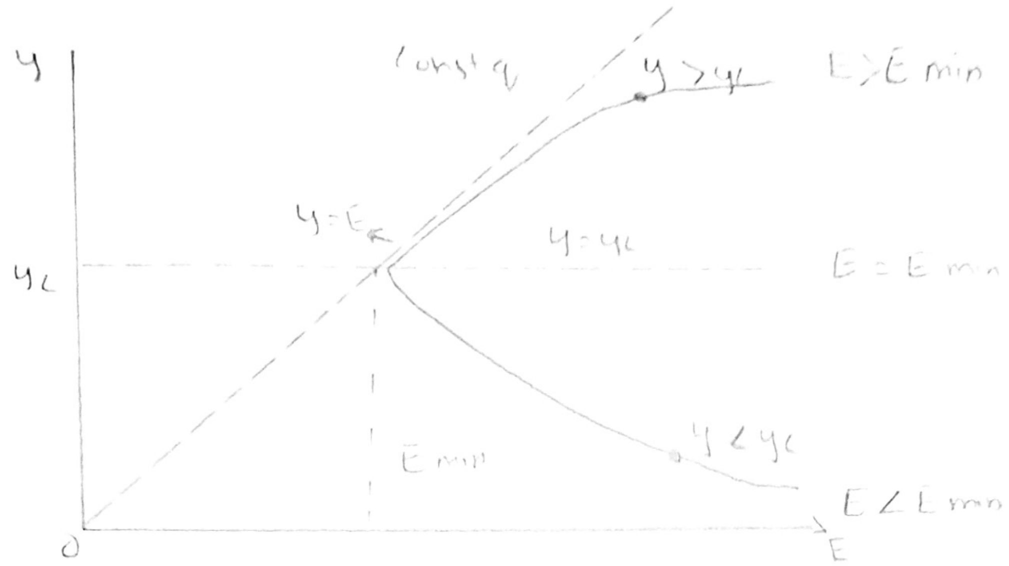
$$\frac{P_1}{9810} + 0.0000224 = 0.86 + 0.000005 + 8.2 \times 10^{-9}$$

$$\frac{P_1}{9810} = 0.86 + 0.000005 + 8.2 \times 10^{-9} - 0.0000224$$

$$\frac{P_1}{9810} = 0.85$$

$P_1 = 0.85 \times 9810$

$P_1 = 8338.5$ N/m^2



The Eq 3 is the three degree polynomial equation and can be used to prepare a plot of specific energy and depth of water (E-y)

How it is obtained

As we know that

Total enery = potential enery + Kinectic energy

$$T.E = P.E + K.E$$

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

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

$$m = W/g$$

ignoring "W" weight of water

$$T.E = h + \frac{V^2}{2g}$$

$$T.E = y + \frac{V^2}{2g}$$

As we know that

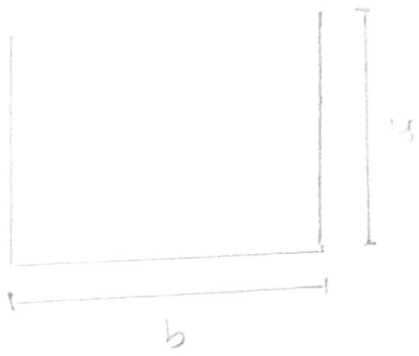
$$Q = AV$$

$$V = \frac{Q}{A} \Rightarrow V^2 = \frac{Q^2}{A^2}$$

Put V^2 in eq (1)

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

Let Suppose the channel in rectangular



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

Also $$Q = qb \longrightarrow (y)$$

Put eq x and y in eq (2)

$$E = y + \frac{Q^2}{A^2 2g} \longrightarrow (3)$$

$$E = y + \frac{Q^2}{y^2 b^2 2g} \quad \text{putting x)}$$

$$E = y + \frac{q^2}{2gy} \quad \text{(putting y)}$$

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

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

$$(E-y)y^2 = \text{constant} \rightarrow eq^3 \rightarrow eq$$

As q and g are constant

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

$y > y_c$ subcritical flow

$y = y_c$ critical flow

$y < y_c$ Super critical flow