Section - 'A' {Hydraulic Engineering} Page # 01

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Q No! 01

Part - (A) Discharge $= 6938 \, ft^3/sec = \frac{6938}{1000} = 6.938 \, m^3/sec$

Width of apron $= 8m$

mean velocity $= 6938 - 220 = 6718 \, ft/sec$

$$V_1 = \frac{6718 \, ft/sec}{3.28} = 2048.17 \, m/sec$$

1) Height of Hydraulic jump:

As "q" is discharge per unit width

$q = Q/b$

$$= \frac{6.938}{8} = 0.867 \, m^2/sec$$

⇒ As critical depth (y_c) is

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{(0.867)^2}{9.81}\right)^{1/3}$$

$$\boxed{y_c = 0.42 \, m}$$

⇒ Critical velocity :-

As $q = vy \Rightarrow v = q/y$

$$V_c = \frac{q}{y_c} \Rightarrow V_c = \frac{0.867}{0.42}$$

$V_c = 2.064$

As $V_1 > V_c$

Super critical flow :

Water Depth on up stream side is : (of Hydraulic jump)

$Q = AV$

$Q = (by).v$

$$y = \frac{Q}{v.b} \Rightarrow y_1 = \frac{Q}{v_1 . b}$$

$$y_1 = \frac{6.938}{2.061 \times 8}$$

$$\boxed{y_1 = 0.42\,m}$$

By formula

$$y_2 = \frac{-y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2y_1v_1^2}{g}}$$

$$y_2 = \frac{-0.42}{2} + \sqrt{\frac{(0.42)^2}{4} + \frac{2(0.42)(2.061)^2}{9.81}} = 0.428\,m$$

$$\boxed{y_2 = 0.428\,m}$$

$\Rightarrow$ Difference in depths

$$\Delta y = y_2 - y_1$$

$$\cancel{= 0.50 - 0.45}$$

$$= 0.428 - 0.42$$

$$\boxed{\Delta y = 0.008\,m}$$

As,

$$\Delta E = E_1 - E_2$$

Also, $Q_1 = Q_2$

$$A_1V_1 = A_2V_2$$

$$b_1y_1v_1 = b_2 \cdot y_2 \cdot v_2$$

$$\cancel{b} \cdot y_1 \cdot v_1 = \cancel{b} \cdot y_2 \cdot v_2 \qquad b = b_1 = b_2$$

$$v_2 = \frac{y_1v_1}{y_2} = \frac{0.42 \times 2048.17}{0.428} \Rightarrow \boxed{V_2 = 2009.80\,m/sec}$$

$\Rightarrow$ $\Delta E = E_1 - E_2$

$$\left(y_1 + \frac{v_1^2}{2g}\right) - \left(y_2 + \frac{v_2^2}{2g}\right)$$

$$E_1 - E_2 = \left(0.42 + \frac{(2048.17)^2}{2(9.81)}\right) - \left(0.428 + \frac{(2009.80)^2}{2(9.81)}\right)$$

$$E_1 - E_2 = 213812.87 - 205876.88$$

$$\boxed{E_1 - E_2 = 7935.98 \text{ m}}$$

$\Rightarrow$ Power Dissipation in Hydraulic jump:

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

$$= (1000)(9.81)(6.938)(7935.98)$$

$$\Delta p = 540136924.8 \text{ W}$$

$$\boxed{\Delta p = 540136.9248 \text{ KW}}$$

QNO! 01

Part (B)

Channel width (b) = 4m

Discharge = 6938 ft^3/sec

height of upstream side = 2.9m

height of downstream side = 1.1m

① Downstream velocity :-

As specific Energy is :

$$E_1 = E_2$$

$$y_1 + \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g}$$

Also from Discharge.

$$Q = AV$$

$$\Rightarrow A_1 V_1 = A_2 V_2 \qquad \therefore b = b_1 = b_2$$

$$(b_1 y_1) \cdot v_1 = (b_2 y_2) \cdot v_2 \Rightarrow \cancel{b}\, y_1 \cdot v_1 = \cancel{b} \cdot y_2 \cdot V_2$$

$$y_1 v_1 = y_2 v_2$$

$$v_2 = \frac{y_1 v_1}{y_2}$$

$$\Rightarrow v_2 = \left(\frac{2.9}{1.1}\right) v_1 \Rightarrow \boxed{V_2 = 2.63 v_1}$$ Put in eq (1)

$$\Rightarrow 2.9 + \frac{v_1^2}{2g} = 1.1 + \frac{(2.63 v_1)^2}{2g}$$

$$2.9 + \frac{v_1^2}{2g} = 1.1 + \frac{6.91 v_1^2}{2g}$$

$$\Rightarrow \frac{v_1^2}{2g} - \frac{6.91 v_1^2}{2g} = 1.1 - 2.9$$

$$\Rightarrow \cancel{-} \frac{5.91 v_1^2}{2g} = \cancel{-} 1.8$$

$$\Rightarrow 5.91 v_1^2 = 1.8 \times 2 (9.81)$$

$$v_1 = \sqrt{\frac{1.8 \times 2 (9.81)}{5.91}}$$

$$\boxed{V_1 = 2.44 \ m/sec}$$ Put in v_2 eq $\Rightarrow V_2 = 2.63(2.44)$

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

type of flow using Froud Number :

① on upstream side :

$$F_{r1} = \frac{V1}{\sqrt{gy_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = 0.45$$

$Fr < 1$ So its (Sub-Crictical flow)

② On Down Stream Side :

$$F_{r2} = \frac{v_2}{\sqrt{gy_2}} = \frac{6.41}{\sqrt{9.81 \times 1.1}} = 1.95$$

$Fr > 1$ So its (Super-critical flow).

Q NO! 02 :

Part (-A)

Given data:

Depth of channel = 1.8 m

Discharge = $6938 \; ft^3/sec = \frac{6938 \; ft^3}{3.28 \; m^3} = 196.61$

Channel width = 66 ft = 20.12 m

P = weir height = ?

Solution :-

$Q = aV$

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

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

Put the value in eq/

$$V = \frac{196.61}{20.12 \times 1.8}$$

$$\boxed{V = 5.42 \; m/sec}$$

Critical depth

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

As

$$q = \frac{Q}{b} = \frac{196.61}{20.12} = 9.77\ m^2/sec$$

$$y_c = \left(\frac{(9.77)^2}{9.81}\right)^{1/3} = 2.13\ m$$

$$\boxed{y_c = 2.13\ m}$$

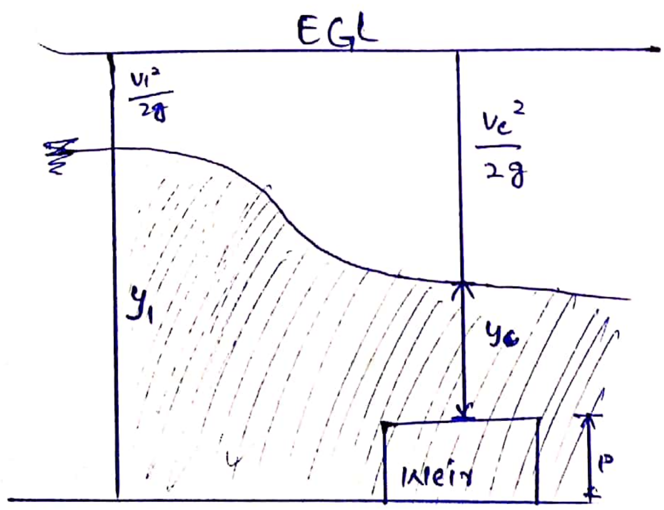
Also

$$V = \sqrt{gy}$$

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

$$V_c = \sqrt{9.81 \times 2.13}$$

$$\boxed{V_c = 4.57\ m/sec}$$



From the figure

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

$$\frac{(5.42)^2}{2 \times 9.81} + 1.8 = \frac{(4.57)^2}{2 \times 9.81} + 2.13 + P$$

$$3.296 = 3.194 + P$$

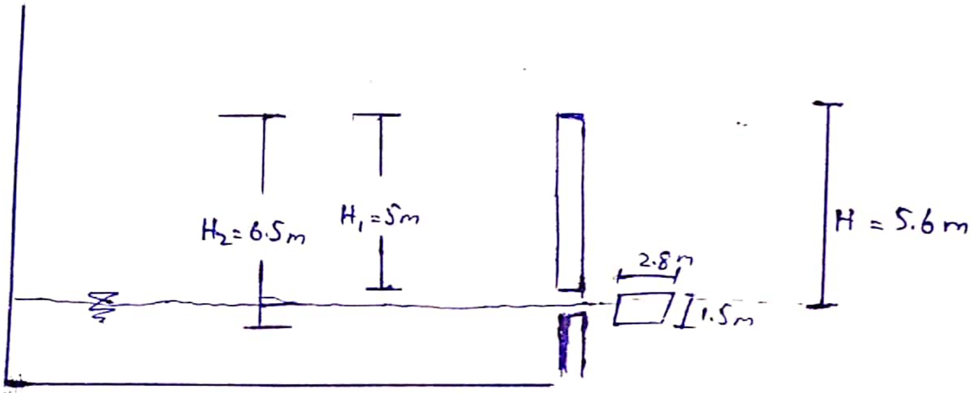
$$\boxed{P = 0.100\,m}$$

The weir should have hight of 0.100 meter measured from the channal bed.

QNo! 02

Part (B)

Given data:



Width = 2.8m

depth = 1.5m

H = 5.6m

H_1 = 5m

H_2 = 6.5m

Cd = 0.6938

Solution :-

Submerged portion:

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

Put the value

$$Q_1 = .6938 \times (2.8)(6.5 - 5.6) \times \sqrt{2(9.81)(5.6)}$$

$$\boxed{Q_1 = 18.32 \ m^3/sec}$$

Free portion

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

$$Q_2 = \frac{2}{3}(.6938) \times (2.8)\sqrt{2(9.81)} \times [(5.6)^{3/2} - (5)^{3/2}]$$

$$\boxed{Q_2 = 11.88 \ m^3/sec}$$

$$\text{Total} = Q_1 + Q_2$$

$$Q_T = 18.32 + 11.88$$

$$\boxed{Q_T = 30.2 \ m^3/sec}$$

Q No/ 03

Part-

Given data:

Diameter $= d_1 = R - 200\,mm$

$6938 - 200\,mm = 6738\,mm$

Diameter $= d_2 = R + 3000\,mm$

$6938 + 3000\,mm = 9938$

Flow rate $(Q) = 0.95\,m^3/sec$

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

$= 6938 + 800 = 7738\,N/m^2$

Calculate:

Loss of head due to sudden enlargment ?

Power lost due to sudden enlargment.

Pressure in smaller pipe:

Scanned with CamScanner

1. Loss of head due to Sudden enlargment :

$d_1 = 6738\ mm = 6.73\ m$

$A_1 = \frac{\pi}{4}(6.73)^2 = 35.57$

$d_2 = 9938 = 9.93\ m$

$A_2 = \frac{\pi}{4}(9.93)^2 = 77.44 m$

As : $Q = AV$

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

$V_1 = \frac{0.95}{35.57} = \boxed{0.026\ m/sec}$

Similarly

$V_2 = Q/A_2$

$V_2 = \frac{0.95}{77.44} = \boxed{0.012\ m/sec}$

By formula of Sudden Enlargment:

$$he = \left(1 - \frac{A1}{A2}\right)^2 \times \left(\frac{(V_1 - V_2)^2}{2g}\right)$$

$$= \left(1 - \frac{35.57}{77.44}\right)^2 \times \frac{(0.026 - 0.012)^2}{2 \times 9.81}$$

$$(0.29) \times \frac{1.96 \times 10^{-4}}{19.26}$$

$$\boxed{he = 2.89 \times 10^{-6}}$$

Power loss due to sudden Enlargment

$$P = \rho g Q he$$

$$P = (1000)(9.81)(0.95)(2.89 \times 10^{-6})$$

$$\boxed{P = 0.027 = 2.7 \times 10^{-2} W}$$

Pressure in the smaller pipe

By using Bernolli's Equation.

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + he$$

$$\frac{P_1}{(1000)(9.81)} + \frac{(0.026)^2}{2(9.81)} = \frac{7738}{(1000)(9.81)} + \frac{(0.012)^2}{2(9.81)} + (2.89 \times 10^{-6})$$

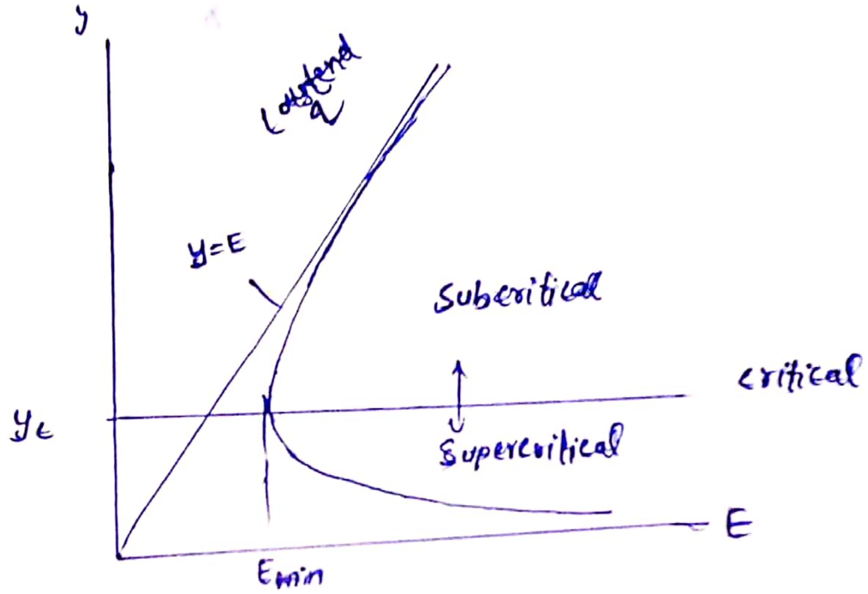
$$\frac{P}{9810} + 3.44 \times 10^{-5} = 0.788 + 7.33 \times 10^{-6} + (2.89 \times 10^{-6}$$

$\cancel{P_1 = 7730.04}$

$$\boxed{P_1 = 7730.04 \ N/m^2}$$

Q No! 03

Part (B)



Specific Energy Curve / Blue curve Indicates :

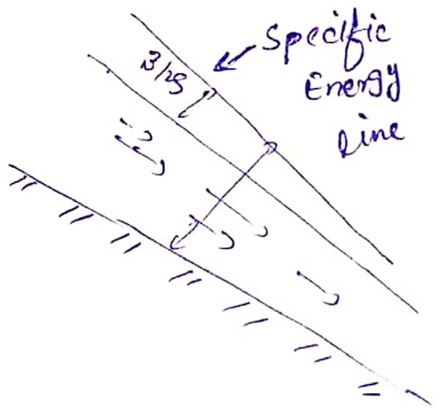
This curve indicates that when depth increases then critical depth y_c then the flow condition is sub-critical, when depth decreases then y_c the flow condition is super critical.

When depth increases then y_c then specific energy increases, when depth decreases then y_c the specific energy decreases.

* Procedure to obtained curve :

Energy per unit weight of liquid with due respective bottom of the channel

$$E = h + \frac{V^2}{2g} \longrightarrow (1)$$



Also $E = E_p + E_k$

where E_p = Potential energy of flow $= h$

E_k = Kinetic energy of flow $= \frac{V^2}{2g}$

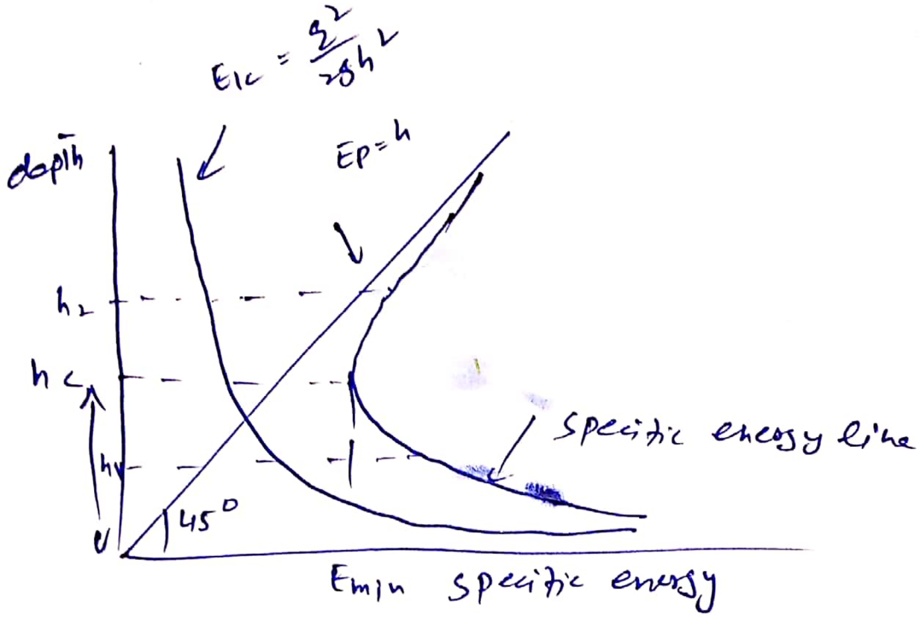
$Q = AV$

$A = b \times h$

$V = \frac{Q}{A} = \frac{Q}{b \times h}$, $Q/b = q$

$= q/h$

$(1) \Rightarrow \quad E = h + \frac{q^2}{2gh^2} = E_p + E_k$



Explaination :

$y > y_c$ $E > E_{min}$ (sub Critical flow)

$y = y_c$ $E = E_{min}$ (Critical flow)

$y < y_c$ $E = E_{min}$ (Super critical flow)

The End .