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Semester: 6th

Subject: Hydraulics Engineering

Section: A

Question-01
(Part-A)

Ans:-

Given:-

Discharge (Q) = 7829 Lit/sec

$= \frac{7829}{1000} = 7.829\ m^3/sec$

Bredth (b) = 8m

Mean Velocity (V) = 7829 - 220

= 7609 ft/sec

$= \frac{7609}{3.28}$ $\boxed{= 2319.81\ m/sec}$

1- Height of Hydraulic Jump:-

As we know that "q" → discharge per unit bredth,

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

$$q = \frac{7.829}{8} \Rightarrow 0.9786\ m^3/sec$$

$$\boxed{q = 0.9786\ m^3/sec}$$

→ Critical Depth:-

By formula

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

$$y_c = \left(\frac{(0.9786)^2}{9.81}\right)^{1/3}$$

$$\boxed{y_c = 0.46m}$$

→ Critical Velocity:-

As we know that

$$q = Vy \Rightarrow V = q/y$$

$$V_c = q/y_c$$

$$\Rightarrow V_c = \frac{0.9786}{0.46}$$

$$\Rightarrow \boxed{V_c = 2.127 m/sec}$$

Depth of water on Upstream Side:-
(of Hydraulic Jump)

By using Discharge formula

$$Q = AV$$

$Q = (b \times y).V$

$\rightarrow y = \frac{Q}{V.b}$

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

$\rightarrow y_1 = \frac{7.829}{2319.81 \times 8} \rightarrow \boxed{y_1 = 0.0004218m}$

Also

By using formula, we will find water depth on downstream side.

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

$\rightarrow y_2 = -\frac{0.0004218}{2} + \sqrt{\frac{(0.0004218)^2}{4} + \frac{2(0.0004218)(2319.81)^2}{9.81}}$

$\boxed{y_2 = 21.51}$

Difference In Depths:-

$\Delta y = y_2 - y_1$

$=$

$\Delta y = 21.51 - 0.0004218$

$\boxed{\Delta y = 21.50m}$

By Discharge formula,

$$Q_1 = Q_2$$

$$A_1 V_1 = A_2 V_2$$

$$(b_1 \cdot y_1) V_1 = (b_2 \cdot y_2) \cdot V_2$$

$$\cancel{b} \cdot y_1 \cdot V_1 = \cancel{b} \cdot y_2 \cdot V_2 \qquad (\because b = b_1 = b_2)$$

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

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

$$V_2 = \frac{(0.0004218)(2319.81)}{(21.51)}$$

$$\boxed{V_2 = 0.045}$$

As we know that

$$\Delta E = E_1 - E_2$$

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

$$= \left(0.000421 + \frac{(2319.81)^2}{2(9.81)}\right) - \left(21.51 + \frac{(0.045)^2}{2(9.81)}\right)$$

$$\boxed{E_1 - E_2 = 274265.87\,m}$$

Power Dissipation In Hydraulic Jump:-

By Using formula

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

$= (1000)(9.81)(7.829)(274265.87)$

$\boxed{\Delta P = 2.1 \times 10^{10}\ W}$

$\Delta P =$

Q.No-1 (Part-B)

Ans:-

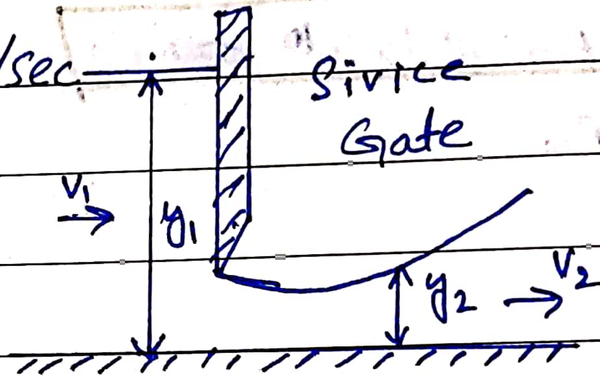
Given data:-

Channel width (b) = 4m

Discharge = 7829 ft³/sec

$$= \frac{7829}{(3.28m)^3}$$

$$= 221.83$$



Depth on upstream side = 2.9m

Depth on Downstream side = 1.1m

Sol:-

First we have to find downstream velocity

1- Downstream Velocity:-

As from Specific Energy Equation, Specific energy remains same on both streams.

So,

$$E_1 = E_2$$

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

→ Also from Discharge Equation:

$Q = Av$

$\Rightarrow Q = A_1 V_1 = A_2 V_2$

$(b_1 y_1).V_1 = (b_1 y_2).V_2$

As $b = b_1 = b_2$, So

$b.y_1.V_1 = b.y_2.V_2$

$\rightarrow V_2 = \dfrac{y_1 V_1}{y_2}$

$V_2 = \dfrac{2.9}{1.1} V_1 \Rightarrow \boxed{V_2 = 2.63 V_1}$

⇒ Now put the 'V_2' equation in eq ①,

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

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

$$\frac{V_1^2}{2(9.81)} - \frac{6.91V_1^2}{2(9.81)} = 1.1 - 2.9$$

$$\cancel{-}\frac{5.91V_1^2}{19.62} = \cancel{-}1.8$$

$$5.9V_1^2 = 1.8$$

$$V_1 = \sqrt{\frac{1.8 \times 19.62}{5.91}}$$

$\boxed{V_1 = 2.44 m/sec}$

Put this value in "V_2" equation.

$\Rightarrow V_2 = 2.44(2.63)$

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

2. Type of flow Determination:-

- On Upstream Side:-

By using Froud Number

$$Fr_1 = \frac{V_1}{\sqrt{gy_1}} = \frac{2.44}{\sqrt{(9.81)(2.9)}}$$

$$= 0.45.$$

$$= 0.45 < 1$$

$\downarrow$

So this is Subcritical Flow

$(Fr < 1)$

- On Downstream Side:-

Using Froud Number,

$$Fr_2 = \frac{V_2}{\sqrt{gy_2}} = \frac{6.41}{\sqrt{(9.81)(1.1)}} = 1.95$$

$$1.95 > 1$$

$\downarrow$

Super-critical flow

$(Fr > 1)$

Question -02
(Part-A)

Ans:-

Given data:-

Channel depth (d) = 1.8m

Discharge = 7829 ft^3/sec

$$= \frac{7829}{(3.28m)^3} = 221.91\ m^3/sec$$

width of channel (b) = 66 ft

$$= \frac{66}{3.28} \boxed{= 20.1m}$$

Weir Height (P) = ?

Sol:-

By using discharge formula,

$Q = AV$

$V = Q/A \Rightarrow V_1 = Q/A \Rightarrow V_1 = Q/b\times y$

$$\Rightarrow V_1 = \frac{221.91}{20.1\times1.8} \Rightarrow \boxed{V_1 = 6.133\ m/sec}$$

Critical Depth:-

By formula,

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

where $q = Q/b$

$$= \frac{221.91}{20.1} \quad \boxed{= 11.04\,m^2/sec}$$

So,

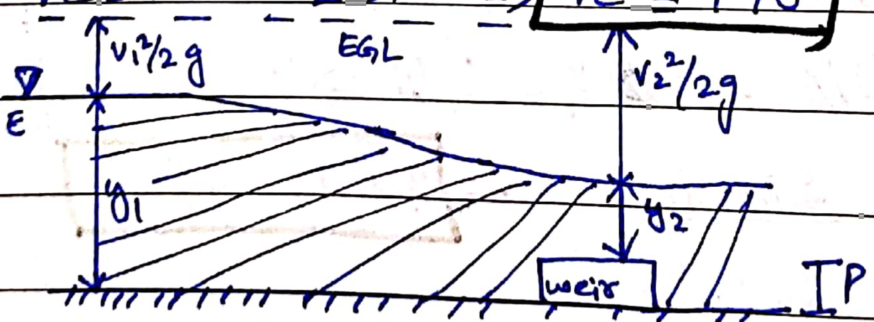
$$y_c = \left(\frac{(11.04)^2}{9.81}\right)^{1/3}$$

$$\boxed{y_c = 2.31}$$

Also $V = \sqrt{gy}$

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

$$V_c = \sqrt{9.81 \times 2.31} \Rightarrow \boxed{V_c = 4.76}$$



According to the figure

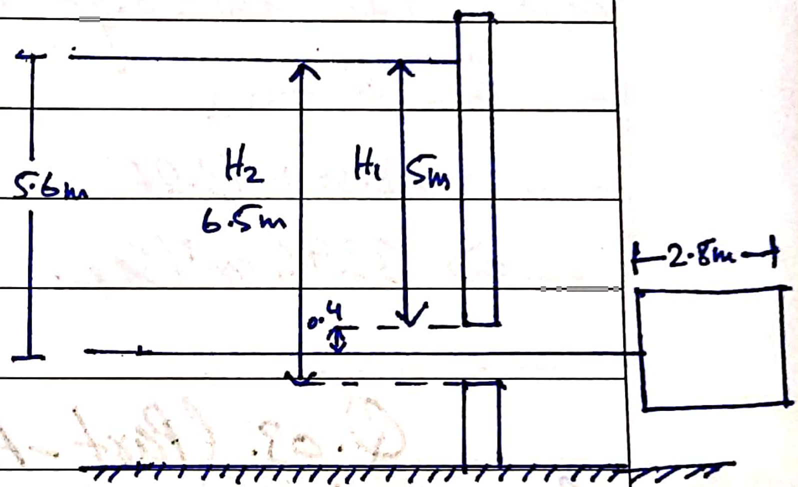
$$\frac{V_1^2}{2g} + y_1 = \frac{V_c^2}{2g} + y_c + P$$

$$\frac{(6.183)^2}{2\times 9.81} + 1.8 = \frac{(4.76)^2}{2\times 9.81} + 2.31 + P$$

$$\boxed{P = 0.25}$$

Q.No.02 (Part-B)

Ans:- Given Data:-



Breadth $(b) = 2.8m$

Depth $(d) = 1.5m$

$H_1 = 5m$

$H_2 = 5m + 1.5 = 6.5m$

$H = 5m + 0.6m = 5.6m$

$Cd = 0.78$

Sol:-

1- Discharge through Sub-merged Portion:-

By using formula.

$Q_1 = Cd \times b \times (H_2 - H_1) \times \sqrt{2gH}$

$= 0.78 \times 2.8 (6.5 - 5.6) \times \sqrt{(2)(9.81)(5.6)}$

$= 20.60 m^3/sec.$

$$\boxed{Q_1 = 20.60 m^3/sec}$$

2- Discharge through Free Portion:-

By using formula.

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

$$= \frac{2}{3}(0.78)\times(2.8)\sqrt{2(9.81)}\times\left[(5.6)^{3/2} - (5)^{3/2}\right]$$

$$Q_2 = 13.36 \; m^3/sec.$$

Now total discharge will be,

$$Q = Q_1 + Q_2$$

$$= 20.60 + 13.26$$

$$\Rightarrow 33.96 \; m^3/sec.$$

Q.03. (Part-A)

Given data:-

$$d_1 = R_1 - 200mm$$

$$= 7829 - 200 = 7629 \; mm$$

$$d_2 = R + 3000mm$$

$$= 7829 + 3000mm = 10829 \; mm$$

Flowrate $(Q) = 0.95 \; m^3/sec$

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

$$= 7829 + 800$$

$$= \boxed{8629 \; N/m^2}$$

Sol :- 1- Head loss due to Sudden Enlargement:-

$d_1 = 7629mm = 7.629m$

$\Rightarrow A_1 = \frac{\pi}{4}(d_1)^2 = \frac{3.14}{4}(7.629)^2$

$\boxed{A_1 = 45.6}$

$d_2 = 10829mm = 10.829m$

$\Rightarrow A_2 = \frac{\pi}{4}(d_2)^2 = \frac{\pi}{4}(10.829)^2$

$\boxed{A_2 = 92.05}$

By discharge formula,

$Q = AV$

$V = Q/A$

$\Rightarrow V_1 = Q/A_1 = \frac{0.95}{45.6} \boxed{= 0.0208}$

Similarly:-

$\rightarrow V_2 = Q/A_2$

$= \frac{0.95}{92.05} = \boxed{0.0103}$

$\rightarrow$ By formula of Sudden Enlargement:-

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

$h_L = \left(1 - \frac{(45.6)}{(92.05)}\right)^2 \times \left(\frac{(0.0208 - 0.0103)^2}{2 \times 9.81}\right)$

Scanned with CamScanner

$$\boxed{h_c = 2.58 \times 10^{-3}}$$

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

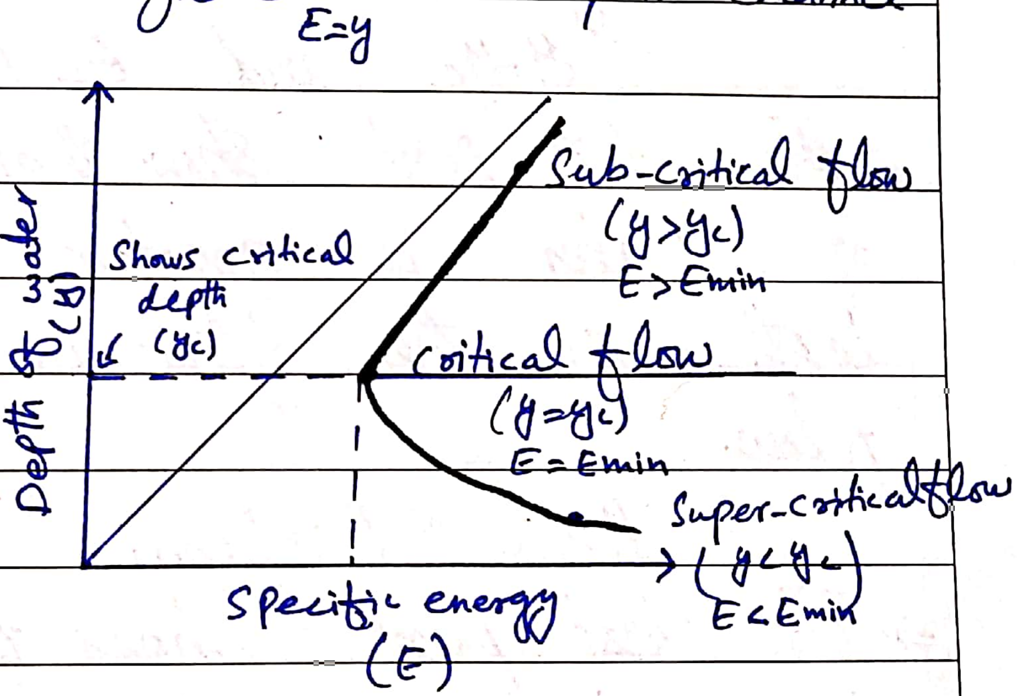
$$\frac{P_1}{(1000)(9.81)} + \frac{(0.0268)^2}{2(9.81)} = \frac{P_2}{(1000)(9.81)} + \frac{(0.0103)^2}{2(9.81)} + 2.58 \times 10^{-3}$$

$$\frac{P_1}{(1000)(9.81)} + \frac{(0.0268)^2}{2(9.81)} = \frac{8629}{(1000)(9.81)} + \frac{(0.0103)^2}{2(9.81)} + 2.58 \times 10^{-3}$$

$$\boxed{P_1 = 8654.1}$$

(Part-B)

Ans:- First we define Specific energy as "Specific energy is a parameter that can be used to clarify the meaning of super critical, Sub-critical and critical flow in an open channel"



★ Black Curve:-

From the given graph or figure the black curve is the 3-degree polinomial curve which show the flow is critical flow, Sub critical flow and super critical flow.

⇒ The middle point show that the depth of water is equal to the critical depth corresponding to minimum energy so the flow is critical flow.

$y = y_c$ and $E = E_{min}$

⇒ The top point show that depth of water is greater than critical depth so the flow is sub-critical flow.

$y > y_c$ & $E > E_{min}$

⇒ The test point shows that the water depth is less than

Critical depth:-

is a depth of water at which maximum specific energy is obtained".

⇒ The given figure or graph consists of two axis
① x-axis ⇒ Specific energy
② y-axis → Depth of water

⇒ From the given figure, the center line where $E = y$ show that the specific energy is directly proportional to specific energy

$E \propto y$.