Mid term paper

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ID: 7807

Section: 'A'

Subject: Hydraulic Engg

Submitted to: Engr. Fawad Ahmad.

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Section 'A'

Q: 1/ Part "A"

Given data:-

Q = Discharge = 7807 Lit/sec

$= \frac{7807}{1000} = 7.807 \, m^3/sec$

Breadth (b) = 8m

Mean velocity (v) = 7807 − 220

= 7587 ft/sec

$= \frac{7587}{3.28} = 2313.1 \, m/sec$

1- Height of Hydraulic Jump:-

we know that

$q = \frac{Q}{b} = \frac{7.807}{8} = 0.975 \, m^2/sec$

$\boxed{q = 0.975 \, m^2/sec}$

→ Critical depth:

$y_c = \left(\frac{(q)^2}{g}\right)^{1/3} = \left(\frac{(0.975)^2}{9.81}\right)^{1/3} \Rightarrow \boxed{y_c = 0.45 \, m}$

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⇒ Critical velocity :-

we know that

$q = Vy$

$V = q/y \Rightarrow V_c = q/y_c$

$V_c = \frac{0.975}{0.45} = 2.16 \, m/sec$

Depth of water on upstream side :-

By Discharge formula:

$Q = AV$

$\Rightarrow Q = (b \times y) \cdot v \Rightarrow y = \frac{Q}{V_c \cdot b}$

$y_1 = \frac{Q}{V_c \cdot b} = \frac{7.807}{2.16 \times 8} = 0.45m$

$\boxed{y_1 = 0.45m}$

Down stream water depth.

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

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$$y_2 = \frac{-0.45}{2} + \sqrt{\frac{(0.45)^2}{4} + \frac{2(1.45)(2.16)^2}{9.81}}$$

$$\boxed{y_2 = 0.46}$$

Difference in depth:-

$$\Delta y = y_2 - y_1$$

$$= 0.46 - 0.45$$

$$\boxed{\Delta y = 0.01\ m}$$

Now

$$Q_1 = Q_2$$

$$A_1 V_1 = A_2 V_2$$

$$(b_1 \cdot y_1) \cdot v_1 = (b_2 \cdot y_2) V_2$$

$$b \cdot y_1 \cdot v_1 = b \cdot y_2 \cdot V_2$$

$$y_1 V_1 = y_2 V_2$$

$$V_2 = \frac{y_1 V_1}{y_2} = \frac{0.45 \times 2313.1}{0.46}$$

$$\boxed{V_2 = 2262.81\ m/sec}$$

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Section: A

Now

$$\Delta E = E_1 - E_2$$

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

$$= \left(0.45 + \frac{(2313.1)^2}{2(9.81)}\right) - \left(0.46 + \frac{(2262.81)^2}{2(9.81)}\right)$$

$$= 272679.8 - 260974.42$$

$$\boxed{E_1 - E_2 = 11705.38}$$

Power Dissipation in hydraulic jump:

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

$$= (1000)(9.81)(7.807)(11705.38)$$

$$\Delta P = 896476075.2 \text{ W}$$

$$\boxed{\Delta P = 896476.0752 \text{ kW}}$$

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section: 'A'

Q:1/ (Part B)

Given data:-

Discharge = Q = 7807 ft^3/sec

$= \frac{7807}{(3.28m)^3} = 221.23$

$Q = 221.23$

channel width $(b) = 4m$

Depth on upstream side = 2.9m

Depth on downstream side = 1.1m

Soln:-

1- Downstream velocity:-

As from Specific Energy Equation:

$E_1 = E_2$

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

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Section: "A"

Discharge Equation

$$Q = AV$$

$$Q = A_1 V_1 = A_2 V_2$$

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

$$y_1 V_1 = y_2 V_2$$

$$V_2 = \frac{y_1 V_1}{y_2} = \frac{2.9}{1.1} V_1$$

$$\boxed{V_2 = 2.63 V_1}$$

Put V_2 in (1)

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

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

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

$$2.9 \frac{V_1^2}{2g} = 1.1 + \frac{6.91 V_1^2}{2g}$$

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

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

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

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

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

Now put in V_2.

~~$V_2 = 2.44 (2.63$~~

$$V_2 = 2.63 (2.44)$$

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

2- Type of flow :

- On upstream side :

By using Froud Number.

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$$Fr_1 = \frac{V_1}{\sqrt{gy_1}} = \frac{9.44}{\sqrt{9.81 \times 2.9}} = 0.45$$

$0.45 < 1 \Rightarrow$ Subcritical Flow ($Fr < 1$)

- On Downstream Side:-

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

$1.95 > 1 \Rightarrow$ Super Critical flow.

Q: 2/ (part "A")

Given data:-

Discharge = 7807 ft^3/sec = 221.23 m^3/sec

channel depth (d) = 1.8 m

Channel width (b) = 66 ft = $\frac{66}{3.28}$ = 20.1 m

weir height (P) = ?

Solution:-

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(9)

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By Discharg formula :-

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

$$V_1 = \frac{221.23}{20.1 \times 1.8} = 6.11$$

$$\boxed{V_1 = 6.11 m/sec}$$

Critical depth :-

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

where $q = Q/b$

$$= \frac{221.23}{20.1} = 11.006 \ m^2/sec$$

So $$y_c = \left(\frac{(11.006)^2}{9.81}\right)^{1/3}$$

$$\boxed{y_c = 2.31}$$ Also $V = \sqrt{gy}$

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

$$V_c = \sqrt{9.81 \times 2.31} = \boxed{V_c = 4.77 m/sec}$$

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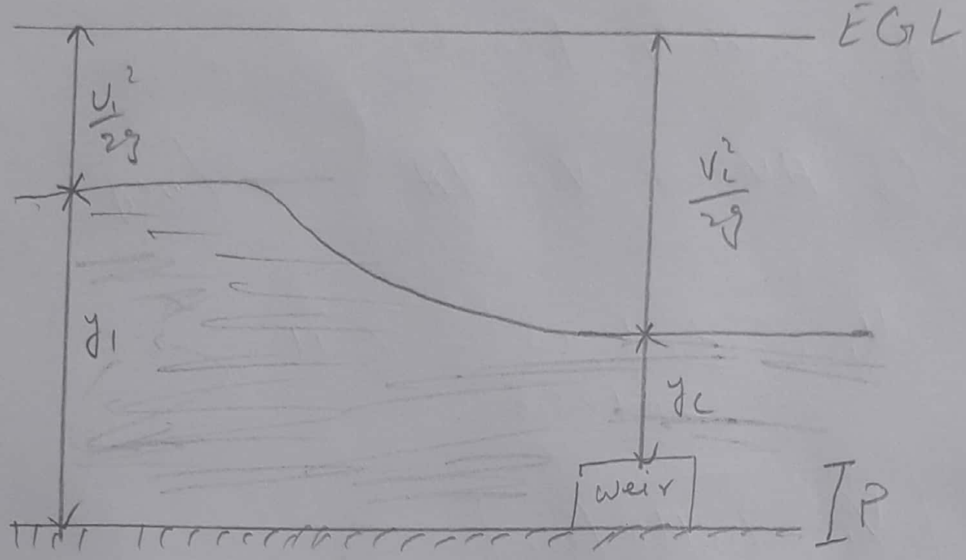

According to figure

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

$$\frac{(6.11)^2}{2\times 9.81} + 1.8 = \frac{(4.77)^2}{2\cdot 9.81} + 2.31 + P$$

$$1.902 + 1.8 = 1.159 + 2.31 + P$$

$$3.702 = 3.469 + P$$

$$\boxed{P = 0.233\,m}$$

So weir height should be 0.233 m from channel bed.

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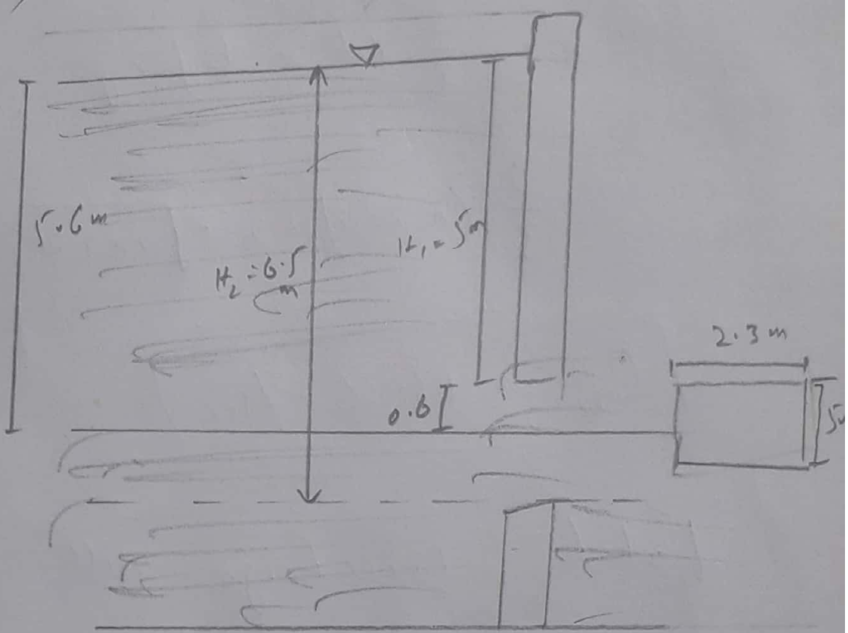
Q: 9/ (Part B)



Given data:

Depth = d = 1.5m

Breadth = b = 2.8m

H_1 = 5m

H_2 = 5m + 1.5m = 6.5m

H = 5m + 0.6 = 5.6m

Cd = 0.7805

Solution:

1- Discharge Throug Submerged Portion

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

$$= 0.7807 \times 2.8(6.5 - 5.6) \times \sqrt{2(9.81)(5.6)}$$

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

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Discharge through free portion:-

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

$$= \frac{2}{3}(0.7807) \times 2.8\sqrt{2\times 9.81} \times \left[(5.6)^{3/2} - (5)^{3/2}\right]$$

$$\boxed{Q_2 = 13.36\ m^3/sec}$$

Total Discharge will

$$Q = Q_1 + Q_2$$

$$Q = 20.60 + 13.36$$

$$\boxed{Q = 33.96\ m^3/sec}$$

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Q: 3/ Part "A"

Given data :-

$d_1 = 7807 - 200\ mm = 7607\ mm$

$d_2 = 7807 + 3000 = 10807\ mm$

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

Pressure $= 7807 + 800\ N/m^2$

$= 8607\ N/m^2$

Soln :-

Headloss due to Sudden Enlargment :

$d_1 = 7607\ mm = 7.60\ m$

$\Rightarrow A_1\ \frac{\pi}{4}(d_1)^2 = \frac{\pi}{4}(7.60)^2$

$\boxed{A_1 = 45.3\ m^2}$

$d_2 = 10807\ mm$

$\Rightarrow A_2 = \frac{\pi}{4}(d_2)^2 = \frac{\pi}{4}\left(\frac{10807}{1000}\right)^2 = 91.68$

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(14)

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By Discharge

~~Q = A/V~~ $Q = AV$

$V_1 = Q/A_1 = \frac{0.95}{45.3} = 0.020\ m/sec$

Now

$V_2 = Q/A_2 = \frac{0.95}{91.68} = 0.010\ m/sec$

So,

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

$= \left(1 - \frac{45.3}{91.68}\right)^2 \times \left(\frac{(0.020 - 0.010)^2}{2 \times 9.81}\right)$

$= (0.255)(5.096 \times 10^{-6})$

$h_e = 1.302 \times 10^{-6}\ m$

<u>Power loss becaus of Sudden Enlargment:-</u>

$P = \rho g Q h_e$

$= (1000)(9.81)(0.95)(1.302 \times 10^{-6})$

$P = 0.012\ W$

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3- Pressure in Similar Pipe:-

By Bernouli Equation:-

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

$$\frac{P_1}{(1000)(9.81)} + \frac{(0.020)^2}{2\cdot(9.81)} = \frac{P_2}{(1000)(9.81)} + \frac{(0.010)^2}{2(9.81)} + 1.302\times10^{-6}$$

$$\frac{P_1}{9810} + 0.0000203 = \frac{8607}{9810} + 0.00000509 + 0.00000130 2$$

$$\frac{P_1}{9810} = 0.877 + 0.00000509 + 0.000001302 - 0.0000203$$

$$\frac{P_1}{9810} = 0.876$$

$$P_1 = 0.876 \times 9810$$

$$\boxed{P_1 = 8593.56\ N/m^2}$$

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(16)

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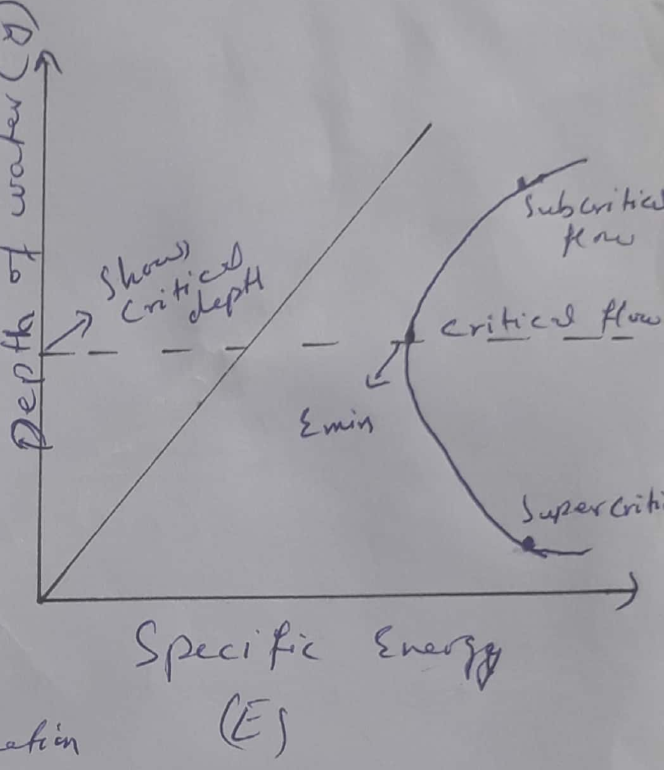
Q: 3 (Part B)

Ans:-

⇒ The above graph consist of two axes: (Specific Energy and Depth of water.



⇒ From the derivation of Specific Energy Equation, three degree polynomial equation is obtained.

$$(E-y)y^2 = \frac{q^2}{2g} \quad (1)$$

⇒ In above Equation:

E ⇒ Specific Energy

y ⇒ depth of water

q = discharge per unit breadth

⇒ Black Solid line in the graph show the direct relation of Specific ~~Engy~~ Energy.

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(17)

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⇒ The Blue 3-degree Curve Consist of 3 points

⇒ 1) Sub critical ($y > y_c$)

2) critical flow ($y = y_c$)

3) Super Critical flow ($y < y_c$)

→ Critical depth is the depth of water at which minimum Specific Energy is obtained.

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