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TECHNOLOGY: Bsc Civil Engg

PAPER: HYDRAULICS ENGINEERING

IQRA NATIONAL UNIVERSITY

PESHAWAR HAYATABAD PHASE II

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Q.NO 1 | Part_A

Given DATA:

Channel Width $= b = 8m$

Discharge $= Q = 7866$ lit/sec $= 7.866\ m^3/sec$

Mean Velocity $= V = R - 220 = 7866 - 220$

$\Rightarrow V = 7646$ ft/sec

$\Rightarrow V = \dfrac{7646}{3.28} = \boxed{2331.097\ m/sec}$

As we know that

$Q = qb$

$\Rightarrow q = Q/b \Rightarrow q = \dfrac{7.866}{8} = 0.98325\ m^3/sec$

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

$= \left[\dfrac{(0.98325)^2}{9.81}\right]^{1/3}$

$\Rightarrow \boxed{y_c = 0.0334m}$

As it is Rectangular Section

$Q = qb \longrightarrow ①$

$Q = AV \longrightarrow ②$

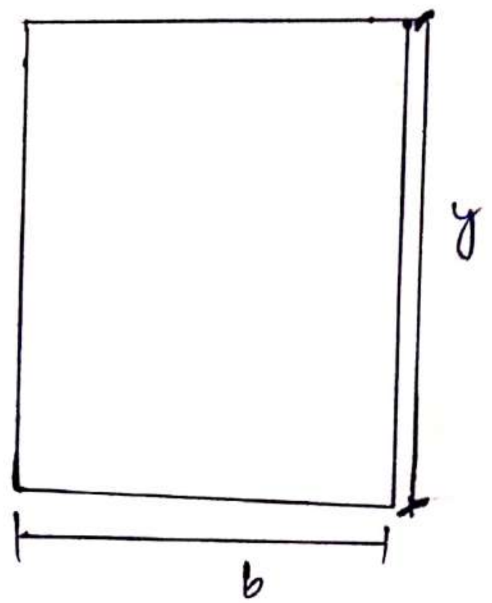
Equating Eq ① and ②

$qb = AV$

$q\cancel{b} = y\cancel{b}V$

$q = yV$

$V_c = q/y_c$



$$V_c = \frac{0.98325}{0.0334}$$

$V_c = 29.438\ m/sec$

$V > V_c$ (Super Critical Flow)

Height of Hydraulic Jump on the upstream side.

As $Q = AV$

$$\Rightarrow Q = byV$$

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

$$\Rightarrow y_1 = \frac{7.866}{2331.097 \times 8}$$

$$\Rightarrow \boxed{y_1 = 0.0004 m}$$

$$y_2 = \frac{0.0004}{2} + \sqrt{\frac{(0.0004)^2}{4} + \frac{2(0.0004)(2331.097)^2}{\times 9.81}}$$

$$\boxed{y_2 = 21.0502 m}$$

$$\Delta Y = y_2 - y_1$$

$$\Delta Y = 21.0502 - 0.0004$$

$$\boxed{\Delta Y = 21.0498}$$

$$\Delta E = E_1 - E_2$$

As we know that

$$Q_1 = Q_2$$

P.T.O

$$A_1V_1 = A_2V_2$$

$$\cancel{b}y_1V_1 = \cancel{b}y_2V_2 \qquad \because b_1 = b_2 = b$$

$$\Rightarrow V_2 = \frac{y_1V_1}{y_2}$$

$$V_2 = \frac{0.0004 \times (2331.097)}{21.0502}$$

$$\boxed{V_2 = 0.0443 \text{ m/sec}}$$

$$\Delta E = E_1 - E_2$$

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

$$= \left(0.0004 + \frac{(2331.097)^2}{2\times 9.81}\right) - \left(21.0502 + \frac{(0.0443)^2}{2\times 9.8}\right)$$

$$\boxed{E_1 - E_2 = 26653813.82 \text{ m}}$$

P.T.O

II Power Absorbed:

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

$$\Delta P = 1000 \times 9.81 \times 7.866 (26653813.82)$$

$$\boxed{\Delta P = 2.05 \times 10^9 \text{ KW}}$$

QNO: 1 **Part - B**

$b = 4m$

$$Q = 7866 \text{ ft}^3/\text{sec} = \frac{7866}{(3.28)^3}$$

$$= 222.911 \text{ m}^3/\text{sec}$$

$y_1 = 2.9 m$

$y_2 = 1.1 m$

Let specific Energy at upstream and downstream side.

P.T.O

$$E_1 = E_2$$

$$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g} \rightarrow 1$$

As we know that

$$Q = A_1V_1 = A_2V_2$$

$$by_1V_1 = by_2V_2 \qquad \because b_2 = b_1 = b$$

$$V_2 = \frac{y_1V_1}{y_2}$$

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

$$\boxed{V_2 = 2.634V_1} \longrightarrow 2$$

Put the value of Equation 2 in Equation 1

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

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

P.T.O

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

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

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

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

Now put the velocity of V_1 in Equation (1)

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

$$\Rightarrow 2.9 + \frac{(2.44)^2}{2 \times 9.81} = 1.1 + \frac{V_2^2}{2 \times 9.81}$$

$$\Rightarrow 2.9 - 1.1 = \frac{V_2^2}{2 \times 9.81} - \frac{(2.44)^2}{2 \times 9.81}$$

P.T.O

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

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

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

$$\boxed{V_2 = 6.42 \text{ m/sec}}$$

Using Froud Number To Determine Type of Flow.

<u>upstream Side:-</u>

$$Fr_1 = \frac{V_1}{\sqrt{g y_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}}$$

$$\Rightarrow \boxed{Fr_1 = 0.457 < 1}$$

$\Downarrow$

Subcritical Flow

Downstream Flow:-

$$Fr_2 = \frac{V_2}{\sqrt{g y_2}} = \frac{6.42}{\sqrt{9.81 \times 1.1}} = 1.95 > 1$$

supercritical Flow.

QN.O: 2 Part - A

Given DATA

$y = 1.8 \quad b = 66' = \frac{66}{3.28}$

$\Rightarrow \boxed{b = 20.12\,m}$

$Q = \frac{7866}{(3.28)^3} = 222.911\ m^3/sec$

Required Data:

Minimum Height of Weir = ?

$Q = AV$

$\Rightarrow V = Q/A = \frac{Q}{by} = \frac{222.911}{20.12 \times 1.8}$

$\Rightarrow \boxed{V = 6.155\ m/sec}$

As We know That

$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{(11.079)^2}{9.81}\right)^{1/3}$

$\Rightarrow y_c = \left(\frac{122.7442}{9.8}\right)^{1/3}$

P.T.O

$$\Rightarrow \boxed{y_c = 4.1707 m}$$

Also

$$V = \sqrt{gy}$$

$$V_c = \sqrt{9.81 \times 4.1707}$$

$$\boxed{V_c = 6.396 \ m/sec}$$

Now According to Specific Energy

$$E_1 = E_2$$

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

$$1.8 + \frac{(6.155)^2}{2 \times 9.81} = 4.1707 + \frac{(6.396)^2}{2 \times 9.81} + P$$

$$\Rightarrow 1.8 + 1.930 - 2.085 - 4.1707 = P$$

$$\Rightarrow \boxed{P = -2.5257 m}$$

P.T.O

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QNO 2 | Part - B

Given DATA:

$b = 2.8$

$d = 1.5m$

$H_1 = 5m$

$H_2 = 5 + 1.5 = 6.5m$

$H = 5 + 0.6 = 5.6m$

$Cd = 0.7866$

Required Data:

$Q = ?$

Discharge through Submerged Portion

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

$Q_1 = 0.7866 \times 2.8 \times (6.5 - 5.6) \times \sqrt{2 \times 9.81 \times 5.6}$

$Q_1 = 0.7866 \times 2.8 \times 0.9 \times 10.482$

$\boxed{Q_1 = 20.78 \ m^3/sec}$

Discharge of free portion

P.T.O

Discharge of free portion.

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

$$Q_2 = \frac{2}{3} \times (0.7866 \times 2.8) \times \sqrt{2 \times 9.81} \left[(5.6)^{3/2} - (5)^{3/2} \right]$$

$$Q_2 = \frac{2}{3} \times (2.20248) \times 4.429 \; (25.308)$$

$$\boxed{Q_2 = 164.582 \ m^3/sec}$$

Total Discharge

$$Q = Q_2 + Q_1$$

$$Q = 164.582 + 20.78$$

$$Q = 20.78 + 164.582$$

$$\boxed{Q = 185.362 \ m^3/sec}$$

P.T.O For QNO: 3

QN.O: 03

Part-A

Given Data:

$P_1 = R + 800 = 7866 + 800 = 8,666\ N/m^2$

$d_1 = R - 200 = 7866 - 200 = 7666\,mm$

$\Rightarrow \boxed{7.666\ m}$

$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4}(7.666)^2 = \boxed{46.156\ m^2}$

$d_2 = R + 3000 = 7866 + 3000 = 10866\,mm$

$\Rightarrow \boxed{10.866\ m}$

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

$A_2 = \frac{\pi}{4}(10.866)^2 = \boxed{92.732\ m^2}$

$Q = 0.95\ m^3/sec$

$Q = AV$

$\Rightarrow V = Q/A$

$\Rightarrow V_1 = Q_1/A_1 = \frac{0.95}{46.156} = \boxed{0.0205\ m/se}$

$V_2 = \frac{Q_2}{A_2} = \frac{0.95}{92.732} = \boxed{0.0102\ m/sec}$

(1) Headloss Due To Sudden Enlargement:

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

$$= \left[1 - \frac{46.156}{92.732}\right]^2 \frac{(0.0205 - 0.0102)^2}{2 \times 9.81}$$

$$\Rightarrow \frac{0.2523 \times 1.06 \times 10^{-6}}{19.62}$$

$$\boxed{h_e \Rightarrow 1.36 \times 10^{-6}\ m}$$

(2) Power Loss due To Sudden Enlargement:

$$P = \rho g Q h_e$$

$$P = 1000 \times 9.81 \times 0.95 \times 1.36 \times 10^{-6}$$

$$\boxed{P = 0.0126\ W}$$

P.T.O

(3) Pressure in the smaller pipe (if the pipe is horizental)

According To Bernoulli's Equation.

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

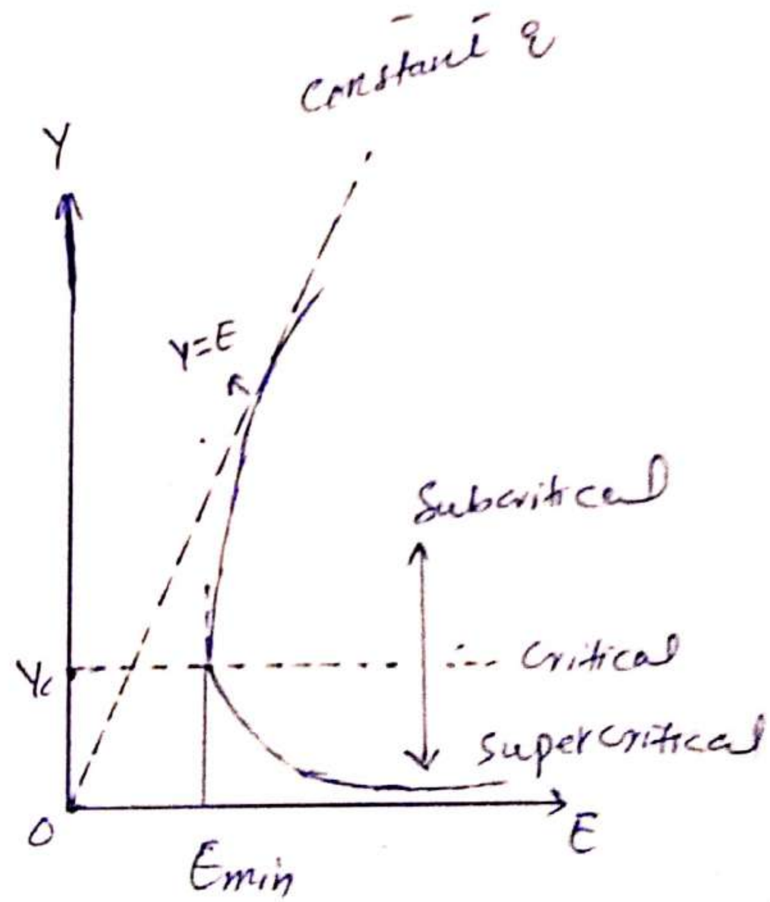
$$\frac{8666}{1000 \times 9.81} + \frac{(0.0205)^2}{2 \times 9.81} = \frac{P_2}{2 \times 9.81} + \frac{(0.0102)^2}{2 \times 9.81} + 1.36 \times 10^{-6}$$

$$\boxed{P_2 = 17.353\ N/m^2}$$

P.T.O

For QNO: 03 Part B:

Q NO: 3 PART :B:



P.T.O

Explanation:

The above graph is plot b/w depth flow (y) and specific Energy (E). It is made from three (3) degree polynomial equation which shows us the different specific energy for the depth flow which may be either

i) Subcritical
ii) Critical
iii) Supercritical

Specific Energy is used to clarify the meaning of the above terms in on open channel

How this is Acheived =?

Total Energy = Potential Energy + Kinetic Energy

$$T.E = mgh + \frac{1}{2} m v^2 \qquad \because w = mg$$

$$T.E = Wh + \frac{1}{2}\frac{W}{g} V^2 \qquad m = \frac{w}{g}$$

P.T.O

Ignoring W weight of water.

$$\boxed{T.E = y + \frac{V^2}{2g}} \rightarrow (1)$$

As we know that

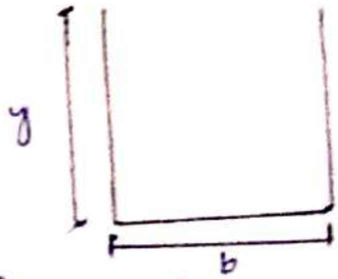
$Q = VA$

$V = Q/A$

$V^2 = Q^2/A^2$ squaring Both sides.

Put V^2 in Equation (1)

$$E = y + \frac{Q^2}{A^2 \, 2g}$$



Let's suppose the channel is Rectangular

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

$Q = qb \rightarrow (y)$

putting values of (x) & (y) in Equation (2)

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

P.T.O

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

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

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

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

As "q" and "g" are Constant

(*) Critical Depth is the flow depth corresponding to minimum Specific Energy.

$y > y_c \Rightarrow$ Subcritical flow

$y = y_c \Rightarrow$ Critical flow.

$y < y_c \Rightarrow$ Supercritical flow.

END PAPER :