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SUBMMITTED TO : Engr. FAWAD

SUBJECT :- "HYDRAULIC ENGG."

SMSTER :- 6^{th}

"MID-TERM"

Q.No. 1

"PART-A"

⇒ Let Suppose a rectangular Channel, discharges R Ltr/sec of water into 8m wide apron with zero slope. Mean velocity is R-220 ft/sec

⇒ **Calculate :-**

* Height of Hydraulic Jump - (m)
* Power Absorb due to Hydraulic Jump - (KW)

⇒ **GIVEN DATA :-**

Channel width = b = 8m

Disharge = Q = 7863 Ltr/sec = 7.863 m³/sec

Mean Velocity = V = R-200 = 7863-200

= 7663 ft/sec

= 2321.95 m/sec

OAs we know;

$$Q = qb$$

$$q = Q/b = \frac{7.863}{8} = 0.9828 \text{ m}^2/\text{sec}.$$

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

$= \left(\frac{0.9828^2}{9.81}\right)^{1/3} = 0.328\text{m}.$

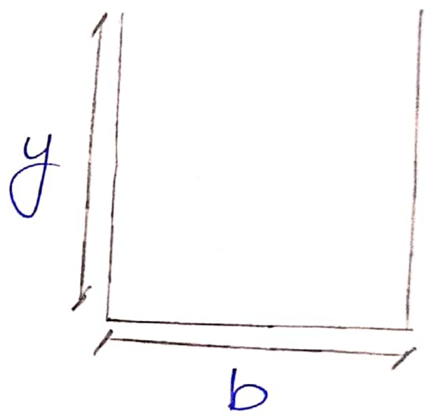
$y = 0.328$ m

$\Rightarrow$ As it is rectangular section.

$Q = qb \quad -①$

$Q = AV \quad -②$

Eq ① and ②



$qb = AV$

$qb = ybV$

$q = yV$

$V_c = q/y_c = \frac{0.9828}{0.328} = 2.99 \text{ m/s}$

$\therefore V > V_c$ (supercritical flow)

$\Rightarrow$ Height of hydraulic Jump on the upstream Side

As

$Q = AV$

$Q = byV$

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

$$y_1 = \frac{7.863}{2321.95 \times 8} = 0.0004\,m.$$

$$y_2 = -\frac{y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2y_1V_1}{g}}$$

$$y_2 = -\frac{0.004}{2} + \sqrt{\frac{(0.004)^2}{4} + \frac{2(9.81)(2321.95)^2}{9.81}}$$

$$y_2 = 20.96\,m$$

$$\Delta y = y_2 - y_1$$

$$= 20.96 - .0004$$

$$\Delta y = 20.95$$

$$\therefore \Delta E = E_1 - E_2 .$$

As we know that

$$Q_1 = Q_2$$

$$A_1V_1 = A_2V_2 \qquad \therefore b_1 = b_2 = b$$

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

$$V_2 = y_1V_1/y_2$$

$$\boxed{V_2} = \frac{0.0004 \times (2321.95)}{20.96} = 0.044\,m/s$$

$$\Delta E = E_1 - E_2 = \left(y^1 + \frac{V_1^2}{2g}\right) - \left(y^2 + \frac{V_2^2}{2g}\right)$$

$$= \left(0.0004 + \frac{2321.95^2}{2\times 9.81}\right) - \left(20.96 + \frac{0.0442^2}{2\times 9.81}\right)$$

$$E_1 - E_2 = 274772.71 m.$$

→ power absorbed:-

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

$$\Delta P = 1000\times 9.81\times 7.836 (274772.71)$$

$$\Delta P = 2.11\times 10^{10} W$$

$$\Delta P = 21122096.97 kN.$$

QNO.1

PART-B :-

⇒ NUMERICAL:-

Solution:-

⇒ Given Data:-

$b = 4m$

$Q = 7863\ ft^3/s = \frac{7863}{(3.28)^3} = 222.826\ m^3/sec.$

$y_1 = 2.9m$

$y_2 = 1.1m$

let Specific energy at upstream & downstream

$E_1 = E_2$

$$y_1 + \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g} \quad —① $$

As we know that

$Q = A_1V_1 = A_2V_2$

$by_1V_1 = by_2V_2$

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

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

$$V_2 = 2.634 V_1 \quad — (2).$$

put the values of eq (2) in eq (1).

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

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

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

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

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

$$V_1 = 2.44 \ m/s.$$

→ Now put value of " V_1 " in eq (1).

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

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

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

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

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

$$1.8 \times 2 \times 9.81 = V_2^2 - 5.95$$

$$\sqrt{V2} = \sqrt{41.266}$$

$$V_2 = 6.42 \ m/s$$

→ Using Froud No to determine type of flow.

⇒ Upstream Side :-

$$Fr_1 = \frac{V_1}{\sqrt{gy_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = 0.457 < 1$$

(Subcritical flow)

⇒ Downstream Side :-

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

(Supercritical Flow)

Q NO.2

PART-A :-

⇒ NUMERICAL :-

Solution :-

⇒ Given DATA :-

$y = 1.8m$

$b = 66' = \frac{66}{3.28} = 20.12\,m.$

$Q = \frac{7863}{(3.28)^3} = 222.85\ m^3/sec.$

⇒ Required DATA :-

Minimum height (P) of weir

$Q = AV$

$V = Q/A = Q/by = \frac{22.85}{20.12 \times 1.8} = 6.33\ m/sec$

As we know;

$y_c = (q^2/g)^{1/3} = \left(\frac{11.04^2}{9.8}\right)^{1/3}$ $\therefore q = Q/b$

$= \frac{222.85}{20.12}$

$y = 2.32\,m.$

$= 11.07\ m^2/s$

Also

$$V = \sqrt{gy}$$

$$V_c = \sqrt{g y_c} = \sqrt{9.81 \times 2.32}$$

$$V_c = 4.77 \text{ m/sec.}$$

Now;

According to specific energy.

$$E_1 = E_2$$

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

$$1.8 + \frac{6.13^2}{2 \times 9.81} = \frac{4.77^2}{2 \times 9.81} + 2.32 + P$$

$$3.72 = 3.48 + P$$

$$P = 3.72 - 3.48$$

$$P = 0.24 \text{ m}$$

Q.NO.2

PART-B :-

* NUMERICAL :-

⇒ GIVEN DATA :-

$b = 2.8\,m$
$d = 1.5\,m$
$H_1 = 5\,m$
$H_2 = 5 + 1.5 = 6.5\,m$
$H = 5 + 0.6 = 5.6\,m$
$C_d = 0.7863$

⇒ Required DATA :-

$Q = ?$

→ Discharge through Submerged portion.

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

$$= 0.7863 \times 2.8 \times (6.5 - 5.6) \times \sqrt{2 \times 9.81 \times 5.6}$$

$$Q_1 = 20.85\ m^3/sec$$

→ Discharge OF Free portion :-

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

$Q_2 = \frac{2}{3} (0.7863) \times 2.8 \sqrt{2 \times 9.81} \left[5.6^{3/2} - 5^{3/2} \right]$

$Q_2 = 13.422 \ m^3/sec$

⇒ Total Dishcharge :-

$Q = Q_1 + Q_2$

$Q = 20.69 + 13.422$

$Q = 34.11 \ m^3/sec.$

Q NO.3

PART-A :-

⇒ NUMERICAL :-

SOLUTION :-

⇒ GIVEN DATA :-

$P_1 = R + 800 = 7863 + 800 = 8663 \ N/m^2$

$d_1 = R - 200 = 7863 - 200 = 7663 \ mm$

$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4}(7.663)^2 = 46.11 \ m^2$

$d_2 = R + 3000 = 7863 + 3000 = 10863 \ mm.$

$= 10.863 \ m.$

$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4}(10.863)^2 = 92.68 \ m^2.$

$Q = 0.95 \ m^3/sec.$

$\therefore \ Q = AU$

$V = Q/A$

$V_1 = Q_1/A_1 = \frac{0.95}{45.79} = 0.012 \ m/s.$

$$V_2 = Q_2/A_2 = \frac{0.95}{92.68} = 0.010 \; m/s$$

1. HEAD Loss due to sudden enlargement.

$$h_e = \left(1 - \frac{A_1}{A_2}\right)^2 \left(\frac{V_1 - V_2}{2g}\right)^2 = \left(1 - \frac{46.11}{92.68}\right)^2 \times \left(\frac{0.021 - 0.01}{2 \times 9.81}\right)$$

$$h_e = 1.60 \times 10^{-6} \, m$$

$$h_e = 0.0000016 \, m$$

2. Power Loss due to sudden enlargment

$$P = \rho g Q h_e$$

$$P = 1000 \times 9.81 \times 0.95 \times 1.6 \times 10^{-6}$$

$$P = 0.015 \, W$$

3. Pressure in the Smallest Pipe :-

Apply Bernoulli's eq.

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

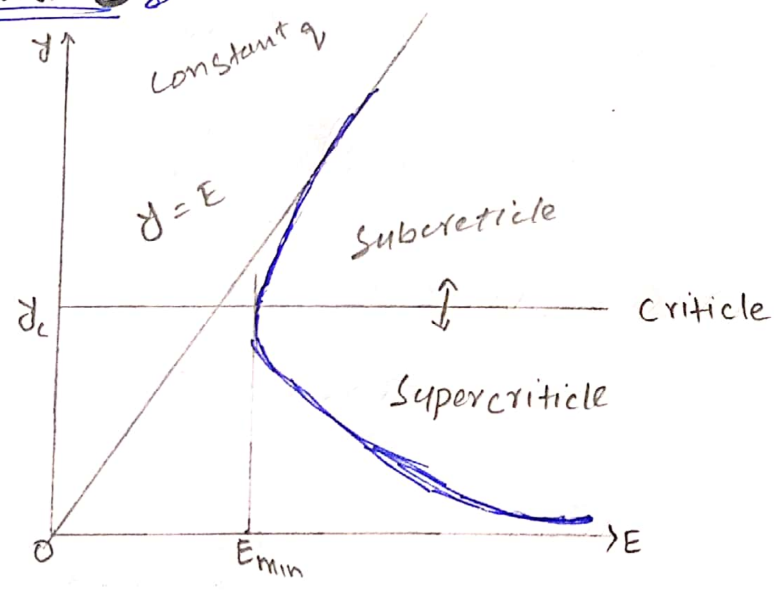
$$\frac{8663}{1000 \times 9.81} + \frac{0.021^2}{2 \times 9.81} = \frac{P_2}{1000 \times 9.81} + \frac{0.01^2}{2g} + 1.56 \times 10^{-6}$$

$$P_2 = 0.879 \times 9820.$$

$$P_2 = 8631.78 \ N/m^2.$$

Q No. 3

PART. B:



⟹ What does this Blue curve indicates. How it is obtained. Explain the above figure from each and every point Q-Veiw?

ANSWER: The above graph is plot between depth flow (y) and Specific energy (E). It is made from three degree polynomial equation which show us the different specific energy for the depth flow which may be either,

- → Subcritical.
- → critical.
- → Supercritical.

Specific Energy is used to clarify the meaning of the above terms in an open ~~challenge~~ channel.

⇒ HOW THIS ACHIEVED ?

Total energy = Potential energy + Kinetic Energy.

$$T.E = mgh + \frac{1}{2} mV^2 \qquad \therefore W = mg$$

$$m = W/g$$

$$= Wh + \frac{1}{2}\frac{W}{g}V^2$$

" Ignoring "W" Weight of water

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

As we know that;

$$Q = VA$$

$$V = Q/A \quad \therefore \text{Squaring B/s.}$$

$$y^2 = \frac{Q^2}{A^2}$$

Put y^2 in eq ①

$$E = y + \frac{Q^2}{A^2 2g} \quad \text{—— ②}$$

Let suppose the channel is rectangular

$$A = y \times b \quad \text{—— (x)}$$

$$Q = qb \quad = \text{(y)}$$

putting values of "x" and "y" in ②.

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

$$E = y + \frac{q^2}{y^2 2g} \quad \text{— putting } y$$

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

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

$$\boxed{(E-y)y^2 = \text{constant}}$$

As "q" and "g" are constants.

* 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.

THE END