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Section B

Semester 6th

Subject Hydrulic Engineering

Submitted To;

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Q.1 (A)

Given Data :-

⊙ Discharge $Q = 7831$ liter/sec

$Q = 7.831\ m^3/sec$

-: 1 liter = 0.001 m^3

⊙ width of channel $= b = 8m$

⊙ Mean velocity $V = R - 220$ ft/sec

$V = 7831 - 220$

$V = 7611$ ft/sec -: 1ft = 0.3048 m

or $V = 2319.83\ m^2/sec$

(1) Height of Hydraulic Jump :-

As We know that,

$$Q = qb$$

$$q = Q/b$$

$$q = \frac{7.831}{8} = 0.9788\ m^2/sec$$

Now Critical depth

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

$$y_c = \left(\frac{(0.9788)^2}{9.81}\right)^{1/3}$$

$$y_c = (0.0976)^{1/3}$$

$$\boxed{y_c = 0.4604m}$$

As it is a rectangular Section

$Q = qb$ —(i)
$Q = AV$ —(ii)
Compare eq (i) and eq (ii)

$qb = AV$
$qb = ybV$

$q = yV$

$V_c = q/y_c$

$\because q = 0.9788\ m^2$
$\because y_c = 0.4604\ m$

$V_c = \frac{0.9788}{0.4604}$

$V_c = 2.125\ m/sec$

Thus flow is Super Critical because $(V > V_c)$

Height of Hydraulic jump on the upstream side

As $Q = AV$
$Q = byV$

$y_1 = Q/v_1 b$

$$y_1 = \frac{7.831}{2.125 \times 8} \Rightarrow y_1 = 0.4606m$$

$$\boxed{y_1 = 0.4606m}$$

Now depth at down stream

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

$$y_2 = \frac{0.4606}{2} + \frac{(0.4606)^2}{4} + \frac{2(0.4606)(2.125)^2}{9.81}$$

$$\boxed{y_2 = 0.707m}$$

Difference in depth :-

$$Dy = y_2 - y_1$$

~~Dy = 0.4606~~

$$Dy = 0.707 - 0.4646$$

$$\boxed{Dy = 0.24m}$$

By Discharge Formula

$$Q_1 = Q_2$$

$$A_1V_1 = A_2V_2 \quad \because Q = AV$$

Now

$$by_1V_1 = by_2V_2 \quad \because A = b*y$$

$$V_2 = y_1V_1 / y_2$$

$$V_2 = \frac{0.4606 * 2319.83}{0.707}$$

$$\boxed{V_2 = 1524.45 \text{ m/sec}}$$

Since

$$\Delta E = E_1 - E_2$$

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

$$= \left[0.4606 + \frac{(2319.83)^2}{2*9.81}\right] - \left[0.707 + \frac{(1524.45)^2}{2*9.81}\right]$$

$$E_1 - E_2 = \Delta E = 274292.57 - 118448.60$$

$$E_1 - E_2 = 155843.97 \text{m}$$

$$\boxed{E_1 - E_2 = 155843.97 \text{m}}$$

Power Dissipation in Hydraulic Jump

We know that, ∵ $\Delta E = 155843.97$ m

$$\Delta P = \rho g Q [E_1 - E_2] \quad \because \Delta E = E_1 - E_2$$

$$\Delta P = 1000 * 9.81 * 7.831 * (155843.97)$$

$$\boxed{\Delta P = 1.197 * 10^{10} \text{ watts}} \quad \because 10^{10}$$

Now In (KW)

$$\boxed{\Delta P = 11972262.61 \text{ KW}}$$

Thus the Required Results

part (B)

Given Data :-

- Width of Channel $b = 4m$
- Discharge $Q = 7831\ ft^3/sec$

or

$Q = 221.74\ m^3/sec$

- $y_1 = 2.9m$
- $y_2 = 1.1m$

Let Suppose Specific Energy at upstream and downstream Side we have

$E_1 = E_2$

$$y_1 + \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g} \quad \text{—— (i)}$$

We know

$Q = A_1V_1 = A_2V_2$

$b y_1 v_1 = b y_2 v_2$

$v_2 y_2 = y_1 v_1$

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

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

$$\boxed{V_2 = 2.6363\ V_1} \quad \text{—— (ii)}$$

put eq (ii) in eq (i)
and also value of y_1, y_2
and v_1
then

$$2.9 + \frac{v_1^2}{2(9.81)} = 1.1 + \frac{(2.6363 v_1)^2}{2(9.81)}$$

$$2.9 + \frac{v_1^2}{19.62} = 1.1 + \frac{6.950 v_1^2}{19.62}$$

$$2.9 - 1.1 = \frac{6.950 v_1^2}{19.62} - \frac{v_1^2}{19.62}$$

$$1.8 = \frac{6.950 v_1^2 - v_1^2}{19.62}$$

$$1.8 = \frac{5.95 v_1^2}{19.62}$$

$$5.95 v_1^2 = 35.316$$

$$v_1^2 = 5.935$$

$$v_1 = \sqrt{5.935}$$

$$\boxed{v_1 = 2.436 \text{ m/sec}}$$

put v_1 in eq (ii) we get "v_2"
(ii) ⇒

$$v_2 = 2.6363 * 2.436$$

$$\boxed{v_2 = 6.422 \text{ m/sec}}$$

As Using Froud Number to determine type of flow

At Upstream Side :-

We know that;

$$Fr_1 = \frac{V1}{\sqrt{gy1}} = \frac{2.436}{\sqrt{9.81 * 2.9}}$$

$$\Rightarrow Fr_1 = \frac{2.436}{5.33} = 0.457$$

$Fr_1 = 0.457 < 1$

as Sub-critical Flow

At Downstream :-

$$Fr2 = \frac{(V_2)}{\sqrt{gy_2}}$$

$$Fr_2 = \frac{(6.422)}{\sqrt{9.81 * 1.1}} = \frac{6.422}{3.284}$$

$\Rightarrow Fr_2 = 1.955$

$Fr2 = 1.955 > 1$

As (Super Critical Flow)

Q.2 part (A)

Given Data :-

- $y = 1.8m$ (Depth of Channel)
- $Q = 7831\ ft^3/sec$ (Discharge)
  or
  $Q = 221.74\ m^3/sec$
- Width of Channel $b = 66'$ —: 1ft = 3.28 m
  or $b = 20.11\ m$

Required :-

- Minimum Height of water (weir)
  $P = ?$

Solution :-

As
$$Q = AV$$
$$V = Q/A \qquad \text{—: } A = by$$
$$V = Q/by = \frac{221.74}{20.11 * 1.8}$$
$$V_1 = 6.125\ m/sec$$

We have

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

$$y_c = \left[\frac{(11.02)^2}{9.81}\right]^{1/3}$$

For 'q' = ?

$$q = Q/b$$

$$q = \frac{221.74}{20.11}$$

$$q = 11.02\ m^2$$

$$y_c = (12.379)^{1/3}$$

$$\boxed{y_c = 2.31\ m}$$

Also we know that;

$$V = \sqrt{gy} \qquad \because V = V_c$$

$$\because y = y_c$$

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

$$V_c = \sqrt{9.81 * 2.31}$$

$$\boxed{V_c = 4.76\ m/sec}$$

According to Specific Energy we have;

$$E_1 = E_2$$

$$y_1 + \frac{v_1^2}{2g} = \frac{v_2^2}{2g} + y_c + P \quad \text{(A)}$$

put valus in eq (A) we get 'P'

$$1.8 + \frac{(6.125)^2}{2(9.81)} = \frac{(4.76)^2}{2(9.81)} + 2.31 + P$$

$$3.712 = 3.464 + P$$

$$\boxed{P = 0.25\ m}$$

Thus the Required result //

It is the weir height from the channel bed //

part (B)

Given Data :-

- Width $b = 2.8m$
- Depth $d = 1.5m$
- $H_1 = 5m$
- $H_2 = 5+1.5 = 6.5m$
- $H = 5+0.6 = 5.6m$
- $cd = 0.7831$

Required :-

- Discharge through Orifice $Q = ?$

Solution :-

As Discharge through Submerged portion we have;

$$Q_1 = cd * b * (H_2 - H) * \sqrt{2gH}$$

put values

$$Q_1 = 0.7831 * 2.8 * (6.5 - 5.6) * \sqrt{2 * 9.81 * 5.6}$$

$$\boxed{Q_1 = 20.68 \ m^3/sec}$$

As Discharge through Free portion we have;

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

put valus

$$Q_2 = \frac{2}{3} * 0.7831 * 2.8\sqrt{2*9.81} * \left[(5.6)^{3/2} - (5)^{3/2}\right]$$

$$\boxed{Q_2 = 13.409\ m^3/sec}$$

Now Total Discharge 'Q'

$$Q = Q_1 + Q_2$$

$$Q = 20.68 + 13.409$$

$$\boxed{Q = 34.089\ m^3/sec}$$

Thus the Required Discharge 'Q' through the orifice //

Q.3 part (A)

Given Data :-

- $d_1 = R - 200\,mm$

  $d_1 = 7831 - 200$

  $d_1 = 7631\,mm$
- $d_2 = R + 3000\,mm$

  $d_2 = 7831 + 3000$

  $d_2 =$ ~~8131 mm~~ $10831\,mm$
- Discharge $Q = 0.95\,m^3/sec$
- Pressure in pipe $p_1 = R + 800$

  $p_1 = 7831 + 800$

  $p_1 = 8631\,N/m^2$

Required :-

(1) Head loss Due to Sudden Enlargment = ?

(2) power lost Due to Sudden Enlargment = ?

(3) Pressure in Smaller pipe = ?

Solution :-

(1) Head loss due to Sudden Enlargment :-

$d_1 = 7831mm$

or $d_1 = 7.831\,m$

As $A1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4} (7.831)^2$

$$A1 = 48.16 \ m^2$$

Now

$d_2 = 10831 \ mm$ or $d_2 = 10.831 m$

$A2 = \pi/_4 (d_2)^2$

$A2 = \frac{3.14}{4} (10.831)^2$

$$A2 = 92.08 \ m^2$$

As we know that;

$Q = AV$

$V = Q/_A$ or $V_1 = Q/_{A1}$

$V1 = 0.95/_{48.16}$

$$V1 = 0.019 \ m/sec$$

As

$V2 = Q/_{A2}$

$V2 = 0.95/_{92.08}$

$$V2 = 0.0103 \ m/sec$$

As Sudden Enlargment

$$he = \left(1 - \frac{A1}{A2}\right)^2 * \left(\frac{(V1 - V2)^2}{2g}\right)$$

$$he = \left(1 - \frac{48.16}{92.08}\right)^2 * \left[\frac{(0.019 - 0.0103)^2}{2(9.81)}\right]$$

$$he = 0.227 * 3.857 * 10^{-6}$$

$$\boxed{he = 8.75 * 10^{-7} \, m}$$

(2) power lost due to Sudden Enlargment :-

As we know that

$$P = \rho g Q he$$

$$P = 1000 * 9.81 * 0.95 * (8.75 * 10^{-7})$$

$$P = 8.15 * 10^{-4}$$

or

$$\boxed{P = 0.000815 \, W}$$

(3) Pressure in Smaller Pipe :-

According to Bernoulli Equation we have;

$$\frac{P1}{\rho g} + \frac{V1^2}{2g} = \frac{P2}{\rho g} + \frac{V2^2}{2g} + he$$

$$\frac{P1}{1000 * 9.81} + \frac{(0.019)^2}{2 * 9.81} = \frac{P2}{1000 * 9.81} + \frac{(0.0103)^2}{2 * 9.81} + (8.75 * 10^{-7})$$

$$\frac{P1}{9810} + 0.0000183 = \frac{P2}{9810} + (6.28 * 10^{-6})$$

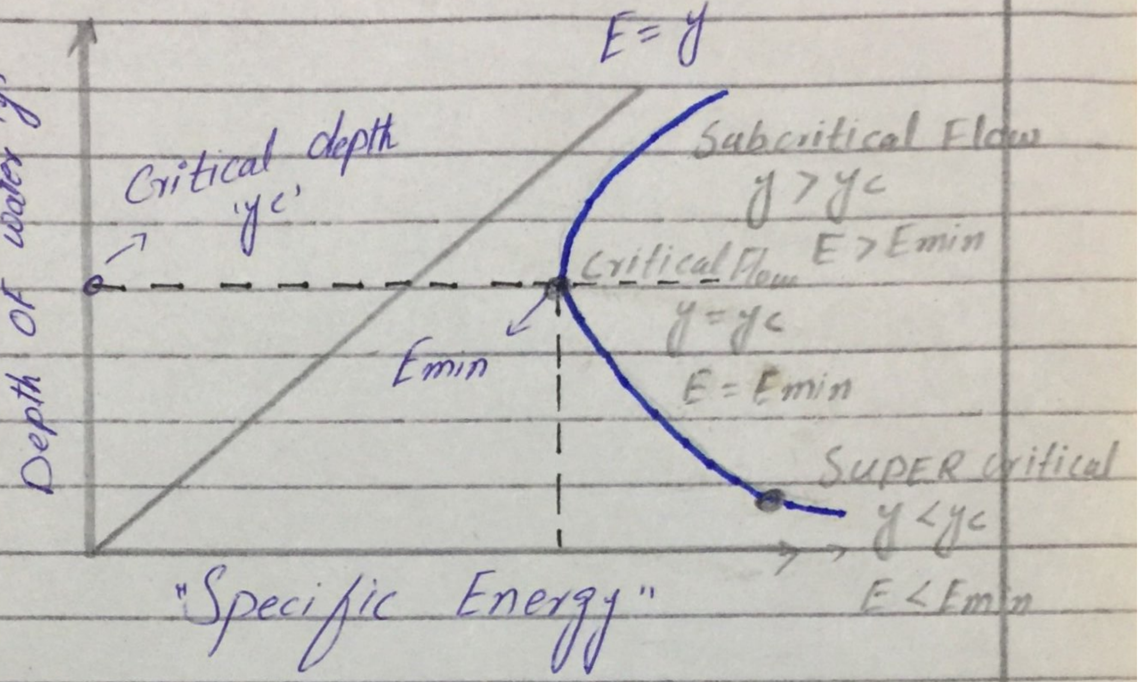
$$\frac{8631}{9810} + 0.0000183 = \frac{P2}{9810} + (6.28 * 10^{-6})$$

$$0.8798 = \frac{P2}{9810} + (6.28 * 10^{-6})$$

$$P2 = 8630.77 \, N/m^2$$

Thus the Required Results

Part (B)



Blue Curve :-

From the above Figure ;

The blue curve is the 3-degree polynomial curve which show the flow is critical , sub critical and super critical flow

⊙ The middle point show the depth of water is equal to the critical depth corresponding to minimum energy so the flow is critical flow ⊙ $y = y_c$ & ⊙ $E = E_{min}$

⊙ The lower point Show That the depth of water is less then the critical depth.

⊙ $y < y_c$ and ⊙ $E < E_{min}$

⊙ The top point Show That the depth of water is greater then The Critical depth.

⊙ $y > y_c$ and ⊙ $E > E_{min}$

Specific Energy:-

Specific Energy is the parameter that Can be used to clarify The meaning of Sub critical, critical and Super Critical flow on open channel.

⊙ The given graph is indicate that the relation b/w depth of water (y) and Critical depth (y_c)

Critical Depth :- "yc"

Critical depth is depth of water at which minimum Specific Energy is Obtained.

Equation For Specific Energy :-

From the derivation of Specific Energy equation there is three polynomials Equation is obtained.

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

- E = Specific Energy
- y = Depth of water
- q = Discharge per unit width its unit is m^2/sec