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ID NO = 7823

SECTION = A

PAPER = HYDRAULICS ENGINEERING

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QUESTION NO#01 (Part=A)

GIVEN DATA:-

Discharge = 7823 Lit/sec
= 7.823 m^3/sec

Width of apron = 8m

Mean velocity = 7823 − 220 = 7603
$= \frac{7603}{3.28} = 2317.9$ m/sec

SOLUTION:-

Height of hydraulic Jump

As 'q' is discharge per unit Width

$$q = \frac{Q}{b} \Rightarrow \frac{7.823}{8}$$

$$\boxed{q = 0.977\ m^2/sec}$$

⇒ As Critical depth (y_c)

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{(0.977)^2}{9.81}\right)^{1/3}$$

$$\boxed{y_c = 0.45m}$$

Critical velocity

$q = vy \Rightarrow v = q/y$

$V_C = \frac{q}{y_c} \Rightarrow V_C = \frac{0.977}{0.45}$

$V_C = 2.17 \, m/sec$

As $V_1 > V_C$
(super critical flow)

Water depth on upstream side

$Q = AV$

$Q = (by) \cdot v$

$y = \frac{Q}{V \cdot b} \Rightarrow y_1 = \frac{Q}{V_1 b}$

$y_1 = \frac{7.823}{2.17 \times 8}$

$y_1 = 0.45 m$

By formula:-

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

putting the value

$$y_2 = -\frac{0.45}{2} + \sqrt{\frac{(0.45)^2}{4} + \frac{2\,(0.45)(2.17)^2}{9.81}}$$

$$\boxed{y_2 = 0.469\text{m}}$$

Difference in depths:-

$$\Delta y = y_2 - y_1$$

$$\Delta y = 0.469 - 0.45$$

$$\boxed{\Delta y = 0.019\text{m}}$$

As $\Delta E = E_1 - E_2$

Also $Q_1 = Q_2$

$$A_1 V_1 = A_2 V_2$$

$$b_1 y_1 V_1 = b_2 y_2 V_2$$

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

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

By putting the values

$$V_2 = \frac{0.45 \times 2317.9}{0.469}$$

$$\boxed{V_2 = 2223.99 \, m/sec}$$

$$\Rightarrow \Delta E = E_1 - E_2$$

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

$$E_1 - E_2 = \left(0.45 + \frac{(2317.9)^2}{2(9.81)}\right) - \left(0.469 + \frac{(2223.99)^2}{2(9.81)}\right)$$

$$E_1 - E_2 = 273836.35 - 252096.87$$

$$\boxed{E_1 - E_2 = 21739.48 \, m}$$

__Power dessipation in Hydraulic Jump__

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

$$\Delta P = (1000)(9.81)(7.823)(21739.48)$$

$$\boxed{\Delta P = 1668366610 \, W}$$

QUESTION NO = 01 (Part = B)

GIVEN DATA:-

Channel width = 4m

Discharge = 7823 ft^3/sec

Height of upstream side = 2.9m

Height of downstream side = 1.1m

(i) SOLUTION:-

Down stream velocity

Specific Energy is;

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

Also

From discharge

$$Q = AV$$

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

$$\cancel{b} \cdot y_1 \cdot V_1 = \cancel{b} \cdot y_2 \cdot V_2 \quad \because b = b_1 = b_2$$

$$\gamma_1 \cdot V_1 = \gamma_2 \cdot V_2$$

$$V_2 = \frac{\gamma_1 V_1}{\gamma_2}$$

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

$$\boxed{V_2 = 2.63V} \rightarrow (B)$$

Putting Eq (B) in (A)

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

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

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

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

$$5.91V_1^2 = 1.8(2g)$$

$$5.91V_1^2 = 1.8(2)(9.81)$$

$$V_1^2 = \frac{1.8 \times 2\,(9.81)}{5.91}$$

$$V_1 = \sqrt{\frac{1.8 \times 2\,(9.81)}{5.91}}$$

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

Put in Eq (B)

$$V_2 = 2.63\,(2.44)$$

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

Type of flow using Froud Number;

① UP-stream:-

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

$$Fr_1 = 0.45$$

$Fr_1 < 1$

(Sub-critical flow)

② **Down-stream:-**

$$Fr_2 = \frac{V_2}{\sqrt{g y_2}} = \frac{6.41}{\sqrt{(9.81)(1.1)}}$$

$Fr_2 = 1.95$

$Fr_2 > 1$

(Super critical flow)

QUESTION NO=02 (Part=A)

GIVEN DATA:-

Depth of channel = 1.8m

Discharge = 7823 = 221.69 m^3/sec

Width of channel = 66 ft = 20.1m

P = weir height = ?

SOLUTION:-

We know that

$$Q = AV$$

$$V = Q/A \Rightarrow V_1 = Q/A$$

$$\frac{Q}{b \times y} = V_1 \Rightarrow V_1 = \frac{Q}{b \times y}$$

$$V_1 = \frac{221.69}{20.1 \times 1.8}$$

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

Critical depth

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

As $q = Q/b = \frac{221.69}{20.1}$

$q = 11.1 m^3/sec$

$$y_c = \left(\frac{(11.1)^2}{9.81}\right)^{1/3} = 2.32m$$

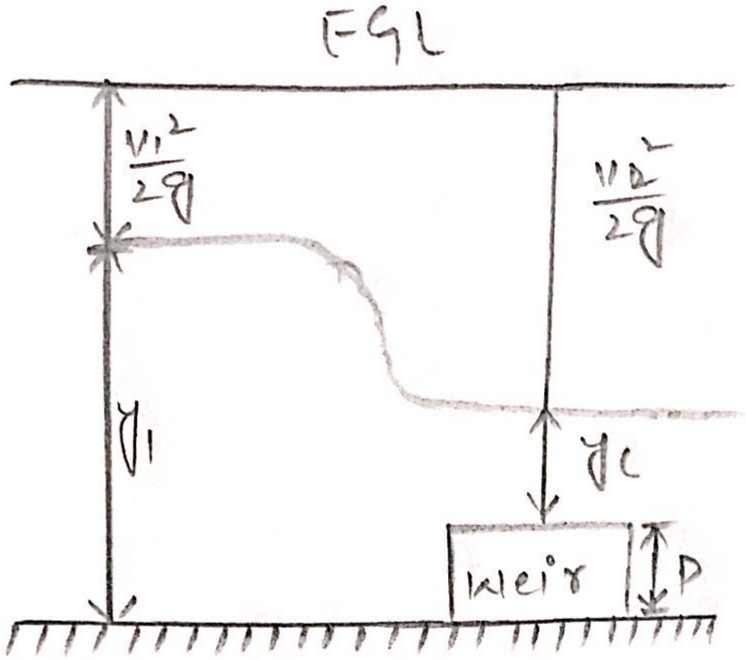
$$\boxed{y_c = 2.32m}$$

Also $V = \sqrt{gy}$

$V_c = \sqrt{gy_c}$

$V_c = \sqrt{(9.81)(2.32)}$

$$\boxed{V_c = 4.77 m/sec}$$



From Figure

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

$$\frac{(6.11)^2}{2(9.81)} + 1.8 = \frac{(4.77)^2}{2(9.81)} + 2.32 + P$$

$$1.902 + 1.8 = 1.159 + 2.32 + P$$

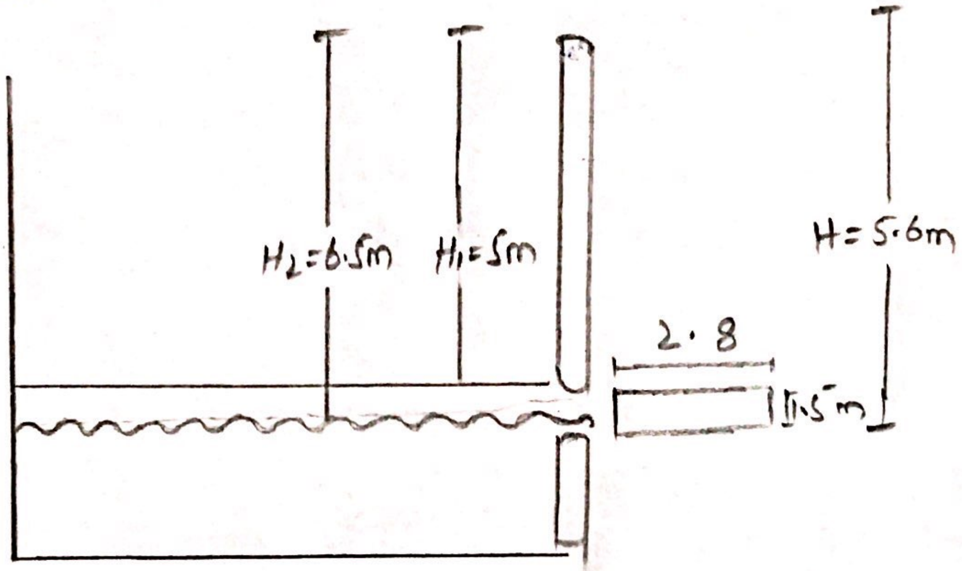
$$3.702 = 3.479 + P$$

$$\boxed{P = 0.223m}$$

QUESTION NO=2 (Part=B)

GIVED DATA:-

Width = 2.8m
depth = 1.5m



$H_1 = 5m$
$H_2 = 6.5m$
$H = 5.6m$
$cd = 0.7823$

SOLUTION:-

Submerged Portion

$Q_1 = cd \times b \times (H_2 - H) \times \sqrt{2gh}$

$Q_1 = 0.7823 \times 2.8 (6.5 - 5.6) \times \sqrt{(2)(9.81)(5.6)}$

$Q_1 = (2.190)(0.9)(10.48)$

$Q_1 = 20.65 m^3/sec$

Free Portion

$$Q_2 = \frac{2}{3} c_d \times b\sqrt{2g} \times (H^{3/2} - H_1^{3/2})$$

$$Q_2 = \frac{2}{3}(0.7823) \times (2.8)(\sqrt{(2)(9.81)})$$

$$= ((5.6)^{3/2} - (5)^{3/2})$$

$$Q_2 = (0.521)(12.40)(13.25 - 11.18)$$

$$\boxed{Q_2 = 13.37 m^3/sec}$$

Total $= Q_1 + Q_2$

$$Q = 20.65 + 13.37$$

$$\boxed{Q = 34.02 m^3/sec}$$

QUESTION NO#03 (Part = A)

GIVEN DATA:-

$d_1 = R - 200mm \Rightarrow 7823 - 200 = 7623mm$

$d_1 = 7623mm$

$d_2 = R + 3000 \Rightarrow 7823 + 3000 = 10823mm$

$d_2 = 10823mm$

Flow Rate $(Q) = 0.95 m^2/sec$

Pressure in large pipe $= R + 800 N/m^2$

$7823 + 800 = 8623 N/m^2$

SOLUTION:-

Ⓐ loss of head due to Sudden enlargement.

$d_1 = 7623mm = 7.623m$

$A_1 = \frac{\pi}{4}(7.623)^2 = 45.6m^2$

$\Rightarrow d_2 = 10823mm = 10.823m$

$A_2 = \frac{\pi}{4}(10.823)^2 = 91.95$

As $Q = AV$

$V = Q/A$

$V_1 = Q/A_1$

Putting the values

$$V_1 = \frac{0.95}{45.6} = 0.020 m/sec$$

$$\boxed{V_1 = 0.020 m/sec}$$

$$V_2 = Q/A_2$$

$$V_2 = \frac{0.95}{91.95} = 0.010 m/sec$$

$$\boxed{V_2 = 0.010 m/sec}$$

Formula of sudden enlargement

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

$$h_e = \left(1 - \frac{45.6}{91.95}\right)^2 \times \frac{(0.020 - 0.010)^2}{2(9.81)}$$

$$h_e = (0.2540) \frac{(0.0001)}{19.62}$$

$$h_e = (0.2540)(0.000005096)$$

$$h_e = 0.00000129$$

$$\boxed{h_e = 1.29 \times 10^{-6} m}$$

(b) Poessure less due to sudden enlargement:

$$P = \rho g Q h_e$$

$$P = (1000)(9.81)(0.95)(1.29\times10^{-6})$$

$$\boxed{P = 0.012W}$$

(c) Pressure in smaller pipe

using Bernoulli's Equation.

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + h_e$$

$$\frac{P_1}{(1000)(9.81)} + \frac{(0.020)^2}{2(9.81)} = \frac{8623}{(1000)(9.81)} + \frac{(0.010)^2}{2(9.81)}$$

$$+ 1.29\times10^{-6}$$

$$\Rightarrow \frac{P_1}{9810} + 2.03^{-5} = 0.879 + 5.09^{-6} + 1.29\times10^{-6}$$

$$\frac{P_1}{9810} = 0.879 + 5.09^{-6} + 1.29\times10^{-6} - 2.03^{-5}$$

$$\frac{P_1}{9810} = 0.850$$

$$P_1 = 0.850 \times 9810$$

$$\boxed{P_1 = 8338.99 \, N/m^2}$$

QUESTION NO # 03 (Part = B)

SPECIFIC ENERGY:-

Specific Energy is a parameter that can be used to clearify the meaning of super-critical, sub critical and critical flow in an open channel.

Critical depth is the depth corresponding to maximum specific Energy.

⇒ $y > y_c$; $E > E_{min}$ (Sub-critical flow)

⇒ $y = y_c$; $E = E_{min}$ (Critical flow)

⇒ $y < y_c$; $E < E_{min}$ (Super critical flow).

Equation ③ is three degree polynomial equation. It can be used to prepare a plot of specific energy.