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Section = B

(1) A: Lets suppose a rectangular channel discharge R Ltr/sec of water into 8m wide apron with zero slope. Mean velocity is R-220 ft/sec

Calculate:- (i) Height of hydraulic jump (m)
(ii) power absorbed due to hydraulic jump (kW)

Ans:-

Given data:

Channel width $= b = 8m$

Discharge $= Q = 7861\,Ltr/sec = 7.861\,m^3/sec$

Mean velocity $= V = R - 200 = 7861 - 200$

$= 7661\,ft/sec$

$= 2335.7\,m/sec$

1) As we know

$$Q = qb$$

$$q = Q/b = \frac{7.861}{8} = 0.983\,m^2/sec$$

$$\rightarrow y_c = \left(\frac{q^2}{g}\right)^{1/3} \Rightarrow \left(\frac{0.983^2}{9.81}\right)^{1/3} = 0.462\,m$$

$$\boxed{y_c = 0.462m}$$

As this is rectangular section

$Q = qb \longrightarrow (1)$

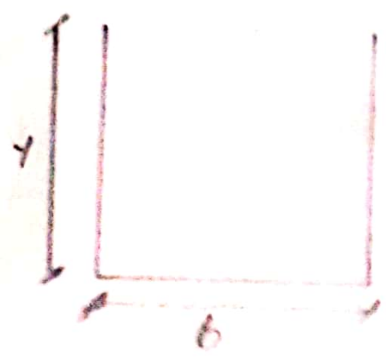
$Q = AV \longrightarrow (2)$

equating (1) and (2)

$qb = AV$

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

$q = yV$



$$V_c = \frac{q}{y_c} = \frac{0.983}{0.462} = 2.127 \text{ m/sec}$$

$\therefore V > V_c$ (Supercritical flow)

Height of hydraulic Jump on the upstream Side.

As $Q = AV$ $\quad Q = byv$

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

$$y_1 = \frac{7.861}{23357 \times 8} = 0.0004^2 m$$

$$y_2 = \frac{-y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2y_1 v_1}{g}}$$

$$y_2 = -\frac{0.00042}{2} + \sqrt{\frac{(0.00042)^2}{4} + \frac{2(0.00042)(23357)}{9.81}}$$

$$\boxed{y_2 = 21.613 m}$$

$$\Delta y = y_2 - y_1 \Rightarrow 21.613 - 0.00042$$
$$\Rightarrow 21.61 m$$

$\therefore \Delta E = E_1 - E_2$

As we know that

$$Q_1 = Q_2 \qquad \therefore b_1 = b_2 = b$$

$$A_1 V_1 = A_2 V_2 \Rightarrow \cancel{b} y_1 v_1 = \cancel{b} y_2 v_2$$

$$V_2 = \frac{y_1 v_1}{y_2}$$

$$V_2 = \frac{0.00042 \times 23357}{21.613} \Rightarrow \boxed{0.0454 \text{ m/sec}}$$

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$$\Delta E = E_1 - E_2 = \left(y_1 + \frac{v_1^2}{2g}\right) - \left(y_2 + \frac{v_2^2}{2g}\right)$$

$$= \left(0.00042 + \frac{2335.7^2}{2(9.81)}\right) - \left(21.613 + \frac{0.0454^2}{2(9.81}\right)$$

$$E_1 - E_2 = 278036.211m$$

→ power obsorbed:-

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

$$\Delta p = 1000 \times 9.81 \times 7.861 (278036.21)$$

$$\boxed{\Delta p = 2.144 \times 10^{10} \, W = 21441154.37 \, KN}$$

8 A Sluice gate Controls the flow in a Channel of width 4m. If the discharge is R Ft^3/sec and the upstream and downstream water depth is 2.9m and 1.1m respectivily Calculate the downstream velocity Also State the Type of flow at upstream and downstream Side using any equation

Sol:- Given data:-

$$b = 4m$$

$$Q = 7861 \frac{ft^3}{sec} = \frac{7861}{(3.28)^3}$$

$$= 222.77 m^3/sec$$

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

Let Specific Energy at upstream and downstream Side.

$$E_1 = E_2$$

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

As we know that

$$Q = A_1V_1 = A_2V_2$$

$$by_1v_1 = by_2v_2 \quad \because b_2 = b_1 = b$$

$$V_2 = \frac{y_1 v_1}{y_2} = \frac{29}{11} v_1$$

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

put the value of EQU 2 in EQU 1

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

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

$$1.8 = \frac{6.938V_1^2 - V_1^2}{19.62} \Rightarrow 1.8\times 19.62 = 5.938V_1^2$$

$$\sqrt{V_1^{\cancel{2}}} = \sqrt{\frac{1.8\times 19.62}{5.938}} \Rightarrow \boxed{V_1 = 2.44\,m/sec}$$

Now put the value of "V_1" in EQU 1

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

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

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

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

$$\sqrt{V_2^{\cancel{2}}} = \sqrt{41.266} \qquad \boxed{V_2 = 6.42\,m/sec}$$

using Froud NO to determine type of flow.

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UPSTREAM SIDE:-

$$Fr_1 = \frac{V_1}{\sqrt{g y_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = 0.457 < 1$$

(Sub Critical flow)

DOWNSTREAM SIDE:-

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

(Supercritical flow)

QNo2) A1

Given data:-

$y_1 = 1.8m$ $b = 66' = \frac{66}{3.28} = 20.12m$

$$Q = \frac{7861}{3.28^3} = 222.769\ m^3/sec$$

Required data:-

Minimum height (p) of weir

$Q = AV$ $V = \frac{Q}{A} = \frac{Q}{by} \Rightarrow \frac{222.769}{20.12 \times 1.8}$

$= 6.15\ m/sec$

As we know:-

$q = Q/b$

$\Rightarrow \frac{222.769}{20.12}$

$= 11.07$

$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{11.07^2}{9.81}\right)$

$y_c = 2.32m$

Also $V = \sqrt{gy} \Rightarrow \sqrt{g y_c}$

$\Rightarrow \sqrt{9.81 \times 2.32}$

$V_c = 4.77\ m/sec$

Now; According to Specific energy. $E_1 = E_2$

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

$$1.8 + \frac{6.15^2}{2 \times 9.81} = \frac{4.77^2}{2 \times 9.81} + 2.32 + P$$

$$3.73 = 3.48 + P$$

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

QNO2:-

(B) Given data:-

$b = 2.8m$ $d = 1.5m$ $H_1 = 5m$

$H_2 = 5 + 1.5 = 6.5m$ $H = 5 + 0.6 = 5.6m$

$Cd = \cancel{0.7861} = 0.7861$

Required data $Q = ?$

Discharge through Submerged portion-

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

$$Q_1 = 0.7861 \times 2.8 \times (6.5 - 5.6) \times \sqrt{2 \times 9.81 \times 5.6}$$

$$Q = 20.76 m^3/sec$$

⇒ Discharge of Free portion

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

$$= \frac{2}{3}(0.7861) \times 2.8\sqrt{2 \times 9.81}\left[5.6^{3/2} - 5^{3/2}\right]$$

$$Q_2 = 13.46 m^3/sec$$

Total Discharge

$$Q = Q_1 + Q_2$$

$$\boxed{Q = 34.225 m^3/sec}$$

QNO3

(A) Given datas-

$$P_1 = R + 800 = 7861 + 800 = 8661 N/m^2$$

$$d_1 = R - 200 = 7861 - 200 = 7661 mm$$
$$= 7.661 m$$

$$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4}(7.661)^2 = 46.07 m^2$$

$$d_2 = R + 3000 = 7861 + 3000 = 10861 mm$$
$$= 10.861 m$$

$$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4}(10.861)^2 = 92.59 m^2$$

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

$$\because Q = AV \Rightarrow V = Q/A = \frac{0.95}{46.07} = 0.02 m/sec$$

$$V_2 = \frac{0.95}{92.59} = 0.01 m/sec$$

1 Head Loss due to Sudden enlargement

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

$$= \left(1 - \frac{45.09}{92.59}\right)^2 \times \left(\frac{0.02 - 0.01}{2 \times 9.81}\right)^2$$

$$he = 1.34 \times 10^{-6} m$$

$$he = 0.0000013 m$$

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2- Power lost due to Sudden enlargment

$$P = \rho g Q h_e$$

$$P = 1000 \times 9.81 \times 0.95 \times 1.34 \times 10^{-6}$$

$$\boxed{P = 0.0125 W}$$

3- pressure In the Smallest pipe.
Apply Bernoullis equ

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

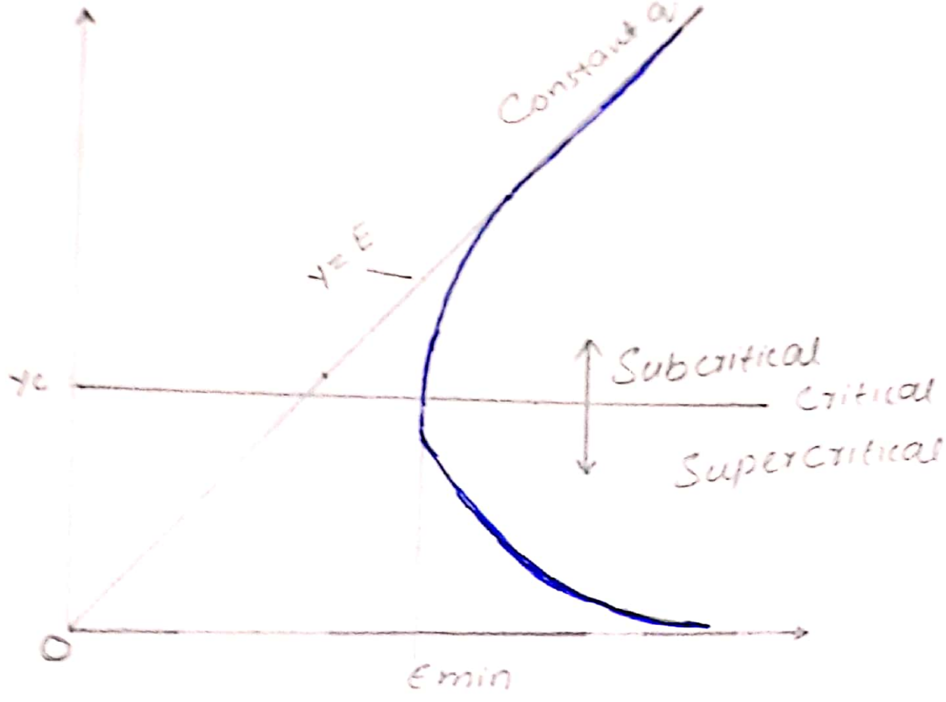
$$\Rightarrow \frac{8661}{1000 \times 9.81} + \frac{0.02^2}{2(9.81)} = \frac{P_2}{1000 \times 9.81} + \frac{0.01^2}{2 \times 9.81} + 1.34 \times 10^{-6}$$

$$\frac{P_2}{1000 \times 9.81} = 0.88289 - 6.4368 \times 10^{-6}$$

$$P_2 = 0.883 \times 9810$$

$$P_2 = 8662.23 \, N/m^2$$

(11)



What does this blue Curve Indicate- HOW it is obtained Explain the above figure from each and every point of view-

Ans- The above graph is plot between depth Flow(y) and Specific Energy(E) It is made from three degree polynomial equation which Shows us the different Specific Energy for the depth flow which may be either (i) Sub critical
(ii) Critical
(iii) Super Critical

Specific Energy is used to Clarify the meaning of the above Terms in an open Channel-

HOW is this Acheived?

Total Energy = potential energy + kinetic Energy

$$T.E = mgh + \frac{1}{2} mv^2 \qquad \because W = mg, \quad m = W/g$$

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

ignoring "W" weight of water

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

As we know that

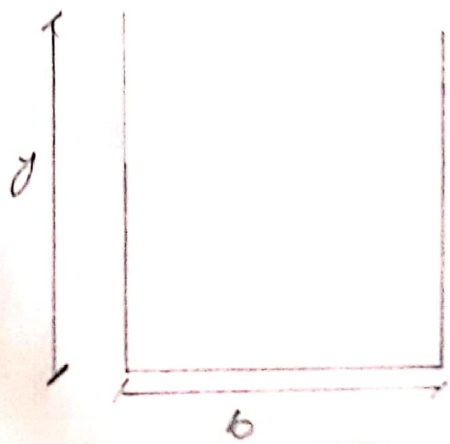
$$Q = VA \qquad V = \frac{Q}{A} \quad \text{Squaring b.s}$$

$$V^2 = \frac{Q^2}{A^2} \quad \text{put } V^2 \text{ in eq (1)}$$

Lets Suppose the Channel is Rectangular

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

$$Q = q\,b \rightarrow (y)$$



putting value of (x) and y in (2)

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

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

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

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

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