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:- 2 CR.HRS

Qno1

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

calculate :-

- Height of hydraulic jump (in unit of meter).
- Power absorbed due to hydaulic jump (In unit of Kw)

Solution:-

Discharge = 7487 liter/sec = 7.487 m^3/sec

width of apron = 8m

Mean velocity = 7487 - 220

= 7267 ft/sec

= $\frac{7267}{3.28}$ = 2215.5 m/sec

1) Height of Hydraulic Jump :-

As 'q' is discharge per unit width $q = Q/b$

$= \frac{7.487}{8}$ $\Rightarrow q = \boxed{0.935\, m^2/sec}$

⇒ As critical depth (y_c) is

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

$$= \left(\frac{(0.935)^2}{9.81}\right)^{1/3}$$

$$\boxed{y_c = 0.44\text{m}}$$

⇒ Critical Velocity :-

As $q = VY$ ⇒ $V = q/Y$

⇒ $V_c = \dfrac{q}{y_c}$ ⇒ $V_c = \dfrac{0.935}{0.44}$

$$\boxed{V_c = 2.12 \text{ m/sec}}$$

As $V_1 > V_c$

Super critical

⇒ Water depth on upstream side is (of Hydralic Jump)

$$Q = AV$$

$$Q = (by).V$$

$$Y = \frac{Q}{V.b} \qquad Y_1 = \frac{Q}{V_1.b}$$

$$y_1 = \frac{7.487}{2.12 \times 8} \qquad y_1 = \boxed{0.44m}$$

By formula

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

$$= \frac{0.44}{2} \sqrt{\frac{(0.44)^2}{2} + \frac{2(0.44)(2.12)^2}{9.81}}$$

$$\boxed{y_2 = 0.48m}$$

⇒ Difference in depth,

$$\Delta y = y_2 - y_1$$

$$= 0.48 - 0.44$$

$$= 0.04m$$

⇒ As,

$$\Delta E = E_1 - E_2$$

Also, $Q_1 = Q_2$

$$A_1 V_1 = A_2 V_2$$

$$b \cdot y_1 \cdot v_1 = b_2 \, y_2 \cdot v_2$$

$$V_2 = \frac{Y_1 V_1}{Y_2}$$

$$= \frac{0.44 \times 2215.5}{0.48}$$

$$\boxed{V_2 = 2030.87 \text{ m/sec}}$$

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

$$\left(Y_1 + \frac{V_1^2}{2g}\right) - \left(Y_2 + \frac{V_2^2}{2g}\right)$$

$$E_1 - E_2 = \left(0.44 + \frac{(2215.5)^2}{2(9.81)}\right) - \left(0.48 + \frac{(2030.87)^2}{2(9.81)}\right)$$

$$E_1 - E_2 = 250175.78 - 210216.22$$

$$\boxed{E_1 - E_2 = 39959.56 \text{m}}$$

$\Rightarrow$ Power Dissipation in Hydraulic Jump:-

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

$$= (1000)(9.81)(7.487)(39959.56)$$

$$\Delta P = 2934928584 \text{ W}$$

$$= 2934928.584 \text{ KW}$$

Q no 1

(B) A sluice gate controls the flow in a channel of width 4m. If the discharge is R ft^3/sec and the upstream and down stream water depth is 2.9 m and 1.1m respectively, calculate the downstream velocity. Also state the type of flow at upstream and downstream side using any Equation

Solution:-

Channel width (b) = 4m

Discharge = 7487 ft^3/sec

height of upstream side = 2.9m

height of downstream side = 1.1m

① Downstream velocity:-

As specific energy is

$$E_1 = E_2$$

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

Also from discharge

$$Q = AV$$

$$\Rightarrow A_1 V_1 = A_2 V_2$$

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

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

$$y_1 V_1 = y_2 V_2$$

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

$$\Rightarrow V_2 = \frac{(2.9)}{1.1} V_1 \qquad \boxed{V_2 = 2.63 V_1}$$

Put in Eq ①

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

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

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

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

$$\Rightarrow 5.91 V_1^2 = 1.8 \times 2 (9.81)$$

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

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

$\Rightarrow$ Put in Eq V_2 Equation

$$V_2 = 2.63 (2.44)$$

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

Types of Flow using froud number

① On upstream side :-

$$F_{r_1} = \frac{V_1}{\sqrt{g y_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = 0.45$$

$F_r < 1 \Rightarrow$ Sub-critical flow

② On down stream side :-

$$F_{r_2} = \frac{V_2}{\sqrt{g y_2}} = \frac{6.41}{\sqrt{9.81 \times 1.1}} = 1.95$$

$F_r > 1$

Super-critical flow

Q no 2

(A) What is the minimum height (in unit of meter) of broad crested weir if it is to function critical depth on the crest. If the water flows along a rectangular channel at a depth of 1.8 m with a discharge of ·R ft^3/sec. The channel width is 66 ft

Solution:-

Depth of channel = 1.8 m

Discharge = 7487 ft^3/sec

$$\frac{7487\ ft^3}{(3.28\ m)^3} = 212.17\ m^3/sec$$

Width of channel = 66 ft = 20.1 m

P = weir height = ?

Sol:-

$Q = AV$

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

$$V_1 = \frac{212.17}{20.1 \times 1.8} \Rightarrow 5.86 \text{ m/sec}$$

$\Rightarrow$ Critical depth :-

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

As, $q = Q/b$

$\Rightarrow 212.17/20.1 = 10.5 \text{ m}^2/\text{sec}$

$$\Rightarrow y_c = \left(\frac{(10.5)^2}{9.81} \right)^{1/3} =$$

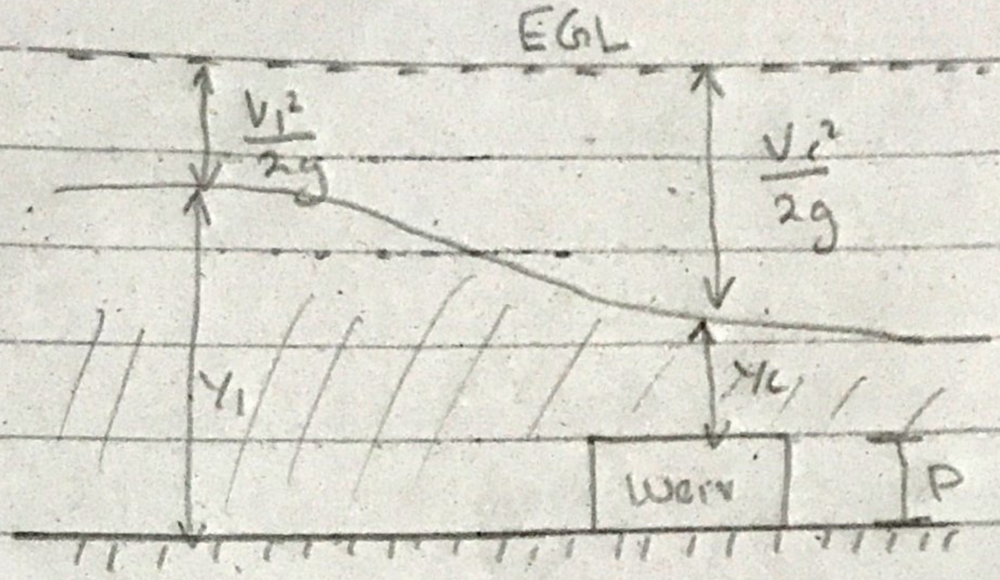
$$\boxed{y_c = 2.23 \text{m}}$$

Also $V = \sqrt{gy}$

$V_c = \sqrt{gy_c}$

$V_c = \sqrt{9.81 \times 2.23}$

$$\boxed{V_c = 4.67 \text{ m/sec}}$$



From the figure

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

$$\frac{(5.86)^2}{2\times 9.81} + 1.8 = \frac{(4.67)^2}{2\times 9.81} + 2.23 + P$$

$$1.750 + 1.8 = 1.111 + 2.23 + P$$

$$3.55 = 3.341 + P$$

$$\boxed{P = 0.209 m}$$

The weir should have height of 0.209m measured from the channel bed.

Q no 2

(B) An orifice in one side of large tank is rectangular in shape. 2·8m broad and 1·5m deep. The water level on one side of the orifice is 5 meters above its top edge. The water level on the other side of the orifice is 0·6m below its top edge. Calculate the discharge through the orifice if coefficient of discharge is Cd = 0·R

Given Data:-

Breadth = 2·8m

Depth = 1.5 m

water level on one side & above its top edge

$(H_1) = 5m$

Water level on other side = 5m + 1·5m

= 7m

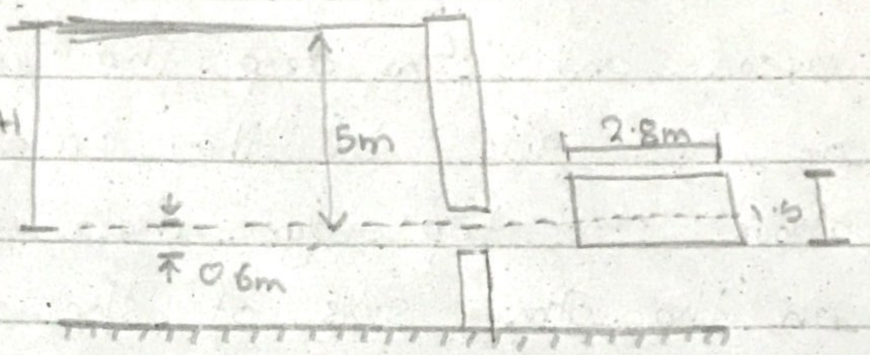
Similarly

H = 5 + 0·6

= 5·6 m

$Cd = 0.78$

Discharge $(Q) = ?$



Solution:-

As by formula

$\Rightarrow$ Discharge through submerged portion

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

$$= 0.78 \times 2.8 \times (7 - 5.6) \times \sqrt{2(9.81)(5.6)}$$

$$Q_1 = 32.04 \ m^3/sec$$

$\Rightarrow$ Discharge through free portion

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

$$= \frac{2}{3} (0.78) \times 2.8 \sqrt{2 \times 9.8} \times \left[(5.6)^{3/2} - (5)^{3/2}\right]$$

$$Q_2 = 13.36 \ m^3/sec$$

=> Total discharge $Q = Q_1 + Q_2$

$= 32.04 + 13.36$

$Q = 45.4\ m^3/sec$

Q no 3

A :- The diameter of a water pipe os suddenly enlarged from R- 200 mm to R+ 3000 mm. the rate of flow through is $0.95 \, m^3/sec$ and the pressure in the larger pipe is $R + 800 \, N/m^2$ calculate

① The loss of Head due to sudden enlargment.

② The power lost due to sudden enlargment.

③ The pressure in the smaller pipe (if the pipe is horizontal).

=> Given Data :-

$d_1 = R - 200 \, mm$

$= 7487 - 200 = 7287 \, mm$

$d_2 = R + 3000 \, mm$

$= 7487 + 3000 = 10484 \, mm$

Flow rate $(Q) = 0.95 \, m^3/sec$

Pressure in larger pipe $= R + 800\ N/m^2$
$= 7487 + 800$
$= 8287\ N/m^2$

Calculate :-
Solution
① Loss of Head due to sudden enbargment
$\Rightarrow d_1 = 7287\ mm = 7.28\ m$
$A_1 = \frac{\pi}{4}(7.28)^2 = 41.6\ m^2$

$\Rightarrow d_2 = 10484 = 10.48\ m$
$A_2 = \frac{\pi}{4}(10.48)^2 = 86.29\ m^2$

As
$Q = AV$
$V = Q/A$ $\Rightarrow V_1\ Q/A_1$
$V_1 = \frac{0.95}{41.6} = \boxed{0.022\ m/sec}$

Simalary
$V_2 = Q/A_2$

$$V_2 = \frac{0.95}{86.29} = \boxed{0.011 \text{ m/sec}}$$

By formula of Sudden Enlargment

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

$$\left(1 - \frac{41.6}{86.29}\right)^2 \times \left(\frac{0.022 - 0.011}{2 \times 9.81}\right)^2$$

$$= (0.268)\left(\frac{1.21 \times 10^{-4}}{19.62}\right)$$

$$\boxed{h_e = 1.65 \times 10^{-6} \text{ m}}$$

(b) Power loss due to sudden enlargment

$$P = \rho g Q h_e$$

$$= (1000)(9.81)(0.95)(1.65 \times 10^{-6})$$

$$\boxed{P = 0.015 \text{ W}}$$

Pressure in the smaller pipe
By using Bernoullis Equation

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

$$\frac{P_1}{(1000)(9.81)} + \frac{(0.022)^2}{2(9.81)} = \frac{7487}{(1000)(9.81)} + \frac{(0.011)^2}{2(9.81)} + 1.65\times10^{-6}$$

$$\frac{P_1}{9810} + 2.46687054\times10^{-5} = 0.763 + 6.167176351\times10^{-6} + 1.65\times10^{-6}$$

$$\frac{P_1}{9810} = 0.763 + 6.167176351\times10^{-6} + 1.65\times10^{-6} - 2.46687054\times10^{-5}$$

$$\frac{P_1}{9810} = 0.762$$

$$P_1 = 0.762 \times 9810$$

$$\boxed{P_1 = 7475.56\ N/m^2}$$

Qno 3

(B)

First we define specific energy as specific energy is a parameter that can be used to crarify the meaning of super critical, sub-critical and critical flow in an open channel.