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QNO1:- 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 $= Q = 7888 \frac{ltr}{sec} = 7.888 \frac{m^3}{sec}$

Mean velocity $= v = R-200 = 7888-200$

$= 7688\ ft/sec$

$= 2343.9\ m/sec$

(i) As we know that

$Q = qb \qquad q = \frac{Q}{b} = \frac{7.888}{8} = 0.986 \frac{m^2}{sec}$

$$y_c = \left(\frac{q^2}{g}\right)^{\frac{1}{3}} = \left(\frac{0.986^2}{9.81}\right)^{\frac{1}{3}} = 0.463m$$

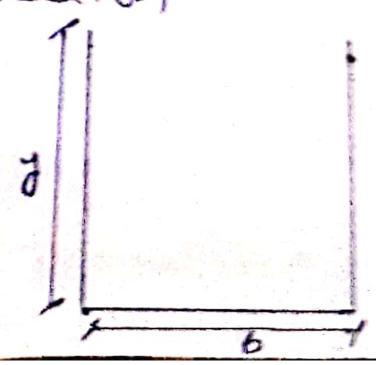
As this is rectangular section

$Q = qb \rightarrow (1)$

$Q = AV \rightarrow (2)$

$qb = AV \Rightarrow qb = ybv$

$q = yv$



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$$v_c = \frac{q}{y_c} = \frac{0.986}{0.463} = 2.129 \text{ m/sec}$$

$\because v > v_c$ (Supercritical flow)

Height of hydraulic jump on the up stream side-

As $Q = AV$ = $Q = byv$

$$y_1 = \frac{Q}{v_1 b} = \frac{7.888}{2343.9 \times 8} = 4.2 \times 10^{-4} m$$

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

$$= -\frac{0.00042}{2} + \sqrt{\frac{0.00042^2}{4} + \frac{2(4.2 \times 10^{-4})(2343.9)}{9.81}}$$

$y_2 = 21.512 m$

$\Delta y = y_2 - y_1 = 21.512m - 0.00042$

$= 21.52 m$

$\therefore \Delta E = E_1 - E_2$

As we know that

$Q_1 = Q_2$ $\quad\quad\quad \because b_1 = b_2 = b$

$A_1 v_1 = A_2 v_2 \quad \cancel{b} y_1 v_1 = \cancel{b} y_2 v_2$

$$v_2 = \frac{y_1 v_1}{y_2} = \frac{0.00042 \times 2343.9}{21.512}$$

$$\boxed{V_2 = 0.0457 \ \frac{m}{sec}}$$

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

$$\Rightarrow \left(0.00042 + \frac{23439^2}{2(9.81)}\right) - \left(21.512 - \frac{0.0457^2}{2(9.81)}\right)$$

$$E_1 - E_2 = 28800136 - 21.51$$

$$= 28799992.08 m$$

→ power absorbed :-

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

$$= 1000 \times 9.81 \times 7.888 (287999\,2.08)$$

$$\boxed{\Delta P = 2.2285 \times 10^{9} W}$$

QNO2:-

(a) Given data: $y_1 = 1.8m$ $b = \frac{66'}{3.28} = 20.12m$

$Q = \frac{7888}{3.28^3} = 223.583 \, m^3/sec$

Required data:- Minimum height (P) of weir

$Q = AV$ $V = \frac{Q}{A} = \frac{Q}{by} = \frac{223.58}{20.12 \times 1.8}$

$= 6.173 \, m/sec$

As we know that:-

$\therefore q = \frac{Q}{b}$

$= \frac{223.58}{20.12}$

$= 11.11 \, m^2/sec$

$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{11.011^2}{9.81}\right)^{1/3}$

$y_c = 2.33m$

Also $v = \sqrt{gy} = \sqrt{gy_c} \Rightarrow \sqrt{9.81 \times 2.32}$

$V_c = 4.77 \, m/sec$

Now according to Specific energy $E_1 = E_2$

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

$$1.8 + \frac{6.173^2}{2(9.81)} = \frac{4.77^2}{2(9.81)} + 2.32 + P$$

$$3.731 = 3.482 + P$$

$$\boxed{P = 0.249m}$$

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QNO2

(b) Given data :- $b = 2.8m$ $d = 1.5m$ $H_1 = 5m$

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

$Cd = 0.7888$ Required $Q = ?$

Discharged through Submerged portion-

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

$$= 0.7888 \times 2.8 \times (6.5 - 5.6) \times \sqrt{2 \times 9.81 \times 5.6}$$

$$Q = 20.831 \, m^3/sec$$

⇒ Discharge of free portion:-

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

$$Q_2 = \frac{2}{3} (0.7888) \times 2.8 \sqrt{2 \times 9.8} \left(5.6^{3/2} - 5^{3/2} \right)$$

$$Q_2 = 13.506 \, m^3/sec$$

Total discharge

$$Q = Q_1 + Q_2$$

$$Q = 20.831 + 13.506$$

$$= 34.337 \, m^3/sec$$

(B) A Sluice gate Controls the flow in a Channel of width 4m. If the discharge is 7888 ft^3/sec and the upstream and downstream water depth is 2.9m and 1.1m respectivity Calculate the downstream velocity. Also State the type of flow at upstream and downstream side using any equation.

Sol: Given data: $b = 4m$ $Q = 7888 \, ft^3/sec$

$$= \frac{7888}{(3.28)^3} = 311.9 \, m^3/sec$$

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

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

$$Q = A_1V_1 = A_2V_2 \Rightarrow \cancel{b}y_1V_1 = \cancel{b}y_2V_2$$

$$V_2 = \frac{y_1V_1}{y_2} = \frac{2.9 \, V_1}{1.1}$$

$$\boxed{V_2 = 2.636 \, V_1} \longrightarrow (2)$$

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put the value of equ (2) in eq (1)

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

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

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

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

Now put the value of "V_1" in eq (1)

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

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

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

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

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

using froud NO to determine type of flow -

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)

DOWN Stream Side:-

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

(Supercritical Flow)

QNO3(A) Given data:- $P_1 = 800 + R$

$= 7888 + 800 = 8688 \, N/m^2$

$d_1 = R - 200 = 7888 - 200 = 7688 \, mm$

$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4}(7.688)^2 = 46.397 \, m^2$

$d_2 = R + 3000 = 7888 + 3000 = 10888 \, mm$

$= 10.888 \, m$

$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4}(10.888)^2 = 93.06 \, m^2$

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

$\therefore Q = AV = V = \frac{Q}{A} = \frac{0.95}{46.397} = 0.0204 \, m/sec$

$V_2 = \frac{0.95}{93.06} = 0.01 \, m/sec$

(1) Head loss due to sudden enlargement

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

$= \left(1 - \frac{46.397}{93.06}\right)^2 \left(\frac{0.0204 - 0.01}{2 \times 9.81}\right)^2$

$= 1.32 \times 10^{-6} \, m$

(2) ⇒ power lost due to Sudden enlargment $P = \rho g Q h_e$

$P = 1000 \times 9.81 \times 0.91 \times 1.32 \times 10^{-6}$

$\boxed{P = 0.0225 W}$

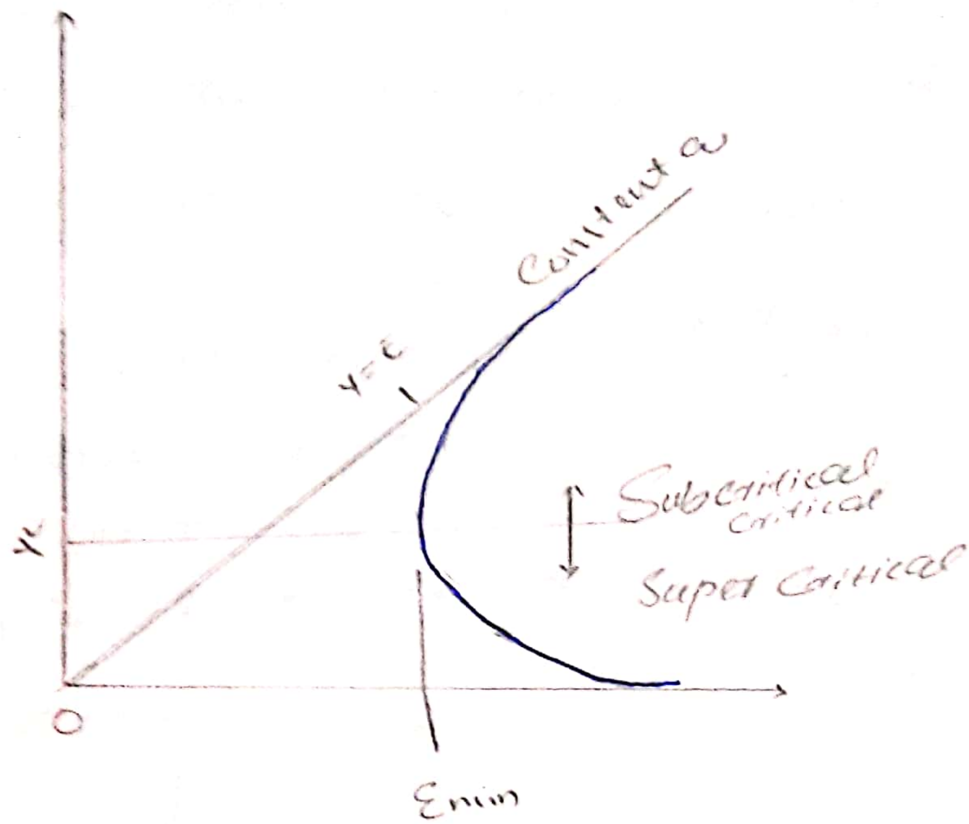
(3) pressure in the Smallest pipe apply Bernoulli's equation

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

$$\frac{8688}{1000 \times 9.81} + \frac{0.0204^2}{2 \times 9.81} = \frac{P_2}{1000 \times 9.81} + \frac{0.01^2}{2 \times 9.81} + 1.32 \times 10^{-6}$$

$P_2 = 0.873 \times 9810$

$P_2 = 85641.3 \, N/m^2$



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 ① Sub Critical
② Critical
③ Super Critical

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Speci7 Energy is used to Clari7y the meaning o7 the above terms in an open Channel.

How is this achieved?

Total Energy = potential energy + Kinetic Energy

$\because w = mg$

$T.E = mgh + \frac{1}{2}mv^2$

ignoring "w" weight o7 water $m = \frac{w}{g}$

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

As we know that.

$Q = VA \qquad V = \frac{Q}{A}$ Squaring on b/s

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

let Suppose the Channel is Rectangular

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

$Q = q \times b \longrightarrow (y)$

putting value o7 (x) and y in eq (1)

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

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

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

$(E-y)y^2 =$ Constant

As q and g are Constant

* Critical depth is the flow depth Corresponding to minimum Specific energy

$y > y_c =$ Sub critical flow

$y = y_c =$ Critical flow

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

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

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

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