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SUBMITTED TO : ENGR. FAWAD

SUBJECT : HYDRAULIC ENGINEERING

MODULE : 6th

SECTION : B

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1 A- Lets suppose a rectangular channel, discharges 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 = 7836 ltr/sec = 7.836 m^3/sec

Mean velocity = V = R - 200 = 7836 - 200

= 7616 ft/sec

= 2321.95 m/sec

i) As we know

$$Q = qb$$

$$q = Q/b = \frac{7.836}{8} = 0.9795\ m^2/sec$$

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

$$= \left(\frac{0.9795^2}{9.81}\right)^{1/3} = 0.461\,m$$

$$\boxed{y_c = 0.461m}$$

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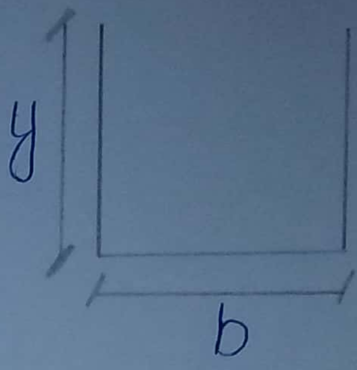
 7836

As it is rectangular section



$Q = qb$ — ①

$Q = AV$ — ②

Equating ① & ②

$qb = AV$

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

$q = yV$

$V_c = q/y_c = \frac{0.9795}{0.461} = 2.125\,m/sec$

$\therefore V > V_c$ (Supercritical flow)

Height of hydraulic jump on the upstream side.

As $Q = AV$

$Q = byV$

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

$y_1 = \frac{7.836}{2321.95 \times 8} = 0.0004m$

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

$$y_2 = \frac{-0.0004}{2} + \sqrt{\frac{(0.0004)^2}{4} + \frac{2(9.81)(2321.95)^2}{9.81}}$$

$$\boxed{y_2 = 20.96m}$$

$$\Delta y = y_2 - y_1$$
$$= 20.96 - 0.0004$$

$$\boxed{\Delta y = 20.95m}$$

ii)

$\therefore \Delta E = E_1 - E_2$

As we know that

$$Q_1 = Q_2$$
$$A_1V_1 = A_2V_2 \qquad \therefore b_1 = b_2 = b$$
$$\cancel{b}y_1v_1 = \cancel{b}y_2v_2$$
$$V_2 = y_1v_1/y_2$$

$$\boxed{V_2 = \frac{0.0004 \times (2321.95)}{20.96}} = \boxed{0.044\ m/sec}$$

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

$$= \left(0.0004 + \frac{2321.95^2}{2 \times 9.81}\right) - \left(20.96 + \frac{0.044^2}{2 \times 9.81}\right)$$

$$E_1 - E_2 = 274772.71m$$

→ Power absorbed :

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

$$\Delta P = 1000 \times 9.81 \times 7.836 (274772.71)$$

$$\Delta P = 2.11 \times 10^{10} W$$

$$\boxed{\Delta P = 21122096.97 \text{ KN}}$$

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 downstream water depth is 2.9m and 1.1m respectively, Calculate the downstream velocity. Also state the type of flow at upstream and downstream side using any equation.

Sol: Given data

$$b = 4m$$

$$Q = 7836 \; ft^3/sec = \frac{7836}{(3.28)^3} = 222.06 \; m^3/sec$$

$$y_1 = 2.9m$$

$$y_2 = 1.1m$$

Let Specific Energy at upstream & downstream side:

$$E_1 = E_2$$

$$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g} \quad \text{——} \; (1)$$

As we know that

$$Q = A_1 V_1 = A_2 V_2$$

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

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

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

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

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

$$2.9 + \frac{v_1^2}{2\times 9.81} = 1.1 + \frac{(2.634v_1)^2}{2\times 9.81}$$

$$2.9 - 1.1 = \frac{6.938v_1^2}{19.62} - \frac{v_1^2}{19.62}$$

$$1.8 = \frac{6.938v_1^2 - v_1^2}{19.62}$$

$$1.8 \times 19.62 = 5.938 v_1^2$$

$$v_1^2 = \sqrt{\frac{1.8 \times 19.62}{5.938}}$$

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

Now put the value of "v_1" in equ (1)

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

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

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

$$1.8 = \frac{V_2^2 - 5.95}{2g}$$

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

$$\sqrt{V_2^2} = \sqrt{41.266}$$

$$\boxed{V_2 = 6.42 \, m/sec}$$

Using Froud No to determine type of flow:

UPSTREAM SIDE:

$$F_{r1} = \frac{V_1}{\sqrt{g y_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = 0.457 < 1$$

(Sub critical flow)

DOWNSTREAM SIDE

$$F_{r2} = \frac{V_2}{\sqrt{g y_2}} = \frac{6.42}{\sqrt{9.81 \times 1.1}} = 1.95 > 1$$

(Supercritical flow)

2-

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

Sol: Given data

$$y = 1.8m$$
$$b = 66' = \frac{66}{3.28} = 20.12m$$
$$Q = \frac{7836}{3.28^3} = 222.061\ m^3/sec$$

Required data:

Minimum height (P) of weir.

$$Q = AV$$
$$V = \frac{Q}{A} = \frac{Q}{by} = \frac{222.06}{20.12 \times 1.8} = 6.13\ m/sec$$

As we know

$$y_c = \left(q^2/g\right)^{1/3} = \left(\frac{11.04^2}{9.81}\right)^{1/3}$$

$$\therefore q = Q/b = \frac{222.06}{20.12} = 11.04\ m^2/s$$

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

Also

$$V = \sqrt{gy}$$
$$V_c = \sqrt{gy_c} = \sqrt{9.81 \times 2.32}$$
$$\boxed{V_c = 4.77\ m/sec}$$

Now ; According to specific energy

$$E_1 = E_2$$

$$y_1 + \frac{v_1^2}{2g} = \frac{v_c^2}{2g} + y_c + P$$

$$1.8 + \frac{6.13^2}{2\times9.81} = \frac{4.77^2}{2\times9.81} + 2.32 + P$$

$$3.72 = 3.48 + P$$

$$P = 3.72 - 3.48$$

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

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 5m above it's top edge. The water level on the other side of the orifice is 0.6m below it's top edge. Calculate the discharge through the orifice if coefficient of discharge Cd = 0.R.

Sol: Given data

$b = 2.8m$

$d = 1.5m$

$H_1 = 5m$

$H_2 = 5+1.5 = 6.5m$

$H = 5+0.6 = 5.6m$

$Cd = 0.7836$

Required data $Q = ?$

Discharge through submerged portion

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

$$= 0.7836 \times 2.8 \times (6.5 - 5.6) \times \sqrt{2 \times 9.81 \times 5.6}$$

$$\boxed{Q_1 = 20.69 \, m^3/sec}$$

Discharge of free portion

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

$$Q_2 = \frac{2}{3}(0.7836) \times 2.8 \sqrt{2 \times 9.81} \left[5.6^{3/2} - 5^{3/2} \right]$$

$$\boxed{Q_2 = 13.422 \, m^3/sec}$$

Total Discharge

$$Q = Q_1 + Q_2$$

$$Q = 20.69 + 13.422$$

$$\boxed{Q = 34.11 \, m^3/sec}$$

P.T.O

3

A- The diameter of a water pipe is 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 enlargement.
2- The power lost due to sudden enlargement.
3- The pressure in the smallest pipe (If the pipe is horizontal).

Sol: Given data

$$P_1 = R + 800 = 7836 + 800 = 8636 \, N/m^2$$

$$d_1 = R - 200 = 7836 - 200 = 7636 \, mm = 7.636 \, m$$

$$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4}(7.636)^2 = 45.79 \, m^2$$

$$d_2 = R + 3000 = 7836 + 3000 = 10836 \, mm = 10.836 \, m$$

$$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4}(10.836)^2 = 92.22 \, m^2$$

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

$$\therefore Q = AV$$

$$V = Q/A$$

$$V_1 = \frac{Q_1}{A_1} = \frac{0.95}{45.79} = 0.021 \, m/sec$$

$$V_2 = \frac{Q_2}{A_2} = \frac{0.95}{92.22} = 0.01 \, m/sec$$

1- Head loss due to sudden enlargement.

$$h_e = \left(1 - \frac{A_1}{A_2}\right)^2 \frac{(V_1 - V_2)^2}{2g} = \left(1 - \frac{45.79}{92.22}\right)^2 \times \frac{(0.021-0.01)^2}{2\times9.81}$$

$$h_e = 1.56\times10^{-6} m$$

$$\boxed{h_e = 0.0000015 m}$$

2- Power lost due to sudden enlargment.

$$P = \rho g Q h_e$$

$$P = 1000\times9.81\times0.95\times1.5\times10^{-6}$$

$$\boxed{P = 0.014 W}$$

3- Pressure inthe smallest pipe

Apply Bernoulli's equ

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

$$\frac{8636}{1000\times9.81} + \frac{0.021^2}{2\times9.81} = \frac{P_2}{1000\times9.81} + \frac{0.01^2}{2g} + 1.56\times10^{-6}$$

$$P_2 = 0.879\times9810$$

$$\boxed{P_2 = 8632.73 N/m^2}$$

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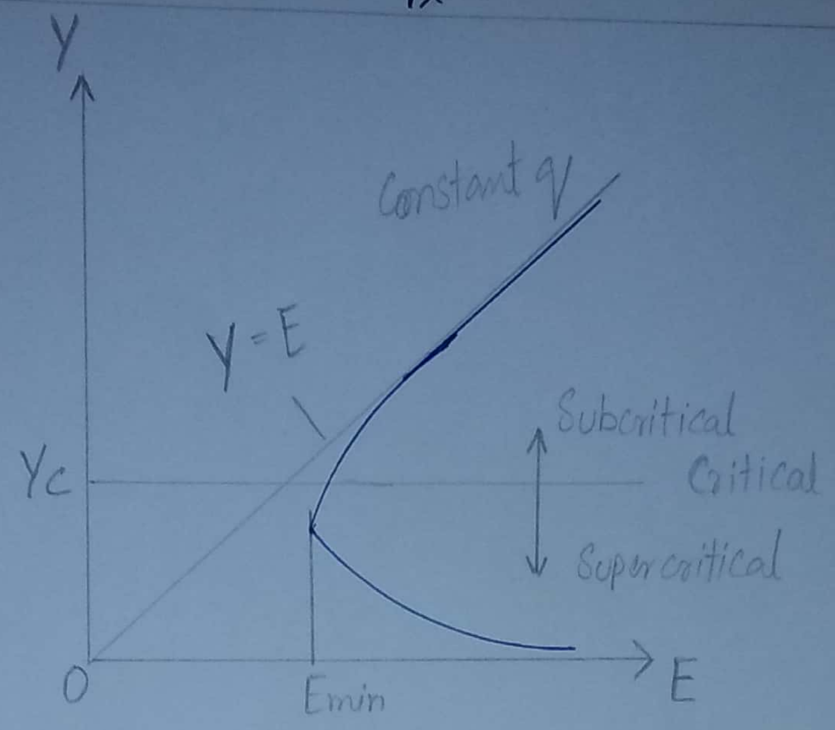
3
B-



What does this blue curve indicates. 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) Subcritical
ii) Critical
iii) Supercritical

Specific Energy is used to clarify the meaning of the above terms in an open channel.

HOW IS THIS ACHEIVED?

P.T.O

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.

$$T.E = h + \frac{v^2}{2g}$$

$$\boxed{T.E = y + \frac{v^2}{2g}} \quad \text{— } 1$$

As we know that

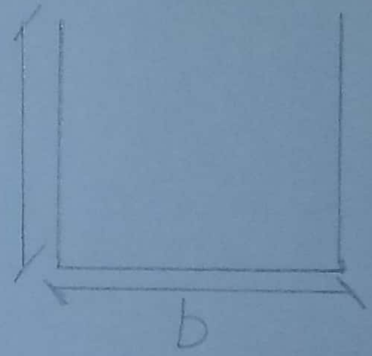
$$Q = VA$$

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

$$V^2 = \frac{Q^2}{A^2}$$

put v^2 in equ 1

$$\boxed{E = y + \frac{Q^2}{A^2 \cdot 2g}} \quad \text{— } 2$$



let's suppose the channel is Rectangular.

$$A = y \times b \quad \text{— } x$$

$$Q = q\, b = y$$

putting value of x 3 y in 2

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

$$E = y + \frac{q^2}{y^2 \cdot 2g} \quad \text{— putting (4)}$$

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

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

$$\boxed{(E-y)y^2 = \text{constant}}$$

As "q" and "g" are constants.

★ 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