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SECTION : B

SUBJECT : HYDRAULIC ENGINEERING

SEMESTER : 6th.

SUBMITTED TO : ENGR. FAWAD AHMAD

MID EXAM.

QUESTION: 01 (a)

Let suppose a rectangular channel, discharge R l/sec of water into 8m wide apron with zero slope. Mean velocity is R- 220 ft/sec.

Calculate:

1. Height of hydraulic jump (in unit of meter)
2. Power absorbed due to hydraulic jump (in unit KW).

GIVEN DATA:

- Channel width = b = 8m.
- Discharge = Q = 7857 l/sec

$$= \frac{7857}{1000} = 7.857\ m^3/sec.$$

- Mean Velocity = V = R - 220

$$= 7857 - 220 = 7637\ ft/sec$$

$$= \frac{7637\ ft}{3.28\ m} = 2389.02\ m/sec.$$

REQUIRED:

- Height of hydraulic jump = ?
- Power absorbed due to hydraulic jump = ?

SOLUTION:

1. Height of hydraulic jump:

As $Q = qb$

$$q = Q/b = \frac{7.857}{8} = 0.982\ m^2/sec.$$

Critical Depth y_c :

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

$$= \left(\frac{(0.982)^2}{9.81}\right)^{1/3}$$

$$\boxed{y_c = 0.46\,m}$$

Critical Velocity V_c:

$$q = yV$$

$$V_c = q/y_c = \frac{0.982}{0.46}$$

$$\boxed{V_c = 2.13\,m/sec}$$

$V_1 > V_c$ (super critical flow).

Depth Of Water on Upstream Side :

$$Q = AV$$

$$Q = byV$$

$$y_1 = Q/V_1 b$$

$$y_1 = \frac{7.857}{2389.02 \times 8}$$

$$\boxed{y_1 = 0.000411\,m}$$

Now

$$y_2 = -\frac{y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2y_1V_1^2}{g}}$$

$$y_2 = -\frac{0.000411}{2} + \sqrt{\frac{(0.000411)^2}{4} + \frac{2(0.000411)(2389.02)^2}{9.81}}$$

$$\boxed{y_2 = 21.86}.$$

Difference In Depth:

$$\Delta y = y_2 - y_1$$

$$= 21.86 - 0.000411$$

$$\boxed{\Delta y = 21.86\,m}$$

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

As we know ~~th~~ that

$$Q_1 = Q_2$$

$$A_1V_1 = A_2V_2$$

$$\cancel{b}y_1V_1 = \cancel{b}y_2V_2$$

$$y_1V_1 = y_2V_2$$

$$V_2 = \frac{y_1V_1}{y_2}$$

$$= \frac{(0.000411)(2389.02)}{21.86}.$$

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

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

$$= \left(0.000411 + \frac{(2389.02)^2}{2(9.81)}\right) - \left(21.86 + \frac{(0.044)^2}{2(9.81}\right)$$

$$= 290897.88 - 21.8600$$

$$\boxed{E_1 - E_2 = 290876.019\,m}$$

2. Power Dissipated In Hydraulic Jump:

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

$$= (1000)(9.81)(7.857)(290876.019)$$

$$= 2.24 \times 10^{10}\ W$$

$$\boxed{\Delta P = 22419900\ KW}$$

QUESTION: 01 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.

QUESTION: 1B

GIVEN DATA:

- height at upstream = 2.9m
- height at downstream = 1.1m.
- Discharge, Q = 7857 ft^3/sec.
- Channel width, b = 4m.

REQUIRED:

- Downstream Velocity:
- State type of Flow at upstream and downstream.

SOLUTION:

1. Downstream Velocity:

$$E_1 = E_2.$$

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

Also from Discharge.

$$Q = A_1V_1 = A_2V_2$$

$$b_1y_1V_1 = b_2y_2V_2$$

$$\cancel{b}y_1V_1 = \cancel{b}y_2V_2$$

$$y_1V_1 = y_2V_2$$

$$V_2 = \frac{y_1V_1}{y_2}$$

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

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

Putting value of V_2 in eq (1)

$$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g}$$

$$2.9 + \frac{V_1^2}{2(9.81)} = 1.1 + \frac{(2.636V_1)^2}{2(9.81)}$$

$$2.9 + \frac{V_1^2}{19.62} = 1.1 + \frac{6.94V_1^2}{19.62}$$

$$2.9 - 1.1 = \frac{6.94V_1^2}{19.62} - \frac{V_1^2}{19.62}$$

$$1.8 = \frac{5.94V_1^2}{19.62}$$

$$(1.8)(19.62) = 5.94V_1^2$$

$$\frac{35.316}{5.94} = V_1^2$$

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

Putting V_1 in eq (2)

$$V_2 = 2.636 V_1$$

$$= (2.636)(2.44)$$

$$\boxed{V_2 = 6.43 \text{ m/s}}$$

2. Type Of Flow By Using Fraud Number:

a) At Upstream Side:

$$F_r = \frac{V_1}{\sqrt{g y_1}} = \frac{2.44}{\sqrt{(9.81)(2.9)}}$$

$$\boxed{F_r = 0.45 < 1 \quad (\text{Sub critical Flow})}$$

b) At Down Stream Side:

$$F_r = \frac{V_2}{\sqrt{g y_2}} = \frac{6.42}{\sqrt{(9.81)(1.1)}}$$

$$\boxed{F_r = 1.95 > 1}$$

Flow is Super critical.

QUESTION : 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 water flows along a rectangular channel at a depth of 1.8m with a dischage of Q ft^3/sec the channel width is 66 ft.

GIVEN DATA:

- Channal Depth, $y = 1.8m$
- Channal Width, $b = 66\ ft = 20.1m$.
- Discharge, $Q = 7857\ ft^3/sec$.

$$= \frac{7857\ ft^3}{(3.28\ m)^3} = 222.656\ m^3/sec.$$

REQUIRED:

Weir height, $P = ?$

SOLUTION:

As $Q = AV$

$$V_1 = Q/A$$

$$V_1 = Q/by$$

$$V_1 = \frac{222.656}{(20.1)(1.8)}$$

$$\boxed{V_1 = 6.153\ m/sec.}$$

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Critical Depth:

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

$\therefore Q = qb$

$q = Q/b$

$$y_c = \left(\frac{(222.656)^2}{(20.1)^2\,(9.81)}\right)^{1/3}$$

$$y_c = 2.321\text{m}$$

Also

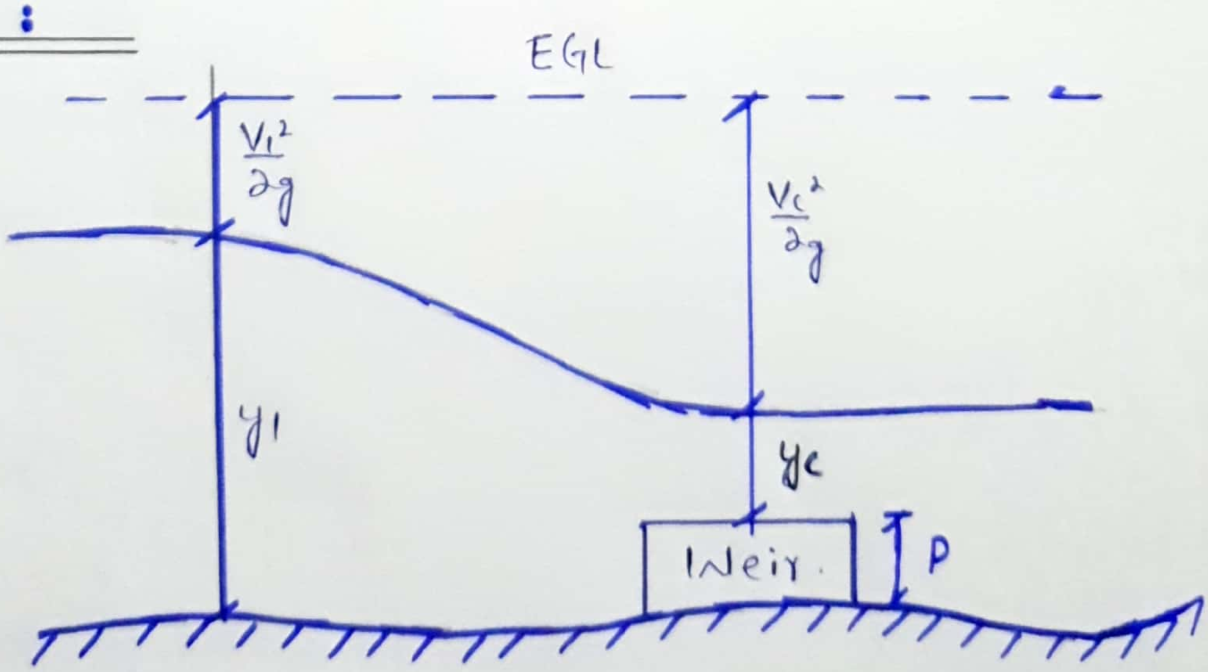
$$V = \sqrt{gy}$$

$$V_c = \sqrt{gy_c}$$

$$= \sqrt{9.81 \times 2.321}$$

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

Figure :



From Figure:

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

$$\frac{(6.153)^2}{2(9.81)} + 1.8 = \frac{(4.77)^2}{2(9.81)} + 2.321 + P$$

$$3.729 = 1.1596 + 2.321 + P$$

$$P = 3.729 - 3.8406$$

$$\boxed{P = 0.248m}$$

Thus the weir should have a height of 0.248m measured from channel bed level.

QUESTION 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 orifice if co-efficient of discharge is cd=0·R.

GIVEN DATA:

Width, $b = 2{\cdot}8\,m$

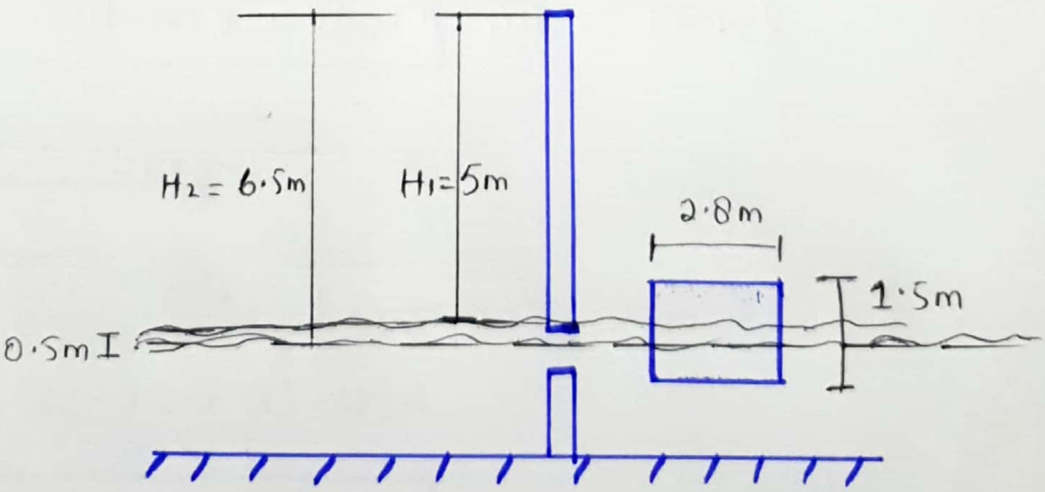
depth, $d = 1{\cdot}5\,m$.

$H_1 = 5\,m$

$H_2 = 5 + 1{\cdot}5 = 6{\cdot}5\,m$

$H = 5 + 0{\cdot}6 = 5{\cdot}6\,m$

$Cd = 0{\cdot}7857$



REQUIRED :

- Discharge through the orifice.

SOLUTION:

Discharge Through Submerge Portion

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

$$= 0.7857 \times 2.8 \times (6.5 - 5.6) \times \sqrt{2(9.81)(5.6)}$$

$$\boxed{= 20.75 \ m^3/sec}$$

Discharge Through Free Portion:

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

$$= \frac{2}{3} \times 0.7857 \times 2.8 \sqrt{2(9.81)} \left[(5.6)^{3/2} - (5)^{3/2} \right]$$

$$\boxed{= 13.458 \ m^3/sec}$$

Total Discharge:

$$Q = Q_1 + Q_2$$

$$= 20.75 + 13.458$$

$$\boxed{Q = 34.211 \ m^3/sec}$$

QUESTION : 03 (a)

The diameter of a water pipe is suddenly enlarged from R - 200mm to R + 3000mm, 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. Loss of head due to sudden enlargement
2. The power lost due to sudden enlargement.
3. The pressure in the smaller pipe (if pipe is horizental).

GIVEN DATA:

$d_1 = R - 200$

$= 7857 - 200 = 7657mm$

$d_2 = R + 3000$

$= 7857 + 3000 = 10857mm$

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

Pressure in larger pipe $= R + 800$

$= 7857 + 800$

$= 8657\ N/m^2$.

SOLUTION:

1. The Loss Of Head Due To Sudden Enlargement:

$d_1 = 7657\,mm = 7.657\,m$

$A_1 = \frac{\pi}{4} d^2 = \frac{\pi}{4}(7.657)^2$

$\boxed{A_1 = 46.04\,m^2}$

$d_2 = \cancel{\frac{\pi}{4} d^2}\ 10857\,mm = 10.857\,m$

$A_2 = \frac{\pi}{4} d^2 = \frac{\pi}{4}(10.857)^2$

$\boxed{A_2 = 92.578\,m^2}$.

As,

$Q = AV$

$V = Q/A$

So

$V_1 = \frac{Q}{A_1} = \frac{0.95}{46.04}$

$\boxed{V_1 = 0.0206\,m/s}$

Similarly

$V_2 = \frac{Q}{A_2} = \frac{0.95}{92.578}$

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

Finding head Loss By Formula:

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

$$= \left(1 - \frac{46.04}{92.57}\right)^2 \frac{(0.02 - 0.01)^2}{2(9.81)}$$

$$\boxed{h_e = 1.287 \times 10^{-6}\ m.}$$

b. Power Lost Due To Sudden Enlargement:

$$P = \rho g Q h_e$$

$$= (1000)(9.81)(0.95)(1.287 \times 10^{-6})$$

$$\boxed{P = 0.0119\ W.}$$

c. Pressure In The Smaller Pipe :

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

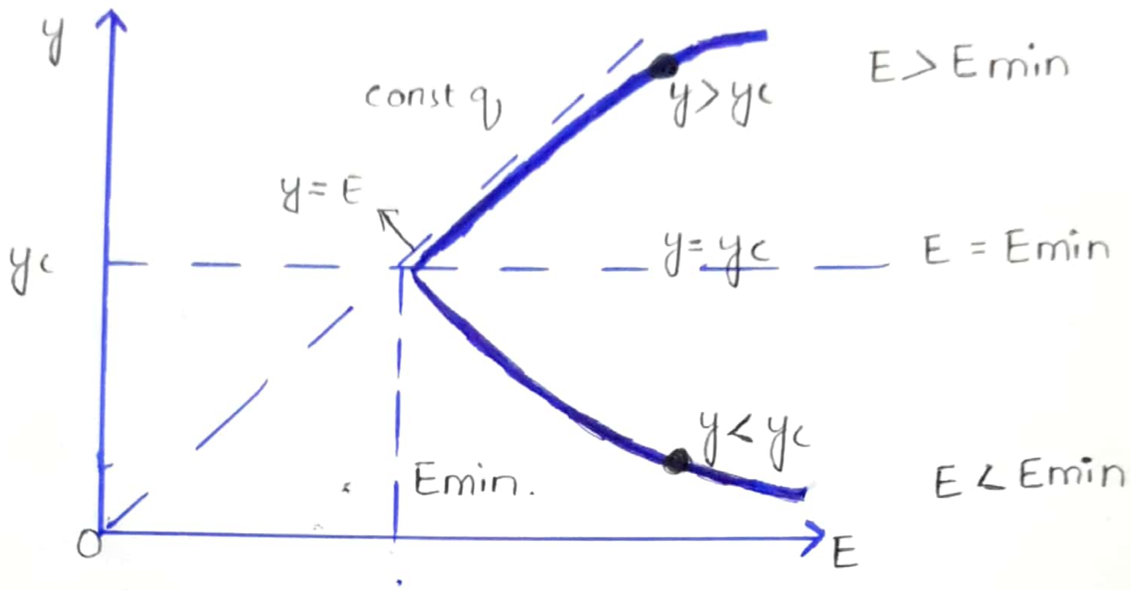
$$\frac{P_1}{9810} + \frac{(0.02)^2}{2(9.81)} = \frac{8657}{1000 \times 9.81} + \frac{(0.01)^2}{2(9.81)} + 1.287 \times 10^{-6}$$

$$\frac{P_1}{9810} + 2.038 \times 10^{-5} = 0.882$$

$$P_1 = 0.882 \times 9810$$

$$\boxed{P_1 = 8651.43\ N/m^2.}$$

QUESTION : 03 B



The Eq 3 is the three degree polynomial equation and can be used to prepare a plot of specific energy and depth of water (E-y)

How It is Obtained:

As We know that

Total Energy = Potential energy + Kinectic energy

$$T.E = P.E + K.E$$

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

$$= Wh + \frac{1}{2} \frac{W}{g} v^2 \qquad \therefore W = mg, \quad m = W/g.$$

ignoring "w" weight of water.

$$T \cdot E = h + \frac{V^2}{2g}$$

$$\boxed{T \cdot E = y + \frac{V^2}{2g}.}$$

As we know that $Q = AV$

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

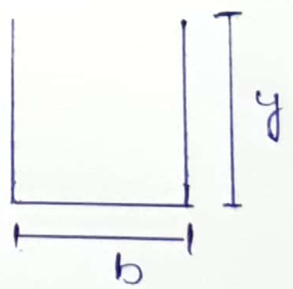
Put V^2 in eq (1)

$$E = y + \frac{Q^2}{A^2\,2g} \rightarrow (2)$$

Let Suppose the channel is rectangular.

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

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



put eq x and y in eq (2)

$$E = y + \frac{Q^2}{A^2\,2g} \rightarrow (3)$$

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

$$E = y + \frac{q^2}{2gy} \quad \text{(Putting y.}$$

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

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

$$(E - y)\,y^2 = \text{constant} \rightarrow eq^3 \rightarrow eq\ (3)$$

As q and g are constant.

=> Critical depth is flow depth corresponding to minimum specific energy.

$y > y_c$ Subcritical Flow

$y = y_c$ Critical Flow

$y < y_c$ Super critical Flow.