EXAM : MID TERM (ONLINE)

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ID	7802
SECTION	"A"
SEMESTER	6th
SUBJECT :-	HYDRAULICS ENGINEERING
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QUESTION : 01

PART : (a)

Given Data:-

Discharge = 7802 lit/sec

$= \frac{7802}{1000}\ m^3/sec$

$= 7.802\ m^3/sec$

Width of apron = 8 m

Mean velocity (V_1) = 7802 − 220 = 7582 ft/sec

$= \frac{7582}{3.28} = 2311.6\ m/sec$

Required:

Height of hydraulic jump = ?

Power absorbed due to hydraulic jump = ?

Solution :- (1) Height of Hydraulic Jump:

Finding 'q'

q = Discharge per unit width.

$q = Q/b$

$\Rightarrow q = \frac{7.802}{8}$

$\Rightarrow q = 0.975 m^2/sec$

Now finding critical depth (y_c)

$y_c = (q^2/g)^{1/3}$

$y_c = \left(\frac{(0.975)^2}{9.81}\right)^{1/3}$

$y_c = \left(\frac{0.950}{9.81}\right)^{1/3}$

$= (0.968)^{1/3}$

$y_c = 0.45 m$

Now Finding Critical velocity.

$q = V/y, \; vy$

$V = q/y$

$V_c = q/y_c$

Now putting values of q and y_c

$V_c = \frac{0.975}{0.45} = 2.16 m/sec$

As $V_1 > V_c$ $\Rightarrow$ so super critical flow.

Water Depth on Upstream side:

$Q = AV$

$Q = (by)V$

$y = \frac{Q}{Vb}$

Now putting the values of Q, v, b we get

$y = \frac{7.802}{2.16 \times 8}$

$y_1 = \frac{7.802}{17.28} = 0.451\ m$

Now we know by formula

$y_2 = \frac{-y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2y_1v_1^2}{g}}$

$= \frac{-0.451}{2} + \sqrt{\frac{(0.451)^2}{4} + \frac{2(0.451)(2.16)^2}{9.8}}$

$= \frac{-0.451}{2} + 0.69$

$= -0.225 + 0.69$

$y_2 = 0.465\ m$

Difference in depth:-

Now finding difference in depth so

$\Delta y = y_2 - y_1$

putting values of y_1 and y_2

$\Delta y = 0.465 - 0.45$

$\Delta y = 0.015$

Now we know $\Delta E = E_1 - E_2$

We also know

$$Q_1 = Q_2$$
$$A_1 V_1 = A_2 V_2$$
$$b_1 y_1 V_1 = b_2 y_2 V_2 \qquad \therefore b_1 = b_2 = b$$
$$b y_1 V_1 = b y_2 V_2$$
$$V_2 = \frac{y_1 V_1}{y_2}$$

Now putting value

$$V_2 = \frac{0.451\,(2311.6)}{0.465}$$
$$V_2 = 2241.9$$

Now we know

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

putting values

$$\Delta E = \left(0.451 + \frac{(2311.6)^2}{2(9.81)}\right) - \left(0.465 + \frac{(2241.9)^2}{2(9.81)}\right)$$
$$= \left(0.451 + \frac{5343494.5}{19.62}\right) - \left(0.465 + \frac{5026115.6}{19.62}\right)$$
$$= (0.451 + 272349.3) - (0.465 + 256173.06)$$
$$= (272{,}349.751) - (256{,}173.525)$$

$$\Delta E = 16{,}176.22\,m.$$

POWER DISSIPATION :-

We know by formula

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

putting values,

We know $\rho = 1000$ so we get

$\Delta P = 1000 (9.81)(7.802)(16,176.22)$

$= 1,238,089,379.$ W

$= 1238089.379$ KW.

QUESTION: 01

PART: (B)

Given Data:

Discharge = 7802 ft3/sec

Channel Width = (b) = 4m

height of upstream side = y_1 = 2.9m

height of downstream side = y_2 = 1.1m

Required:

Downstream velocity = ?

Solution:

Downstream velocity :-

As we know about specific Energy

$E_1 = E_2$

So we have

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

Also from Discharge (Q) we know

$Q = AV$

Now $Q_1 = Q_2$

$A_1 V_1 = A_2 V_2$

$(b_1 y_1) V_1 = (b_2 y_2) V_2$ $\quad (A = by)$

$b y_1 v_1 = b y_2 v_2$ $\quad (\because b = b_1 = b_2)$

$\Rightarrow \quad v_2 = \frac{y_1 v_1}{y_2}$

putting values of y_1 and y_2 we get

$V_2 = \frac{(2.9)}{(1.1)} v_1 = 2.63 v_1$

$V_2 = 2.63 v_1 \quad$ — (II)

putting value of V_2 in eq (I) we get

$2.9 + \frac{v_1^2}{2g} = 1.1 + \frac{(2.63 v_1)^2}{2g}$

$2.9 + \frac{v_1^2}{2g} = 1.1 + \frac{6.91 v_1^2}{2g}$

$\Rightarrow \quad \frac{v_1^2}{2g} - \frac{6.91 v_1^2}{2g} = 1.1 - 2.9$

$\Rightarrow \quad + \frac{5.91 v_1^2}{2g} = +1.8$

$\Rightarrow \quad 5.91 v_1^2 = 1.8 \times 2(9.81) \quad (g = 9.81)$

$\Rightarrow \quad v_1^2 = \frac{1.8 \times 2(9.81)}{5.91}$

$\Rightarrow \quad v_1 = \sqrt{\frac{1.8 \times 2(9.81)}{5.91}}$

$\Rightarrow \quad \boxed{v_1 = 2.44 \text{ m/sec}}$

putting value of v_1 in eq (II) so we get

$V_2 = 2.63(2.44)$

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

Type of Flow using Froud Number:

(i) On upstream side :-

$$Fr_1 = \frac{V_1}{\sqrt{gy_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = 0.45$$

$Fr < 1$

So, sub-critical flow.

(ii) On Downstream side :-

$$Fr_2 = \frac{V_2}{\sqrt{gy_2}} = \frac{6.41}{\sqrt{9.81 \times 1.1}} = 1.95$$

$Fr > 1$

So, super-critical flow.

QUESTION: 02

PART: (A)

Given Data:

Discharge = $7802\ ft^3/sec = \frac{7802\ ft^3}{(3.28m)^3} = 221.14\ m^3/sec$

Depth of channel = 1.8 m

Width of channel = 66ft = 20.1m

Required:

Height = P = ?

Solution:-

Since we know

$Q = AV$

$V = Q/A$

$V = Q/_{bxy}$

putting value, we get

$$V = \frac{221.14}{20.1 \times 1.8}$$

$V = 6.11\ m/sec$

Critical Depth:-

Now as we know

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

$q = Q/b$

$q = 221.14/20.1$

$q = 11.01\ m^2/sec$

putting value of q in yc equation, we get

$$y_c = \left(\frac{(11.01)^2}{9.81}\right)^{1/3}$$

$$y_c = 2.32\ m.$$

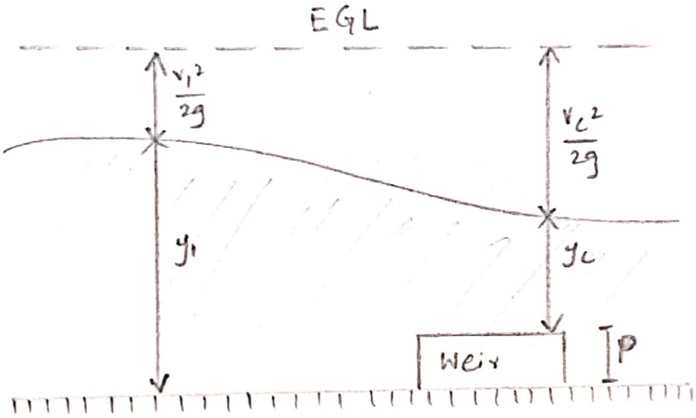
Now we know from formula:-

$$V = \sqrt{gy}$$

$$V = \sqrt{gy_c}$$

$$V = \sqrt{9.81 \times 2.32}$$

$$V = 4.77\ m/sec$$



From Figure above:-

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

putting values

$$\frac{(6.11)^2}{(2\times 9.81)} + 1.8 = \frac{(4.77)^2}{2(9.81)} + 2.32 + P$$

$$1.902 + 1.8 = 1.159 + 2.32 + P$$

$$P = 0.223\ m.$$

QUESTION: 02

PART:(B)

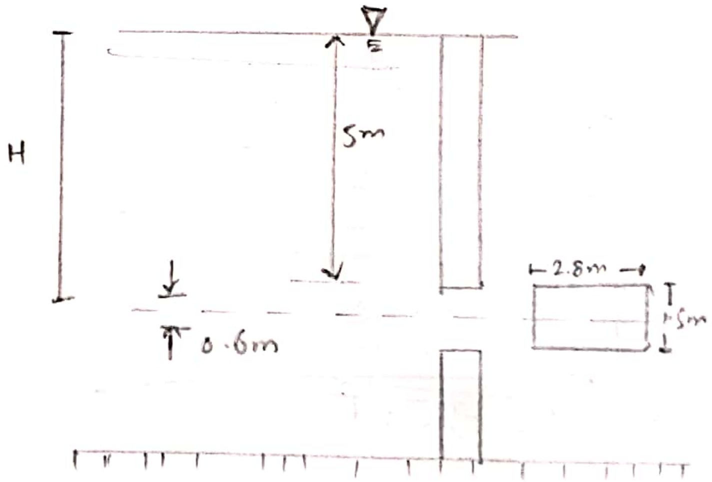
Given Data:-

Breadth = 2.8m
Depth = 1.5m
Water level on one side = $H_1 = 5m$
Water level on other side = $H_2 = 5m + 1.5 - 7m$
$H = 5 + 0.6$
$= 5.6m$
Cd = 0.7802

Required:-

Discharge = Q = ?

Solution:-



Submerged Portion:
We know

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

putting values from given data we get.

$Q_1 = 0.7802 \times 2.8 \times (6.5 - 5.6)(\sqrt{2(9.81)(5.6)})$

$Q_1 = 20.59\ m^3/sec$

For Free portion:-

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

putting values we get

$$Q_2 = \frac{2}{3}(0.7802) \times 2.8\sqrt{2(9.81)}\,[(5.6)^{3/2} - (5)^{3/2}]$$

$$Q_2 = 27.42 \ m^3/sec$$

QUESTION: 03

PART: (A)

Given Data:-

1st Diameter $= d_1 = R - 200\ mm$

$= 7802 - 200\ mm = 7602\ mm$

2nd Diameter $= d_2 = R + 3000\ mm$

$= 7802 + 3000\ mm = 10,802\ mm$

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

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

$= 7802 + 800$

$= 8602\ N/m^2$

Required:-

Loss of head due to sudden enlargement = ?

Power lost due to sudden enlargement = ?

Pressure in smaller pipe = ?

Solution:-

1. **Loss of head due to sudden enlargement:-**

We have $d_1 = 7602\ mm = 7.60\ m$

so, $A_1 = \frac{\pi}{4}(7.61)^2 = 45.34\ m^2$

Now, $d_2 = 10,802\ mm = 1.08\ m$

so $A_2 = \frac{\pi}{4}(1.08)^2$

$A_2 = 0.915\ m^2$

As we know

$Q = AV$

$V = Q/A$

$V_1 = Q/A_1$

$$V_1 = \frac{0.95}{45.34}$$

$V_1 = 0.020\ m/sec$

Now we have

$V_2 = Q/A_2$

putting values

$$V_2 = \frac{0.95}{0.915}$$

$V_2 = 1.038\ m/sec$

By formula of sudden enlargement.

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

putting values, we get

$$= \left(1 - \frac{45.34}{0.915}\right)^2 \times \left(\frac{(0.020 - 1.038)^2}{2 \times 9.81}\right)$$

$$= 2357.1 \times \left(\frac{(-1.01)^2}{19.62}\right)$$

$$= 2357.1 \times \frac{1.02}{19.62}$$

$$= 2357.1 \times 0.05$$

$$= 117.85\ m.$$

2. Power Loss due to sudden Enlargement:-

$P = \rho g Q h_e$

putting value

$P = (1000)(9.81)(0.95)(117.85)$

$= 10{,}98{,}303.075\ W$

3. **Pressure in smaller pipe:-**

Using Bernauli's Equation:-

We know:

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

putting values:

$$\frac{P_1}{(1000)(9.81)} + \frac{(0.020)^2}{2(9.81)} = \frac{1098303.07}{(1000)(9.81)} + \frac{(1.038)^2}{2(9.81)} + 117.85$$

$$\frac{P_1}{9810} + 0.0000203 = 111.95 + 0.054 + 117.85$$

$$\frac{P_1}{9810} = 111.95 + 0.054 + 117.85 + 0.0000203$$

$$\frac{P_1}{9810} = 229.85$$

$$P_1 = 22,54,828.5 \text{ N/m}^2.$$

QUESTION: 03

PART: (b)

SPECIFIC ENERGY:- Specific energy is a parameter which can be used for clarifying the meaning of super-critical, sub critical and critical flow. In an open channel critical depth is the depth which corresponds to maximum specific Energy.

Now

if $y > y_c$; $E > E_{min}$ (subcritical flow)

$y = y_c$; $E = E_{min}$ (critical flow)

$y < y_c$; $E < E_{min}$ (super-critical flow)

We know that:

$$(E-y)y^2 = q^2/2g$$

q and 2g are constant and this Equation is used to prepare a plot of specific Energy.