Name M.Shawal khan

Id 7813

Section A

Semester 6th

Subject Hydraulics Engineering

Q 1 (A)

Given Data:-

Discharge = 7813 lit/sec = 7.813 m^3/sec.
Width of apron = 8 m.
Mean velocity = 7813 − 220 = 7593 ft/sec

$$= \frac{7593}{3.28} = 2314.9 \text{ m/sec}.$$

Required:-

Height of hydraulic jump
Power absorbed due to hydraulic jump.

Sol:-

1) Height of Hydraulic Jump

Finding 'q' which is discharge per unit width.

$$q = Q/b$$

$$= \frac{7.813}{8}$$

$$= 0.975 \text{ m}^2\text{/sec}.$$

Critical Depth (y_c)

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

$$y_c = \left(\frac{(0.976)^2}{9.81}\right)^{1/3}.$$

$$y_c = 0.45 \text{m}.$$

Now

Critical velocity

$q = Vy$

$V = q/y$

$V_c = q/y_c$

Put values.

$V_c = \frac{0.976}{0.45} = 2.16 m/sec.$

As $V_1 > V_c$ So Super Critical flow.

Water Depth on upstream side

$Q = AV$

$Q = (by)V$

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

Putting values.

$y = \frac{7.813}{2.16 \times 8}$

$y_1 = 0.45m$

Now by formula.

$$y_2 = -\frac{y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2y_1V_c^2}{g}}$$

$$= -\frac{0.45}{2} + \sqrt{\frac{(0.45)^2}{4} + \frac{2(0.45)(2.16)^2}{9.81}}$$

$$= -\frac{0.45}{2} + 0.69$$

$$= -0.225 + 0.69$$

$y_2 = 0.466m$

Difference in depth

$$\Delta y = y_2 - y_1$$

$$= 0.466 - 0.45 \quad = 0.016m$$

Now

$$\Delta E = E_1 - E_2$$

As we know

$$Q_1 = Q_2$$

$$A_1 V_1 = A_2 V_2$$

$$b_1 y_1 V_1 = b_2 y_2 V_2$$

$$b\, y_1 V_1 = b\, y_2 V_2 \qquad \therefore b = b_1 = b_2$$

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

Put values

$$V_2 = \frac{0.45(2314.9)}{0.466}$$

$$V_2 = 2235.4 \, m/sec.$$

$$\Delta E = E_1 - E_2$$

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

$$= \left(0.45 + \frac{(2314.9)^2}{2(9.81)}\right) - \left(0.466 + \frac{(2235.4)^2}{2(9.81)}\right)$$

$$= (0.45 + 273127.52) - (0.466 + 254689.76)$$

$$= 273127.97 - 254690.226$$

$$= 18437.74m.$$

Power Dissipation

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

$= (1000)(9.81)(7.813)(18437.74)$

$= 1413170354 \, W$

$= 1413170.354 \, KW$

Q1 (B)

Given Data:-

Channel width (b) = 4m

Discharge = 7813 ft^3/sec

Height of upstream side = 2.9 m

Height of downstream side = 1.1m.

Required:-

Downstream velocity = ?

Type of flow at upstream & downstream side.

Sol:-

Specific energy is

$$E_1 = E_2$$

$$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g} \longrightarrow eq\ 1$$

Also

$$Q = AV$$

$$A_1 V_1 = A_2 V_2$$

$$(b_1 y_1) V_1 = (b_2 y_2) V_2 \qquad \therefore b = b_1 = b_2$$

$$b y_1 V_1 = b y_2 V_2$$

$$y_1 V_1 = y_2 V_2$$

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

$$V_2 = \frac{(2.9)\,V_1}{1.1} = 2.63 V_1 \rightarrow \text{eq a}$$

Put value of "V_2" in eq 1

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

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

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

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

$$5.91 V_1^2 = 1.8\,(2g)$$

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

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

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

Put value of V_1 in eq a.

$$V_2 = 2.63\,(2.44)$$

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

Type of flow on upstream side using Froud number

$$Fr_1 = \frac{V_1}{\sqrt{gy_1}}$$

Put values

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

As

$Fr < 1$ so sub-critical Flow

On Downstream side

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

As

$Fr > 1$ so super-critical flow.

Given Data:-

Discharge $= 7813 \, ft^3/sec = \frac{7813 \, ft^3}{(3.28m)^3} = 221.40 \, m^3/sec$

Depth of channel $= 1.8m$

Width of channel $= 66ft = 20.1m$.

Required:-

Height $= P = ?$

Sol:-

$Q = AV$

$V = Q/A$

$V = \frac{Q}{b \times y}$

Put values

$V = \frac{221.40}{20.1 \times 1.8}$

$V = 6.11 \, m/sec$

Critical Depth

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

$q = Q/b$

$= 221.40/20.1$

$q = 11.01 \, m^2/sec$

$y_c = \left(\frac{(11.01)^2}{9.81}\right)^{1/3} = 2.32m$.

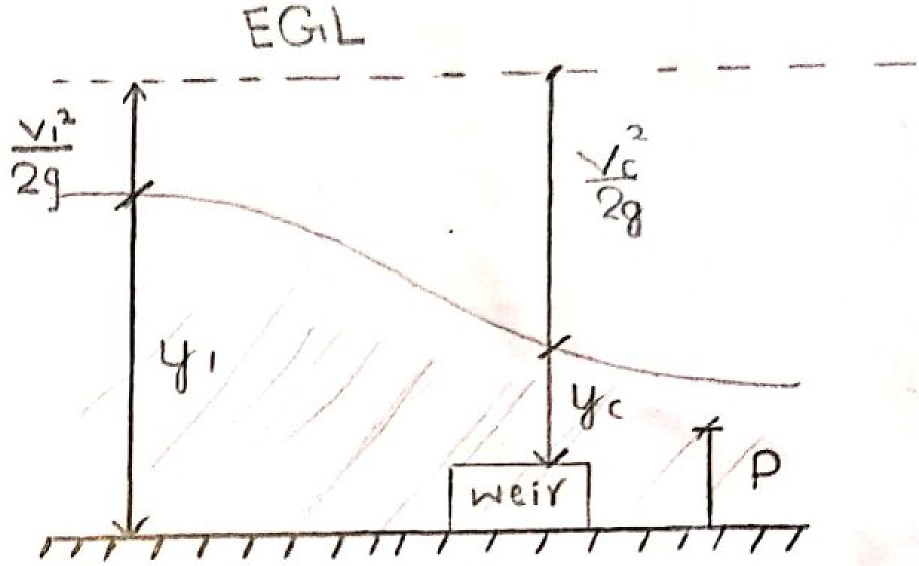
Now

$V = \sqrt{gy}$

$V_c = \sqrt{g y_c}$

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

$= 4.77 \, m/sec.$



From figure

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

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

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

$$P = 0.223 m.$$

Height of water is 0.223m measured from channel bed.

Q2(B)

Given Data:-

Depth = 1.5m

Breadth = 2.8m

Water level on one side = H_1 = 5m

Water level on other side = H_2 = 5m + 1.5 = 7m.

H = 5 + 0.6

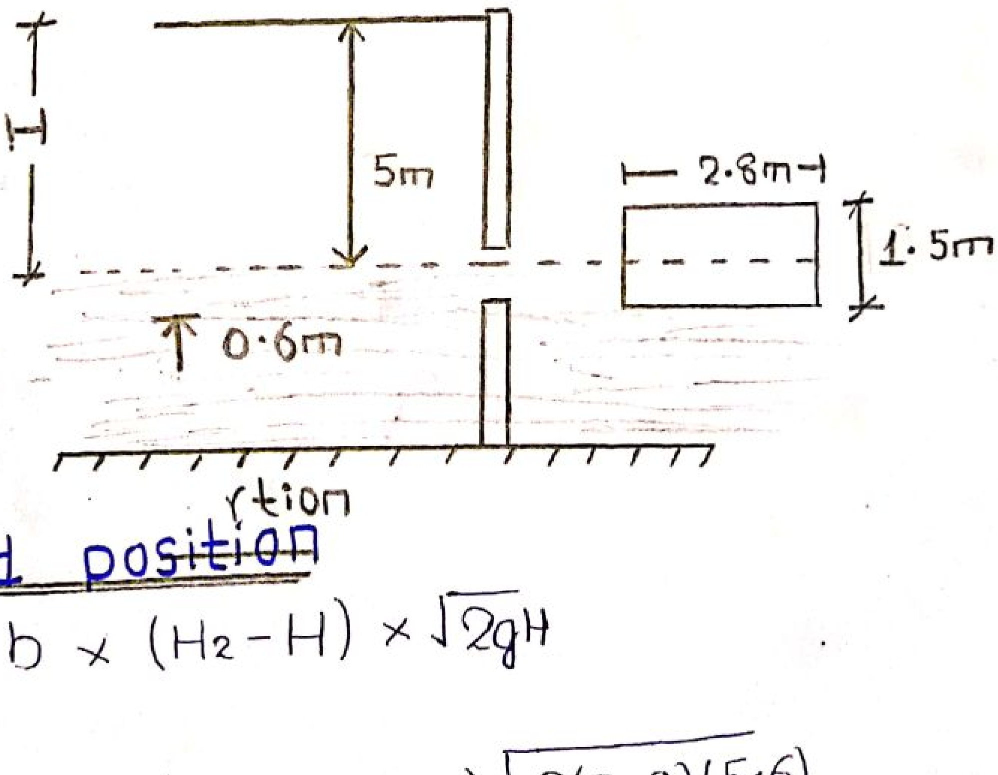
= 5.6m

Cd = 0.7813

Required:-

Discharge = Q = ?

Sol:-



Submerged position

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

Put values

$$Q_1 = 0.7813(2.8)(6.5-5.6)\sqrt{2(9.8)(5.6)}$$

$$Q_1 = 20.62 \, m^3/sec.$$

Free portion:-

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

$$Q_2 = \frac{2}{3}(0.7813) \times 2.8\sqrt{2(9.8)}\,[(15.6)^{3/2} - (5)^{3/2}]$$

$$Q_2 = 13.37 \, m^3/sec.$$

Total discharge

$$Q = Q_1 + Q_2$$

$$= 20.62 + 13.37$$

$$= 33.99 \, m^3/sec.$$

Q3 (a)

Given Data

1st diameter $= d_1 = R - 200mm$

$= 7813 - 200$

$= 7613mm$

2nd diameter $= d_2 = R + 3000mm.$

$= 7813 + 3000$

$= 10813mm.$

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

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

$= 7813 + 800$

$= 8613 N/m^2.$

Required:-

Loss of head due to sudden enlargment = ?

Power lost due to sudden enlargment = ?

Pressure in smaller pipe = ?

Sol:-

Loss due to sudden enlargment

$d_1 = 7613mm = 7.613m$

$$A_1 = \frac{\pi}{4}(7.613)^2 = 45.4m^2.$$

$d_2 = 10813mm = 10.813m$

$$A_2 = \frac{\pi}{4}(10.813)^2 = 91.7m^2.$$

As

$$Q = AV$$

$$V = Q/A$$

$$V_1 = Q/A_1$$

$$V_1 = \frac{0.95}{45.4}$$

$$V_1 = 0.020 \text{ m/sec.}$$

Similarly

$$V_2 = Q/A_2$$

$$V_2 = \frac{0.95}{91.7}$$

$$V_2 = 0.01 \text{ m/sec.}$$

Using formula of sudden enlargment.

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

Put values.

$$h_e = \left(1 - \frac{45.4}{91.7}\right)^2 \times \frac{(0.020 - 0.01)^2}{2(9.81)}$$

$$h_e = 0.254 \frac{(0.0001)}{19.62}$$

$$h_e = 1.29 \times 10^{-6} \text{m}$$

2) Power lost due to sudden enlargment

$P = \rho g Q h_e$

$P = (1000)(9.81)(0.95)(1.29\times10^{-6})$

$P = 0.012W.$

Pressure in smaller pipe:-

Using Bernoulli's equation.

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

$$\frac{P_1}{(1000)(9.81)} + \frac{(0.020)^2}{2(9.81)} = \frac{8613}{(1000)(9.81)} + \frac{(0.01)^2}{2(9.81)} + 1.29\times10^{-6}$$

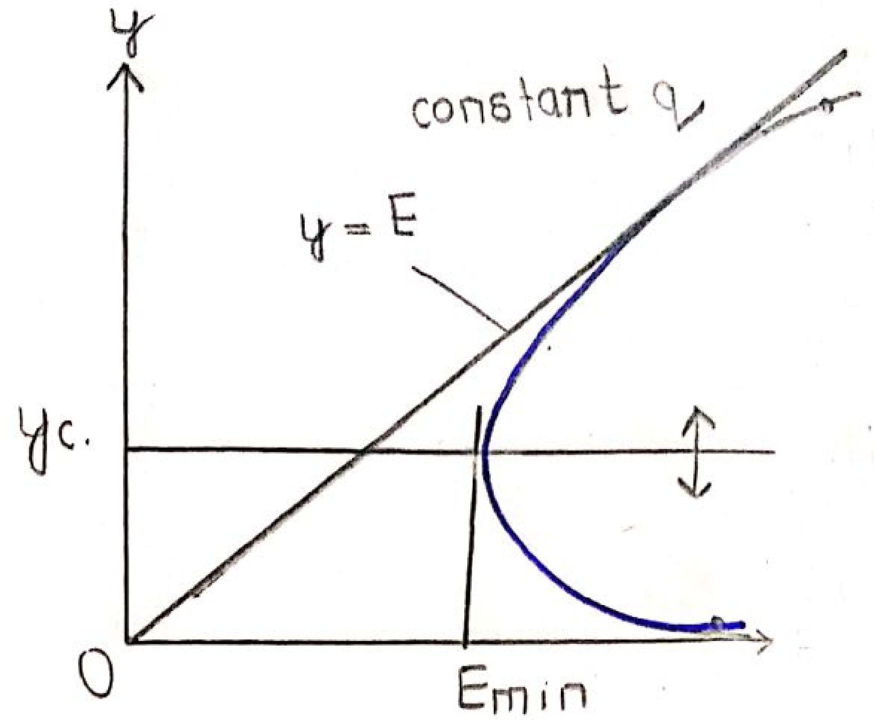
$$\frac{P_1}{9810} + 0.0000203 = 0.877 + 0.000005 + 1.29\times10^{-6}.$$

$$\frac{P_1}{9810} = 0.877 + 0.0000005 + 1.29\times10^{-6} - 0.0000203$$

$$\frac{P_1}{9810} = 0.876$$

$P_1 = (0.876)9810$

$P_1 = 8593.56\ N/m^2$



Curve:-

The blue curve is a 3-degree polynomial curve which indicates whether the flow is critical, Sub-critical or super-critical flow.
The middle point shows depth of water is equal to critical depth corresponding to maximum energy, so flow is critical flow ($y = y_c$, $E = E_{min}$)
The top point of the curve where y (depth of water) is greater than critical depth so flow is sub-critical flow.

$$y > y_c \qquad E > E_{min}$$

E = Specific energy

E_{min} = Minimum Specific energy

The last point of curve shows that depth of water is less than critical depth so flow is super-critical flow

$y < y_c$, $E < E_{min}$.

Specific energy:-

Specific energy is a parameter that can be used to clarify meaning of critical, sub-critical and super-critical flow in a open channel.

The graph shows relation b/w depth of water and critical depth.

Critical depth is that depth at which maximum specific energy.

Specific Energy Equation:-

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

We can plot curve from above equation.

E = Specific energy

y = depth of water.

q = Discharge per unit width.