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Subject :- Hydraulic Engineering

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Qno 1 (A) ①

Given Data:-

Discharge = 7817 Lit/sec

$Q = \frac{7817}{1000} = 7.817\ m^3/sec$

width of apron = 8m

Mean velocity = $7817 - 220 = 7597$ ft/sec

$V_1 = \frac{7597}{3.28} = 2316.15\ m/sec$

Solution:-

Height of hydraulic Jump:-

As "q" is discharge per unit width

$q = Q/b = \frac{7.817}{8} = 0.977\ m^2/sec$

As critical depth (y_c) is

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{(0.977)^2}{9.81}\right)^{1/3}$$

$y_c = 0.45m$

Critical velocity

$q = vy \Rightarrow v = q/y$

$$v_c = \frac{q}{y_c} = \frac{0.977}{0.45}$$

$V_c = 2.171\ m/sec$

Scanned with CamScanner

As $V_1 > V_c$

Super critical flow

water depth on upstream side is (hydraulic Jump)

$$Q = AV$$

$$Q = b y . V$$

$$y = \frac{Q}{b.V} = y_1 = \frac{Q}{V_1 . b}$$

$$y_1 = \frac{7.817}{2.17 \times 8} = 0.45$$

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

$$= \frac{-0.45}{2} + \sqrt{\frac{(0.45)^2}{4} + \frac{2(0.45)(2.17)^2}{9.81}}$$

$$= -0.225 + \sqrt{0.050 + 0.432}$$

$$= -0.225 + 0.694$$

$$y_2 = 0.469 m$$

Difference in depth

$$\Delta y = y_2 - y_1$$

$$0.46 - 0.45 = 0.01 m$$

$$\Delta E = E_1 - E_2$$

$$Q_1 = Q_2$$

$$A_1 V_1 = A_2 V_2$$

$$\cancel{b} y_1 V_1 = \cancel{b} y_2 V_2$$

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

$$V_2 = \frac{0.\cancel{4}6 5 \times 2316.1}{0.46}$$

$V_2 = 2265.75$ m/sec

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

$$\left(0.45 + \frac{(2316.1)^2}{2 \times 9.81}\right) - \left(0.46 + \frac{(2265.75)^2}{2 \times 9.8}\right)$$

$\Delta E = 273411.215 - 261920.004$

$\Delta E = 1149.211$

Power Dissipation in hydraulic

$\Delta P = \rho g Q (\Delta E)$

$= 1000 \times 9.81 \times ((7.817)(1149.211))$

$\Delta P = 88126981.22$ kw

Q no 1 (b)

Given Data:-

Channel width (b) = 4m

Discharge = 7817 ft^3/sec

height upstream = 2.9m

height downstream = 1.1m

Solution:-

Downstream velocity :-

specific energy is

$$E_1 = E_2$$

$$y_1 + \left(\frac{v_1}{2g}\right)^2 = y_2 + \left(\frac{v_2}{2g}\right)^2 \quad —①$$

$$Q_1 = Q_2$$

$$A_1 V_1 = A_2 V_2$$

$$\cancel{b} \cdot y_1 v_1 = \cancel{b} y_2 v_2$$

$$v_2 = \frac{y_1 v_2}{y_2}$$

$$v_2 = \left(\frac{2.9}{1.1}\right) v_1 = v_2 = 2.63 v_1 \text{ put in eq ①}$$

$$2.9 + \left(\frac{v_1}{2g}\right)^2 = 1.1 + \frac{6.91 v_1^2}{2g}$$

$$\left(\frac{v_1}{2g}\right)^2 - \frac{6.91 v_1^2}{2g} = 1.1 - 2.9$$

$$\cancel{-}\frac{5.91 v_1^2}{2g} = \cancel{+}1.8$$

$$5.91(v_1)^2 = 1.8 \times 2(1.8)$$

$$v_1 = \sqrt{\frac{2.8 \times 2(9.8)}{5.91}}$$

$$v_1 = 2.44 \, m/sec$$

Put in eq

$$v_2 = 2.63(2.44)$$

$$v_2 = 6.41 \, m/sec$$

Type of flow by fraud number

1. on upstream side

$$Fr_1 = \frac{v_1}{\sqrt{gy_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = 0.45$$

$Fr < 1$ (sub critical flow)

1 downstream side

$$Fr_2 = \frac{v_2}{\sqrt{gy_1}} = \frac{6.41}{\sqrt{9.81 \times 1.1}}$$

$$= 1.95$$

Super critical flow.

Scanned with CamScanner

Qn 2 (A)

Given Data:-

Depth of channel = 1.8m

Discharge = 7817 ft^3/sec = $\frac{7817}{(3.28)^3}$

width of channel = 66 ft

$b = \frac{66ft}{3.28} = 20.1m$

$Q = 221.52 m^3$

P = weir height = ?

Solution:-

$Q = AV$

$V = Q/A = V_1 = \frac{Q}{A} = V_1 = \frac{Q}{b \times y}$

$V_1 = \frac{22152}{20.1 \times 1.8} = 6.12$ m/sec

⟹ Critical Depth

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

As

$q = Q/b$

$q = \frac{221.52}{20.1} = 11.02$ m^2/sec

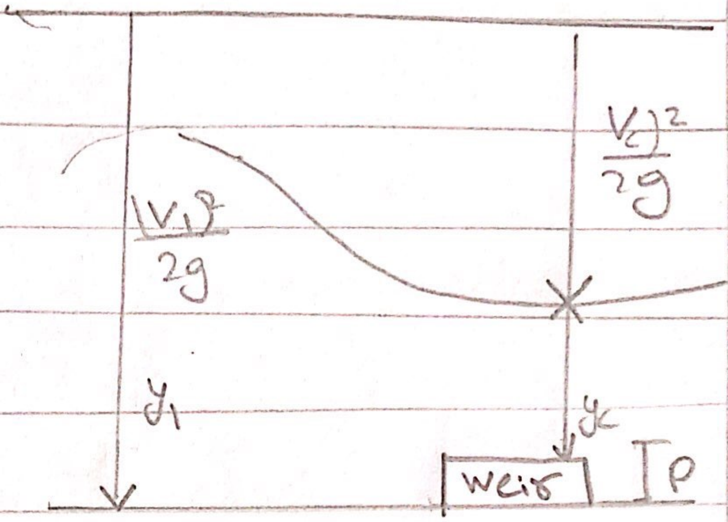
$y_c = \left(\frac{(11.02)^2}{9.81}\right)^{1/3} = 2.3m$

$y_c = 2.32m$

As $V_c = \sqrt{g y_c}$

$= \sqrt{9.81 \times 2.32}$

$V_c = 4.77$ m/sec



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

$$1.8 + \frac{(6.12)^2}{2 \times 9.81} = \frac{(4.77)^2}{2 \times 9.81} + 2.32 + P$$

$$3.708 = 3.479 + P$$

$$P = 0.229\,m$$

The weir should have height of 0.229m measure from the channel bed.

Qn 2(b)

Given Data:-

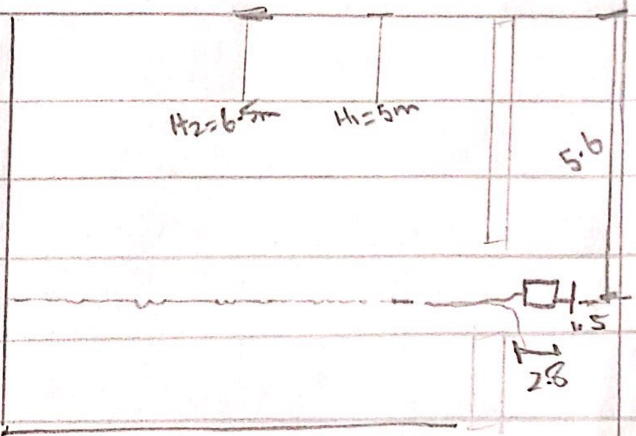
Width = 2.8m

depth = 1.5m

$H_1 = 5m$, $H_2 = 6.5m$

$H = 5.6$

$Cd = 0.7817$



Solution:-

Sub merged portion

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

$= 0.78 \times 2.8 \times (6.5 - 5.6) \sqrt{(2)(9.8)(5.6)}$

$= 20.60$

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

= [illegible]

$= \frac{2}{3}(0.78) \times 2.8 \sqrt{2 \times 9.8} \times [(5.6)^{3/2} - (5)^{3/2}]$

$Q_2 = 0.52 \times 12.40 \times 2.071$

$Q_2 = 13.35$

Total $= Q_1 + Q_2$

$20.6 + 13.35$

$Q = 33.97 \, m^3/sec$

Qno 3 (A)

Given Data:-

$d_1 = R - 200mm = 7817 - 200 = 7617mm$

$d_2 = R + 3000 = 7817 + 3000 = 10817mm$

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

Pressure in large pipe $(P_2) = 7817 + 800 = 8617\ N/m^2$

Solution:-

The loss of head due to sudden enlargment

$d_1 = \frac{7617}{1000} = 7.61m$

$A_1 = \frac{\pi}{4}(7.61)^2 = 45.48m^2$

$d_2 = \frac{10817}{1000} = 10.817$

$A_2 = \frac{\pi}{4}(10.817)^2 = 91.89$

By discharge Formula

$Q = AV$

$V = Q/A$

$V_1 = Q/A_1 = \frac{0.95}{45.4} = 0.02m/sec$

Similarly:- $V_2 = Q/A_2$

$= \frac{0.95}{91.8} = 0.010\ m/sec$

By Formula of sudden enlargment

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

$$= \left(1 - \frac{45.4}{91.8}\right)^2 \times \frac{(0.02 - 0.010)^2}{2 \times 9.81}$$

$$= (0.255)(5.096 \times 10^{-6})$$

$$h_e = 1.302 \times 10^{-6} m$$

2 Power loss Due to sudden Enlargment

By Formula, $P = \rho g Q h_e$

$$= (1000)(9.81)(0.95)(1.302 \times 10^{-6})$$

$$P = 0.012 kW$$

3- Pressure in smaller Pipe:-

By using Bernoulis Equation

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

$$\frac{P_1}{(1000)(9.81)} + \frac{(0.02)^2}{2(9.81)} = \frac{P_2}{(1000)(9.81)} + \frac{(0.01)^2}{2(9.81)} + 1.302 \times 10^{-6}$$

$$\frac{P_1}{9810} + 0.0000203 = \frac{8605}{9810} + 0.00000509 + 0.0000013 12$$

$$\frac{P_1}{9810} = 0.877 + 0.00000509 + 0.00001302 - 0.0000203$$

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

$$P_1 = 0.876 \times 9810$$

$$P_1 = 8593.56\ N/m^2$$

Q no 3 (B)

Ans:-

The blue curve indicates the speific energy curves. It is the energy with refrence to the bed of the channel

Mathematically:-

$$E = y + V_2/2g$$

The bed of the channel is considered as datum line.

For corresponding to minimum specific energy For point "C) There will be only one depth "yc" and this yc is called as "Critical Depth"

It is observed from E-Y diagram drawn for a constant Flow/discharge for any value of "E". There would be two possible depth, called "Y_1" and "Y_2" Known as alternate depth.

Critical, Subcritical and super critical are classified with "Fraud Number":

Denoted by:- Fr

$$Fr = \frac{V}{\sqrt{gh}}$$

v = average velocity of flow

h = depth of flow

g = acceleration due to gravity

If,

$Fr < 1 \rightarrow$ Sub-critical flow

$Fr > 1 \rightarrow$ Super Critical flow

$Fr = 1 \rightarrow$ Critical flow