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Section :- A

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Subject :- Hydraulic Engineering

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MID - TERM EXAMINATION

CIVIL ENGINEERING DEPARTMENT

# QUESTION - 01

## ( PART-A )

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

Calculate :-

1 - Height of Hydraulic Jump (in Meters)

2 - Power absorbed due to Hydraulic Jump (in KW).

## GIVEN:-

Discharge (Q) = 7805 Lit/sec

$= \frac{7805}{1000} = 7.805 \ m^3/sec$

Breadth (b) = 8m

Mean velocity (V) = 7805 - 220

= 7585 ft/sec

$= \frac{7585}{3.28} = 2312.5 \ m/sec$

## 1- HEIGHT OF HYDRAULIC JUMP:-

As we know that "q" → discharge per unit breadth.

$q = \frac{Q}{b}$

$= \frac{7.805}{8} \Rightarrow \boxed{q = 0.975 m^2/sec}$

⇒ Critical Depth :-

By Formula

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

$\boxed{y_c = 0.45m}$

## ⇒ CRITICAL VELOCITY:-

As we know that,

$q = vy$

$v = q/y \Rightarrow v_c = q/y_c$

$$v_c = \frac{0.975}{0.45} \Rightarrow \boxed{v_c = 2.16 \text{ m/sec}}$$

## DEPTH OF WATER ON UPSTREAM SIDE:-
(OF Hydraulic Jump)

By Discharge Formula,

$Q = AV$

$\Rightarrow Q = (b \times y) \cdot v$

$$\Rightarrow y = \frac{Q}{v_c \cdot b} \Rightarrow y_1 = \frac{Q}{v_c \cdot b}$$

$$y_1 = \frac{7.805}{2.16 \times 8} \Rightarrow \boxed{y_1 = 0.45 \text{m}}$$

By Formula,

Water Depth on Downstream Side is,

$$y_2 = \frac{-y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2 y_1 v_1^2}{g}}$$

$$y_2 = \frac{-0.45}{2} + \sqrt{\frac{(0.45)^2}{4} + \frac{2(0.45)(2.16)^2}{9.81}}$$

$$\boxed{y_2 = 0.46 \text{m}}$$

## DIFFERENCE IN DEPTHS:-

$\Delta y = y_2 - y_1$

$= 0.46 - 0.45$

$$\boxed{\Delta y = 0.01 \text{m}}$$

Also by Formula,

$$Q_1 = Q_2$$

$$A_1 V_1 = A_2 V_2$$

$$(b_1 \cdot y_1) \cdot v_1 = (b_2 \cdot y_2) \cdot v_2$$

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

$$y_1 v_1 = y_2 v_2$$

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

$$= \frac{0.45 \times 2312.5}{0.46}$$

$$\Rightarrow \quad \boxed{v_2 = 2262.22 \text{ m/sec}}$$

Now, $\Delta E = E_1 - E_2$

So it becomes,

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

$$= \left(0.45 + \frac{(2312.5)^2}{2(9.81)}\right) - \left(0.46 + \frac{(2262.22)^2}{2(9.81)}\right)$$

$$= 272561.93 - 260838.34$$

$$\boxed{E_1 - E_2 = 11723.59 \text{ m}}$$

## Power Dissipation In Hydraulic Jump:-

By using Formula

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

$$= (1000)(9.81)(7.805)(11723.59)$$

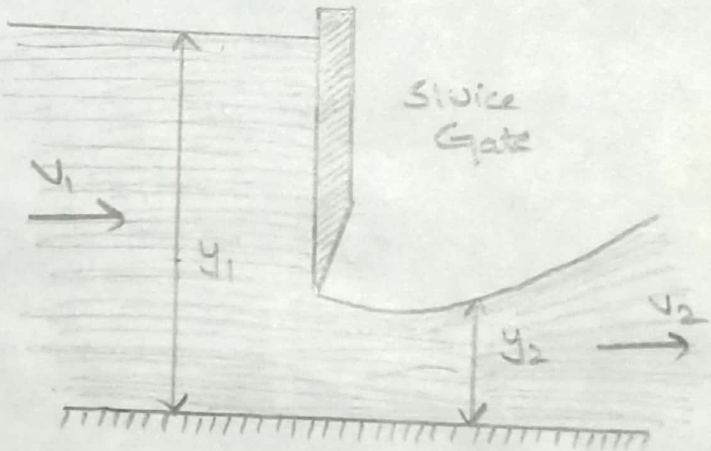
$$\Delta P = 897640701.7 \text{ W}$$

$$\boxed{\Delta P = 897640.7017 \text{ KW}}$$

# ( PART-B )

A Sluice gate controls the flow in a channel of width 4m. If the discharge 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.




## GIVEN DATA:-

Channel Width (b) = 4m

Discharge = 7805 $ft^3/sec$

$$= \frac{7805}{(3.28\,m)^3}$$

$$= 221.18\ m^3/sec$$

Depth on Upstream Side = 2.9m

Depth on Downstream Side = 1.1m

Sol:-

First we have to find downstream velocity

## 1- DOWNSTREAM VELOCITY:-

As from Specific Energy Equation,

Specific Enerergy remains same on both streams

So,

$$E_1 = E_2$$

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

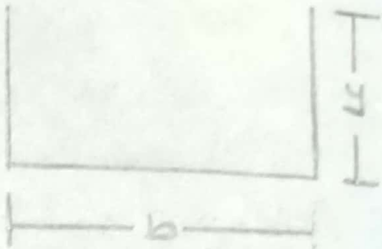
=> Also from Discharge Equation

$$Q = AV$$

$\Rightarrow$ $Q = A_1 V_1 = A_2 V_2$

$(b_1 y_1) \cdot V_1 = (b_2 y_2) \cdot V_2$

As $b = b_1 = b_2$, So




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

$y_1 V_1 = y_2 V_2$

$\Rightarrow$ $V_2 = \dfrac{y_1 V_1}{y_2}$

$V_2 = \dfrac{2.9}{1.1} V_1$ $\Rightarrow$ $\boxed{V_2 = 2.63\, V_1}$

$\Rightarrow$ Now put the '$V_2$' equation in eq ①,

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

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

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

$$\frac{V_1^2}{2(9.81)} - \frac{6.91\, V_1^2}{2(9.81)} = 1.1 - 2.9$$

$$\cancel{-}\frac{5.91\, V_1^2}{19.62} = \cancel{-}1.8$$

$$5.91\, V_1^2 = 1.8$$

$$V_1 = \sqrt{\frac{1.8 \times 19.62}{5.91}}$$

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

Put this value in "$V_2$" equation

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

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

## 2- TYPE OF FLOW DETERMINATION:-

### - ON UPSTREAM SIDE:-

By using Frood Number,

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

$0.45 < 1$

↓

Sub-Critical Flow

$(Fr < 1)$

### - ON DOWNSTREAM SIDE:-

Using Frood Number,

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

$1.95 > 1$

↓

Super-Critical Flow

$(Fr > 1)$

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## (QUESTION-02)

## (PART-A)

What is the minimum height (In meters) of broad Crested weir if 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 $ft^3/sec$ and the channel width is 66 ft.

## GIVEN DATA:-

Channel Depth $(d) = 1.8m$

Discharge $= 7805 \ ft^3/sec$

$= \frac{7805}{(3.28\ m)^3} = 221.18\ m^3/sec$

Width of channel $(b) = 66\ ft$

$= 66/3.28 = 20.1m$

Weir Height $(P) = ?$

Sol:-

By using Discharge Formula,

$Q = AV$

$V = Q/A \Rightarrow V_1 = Q/A \Rightarrow V_1 = Q/b \times y$

$V_1 = \frac{221.18}{20.1 \times 1.8} = \boxed{6.11\ m/sec}$

## CRITICAL DEPTH:-

By Formula,

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

where $q = Q/b$

$= \frac{221.18}{20.1} = 11.1\ m^2/sec$

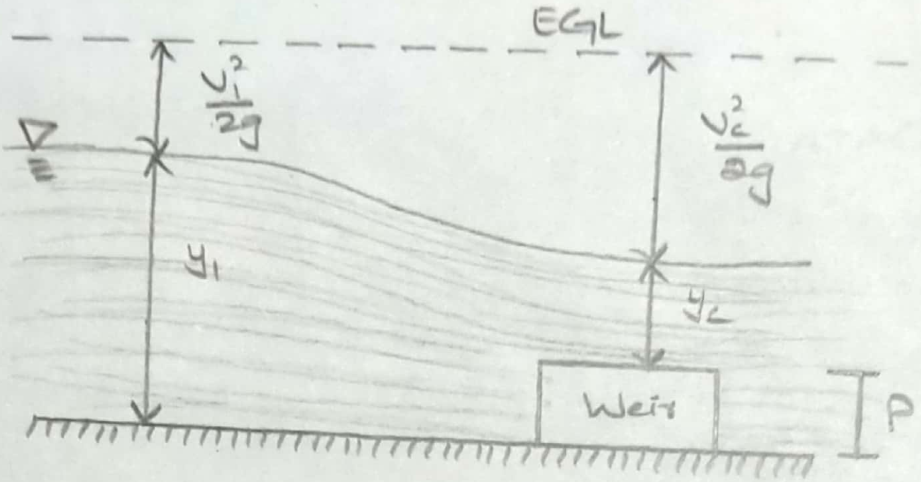
So, $y_c = \left(\frac{(11.1)^2}{9.81}\right)^{1/3}$

$\boxed{y_c = 2.32m}$

Also $V = \sqrt{gy}$

$V_c = \sqrt{g y_c}$

$V_c = \sqrt{9.81 \times 2.32} \Rightarrow \boxed{V_c = 4.77\ m/sec}$




According to the figure,

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

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

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

$$3.702 = 3.479 + P$$

$$\boxed{P = 0.223\,m}$$

So the weir should have height of 0.223 m measured from the channel bed.

## ( PART - B )

An orifice in one side of Large tank is rectangular in shape 2.8 m broad and 1.5 m deep. The water level on one side of the orifice is 5 m above its top edge. The water level on the other side of the orifice is 0.6 m below its top edge. Calculate the discharge through the orifice if co-efficient of discharge is $C_d$ = 0.R

## GIVEN DATA:-

Breadth (b) = 2.8m

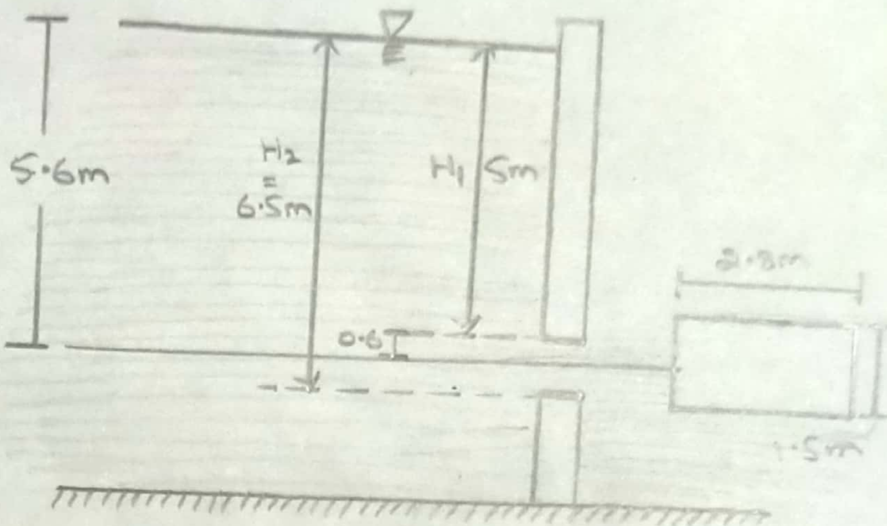
Depth (d) = 1.5m

$H_1 = 5m$

$H_2 = 5m + 1.5m = 6.5m$

$H = 5m + 0.6m = 5.6m$

$Cd = 0.78$




Sol:-

## 1- DISCHARGE THROUGH SUB-MERGED PORTION:-

By using formula

$$Q_1 = Cd \times b \times (H_2 - H_1) \times \sqrt{2gH}$$

$$= 0.78 \times 2.8\,(6.5 - 5.6) \times \sqrt{2(9.81)(5.6)}$$

$$= 20.60\ m^3/sec$$

$$\boxed{Q_1 = 20.60\ m^3/sec}$$

## 2- DISCHARGE THROUGH FREE PORTION:-

By using formula

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

$$= \frac{2}{3}(0.78) \times (2.8)\sqrt{2 \times 9.81} \times \left[(5.6)^{3/2} - (5)^{3/2}\right]$$

$$Q = 13.36\ m^3/sec$$

$$\boxed{Q_2 = 13.36\ m^3/sec}$$

Now Total Discharge will be,

$$Q = Q_1 + Q_2$$
$$= 20.60 + 13.36 \Rightarrow \boxed{Q = 33.96\ m^3/sec}$$

# QUESTION-03

## (PART-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 Smaller pipe (if Pipe is horizontal)

## GIVEN DATA:-

$d_1$ = R-200 mm
= 7805 - 200 = 7605 mm

$d_2$ = R+3000 mm
= 7805 + 3000 = 10805 mm

Flowrate (Q) = 0.95 $m^3/sec$

Pressure in Larger pipe = R+800 $N/m^2$
= 7805 + 800
= 8605 $N/m^2$

Sol:-

## 1- HEAD LOSS DUE TO SUDDEN ENLARGEMENT:-

$d_1$ = 7605 mm = 7.60 m

$\Rightarrow A_1 = \frac{\pi}{4}(d_1)^2 = \frac{\pi}{4}(7.60)^2$

$$\boxed{A_1 = 45.3\ m^2}$$

$d_2 = 10805\ mm$

$\Rightarrow A_2 = \frac{\pi}{4}(d_2)^2 = \frac{\pi}{4}\left(\frac{10805}{1000}\right)^2$

$A_2 = 91.6\ m^2$

By Discharge formula,

$Q = AV$

$V = Q/A$

$\Rightarrow V_1 = Q/A_1 = \frac{0.95}{45.3} = 0.020\ m/sec$

Similarly

$\Rightarrow V_2 = Q/A_2$

$= \frac{0.95}{91.6} = 0.010\ m/sec$

$\Rightarrow$ By Formula of Sudden Enlargement:-

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

$= \left(1 - \frac{45.3}{91.6}\right)^2 \times \frac{(0.020 - 0.010)^2}{2(9.81)}$

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

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

## 2- Power Loss Due To Sudden Enlargement

By formula

$P = \rho g Q h_e$

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

$P = 0.012\ W$

## 3- Pressure In Smaller Pipe:-

By using Bernoulli's Equation,

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + h_e$$

$$\frac{P_1}{(1000)(9.81)} + \frac{(0.020)^2}{2(9.81)} = \frac{P_2}{(1000)(9.81)} + \frac{(0.010)^2}{2(9.81)} + 1.302 \times 10^{-6}$$

$$\frac{P_1}{9810} + 0.0000203 = \frac{8605}{9810} + 0.00000509 + 0.000001302$$

$$\frac{P_1}{9810} = 0.877 + 0.00000509 + 0.000001302 - 0.0000203$$

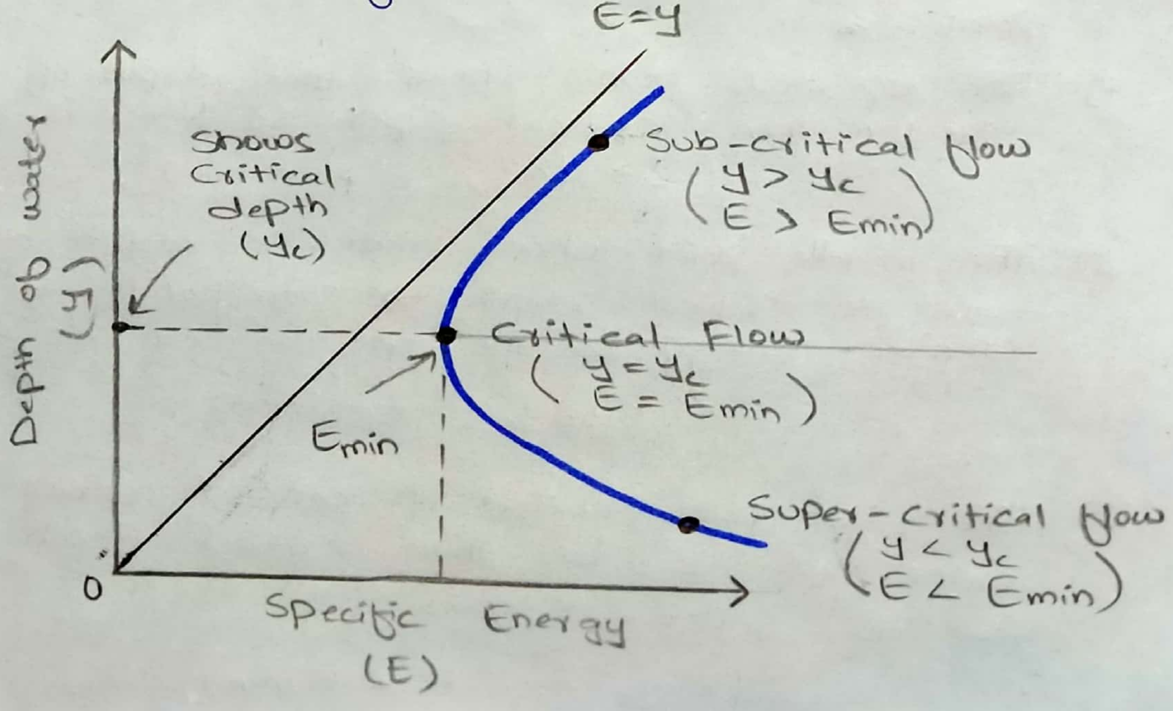
$$\frac{P_1}{9810} = 0.876$$

$$\Rightarrow \quad P_1 = 0.876 \times 9810$$

$$\boxed{P_1 = 8593.56 \ N/m^2}$$

## (PART-B)

First we define Specific Energy as
" Specific energy is a parameter that can be used to clarify the meaning of Super critical, sub-critical and critical flow in an open channel."



=> The above graph consists of two axes.
( Specific Energy → drawn at x-axis )
Depth of water → drawn at Y-axis

=> From the derivation of specific Energy equation, a three degree polyonomial equation is obtained. from the help of this equation

$$(E-y)y^2 = \frac{q^2}{2g} \quad \text{——} (1)$$

we plot a curve of specific Energy

=> In the above eq (1),
E → specific Energy
y → depth of water
q → Discharge per unit breadth

=> The above graph indicates the relation between depth of water (y) and critical depth ($y_c$)

"(Critical depth is the depth of water at which minimum specific energy is obtained)."

=> Black Solid line in the graph shows the direct relation of specific Energy to water depth.

=> The Blue 3-degree polynomial curve consists of 3 Points,

i) The top most point shows that depth of water is greater than critical depth so flow is sub-critical.
$(y > y_c, \ E > E_{min})$,

ii) The middle point shows that the depth of water is equal to critical depth → corresponds to minimum specific Energy so the flow is critical flow.
$(y = y_c, \ E = E_{min})$

iii) The last point (located in bottom) shows that the water depth is less than critical depth so flow is super-critical flow.
$(y < y_c, \ E < E_{min})$