Mid-Term Online Exam

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Semester :- 6th

Section :- A

Subject :- Hydraulic Engineering

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Question = 01

(Part – A) :- Let suppose a rectangular channel Discharges R lit/sec of water into a 8 m wide opran with zero slop. Mean velocity is R-220 ft/sec

Calculate :- ① Height of hydraulic jump (in meter)

② Power absorbed due to hydraulic jump (kw)

$R = 7800$

Given Data :-

* Discharge $Q = 7800$ Lit/sec

$= \frac{7800}{1000} = 7.8\ m^3/sec$

* Wide $= b = 8m$

* Mean velocity $= V = 7800 - 220 = 7580$ ft/sec

$V = \frac{7580}{3.28} = 2310.9\ m^3/sec$

1) Height of Hydraulic Jump :-

As we know that "q" discharge per unit wide.

Now $q = \frac{Q}{b} = \frac{7.8}{8}$

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

⇒ Critical Depth :- By Formula

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

$y_c = 0.45 \, m$

Critical velocity :- As we know that

$$q = Vy \Rightarrow V = q/y = V_c = q/y_c$$

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

Depth of water on upstream side of Hydraulic jump.

By using Discharge formula

$$Q = AV \Rightarrow Q = (b \times y) V$$

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

$$y_1 = \frac{7.8}{(2.16)(8)} \Rightarrow y_1 = 0.45 m$$

Depth of water on down stream side.

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

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

$y_2 = 0.4668 \, m$

Difference in Depth :-

$$\Delta y = y_2 - y_1$$

$$\Delta y = 0.4668 - 0.45$$

$$\boxed{\Delta y = 0.0168 m}$$

By Discharge Formula

$$Q_1 = Q_2$$

$$A_1 V_1 = A_2 V_2$$

$$b y_1 V_1 = b y_2 V_2$$

$$y_1 V_1 = y_2 V_2$$

$$V_2 = \frac{y_1 V_1}{y_2} = \frac{(0.45)(2310.9)}{0.4668}$$

$$\boxed{V_2 = 2227.73 \text{ m/sec}}$$

Then, As we know that

$$\Delta E = E_1 - E_2$$

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

$$\Delta E = \left(0.45 + \frac{(2310.9)^2}{2(9.81)}\right) - \left(0.4668 + \frac{(2227.73)^2}{2(9.81)}\right)$$

$$\Delta E = 272184.89 - 252945.469$$

$$\boxed{\Delta E = 19239.89 m}$$

* Power Dissipation in Hydraulic Jump:-

By Formula

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

$\Delta P = (1000)(9.81)(7.8)(19238.89)$

$\Delta P = 1472197903 \ W$

$\boxed{\Delta P = 1472197.903 \ kW}$

Q1

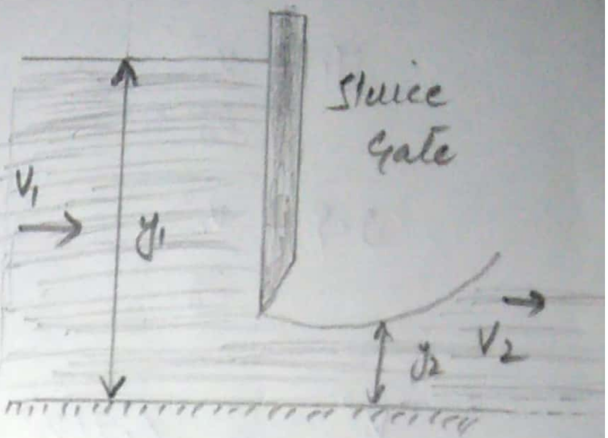
Part - B

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.

2) Also state the type of flow at upstream and downstream side using any equation.

Given Data :-



Channel width = b = 4m

Discharge = Q = 7800 ft^3/sec

$$Q = \frac{7800}{(3.28)^3}$$

$$Q = 221.04 \ m^3/sec$$

Depth on upstream side = 2.9m

Depth on Downstream side = 1.1m

Solution :- First we find downstream velocity

Downstream Velocity :-

As from specific energy equation, specific energy remain same on ~~each~~ both stream,

$$E_1 = E_2$$

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

From Discharge equation

$$Q = AV$$

$$A_1V_1 = A_2V_2 \Rightarrow by_1V_1 = by_2V_2$$

$$y_1V_1 = y_2V_2$$

$$V_2 = \frac{y_1V_1}{y_2} = \frac{2.9 \ V_1}{1.1}$$

$$\boxed{V_2 = 2.63 \ V_1}$$

Put the value of V_2 in eq Ⓐ

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

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

$$\frac{V_1^2}{2\times 9.81} - \frac{6.91 V_1^2}{2\times 9.81} = 1.1 - 2.9$$

$$\frac{V_1^2 - 6.91 V_1^2}{19.62} = -1.8$$

$$+5.91 V_1^2 = +(1.8)(19.62)$$

$$\sqrt{V_1^2} = \sqrt{\frac{(1.8)(19.62)}{5.91}}$$

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

Put V_1 value in this equation $V_2 = 2.63(V_1)$

$$V_2 = 2.63(2.44)$$

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

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⇒ Type of flow on upstream side :-

By Fraud Number

$$F_{r_1} = \frac{V}{\sqrt{g y_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = 0.45$$

$$0.45 < 1$$

The flow is Sub-Critical flow

⇒ On Downstream side :-

using Froud Number

$$F_{r_2} = \frac{V_2}{\sqrt{g y_2}} = \frac{6.41}{\sqrt{9.81 \times 1.01}} = 1.95$$

So $1.95 > 1$

Then the flow is super-critical flow.

Question = 02

PART - A

What is the minimum height (in meter) of broad crested weir. if is to function critical depth on the crest. If water flows along a rectangular channel at a depth of 1.8 m with a discharge of R ft³/sec and the channel width is 66 ft.

GIVEN DATA :-

★ channel Depth $= d = 1.8m$

★ Discharge $= Q = 7800\ ft^3/sec$

$$Q = \frac{7800}{(3.28)^3} = \boxed{221.04\ m^3/sec}$$

★ width of channel $= b = 66\ ft = \frac{66}{3.28} = 20.1m$

Required :-

weir Height $= P = ?$

Solution :-

By Discharge Formula

$$Q = AV$$

$$V_1 = Q/A = \frac{Q}{b \times y} = \frac{221.04}{20.1 \times 1.8}$$

$$\boxed{V_1 = 6.11\ m/sec}$$

Critical Depth :-

By Formula

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

$$q = Q/b = \frac{221.04}{20.1}$$

$$\boxed{q = 11\ m^2/sec}$$

then

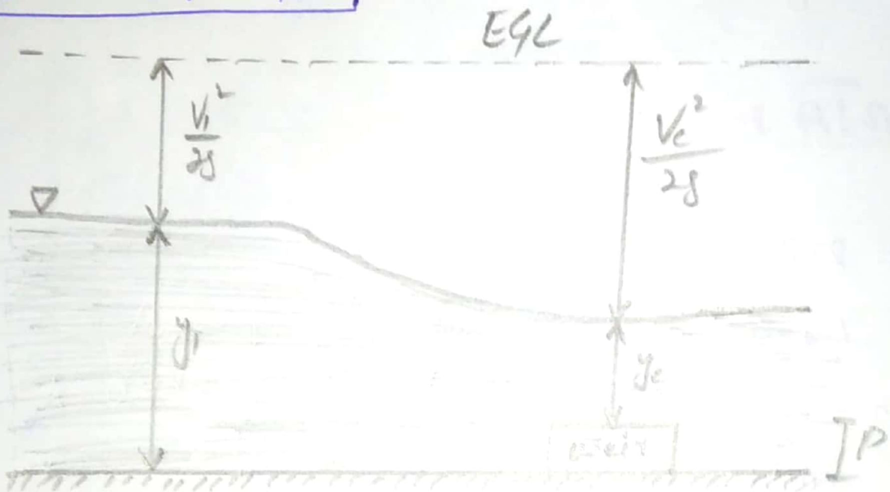
$$y_c = \left(\frac{(11)^2}{9.81}\right)^2$$

$$\boxed{y_c = 2.31\ m}$$

Also $V = \sqrt{gy}$

$$V_c = \sqrt{g y_c} = \sqrt{(9.81)(2.32)}$$

$$\boxed{V_c = 4.76\ m/sec}$$



According to the given figure,

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

$$\frac{(6.11)^2}{2\times 9.81} + 1.8 = \frac{(4.76)^2}{2(9.81)} + 2.31 + P$$

$$1.902 + 1.8 = 1.1548 + 2.31 + P$$

$$P = 3.702 - 3.465$$

$$\boxed{P = 0.237\ m}$$

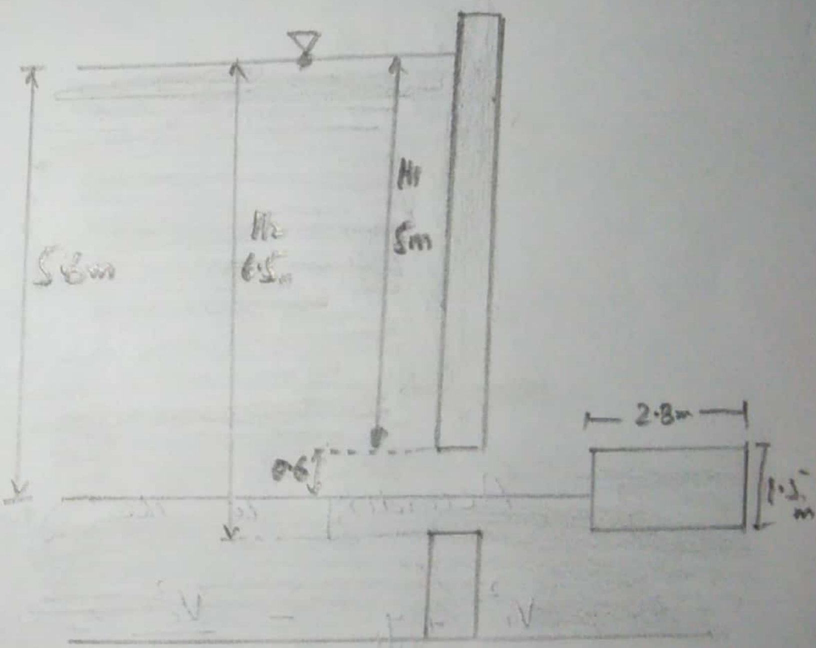
So the weir should have height of 0.237m measured from the channel bed.

Q=2

PART - 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 5m 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 the orifice if co-efficient of Discharge is Cd = 0.R

Given Data:-



Breath = $b = 2.8\,m$

Depth = $d = 1.5\,m$

$H_1 = 5\,m$

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

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

$Cd = 0.78$

Solution:-

Discharge Through Sub-merged Portion:-

By using Formula

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

$$Q_1 = 0.78 \times 2.8 \times (6.5 - 5.6) \times \sqrt{2(9.81)(5.6)}$$

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

⇒ Discharge Through Free Portion :-

By Formula

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

$$Q_2 = \frac{2}{3}(0.78) \times 2.8\sqrt{2\times 9.81} \times \left[(5.6)^{3/2} - (5)^{3/2}\right]$$

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

Now Total Discharge will be

$$Q = Q_1 + Q_2$$

$$Q = 20.60 + 13.36$$

$$\boxed{Q = 33.96 \ m^3/sec}$$

⟺

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 pipe is R + 800

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 (Pipe is horizontal)

Given Data :-

$d_1 = R - 200$

$d_1 = 7800 - 200$

$d_1 = 7600\,mm$

$d_2 = R + 3000$

$d_2 = 7800 + 3000$

$d_2 = 10800\,mm$

Discharge $= Q = 0.95\ m^3/sec$

Pressure in large pipe $= R + 800$

$= 7800 + 800$

$= 8600\ N/m^2$

Solution :-

Head loss Due to Sudden Enlargement

$d_1 = 7600\,mm = 7.6\,m$

$A_1 = \frac{\pi}{4} d^2 = \frac{\pi}{4}(7.6)^2$

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

$d_2 = 10800\,mm = 10.80\,m$

$A_2 = \frac{\pi}{4}(d_2)^2 = \frac{\pi}{4}(10.80)^2$

$\boxed{A_2 = 91.61\,m^2}$

By Discharge Formula

$Q = AV$

$V = Q/A$

$V_1 = Q/A_1$

$V_1 = \frac{0.95}{45.3}$

$\boxed{V_1 = 0.020\ m/sec}$

Similarly: $V_2 = Q/A_2$

$$V_2 = \frac{0.95}{91.61} \Rightarrow \boxed{V_2 = 0.0103 \text{ m/sec}}$$

Formula of Sudden Enlargement

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

$$h_e = \left(1 - \frac{45.3}{91.61}\right)^2 \times \left(\frac{(0.020 - 0.0103)^2}{2(9.81)}\right)$$

$$h_e = (0.255)(4.7956 \times 10^{-6})$$

$$\boxed{h_e = 1.223 \times 10^{-6} \text{ m}}$$

★ Power Loss Due To Sudden Enlargement

As we know that

$$P = \rho g Q h_e$$

$$P = (1000)(9.81)(0.95)(1.223 \times 10^{-6})$$

$$\boxed{P = 0.0114 \text{ W}}$$

★ Pressure in Smaller Pipe :-

Using Bernoulli's Equation

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

$$\frac{P_1}{(1000)(9.81)} + \frac{(0.020)^2}{2 \times 9.81} = \frac{P_2}{1000 \times 9.81} + \frac{(0.0103)^2}{2 \times 9.81} + 1.223 \times 10^{-6}$$

$$\frac{P_1}{9810} + 0.0000203 = \frac{8600}{9810} + 0.000005407 + 0.000001223$$

$$\frac{P_1}{9810} = 0.8766 - 0.0000203$$

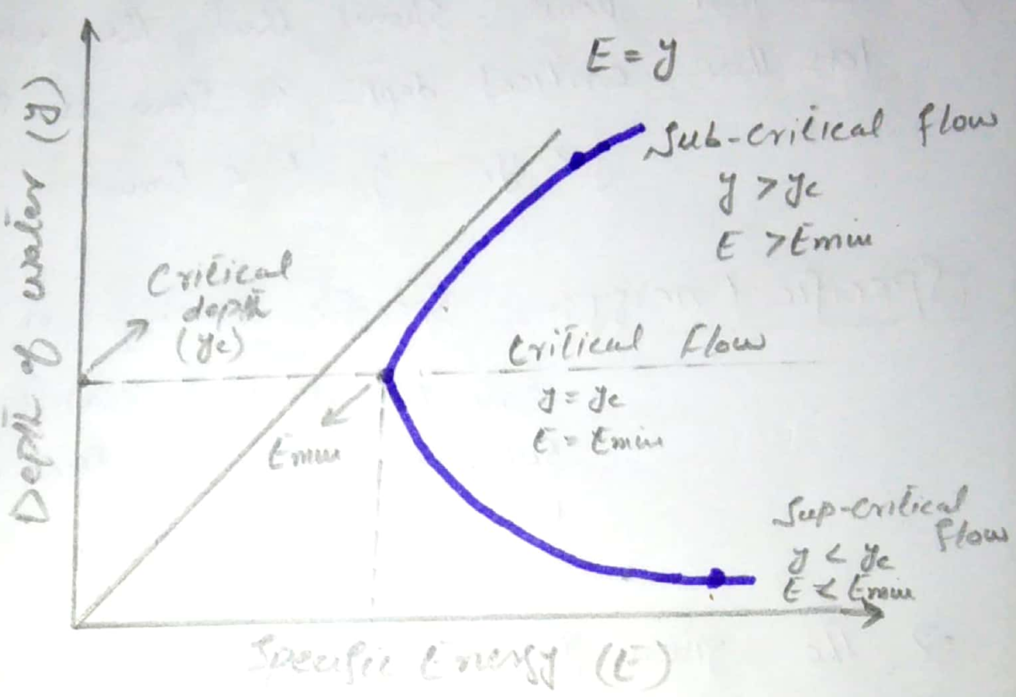
$$\frac{P_1}{9810} = 0.8766$$

$$P_1 = (0.8766)(9810)$$

$$\boxed{P_1 = 8599.86 \ N/m^2}$$

Q3 Part – B

What does This blue curve indicates. Explain the given Figure From each and every point of view.



★ Blue curve :-

From The given graph or figure The blue curve is The 3-degree Polynomial curve which show the flow is critical flow, Sub-critical flow and Super-critical flow.

⇛ The middle point show That the depth of water is equal to The critical depth corresponding to minimum energy so the flow is critical flow.

$y = y_c$ and $E = E_{min}$

⇒ The top point show that depth of water is greater then critical depth so the flow is sub-critical flow.

$y > y_c$ & $E > E_{min}$

⇒ The last point shows that the water depth is less then critical depth so flow is supercritical flow.

$y < y_c$ & $E < E_{min}$

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

⇒ The given graph indicate the relation between depth of water (y) and critical depth (y_c).

Critical depth :- "Critical depth is a depth of water at which minimum specific energy is obtained"

⇒ The given figure or graph consists of two axis.

1. x-axis → specfic energy
2. y-axis → Depth of water.

⇒ From the given figure, the center line where $E = y$ show that the specefic energy is directly ~~Po~~ proportional to specific energy.

$E \propto y$

Equation of specific energy :-

From the derivation of specific energy equation there is three degree polynomial equation is obtained. From the help of this equation

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

we can plot a curve of specific energy.

⇒ From the above equation (★)

E = Specific energy

y = depth of water

q = Discharge per unit width.
It is unit is m^2/sec.

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