MID TERM Online Exam

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Semester :- 6^{th}

Section :- A

Subject :- Hydraulic Engineering

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Question # 1

(Part - A) :- Let suppose a rectangular channel Discharge R Lit/sec of water into a 8m wide . . . . . ?

Calculate :-

1) Height of hydraulic Jump (in meter).

2) Power absorbed due to hydraulic Jump (Kw)

Given Data:-

$R = 7797$

Solution :-

Discharge $Q = 7797$ Lit/sec

$= 7797/1000 = 7.797$

wide $= b = 8m$

Mean velocity $= V = 7797 - 220 = 7577$ ft/sec

$V = 7577/3.28 = 2310.06\ m^3/sec$

1) Height of Hydraulic Jump:-

As we know that "q" discharge Per unit wide Now $q = Q/b = 7.79/8$

$q = 0.973\ m^2/sec$

⇒ Critical Depth By Formula

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

$$= \left(\left(\frac{0.973}{9.81}\right)^2 \right)^{1/3}$$

$y_c = 0.46m$

⇒ Critical velocity:-

we know that

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

$$V_c = \frac{0.973}{0.46}$$

$\Rightarrow 2.12 m/sec$

Depth of water on upstream side of Hydraulic Jump.

By using Discharge formula

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

$\Rightarrow y = Q/v.b \Rightarrow y_1 = Q/v_1 b$

$$\Rightarrow y_1 = \frac{7.79}{2310.06 \times 8}$$

$$\boxed{= 0.000422}$$

To Find water depth on down stream side by using this formula.

$$y^2 = -y_1/2 + \sqrt{y_1^2/4 + 2y_1 v_1^2/g}$$

Putting the values

$$y_2 = \frac{-0.000422}{2} + \sqrt{\frac{0.000422}{4} + \frac{2(0.000422)(2310.06)^2}{9.81}}$$

$y_2 = 21.42m$

Different In Depths.

$\Delta y = y_2 - y_1$

$\Delta y = 21.42 - 0.000422$

$\Delta y = 21.42m$

By Discharge Formula

$$Q_1 = Q_2$$

$$A_1V_1 = A_2V_2$$

$$by_1V_1 = by_2V_2$$

$$y_1V_1 = y_2V_2$$

$$V_2 = y_1V_1/y_2 \Rightarrow \frac{(0.000422)(2310.06)}{21.42}$$

$$= 0.045 \, m/sec$$

we know that

$$\Delta E = E_1 - E_2$$

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

$$E_1 - E_2 = \left[0.000422 + \frac{(2310.6)^2}{2(9.81)}\right] - \left[21.42 + \frac{(0.045)^2}{2(9.81}\right]$$

$$E_1 - E_2 = 271965.18 \, m$$

★ Power Dissipation In Hydraulic Jump.

using Formula As we know that.

$$\Delta p = \rho g Q [E_1 - E_2]$$

$$\Delta p = (1000)(9.81)(7.79)(271965.18)$$

$$\Delta p = 2078355186 \text{ w}$$

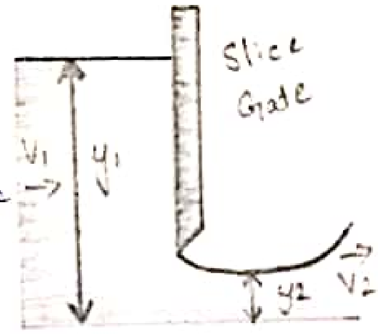
$$\boxed{\Delta P = 2078355.186 \text{ kw}}$$

Q1 Part # B

A Slice gate Controls the flow in a channel of width 4m. If the discharge R ft^3/sec & the up stream & down stream water depth is 2.9m & 1.1m respectively Calculate the down stream Velocity.

Also state the type of flow at up-stream & down stream side using any equation.

Given Data:-



Channel width = b = 4m

Discharge = Q = 7797 ft^3/sec

$$Q = 7797/(3.28)^3$$

$$Q = 220.871\ m^3/sec$$

Depth on up stream side = 2.9m

Depth on down stream side = 1.1m

Solution:- First we Find down stream velocity

As From specific energy Equation specific energy remain same on 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

$Q = AV$

$A_1V_1 = A_2V_2 \implies \cancel{b}y_1V_1 = \cancel{b}y_2V_2$

$y_1V_1 = y_2V_2$

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

$\boxed{V_2 = 2.63V_1}$

Put the value of V_2 in eq *

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

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

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

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

$\cancel{-}\,5.91v_1^2 = \cancel{-}(1.8)(19.62)$

$\sqrt{v_1^2} = \sqrt{\frac{(1.8)(19.62)}{5.91}}$

$v_1 = 2.44\,m/sec.$ put the v_1 value in equation V_2.

$V_2 = 2.63(2.44)$

$V_2 = 6.41\,m/sec$

=) Type of flow on upstream side.
By Fraud Number.

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

$0.45 < 1$

The flow is sub-critical flow.

=> ON Down Stream Side:-

Using Froud Number

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

So,

$1.95 > 1$

Then the flow is super-critical flow

Question = 2 Part A

what is the minimum height (In meter) of broad crested weir if is the function critical depth on the crest.

If water flows along a rectangular at a depth of 1.8m with a discharge of R ft^3/sec and the channel width is 66ft.

Given Data:-

Channel Depth = $d = 1.8m$

Discharge = $Q = 7797\ ft^3/sec$

$$Q = 7797/(3.28)^3$$

$$= 220.9\ m^3/sec$$

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

Required:-

Weir Height = P = ?

Solution:-

By Discharge Formula

$$Q = AV$$

$$V_1 = Q/A = Q/b \times y = 6.10\ m/sec$$

Critical Depth:-

By Formula

$$y_c = (q^2/g)^{1/3} \quad q = Q/b = \frac{220.9}{20.1}$$

$$q = 10.9\ m^2/sec$$

then $y_c = \left((10.98)^2 / 9.81 \right)^{1/3}$

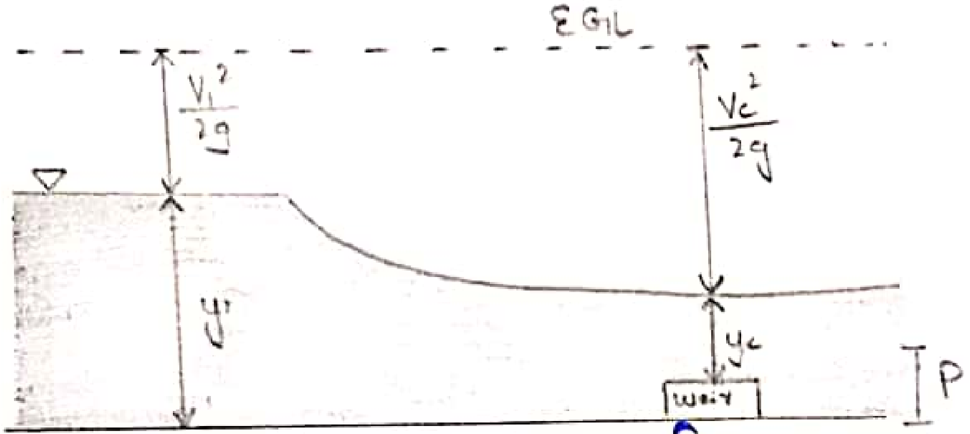
$y_c = \cancel{2}.\ 4.10\,m$

Also

$V = \sqrt{gy}$

$V_c = \sqrt{g y_c} \quad = \sqrt{(9.81)(\cancel{2.89}\ 4.10)}$

$V_c = 6.34\ m/sec$



According to the given figure

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

$$= \frac{(6.10)^2}{2 \times 9.81} + 1.8 = \frac{(6.34)^2}{2(9.81)} + 4.10 + P$$

$$= 3.69 = 6.14 + P$$

$$P = 6.14 - 3.69$$

$$P = 2.458\,m$$

So the weir should have height of 2.458 m measured from the channel bed.

Q2

(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 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 = 2.8m

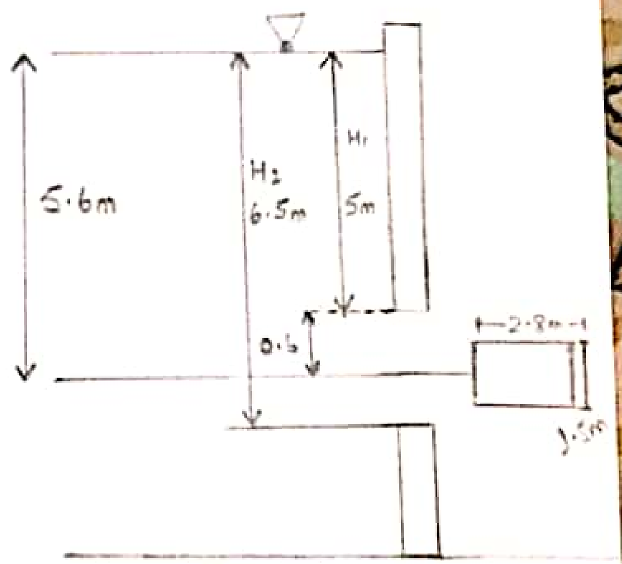
Depth = d = 1.5m

H_1 = 5m

$H_2 = 5 + 1.5 = 6.5m$

$H = 5 + 0.6 = 5.6m$

$cd = 0.77$



Solution:-

Discharge through Sub-Merged Portion
By using Formula

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

$$Q_1 = 0.77 \times 2.8 \times (6.5 - 5.6) \times \sqrt{2(9.81)(5.6)}$$

$$Q_1 = 20.33\ m^3/sec$$

Discharge Through Free Portion.

By Formula

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

$$Q_2 = \frac{2}{3}(0.77) \times 2.8\sqrt{2\times(9.81} \times \left[(5.6)^{3/2} - (5)^{3/2}\right]$$

$$Q_2 = 13.18 \ m^3/sec$$

Now Total Discharge will be

$$Q = Q_1 + Q_2$$

$$Q = 20.33 + 13.18$$

$$Q = 33.51 \ m^3/sec \quad Ans$$

Q: 3 Part A

The diameter of a water pipe is suddenly enlarged from R-200mm to R+3000mm. 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 enlargment
2) The power lost due to sudden Enlargment
3) The pressure in the smaller pipe (pipe is horizontal).

Given Data:-

$d_1 = 7797 - 200 = \frac{7597}{1000}$ mm

$d_1 = 7.597$ m

$d_2 = 7797 + 3000 = \frac{10797}{1000}$ mm

$d_2 = 10.797$

Discharge = Q = 0.95 m^3/sec

Pressure in large pipe = 7797 + 800

= 8597 N/m^2

Solution:- Head loss due to sudden Enlargment

$d_1 = 7.597$ m

$A_1 = \pi/4\ d^2 = \pi/4\ (7.597)^2$

$A_1 = 45.328\ m^2$

$d_2 = 10.797$

$A_2 = \pi/4 (d_2)^2 = \pi/4 (10.797)^2$

$A_2 = 91.55 m^2$

By discharge Formula

$Q = AV$

$V = Q/A$

$V_1 = Q/A_1$

$V_1 = \frac{0.95}{45.32}$

$V_1 = 0.020 \, m/sec$

Similarly:-

$V_2 = Q/A_2$

$V_2 = \frac{0.95}{91.55} = V_2 = 0.01037 \, m/sec$

Formula of Sudden Enlargment

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

$he = \left(1 - \frac{45.328}{91.55}\right)^2 \times \left(\frac{(0.020 - 0.01037)^2}{2(9.81)}\right)$

$he = 1.204 \times 10^{-6} m.$

Power loss due to sudden Enlargment

As we know that

$P = \rho g Q he$

$P = (1000)(9.81)(0.95)(1.204 \times 10^{-6})$

$P = 0.1122 \, w.$

★ Pressure In Smaller Pipe:-

Using Bernoulli's Equation

$$= P_1/\rho g + V_1^2/2g = P_2/\rho g + V_2^2/2g + h_e$$

$$= \frac{P_1}{(1000)(9.81)} + \frac{(0.020)^2}{2\times 9.81} = \frac{P_2}{1000\times 9.81} + \frac{(0.0103)^2}{2\times 9.81} + \frac{1.204\times 10^{-6}}{\text{[illegible]}}$$

$$= P_1/9810 + 0.0000203 = \frac{8600}{9810} + 0.000005407 + 0.000001204$$

$$= P_1/9810 = 0.87666 - 0.0000203$$

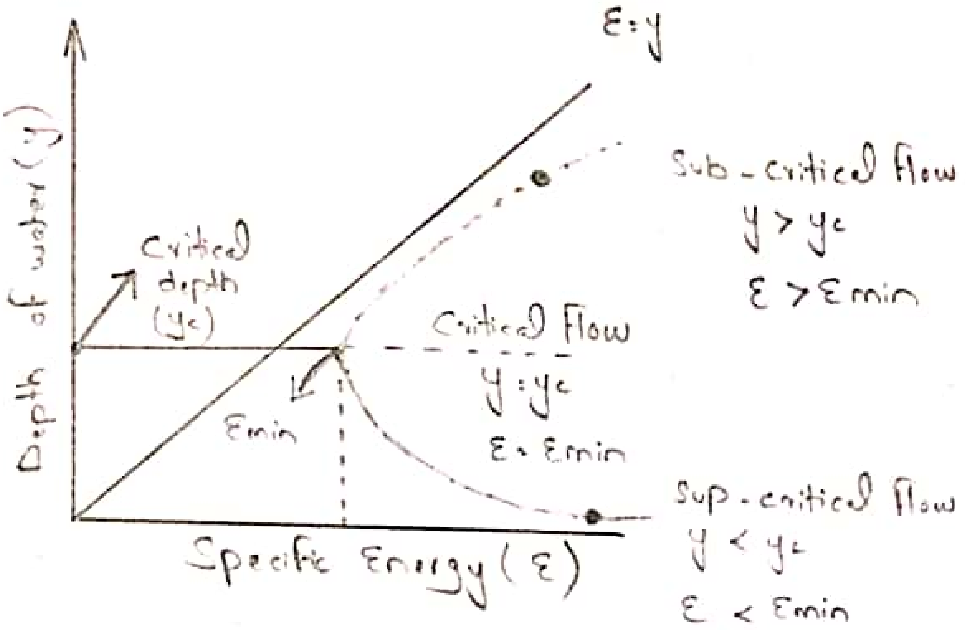
$$= P_1/9810 = 0.8766397$$

$$= P_1 = (0.8766397)(9810)$$

$$P_1 = 8599.835 \ N/m^2$$

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 or figure the blue curve is the 3-degree polynomial curve which show the flow is critical flow, sub-critical flow & 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 ~~equal~~ greater than 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 Super critical flow.

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

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

⇒ The given graph indicate the relation between depth of water (y) & 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 → Specific energy.
2) Y - axis → Depth of water.

⇒ From the given figure, the center line where $E = y$ show that the specific energy is directly Proportional to specific energy

$$E \propto y$$

Equation of Specific Energy: From the derivation of specific energy equation. There is three polynomial equation is obtained.

From the help of the equation

$$(\mathcal{E}-y)y^2 = q^2/2g \longrightarrow \star$$

We can plot a curve of specific Energy.

⇒ From the above equation ★

$\mathcal{E}$ = specific energy

y = depth of water

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

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