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Section : A

paper : Hydraulic Engineering

Exam : Mid Term

Q#01

a) W.I. Suppose a Rectangular - - -
- - - - - - R.220 Ft/sec

Given data:

→ discharge = 7801 Lit/sec
or, $Q_1 = \frac{7801}{1000} = 7.801\ m^3/sec$

→ Channel Width, $b = 8m$

→ Mean velocity $= V = 7801 - 220 = 7581\ Ft/sec$
or, $V = 7581 \times 0.3048\ m/sec$
$V_1 = 2310.68$

Solution:

* ① Height of hydraulic Jump.
we know that
$$q = Q/b = \frac{7.801}{8} = 0.9751\ m^2/sec$$

* ② Critical depth.
we know that

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

$$\Rightarrow y_c = \left(\frac{(0.9751)^2}{9.81}\right)^{1/3}$$

$$\Rightarrow y_c = 0.45938\ m$$

* (3) Critical velocity.

$$\Rightarrow q = Vy$$

or.

$$V_c = q/y_c$$

putting values.

$$\Rightarrow V_c = \frac{0.9751}{0.45938} = 2.1226\ m/s.$$

* (4) depth of water on upstream side.

Now,

$$Q = AV$$

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

$$y = \frac{Q}{V_c b} \Rightarrow y_1 = \frac{Q}{V_c b}$$

$$\Rightarrow y_1 = \frac{7.801}{2.1226 \times 8} = 0.4594m$$

④ * → water depth on downstream Side.

we know that

$$y_2 = \frac{-y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2yv_1^2}{g}}$$

putting values

$$\Rightarrow y_2 = -\left(\frac{0.4594}{2}\right) + \sqrt{\left(\frac{(0.4594)^2}{4} + \frac{2(0.4594)(2.1226}{9.81}\right)}$$

$$\Rightarrow y_2 = -0.2297 + \sqrt{0.0527 + 0.4219}$$

$$\Rightarrow y_2 = 0.45981$$

* (5) difference in depth

$$\Delta y = y_2 - y_1$$

$$= 0.45981 - 0.45940 = 0.00041\,m$$

Now.

$$\Rightarrow Q_1 = Q_2$$

$$\Rightarrow AV_1 = A_2V_2$$

$$\Rightarrow \cancel{b}y_1V_1 = \cancel{b}y_2V_2 \qquad \because b = b_1 = b_2$$

$$\Rightarrow V_2 = \frac{y_1V_1}{y_2}$$

putting values:

$$V_2 = \frac{0.4594 \times 2310.68}{0.4598}$$

$$\Rightarrow V_2 = 2308.66 \text{ m/sec}$$

Now,

(6) $\Delta E = E_1 - E_2$

$$\Rightarrow E_1 - E_2 = \left(y_1 + \frac{V_1^2}{2g}\right) - \left(y_2 + \frac{V_2^2}{2g}\right)$$

putting value.

$$\Rightarrow E_1 - E_2 = \left(0.4594 + \frac{(2310.68)^2}{2 \times 9.81}\right) - \left(0.4598 + \frac{(2308.66)^2}{2 \times 9.81}\right)$$

$$\Delta E = 272133.082 - 271657.493$$

$$\Delta E = 475.589$$

7* Power dissipation in hydraulic Jump.

we knew that

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

putting value.

$$\Rightarrow \Delta p = (1000)(9.81)(7.801)(475.589)$$

$$\Rightarrow \Delta p = 36395784.63 \text{ W}$$

b) A sluice gate . . . .
- - - any Equation.

Given data:

→ Channel width, $b = 4m$
→ discharge $= 7801 \, ft^3/sec$ or

$$= \frac{7801}{(3.28m)^3} = 221.06 \, m^3/sec$$

→ depth on upstream side = 2.9m
→ depth on downstream side = 1.1m

Solution:

* Downstream velocity

As from Specific Energy Equation.
Specific Energy remain same on both streams.

So $E_1 = E_2$

$$\Rightarrow y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g} \rightarrow (1)$$

→ Also from discharge Equation

$$Q = AV$$

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

$$\Rightarrow \cancel{b} y_1 V_1 = \cancel{b} y_2 V_2 \quad \because b_1 = b_2 = b_2$$

or,

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

$$\Rightarrow V_2 = \frac{2.9}{1.1} V_1$$

$\Rightarrow V_2 = 2.63 V_1 \rightarrow (x)$

put value of V_2 in Eq (1)
we get

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

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

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

Or,

$$\Rightarrow V_1^2 = \sqrt{\frac{1.8 \times 19.62}{5.91}}$$

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

from Eq (x)

$$\Rightarrow V_2 = (2.63)(2.44) = 6.41 \text{ m/sec}$$

→ Type of flow determination:

① On upstream side.

$$\Rightarrow Fr_1 = \frac{V_1}{\sqrt{gy_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = 0.45$$

→ $0.45 < 1$ (sub-critical flow)

② On downstream side.

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

→ $1.95 > 1$ (super-critical flow)

Q#02

a) what is the minimum . . . .

- . . . . . . is 60ft.

Given Data:

→ Channel depth = 1.8m

→ discharge, $Q = 7801\ ft^3/sec$

$$Q = \frac{7801}{(3.28\ m)^2} = 221.06\ m^3/sec$$

→ width of channel, $(b) = 66\ ft$ or

$$= \frac{66}{3.08} = 20.1\ m$$

→ weir height $(P) = ?$

SOLUTION:

⇒ $Q = AV$ or $V = Q/A$

$$\Rightarrow V_1 = \frac{Q}{b \times y} = \frac{221.06}{20.1 \times 1.8} = 6.110\ m/sec$$

* Critical depth

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

We know that

$$q = Q/b = \frac{221.06}{20.1} = 10.998\ m^2/sec$$

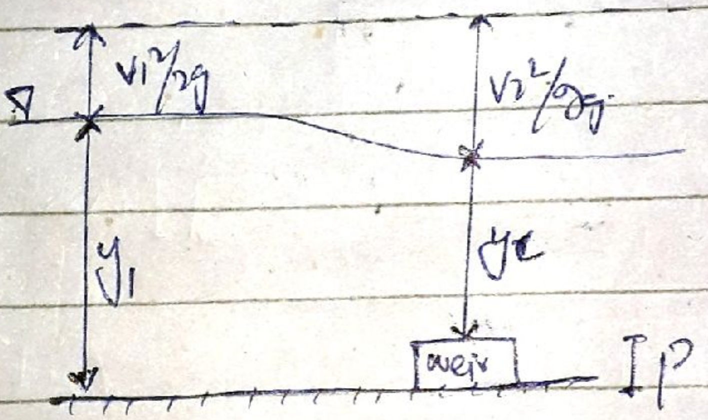
$$\Rightarrow y_c = \left(\frac{(10.998)^2}{9.81}\right)^{1/3}$$

$$\Rightarrow y_c = 2.310 m$$

now,

$$V = \sqrt{gy} \quad \text{or} \Rightarrow V_c = \sqrt{g y_c}$$

$$\Rightarrow V_c = \sqrt{9.81 \times 2.310} = 4.760 m/sec$$



According To figure.

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

putting values

$$\Rightarrow \left(\frac{(6.110)^2}{2\times 9.81} + 1.8\right) = \left(\frac{(4.760)^2}{2\times 9.81} + 2.310 + P\right)$$

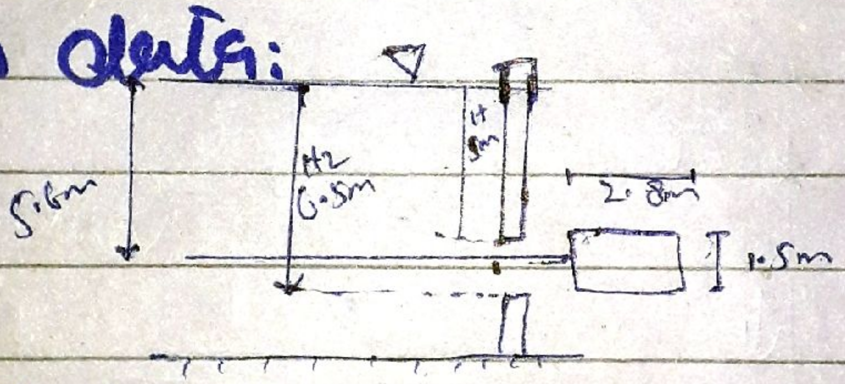
$$\Rightarrow 3.702 = 3.464 + P$$

$\Rightarrow \quad P = 3.702 - 3.464 = 0.238m$

Weir should have height of 0.238m measured from the channel bed.

b) An orifice is one - - -
- - - - - - Cd = 0.R

Given data:



→ Breadth (b) = 2.8m
→ depth, (d) = 1.5m
→ $H_1 = 5m$
→ $H = 5m + 0.6m = 5.6m$
→ $H_2 = 5m + 1.5m = 6.5m$
→ Cd = 0.7801

Solution:

① Discharge Through Sub-merged Portion

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

$\Rightarrow Q_1 = 0.7801 \times 2.8 (6.5 - 5.6) \times \sqrt{2(9.81)(5.6)}$

* $\Rightarrow Q_1 = 20.606 \, m^3/sec$

② Discharge Through free portion

* $Q_2 = \frac{2}{3} cd \times b\sqrt{2g} \times \left(H^{3/2} - H_1^{3/2}\right)$

putting values.

* $\Rightarrow Q_2 = 2/3 \,(0.7801) \times (2.8)\sqrt{2 \times 9.81} \times \left[(5.6)^{3/2} - (5)^{3/2}\right]$

$\Rightarrow Q_2 = 13.366 \, m^3/sec$

Total discharge $= 20.606 + 13.366$

* $Q = 33.972 \, m^3/sec$

Q#03

a) The diameter of - - - -

\- - - - - - - pipe(if pipe is horizontal)

Given data:

→ flow rate $(Q) = 0.95\ m^3/sec$

→ Pressure in large pipe $= R + 800\ N/m^2$

$= 7801 + 800$

$= 8601\ N/m^2$

→ $d_1 = R - 200mm$

$= 7801 - 200 = 7601\ mm = 7.601\ m$

→ $d_2 = R + 3000mm$

$= 7801 + 3000 = 10801\ mm = 10.801\ m$

SOLUTION:

1- Head loss due to Sudden Enlargement.

* $d_1 = 7.601$

⇒ $A_1 = \pi/4\,(d_1)^2 = \pi/4\,(7.601)^2$

⇒ $A_1 = 45.35\ m^2$

* $d_2 = 10.801\ m$

⇒ $A_2 = \pi/4\,(10.801)^2$

⇒ $A_2 = 91.57\ m^2$

We know That

$$Q = AV$$

$$\Rightarrow V = Q/A$$

Now,

$$\ast \Rightarrow V_1 = Q/A_1 = \frac{0.95}{45.35} = 0.020 \, m/sec$$

Similarly,

$$\ast \Rightarrow V_2 = Q/A_2 = \frac{0.95}{91.57} = 0.010 \, m/sec$$

Now, find the Sudden Enlargement, we get

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

putting values

$$\Rightarrow h_e = \left(1 - \frac{45.31}{91.57}\right)^2 \times \left(\frac{(0.020 - 0.010)^2}{2(9.81}\right)$$

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

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

2- power loss due to Sudden Enlargement

we know that

* $P = \rho g Q h_e$

putting values

$\Rightarrow P = (1000)(9.81)(0.95)(1.302\times10^{-6})$

$\Rightarrow P = 0.012W$

3. Pressure on Smaller pipe:

By Bernoulli's Equation

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

putting values

$$\frac{P_1}{(1000)9.81} + \frac{(0.020)^2}{2(9.81)} = \frac{8601}{(1000)(9.81)} + \frac{(0.010)^2}{2(9.81)} + (1.302\times10^{-6})$$

$$\frac{P_1}{9801} + 0.0000203 = 0.8775 + 0.00000509 + 0.000001302$$

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

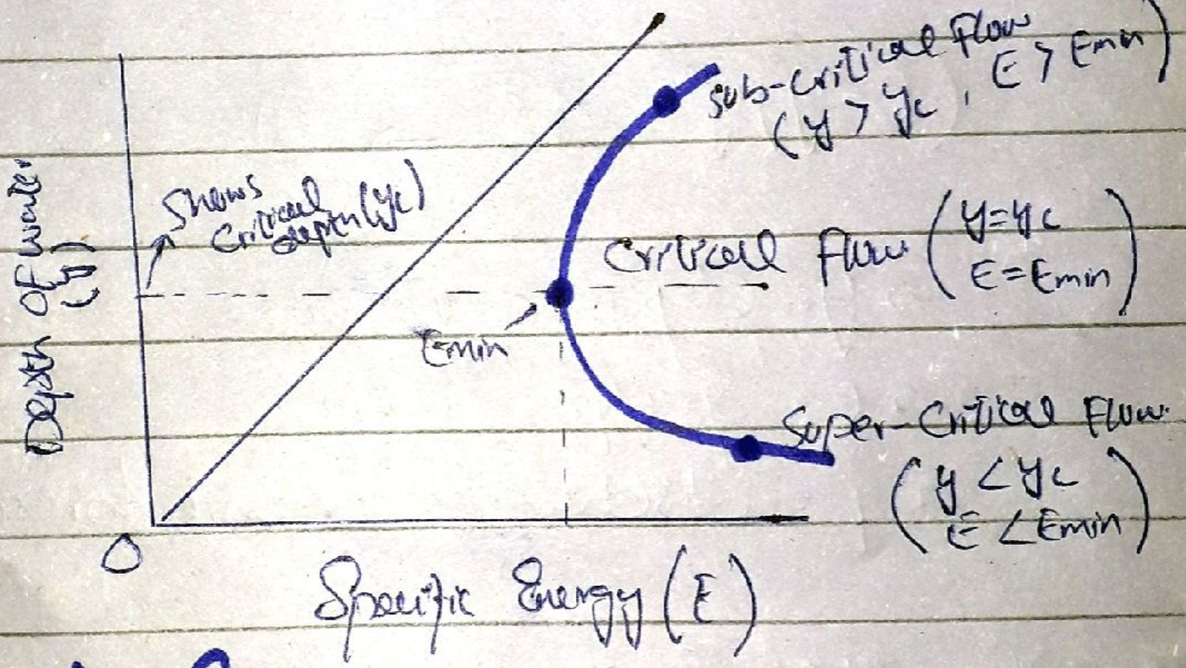
or,

$$\Rightarrow P_1 = 0.8766 \times 9810$$

$$\Rightarrow P_1 = 8591.55 \, N/m^2$$

b) First what does ....
.... point of view.

Ans:



→ Specific Energy:

It is a parameter that can be used to clarify the meaning of Super critical, Sub-critical and critical flow in an open channel.

Now,

To the above the graph

Graph Consist of Two Axis.
① → Depth of water (y)
② → Specific Energy (E)

⇒ from The derivation of Specific Energy Equation, a Three degree polynomial Equation is obtained from help of This Equation.

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

→ y = depth of water
→ E = Specific Energy
→ q = discharge per unit breadth.

⇒ Also the Graph indicates the relation between the depth of water (y) and Critical depth (y_c)

⇒ Black Solid Line showes the directly Relation of Specific Energy To water depth

→ The graph curve part called 3-degree polynomial curve which consist of of three point.

① Top point show that depth of water is greater than critical depth, so flow is sub-critical
($E > E_{min}$, $y > y_c$)

② Middle point shows that depth of water is equal to critical depth
($y = y_c$) & ($E = E_{min}$)

③ Down point shows that the water depth is less than critical depth, so flow is super-critical flow.
($E < E_{min}$, $y < y_c$)