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Section : A

Subject : Hydraulic Engineering

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Date : 26-04-2020

MID-TERM EXAM

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Q#1a

Answer :-

→ Given data:

Channel width = $b = 8\,m$

Discharge = Q = 7828 ltr/sec = $7.828\,m^3/s$

Mean velocity = V = R − 220

= 7828 − 220

= 7608

= 2318.88 m/sec.

i) As we know that : $Q = qb$

$q = Q/b = \frac{7.828}{8}$

$= 0.978\,m^2/s$

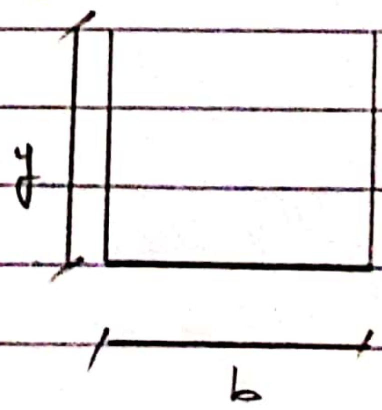
$$\rightarrow y_c = \left(q^2/g\right)^{1/3} = \left(\frac{0.978}{9.81}\right)^{1/3}$$

= 0.4602 m

As it is a rectangular section

$Q = qb$ — ①

$Q = Av$ — ②



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Equating eq 1 and 2

$q b = A v$

$q \cancel{b} = \cancel{\quad} y \cancel{b} v$

$q = y v \quad , \quad v_c = q / y_c$

$= \frac{0.978}{0.4602} = 2.125 \text{ m/sec.}$

$\therefore V > V_2$ (Super Critical flow).

Height of hydraulic jump on the up-stream side.

$Q = A v$

$Q = b y v$

$y_1 = \frac{Q}{V_1 b} = \frac{7.828}{(2318.88)(8)} = 0.0004 \text{m}$

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

$y_2 = \frac{-0.0004}{2} + \sqrt{\frac{(0.0004)^2}{4} + \frac{2(0.0004)(2318.9)^2}{9.81}}$

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$y_2 = 20.94$ m.

$\Delta y = y_2 - y_1$

$= 20.94 - 0.0004$ m

$= 20.93$ m.

ii) $\Delta E = E_1 - E_2$

As we know that.

$Q_1 = Q_2$

$A_1 V_1 = A_2 V_2$

$b y_1 V_1 = b y^2 v_2$ $(\therefore b_1 = b_2 = b)$.

$V_2 = y_1 v_1 / y_2$

$$= \frac{0.0004 \times (2318.90)}{20.94}$$

$V_2 = 0.44$ m/sec

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

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$$= \left(0.0004 + \frac{2312.90}{2\times 9.81}\right) - \left(1.419 + \frac{0.44}{2\times 9.81}\right)$$

$$E_1 - E_2 = 118.19 - 1.42$$
$$= 116.77 \text{ m}.$$

→ Power absorbed:

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

$$= 1000 \times 9.81 \times 7.826 \ (116.77)$$

$$\Delta P = 8962487.02 \text{ kN}.$$

Q #16

→ **Given data :-** $b = 4\text{m}$

$$Q = 7828 \text{ ft}^3/\text{sec}$$
$$= \frac{7828}{(3.28)^3} = 221.83 \text{ m}^3/\text{s}$$

$$y_1 = 2.9 \text{ m}$$
$$y_2 = 1.1 \text{ m}$$

Specific energy at upstream and down stream side:

$$E_1 = E_2$$

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

As we know that :-

$$Q = A_1 V_1 = A_2 V_2$$

$$b y_1 V_1 = b y_2 V_2 \quad (\because b_2 = b_1 = b)$$

$$V_2 = \frac{y_1 V_1}{y_2} = \frac{2.9}{1.1} V_1$$

$$V_2 = 2.636\, V_1 \quad —②$$

Put value eq ② in eq ①
we get.

$$2.9 + \frac{V_1^2}{2 \times 9.81} = 1.1 + \frac{(2.636\, V_1)^2}{2 \times 9.81}$$

$$2.9 - 1.1 = \frac{6.948\, V_1^2}{19.62} - \frac{V_1^2}{19.62}$$

$$1.8 \times 19.62 = 5.948\, V_1^2$$

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$$V_1^2 = \sqrt{\frac{1.8 \times 1962}{5.948}}$$

$V_1 = 2.436$ m/sec.

Now put the value of ~~eq~~ V_1 in eq ①

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

$$2.9 + \frac{2.43^2}{2\times 9.81} = 1.1 + \frac{(2.636\,V_1)^2}{2\times 9.81}$$

$$2.9 - 1.1 = \frac{(2.636\,V_1)^2}{2\times 9.81} - \frac{(2.43)^2}{2\times 9.81}$$

$$1.8 = 0.35\,V_1^2 - 0.30$$

$$V_1^2 = 6$$

$$\sqrt{V_1^{\cancel{2}}} = \sqrt{6}$$

$V_1 = 2.45$ m/sec

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→ Now putting the value of "V_1" in eq ①

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

$$2.9 + \frac{(2.45)^2}{2g} \neq 1.1 + \frac{V_2^2}{2g}$$

$$1.8 = \frac{V_2^2 - 5.9}{2g} = V_2^2 - 0.30$$

$V_2 = 6.42$ m/sec. → using froud no to determine type of flow

→ Upstream side :-

$$Fr_1 = \frac{V_1}{\sqrt{gy_1}} = \frac{2.43}{\sqrt{9.81 \times 2.9}} = 0.45 < 1 \text{ (sub-critical)}$$

→ Down stream side :-

$$Fr_2 = \frac{V_2}{\sqrt{gy_2}} = \frac{6.42}{\sqrt{9.81 \times 1.1}} = 1.95 > 1 \text{ (super-critical)}.$$

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Q # 2 a

→ Given data :- $y = 1.8\,m$, $b = 66'$

$= \frac{66}{3.28}$

$b = 20.12\,m$

$Q = \frac{7828}{3.28^3}$

$= 221.8\ m^3/sec.$

→ Required :-

Minimum height (P) of weir

$Q = AV$

$V = Q/A = Q/by = \frac{221.8}{20.12 \times 1.8} = 6.12\ m/sec.$

As we know that :-

$y_c = (q^2/g)^{1/3}$ $\qquad \because q = Q/b = 11.02\ m^3/sec$

$= (11.02^2/9.81)^{1/3}$

→ $y_c = 2.31\ m.$

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Also $V = \sqrt{gy}$

$$V_c = \sqrt{g y_c} = \sqrt{9.81 \times 2.31}$$

$$= 4.76 \text{ m/sec.}$$

→ Now according to specific energy.

$$E_1 = E_2$$

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

$$1.8 + \frac{(6.12)^2}{2 \times 9.81} = \frac{(4.76)^2}{2 \times 9.81} + 2.31 + P$$

$$3.70 = 3.46 + P$$

$$P = 0.22 \text{ m} \rightarrow \text{Ans.}$$

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Q # 2 b

→ Given data :- $b = 2.8\,m$, $d = 1.5\,m$
$H_1 = 5m$, $H_2 = 5+1.5 = 6.5m$
$H = 5+0.6 = 5.6m$
$Cd = 0.7828$.

→ Required :- $Q = ?$

As we know discharge through submerged portion:

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

$$= 0.7828 \times 2.8\,(6.5 - 5.6) \times \sqrt{2 \times 9.81 \times 5.6}$$

→ $Q_1 = 20.677\ m^3/sec.$

→ discharge of free portion.

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

$$= \frac{2}{3}(0.7828) \times 2.8 \sqrt{2 \times 9.81}\left[5.6^{3/2} - 5^{3/2}\right]$$

$Q_2 = 13.4\ m^3/sec$

→ Total discharge

$Q = Q_1 + Q_2 = 20.677 + 13.4$
$= 34.077\ m^3/sec$ — Ans.

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Q# 3a

→ Given data :-

$P_1 = R + 800 = 7628 + 800 = 8628 \ N/m^2$

$d_1 = R - 200 = 7828 - 200 = 7628 \ mm$

$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (7.628)^2}{4} = 45.69 \ m^2$

$d_2 = R + 3000 = 7828 + 3000$

$= 10828 \ mm = 10.828 \ m$

$A_2 = \frac{\pi d_2^2}{4}$, $Q = 0.95 \ m^3/sec$

$A_2 = 92.08 \ m^2$

$\therefore Q = AV \qquad V = Q/A$

$V_1 = \frac{Q_1}{A_1} = \frac{0.95}{45.67} = 0.02 \ m/sec.$

$V_2 = \frac{Q_2}{A_2} = \frac{0.95}{92.08} = 0.01 \ m/sec.$

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1- Head loss due to sudden enlargement:

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

$$= \left(1 - \frac{45.67}{92.08}\right) = \left(\frac{0.02 - 0.01}{2 \times 9.81}\right)^2$$

$he = 0.00000127$ m.

2- Power loss due to sudden enlargement:

$$P = \rho g Q \, he$$

$$= 1000 \times 9.81 \times 0.95 \times 0.00000127 \text{ m}$$

$\rightarrow P = 0.0118$ W.

3- Pressure in the smallest pipe:

→ Apply Bernoulli's equation.

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

$$= \frac{8628}{1000 \times 9.81} + \frac{(0.02)^2}{2 \times 9.81} = \frac{P_2}{1000 \times 9.81} + \frac{(0.01)^2}{2 \times 9.81} + 1.27 \times 10^{-6}$$

$$P_2 = 8622.92 \text{ N/m}^2$$

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Q # 3b

→ **What the graph indicates:**

The graph is plotted between depth flow (y) and specific energy (E). It is made from 3 degree polynomial equation which show us the different specific energy for the depth flow which may be either sub-critical, critical or super critical.

→ **How the graph is obtained:**

As we know that

Total energy $= K.E + P.E$

$= 1/2\, mv^2 + mgh$

$= wh + 1/2 \frac{w}{g} v^2$

∴ ignoring weight of water (w).

$$T.E = h + \frac{v^2}{2g} \quad - (1)$$

As we know that

$Q = VA \quad , \quad V = Q/A$

squaring both sides.

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$V^2 = Q^2/A^2$ put v^2 in eq ①

we get :

$$E = y + \frac{Q^2}{A^2 2g} \quad - ②$$

→ Suppose the channel is rectangular.

$A = y \times b$ — (i)

$Q = qb$ — (ii)

put i and ii in eq ②

$$E = y + \frac{Q^2}{y^2 b^2 2g} \quad \rightarrow \text{putting i}$$

$$E = y + \frac{q^2}{y^2 2g} \quad \rightarrow \text{putting ii}$$

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

$$(E - y)\,y^2 = \text{Constant} \quad \text{- Ans}$$

End of paper.

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