MID TERM

Name; Syed Najeeb ullah Bacha

ID; 785

Section; "B"

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Subject; Hydrulic Engineering

Instructor; Engr Fawad Ahmad

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Question # 01

part (A)

Answer:

Given data:

channel width = b = 8m

Discharge = Q = 7855 lit/sec = 7.855 m³/sec

Mean velocity = V = R - 200 = 7855 - 200

= 7635 ft/sec

= 2327.03 m/sec

① As we know that

$$Q = qb$$

$$q = \frac{7.855}{8} = 0.981875\ m^3/sec$$

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

$$= \left(\frac{(0.981875)^2}{9.81}\right)^{1/3} = 0.461m$$

$$\boxed{y_c = 0.461m}$$

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As it is rectangular section

$Q = qb \longrightarrow (I)$

$Q = AV \longrightarrow (II)$

$qb = AV$

$q = yv$

$v_c = q/y_c = \frac{0.981875}{0.461}$

$v_c = 2.129 \, m/sec$

$v > v_c$ (supercritical flow)

Height of hydraulic jump on the upstream side

As

$Q = AV$

$Q = byv$

$y_1 = Q/v_1 b$

$y_1 = \frac{7.855}{2327.03 \times 8}$

$y_1 = 0.0004 m$

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

$$= \frac{-0.0004}{2} + \sqrt{\frac{(0.0004)^2}{4} + \frac{2 \times (0.0004)(2327.03)^2}{9.81}}$$

$$= -0.0002 + \sqrt{0.00000004 + 441.59}$$

$$= -0.0002 + 21.01$$

$$= 21.0098$$

$$\boxed{y_2 = 21.0098}$$

$$\Delta y = y_2 - y_1$$

$$\Delta y = 21.0098 - 0.0004$$

$$\Delta y = 21.0102$$

(ii) $\therefore \Delta E = E_2 - E_1$

$$Q_1 = Q_2$$

$$A_1V_1 = A_2V_2$$

$$\cancel{B}y_1V_1 = \cancel{B}y_2V_2$$

$$V_2 = \frac{y_1V_1}{y_2} = \frac{(0.0004)(2327.03)}{21.0098}$$

$$V_2 = 0.044 \text{m/sec}$$

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

$= \left(0.0004 + \frac{2327.03^2}{2 \times 9.81}\right) - \left(21 - \frac{0.044^2}{2 \times 9.81}\right)$

$E - E_2 = 56267 - 20.999$

$E_1 - E_2 = 56246 m$

Power Absorbed

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

$\Delta P = 1000 \times 9.81 \times 7.855 (56246)$

$\boxed{\Delta P = 4334178 KN}$

Question # 01
part (B)

Answer:

Given data:

$Q = 7855\ ft^3/sec$

$Q = \frac{7855}{(3.28)^3} = 222.39\ m^3/sec$

$b = 4m$

$y_1 = 2.9m$

$y_2 = 1.1m$

$E_1 = E_2$

$$y_1 + \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g} \rightarrow (1)$$

As we know that

$Q_1 = Q_2$

$A_1 v_1 = A_2 v_2$

$b y_1 v_1 = b y_2 v_2$

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

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$v_2 = \frac{2.9 v_1}{1.1} = 2.634 v_1 \longrightarrow ①$

put ② in ①

$$2.9 + \frac{v_1^2}{2\times 9.81} = 1.1 + \frac{(2.634 v_1)^2}{19.62}$$

$$2.9 - 1.1 = \frac{6.938 v_1^2}{19.62} - \frac{v_1^2}{19.62}$$

$$1.8 = \frac{6.938 v_1^2 - v_1^2}{19.62}$$

$$\sqrt{v_1^2} = \sqrt{\frac{1.8 \times 19.62}{5.938}}$$

$$v_1 = 2.44\,m/sec$$

Now put the value of "v1" in eq①

$$y_1 + \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g}$$

$$2.9 + \frac{(2.44)^2}{2g} = \frac{1.1 + v_2^2}{2g}$$

$$2.9 - 1.1 = \frac{v_2^2}{2g} - \frac{5.95}{2g}$$

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$$1.8 \times 2 \times 9.81 = V_2^2 - 5.95$$

$$\sqrt{V_2^2} = \sqrt{41.266}$$

$$V_2 = 6.42 \text{ m/sec}$$

Using Froud No to determine type of flow.

UPSTREAM SIDE:

$$F_{r1} = \frac{V_1}{\sqrt{g y_1}} = \frac{2.44}{\sqrt{9.81 \times 2.9}} = 0.457 < 1$$

(subcritical Flow)

DOWN STREAM SIDE:

$$F_{r2} = \frac{V_2}{\sqrt{g y_2}} = \frac{6.42}{\sqrt{9.81 \times 1.1}} = 1.95 > 1$$

(supercritical Flow)

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Question #02
part (A)

Answer:

Given data:

$y = 1.8m \Rightarrow 5.90 ft$

$b = 66 ft$

$Q = 7855 \, ft^3/sec$

Required:

$P = ?$

Solution:

$V1 = \frac{Q}{A} = \frac{Q}{by}$

$V1 = \frac{7855}{5.90 \times 66}$

$V1 = 20.17 \, ft/sec$

$\rightarrow \quad y_c = \left(\frac{q^2}{g}\right)^{1/3} \Rightarrow \left(\frac{Q^2}{b^2 g}\right)^{1/3}$ $\quad \therefore Q = qb$, $q = Q/b$

$= \left(\frac{7855^2}{66^2 \times 32.18}\right)^{1/3} = (440.16)^{1/3}$

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$$y_c = 7.606 \text{ ft}$$

Also

$$V = \sqrt{g y_c}$$

$$V = \sqrt{32.18 \times 7.606}$$

$$\boxed{V = 15.64 \text{ ft/sec}}$$

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

$$\frac{20.17^2}{2 \times 32.18} + 5.90 = \frac{15.64}{2 \times 32.18} + 7.600 + P$$

$$6.321 + 5.90 = 3.800 + 7.600 + P$$

$$12.221 = 11.4 + P$$

$$P = 12.22 - 11.4$$

$$P = 0.821 \text{ ft}$$

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Question # 02
part (B)

Solution:

$b = 2.8m$

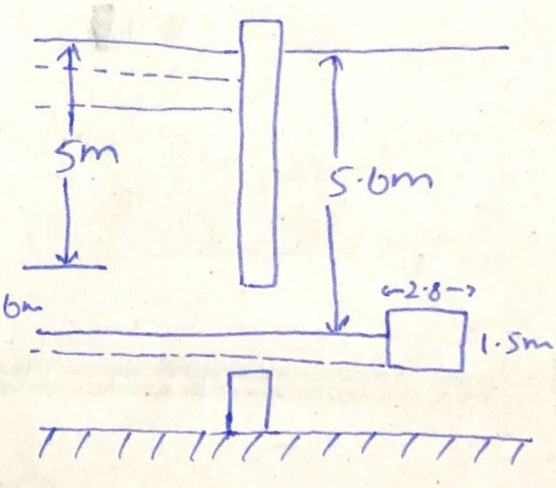
$d = 1.5m$

$H_1 = 5m$

$H_2 = 5 + 1.5 = 6.5m$

$H = 5 + 0.6 = 5.6m$

$cd = 0.7855$



Since the orifice is drowned partially, it will be splited in two portion free orifice and drowned orifice

$$Q_1 = \frac{2}{3} cd\, b \sqrt{2g} \left(H_2^{3/2} - H_1^{3/2}\right)$$

$$\Rightarrow Q_1 = \frac{2}{3} \times 0.7855 \times 2.8 \sqrt{2 \times 9.81} \left[6.5^{3/2} - 5^{3/2}\right]$$

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$Q_1 = 2.319 \times 2.8 (16.51 - 11.180)$

$Q_1 = 35.01 \ m^3/s$

The discharge at drowned portion

$Q_2 = cd.b (H_2 - H) \times \sqrt{2gh}$

$Q_2 = 0.7855 \times 2.8 (6.5 - 5.6) \times \sqrt{2 \times 9.81 \times 5.6}$

$Q = 20.73 m^3/s$

Total discharge $= 35.01 + 20.73$

$= \underline{55.74 \ m^3/s}$

Question #03

Part (A)

Answer:

Given data:

$P1 = P2 + 800\ N/m^2$

$P1 = 7855 + 800\ N/m^2$

$P1 = 8655\ N/m^2$

$\rightarrow d1 = 7655 = 7.655m$

$A1 = \frac{\pi}{4} d^2 = \frac{3.1416}{4} \times 7.655$

$A1 = 46.02 m^2$

$\rightarrow d2 = 10855m = 10.855m$

$A2 = \frac{\pi}{4} d^2 = \frac{3.1416}{4} \times 10.855^2$

$A2 = 92.54 m^2$

$Q = 0.95 m^3/sec$

13)

$Q = AV$

$V = Q/A$

$\therefore V1 = Q/A1 \Rightarrow \frac{0.96}{4602} \Rightarrow 0.0208 m/s$

$\therefore V2 = Q/A2 \Rightarrow \frac{0.96}{92.54} \Rightarrow 0.0103 m/s$

a: Head loss due to suddenly enlarg ment.

$$he = \left(1 - \frac{A1}{A2}\right)^2 \left(\frac{V1 - V2}{2g}\right)^2$$

$$he = \left(1 - \frac{4602}{92.54}\right)^2 \left(\frac{0.0208 - 0.0103}{2 \times 9.8}\right)$$

$$he = (0.2527) \times (0.0000056)$$

$$\boxed{he = 0.0000014 m}$$

b: power loss due to sudden enlargment

$P = \rho g Q he$

$P = 1000 \times 9.81 \times 0.96 \times 0.0000014$

$P = 0.013 W$

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c: pressure in large pipe if the pipe is in horizontal.

∴ According Bernoulli equation

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

$$\frac{8655}{1000 \times 9.81} + \frac{0.0208^2}{2 \times 9.81} = \frac{P_2}{1000 \times 9.81} + \frac{0.0103^2}{2 \times 9.81} + 0.0000014$$

$$0.882 + 0.000022 = \frac{P_2}{9.810} + 0.0000054 + 0.0000014$$

$$0.88202 = \frac{P_2}{9.810} + 0.0000068$$

$$0.88201 = \frac{P_2}{9.810}$$

$$P_2 = 8652.5181\ N/m^2$$

Question # 03
(part B)

Answer: BLUE CRUVE: From the given figure. The blue curve is the 3-degree polynomial curve which show the flow is critical, sub critical and super critical flow.

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

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

⇒ The top point show the depth of water is greater than the critical depth

$$y > y_c \text{ and } E > E_{min}$$

⇒ The lower point show the depth of water is less than the critical depth.

$$y < y_c \text{ and } E < E_{min}$$

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

→ The given graph is indicat the relation between depth of water (y) and critical depth (yc)

Critical depth: Critical depth is depth of water at which minimum specific energy is obtained.

Equation of specific energy:

From the derivation of specific energy equation there is three degree polynomial Equation is obtained

$$(E-y)y^2 = q^2/2g \longrightarrow (A)$$

E = specific energy

y = depth of water

q = discharge per unit width its unit is m^3/sec