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Section	A
Paper	Hydraulic Engineering
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Qno1:-
Ans a) Given:-

channel width $= b = 8m$

$Q = 6977$ lit/sec $= 6.97\ m^3/sec$

mean velocity $(V) = 6977 - 220$ ft/sec

$V_1 = 6757$ ft/sec

$V_1 = 2059.53$ m/sec

Sol:-

$Q = q\, b$

$q = \frac{Q}{b}$

$q = \frac{6.97}{8} = 0.871\ m^2/sec$

$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{0.871^2}{9.81}\right)^{1/3}$

$\boxed{y_c = 0.42m}$

$q = yV$

$V_c = \frac{q}{y_c} = \frac{0.871}{0.42} = 2.07\ m/sec$

$V_1 > V_c$ super critical.

Depth of water on the upstream side of jump:-

$Q = AV$

$Q = ybV$

$y_1 = \frac{Q}{bV_c}$

$y_1 = \frac{6.97}{(8)(2.07)} = 0.4208$

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

$$= \frac{-0.4208}{2} + \sqrt{\frac{0.4208^2}{4} + \frac{2(0.4208)(2.07)^2}{9.81}}$$

$$\boxed{y_2 = 0.4766m}$$

$$\Delta y = y_2 - y_1$$

$$= 0.4766 - 0.4208$$

$$\boxed{\Delta y = 0.0558m}$$

$$\Delta E = E_1 - E_2$$

As we know

$$Q_1 = Q_2$$

$$A_1 V_1 = A_2 V_2$$

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

$$V_2 = \frac{y_1 V_1}{y_2} = \frac{(0.4208)(2059.53)}{0.4766}$$

$$V_2 = 1818.40 \text{ m/sec}$$

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

$$= \left(0.4208 + \frac{2059.53^2}{2\times9.81}\right) - \left(0.4766 + \frac{1818.40^2}{2\times9.81}\right)$$

$$\Delta E = 47659.74$$

Dissipation of power in hydraulic jump:- (3)

$\Delta P = \rho g Q(E_1 - E_2) = 1000 \times 9.81 \times 6.97 (47659.74)$

$= 3258768084 W$

$= 3258768.084 kW.$

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Q no 1:-

(4)

Part B)

channel width $= b = 4m$

$Q = 6977\ ft^3/sec$

height of upstream $= 2.9m$

height of downstream $= 1.1m$

(i) Downstream velocity =

As specific energy

$E_1 = E_2$

$$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g} \quad \text{--- (1)}$$

From discharge

$Q = AV$

$\Rightarrow A_1V_1 = A_2V_2$

$$(\cancel{b_1}y_1)V_1 = (\cancel{b_2}y_2)V_2 \qquad \because b_1 = b_2 = b$$

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

$$V_2 = \frac{2.9}{1.1}V_1 = \boxed{V_2 = 2.63V_1} \quad \text{— (ii)}$$

put in (i)

$$2.9 + \frac{V_1^2}{2 \times 9.81} = 1.1 + \frac{(2.63V_1)^2}{2 \times 9.81}$$

$$2.9 + \frac{V_1^2}{19.62} = 1.1 + \frac{6.91V_1^2}{19.62}$$

$$2.9 - 1.1 = \frac{6.91V_1^2}{19.62} - \frac{V_1^2}{19.62}$$

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$1.8 = 0.301 V_1^2$

$V_1^2 = 5.980$

$V_1 = 2.44$ m/sec.

Put in V_2

$V_2 = 2.63 \times 2.44$

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

Type of flow using frood Number

on upstream side;-

$Fr_1 = \frac{V_1}{\sqrt{g y_1}} = \frac{2.44}{\sqrt{9.81 \times 2.91}} = 0.45$

$Fr_1 < 1$ sub critical flow

on Down stream side;-

$Fr_2 = \frac{V_2}{\sqrt{g y_2}} = \frac{6.41}{\sqrt{9.81 \times 1.1}} = 1.95$

$Fr_2 > 1$

super critical flow.

Qno2

Ans a) $y = h = 1.8m$

$b = 66ft = 20.064 m$

$Q = 6977\ ft^3/sec = 196.01\ m^3/sec$

Reqir: $P =$ weir height =?

$$V_1 = \frac{Q}{A} = \frac{Q}{by}$$

$$V_1 = \frac{196.01}{20.064 \times 1.8} = 5.428\ m/sec.$$

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

$\because Q = qb$

$q = Q/b$

$$y_c = \left(\frac{196.01^2}{(20.064)^2 (9.81)}\right)^{1/3}$$

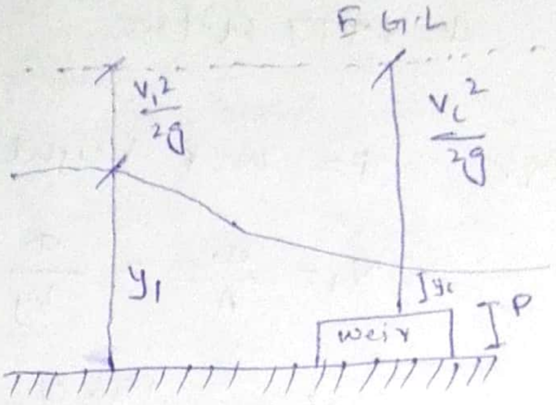
$$= \left(\frac{38419.92}{4179.15}\right)^{1/3}$$

$$= (9.19)^{1/3}$$

$$\boxed{y_c = 2.094\ m}$$

Also $V = \sqrt{g y_c}$

$$V_c = \sqrt{9.81 \times 2.094} = 4.53\ m/sec$$



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

$$\frac{(5.428)^2}{2\times 9.81} + 1.8m = \frac{4.53}{2\times 9.81} + 2.094 + P$$

$$3.301 = 2.324\,P$$

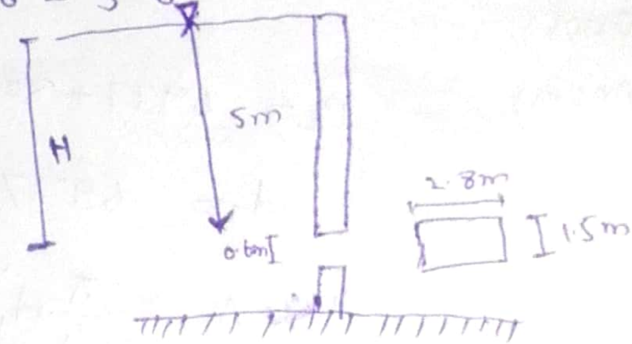
$$\boxed{P = 1.420\,m}$$

Thus the weir should have a height of 1.420m measured from the bed level.

Q no2)
Part b)

$b = 2.8\,m$
$d = 1.5\,m$

$H_1 = 5\,m$
$H_2 = 5m + 1.5 = \cancel{6m}\ 6.5\,m$
$H = 5 + 0.6 = 5.6$
$Cd = 0.6977$



Req :- $Q = ?$

Solution:-

Discharge through submerged portion

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

$$= 0.6977 \times 2.8 \times (6.5 - 5.6) \times \sqrt{2 \times 9.8 \times 5.6}$$

$$= 1.953\,(0.9) \times \sqrt{109.76}$$

$$\boxed{Q_1 = 18.414\ m^3/sec}$$

Discharge through free portion

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

$$Q_2 = \frac{2}{3} \times 0.6977 \times 2.8\sqrt{2 \times 9.81}\left[5.6^{3/2} - 5^{3/2}\right]$$

$$Q_2 = 5.77\,(13.25 - 11.18) = 11.94\ m^3/se$$

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Total discharge = $Q_1 + Q_2$

$$Q = 18.414 + 11.94$$

$$= 30.354 \, m^3/sec$$

Q no3)

Ans a) $P_2 = 6977 + 800 = 7777 \, N/m^2$

$d_1 = 6977 - 200 = 6777 \, mm = 6.7 \, m$

$A_1 = \frac{\pi}{4} d_1^2 = \frac{3.14}{4} (6.7)^2 = 35.23 \, m^2$

$d_2 = 6977 + 3000 = 9977 \, mm = 9.9 \, m$

$A_2 = \frac{\pi}{4} d_2^2 = \frac{3.14}{4} \times 9.9^2 = 76.93 \, m^2$

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

$Q = AV$

$V_1 = \frac{Q}{A_1} = \frac{0.95}{35.23} = 0.0269 \, m/sec$

$V_2 = \frac{Q}{A_2} = \frac{0.95}{76.93} = 0.0123 \, m/sec$

a) Head loss due to sudden enlargement:-

As

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

$$he = \left(1 - \frac{35.23}{76.93}\right)^2 \left(\frac{0.0269 - 0.0123}{2(9.81)}\right)^2$$

$$(0.293)(5.5 \times 10^{-7})$$

$$he = 1.6 \times 10^{-7} m$$

(b) Power loss due to sudden enlargement:-

$$P = \rho g Q h_e$$

$$P = 1000 \times 9.81 \times 0.95 \times 1.6 \times 10^{-7}$$

$$P = 14911.2 \times 10^{-7}$$

$$P = 0.0014 9112 \, W$$

$$P = 0.00149 \, W$$

(c) Pressure in the smaller pipe:-

By using Bernouli Equation

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

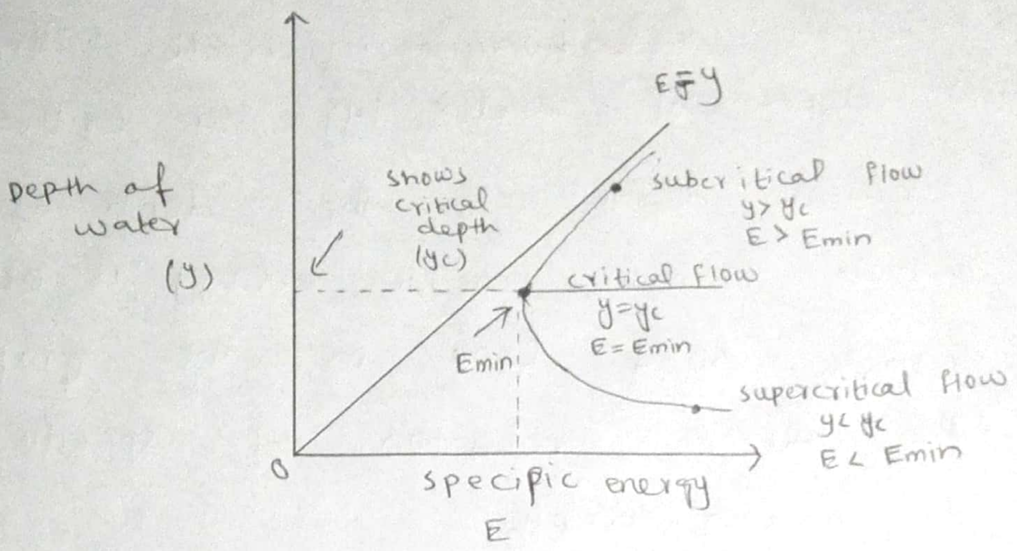
$$\Rightarrow \frac{P_1}{(1000)(9.81)} + \frac{0.0269}{2 \times 9.81} = \frac{7777}{(1000)(9.81)} + \frac{0.0123}{2 \times 9.81} + 1.6 \times 10^{-7} m$$

$$\Rightarrow \frac{P_1}{9810} + 0.00137 = 0.79 + 0.00062 + 1.6 \times 10^{-7}$$

$$P_1 = 0.7906$$

$$P_1 = 7742.54 \, N/m^2$$

Part B:-



First we define specific energy as;

parameter that can be used to clarify the meaning of supercritical, subcritical & critical flow in an open channel.

The graph consist of two axis

x - axis shows specific Energy

y - axis show Depth of water.

→ From the ~~help~~ ~~of~~ Derivation of specific energy equation a three degree polynomial equation is obtained. From the help of this equation we plot a curve of specific energy.

$$(E-y)y^2 = \frac{q^2}{2g} \quad \text{— (i)}$$

→ In the above equation (i)

E = specific Energy

y = depth of water

q = descharge per unit breadth.

→ The above ~~relation~~ graph indicates the relation b/w depth of water (y) & critical depth (y_c)

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

⇒ Black solid line in the graph shows the direct relation of specific energy to water depth

⇒ The blole 3 - degree polynomial curve consist of 3 points

(i) The top most point shows that ($y > y_c$) so flow is sub critical

(ii) The middle point shows that ($y = y_c$) so as correspond to minimum specific energy the flow is critical flow

(iii) The last point (located in bottom) shows that the water depth is less than critical depth so flow is supercritical flow.