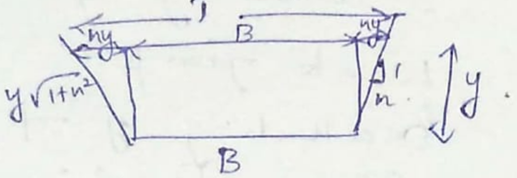
Scheme of Evaluation – Applied Hydraulics – 15CV43

IAT – I

1.) (a) Consider a trapezoidal section.



$A = y[B+ny]$ — (1) => $By = A - ny^2$ => $B = \frac{A}{y} - ny$

$P = B + 2y\sqrt{1+n^2}$ — (1) => $\frac{A}{y} - ny + 2y\sqrt{1+n^2}$

Most economical section,

$\frac{dP}{dy} = 0$ ⟶ (2)

$-\frac{A}{y^2} - n + 2\sqrt{1+n^2} = 0$ ⟶ (1)

$\frac{y[B+ny]}{y^2} + n = 2\sqrt{1+n^2}$

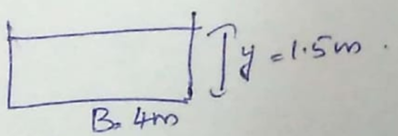
$\frac{B+ny+ny}{y} = 2\sqrt{1+n^2}$

$B+2ny = 2y\sqrt{1+n^2}$

$\frac{B+2ny}{2} = y\sqrt{1+n^2}$ —— (2)

Half Top width = Side slope length.

(b)



$S = 1/1000$

$N = 0.02$

$Q = ?$

Q_{max} dim = ?

% ↑se in Q = ?

$Q = A \times \frac{1}{N} \times R^{2/3} S^{1/2}$

$A = B \times y = 4 \times 1.5 = 6\,m^2$

$P = B + 2y = 4 + 2 \times 1.5 = 7m$.

$R = \frac{A}{P} = \frac{6}{7} = 0.857$

$Q = 6 \times \frac{1}{0.02} \times (0.857)^{2/3} \times (1/1000)^{1/2}$

$= \underline{8.56\,m^3/s}$ —— (2)

Q_{max} => Most economical section.

A = constant. } — (1)

B = 2y.

A = 6

A = By = $2y^2$ = 6 :

y = $\sqrt{3}$ = 1.732 m. } — (1)

B = 3.464 m.

P = B + 2y = 6.928 m   R = y/2 = .866

$Q_{max} = A \times \frac{1}{N} \times R^{2/3} S^{1/2}$

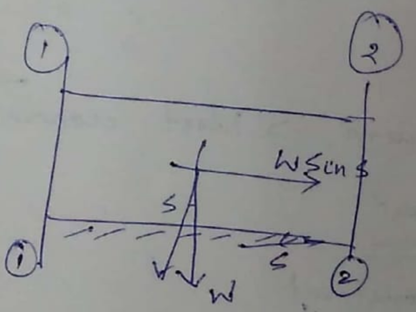
$= 6 \times \frac{1}{0.02} \times .866^{2/3} \times \frac{1}{1000}^{1/2}$

= $8.62 \, m^3/s$ — (2)

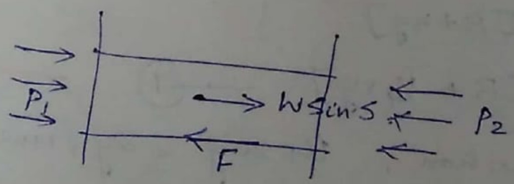
% increase in discharge = $\frac{8.62 - 8.56}{8.56} \times 100$

= 0.7% — (2)

2(a)



FBD



— (2)

$\Sigma F_x = m a_x$ — (1) $a_x = 0$ => uniform flow.

$P_1 - P_2 + W \sin S - F = 0$ — (1) $P_1 = P_2$ => uniform flow.

$W \sin S - F = 0$.

$w A L \sin S - f \times (P \times L) \times V^n = 0$ — (2)

w = unit weight of fluid

A = area of c/s

L = length of channel

f = frictional resistance per unit area per unit velocity

(n = 2) exp

$wAL \sin S - fPLv^2 = 0.$

$wA \sin S = fPv^2$

Since S very small $\sin S \simeq \tan S \simeq S$.

$wAS = fPv^2$

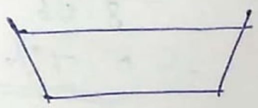
$$v^2 = \frac{wAS}{fP}$$

$$= \frac{w}{f} \times R \times S$$

$$v = \sqrt{\frac{w}{f} RS}$$

$$v = C\sqrt{RS}$$ — (1) C = Chezy's constant

(b.)



$$\frac{1}{n} = \frac{4}{1}$$

$n = 1/4$ — (1)

$Q = 20 m^3/s$

$V = 2 m/s$. — (1)

Lining is minimum => Most economical section.

$A = \frac{Q}{V} = \frac{20}{2} = 10 m^2$ — (1)

Area is kept constant ..

$A = y[B+ny]$.

$10 = y[B + 1/4 \times y]$ — (1) — (1)

Most eco. section, $B + 2ny = 2y\sqrt{1+n^2}$ — (1)

$B + 2 \times 1/4\, y = 2y\sqrt{1+(1/4)^2}$

$B + y/2 = 2y\sqrt{\frac{17}{16}}$

$B = 1.56y$ — (2)

Sub in (1) $10 = y[1.56y + 1/4 \times y]$

$y = 2.35m$

$B = 3.67m$ } — (2)

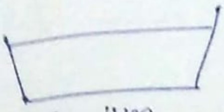
Area of lining = Perimeter × Length of channel (1)

$= B + 2y\sqrt{1+n^2} \times 1$

$= 3.67 + 2 \times 2.35 \sqrt{1+(1/4)^2} \times 1$

$= \underline{8.5 m}$ —— (1)

3. (a)



$n = 1/3$. $Q = 15 m^3/s$.

i) $y_c = \left(\frac{q^2}{g}\right)^{1/3}$ — (1) $q = \frac{Q}{B} = \frac{15}{4} = \underline{3.75 m^3/s/m}$

$= \left(\frac{3.75^2}{9.81}\right)^{1/3} = \underline{1.13m}$ — (1)

— (1)

ii) $E_{min} = \frac{3}{2} y_c$

$= \frac{3}{2} \times 1.13 = \underline{1.7m}$ — (1)

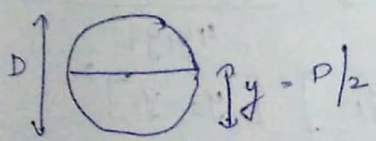
iii) @ $y = 0.8 m$, $y < y_c$

∴ supercritical flow. } (1.5)

$y = 1.5 m$, $y > y_c$

∴ subcritical flow. } (1.5)

(b) $S = 1/4000$ $Q = 5 m^3/s$. $N = 0.012$



$A = \frac{\pi/4 \, D^2}{2} = \frac{\pi D^2}{8}$ — (1) $R = \frac{A}{P} = \underline{D/4}$ — (1)

$P = \frac{\pi D}{2}$ — (1)

$Q = A \times \frac{1}{N} \times R^{2/3} \times S^{1/2}$ —— (2)

$5 = \frac{\pi D^2}{8} \times \frac{1}{0.012} \times (D/4)^{2/3} \times \left(\frac{1}{4000}\right)^{1/2}$ — (1)

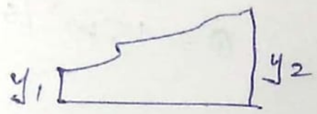
$\frac{5 \times .012 \times 4^{2/3} \times 4000^{1/2}}{\frac{\pi}{8} \times 5} = D^{2+2/3}$

$24.35 = D^{8/3}$

$D = \underline{3.31 m}$ — (2)

Part B

4(a)



— (1)

— (1)

Energy loss, $h_L = E_1 - E_2$

$$= y_1 + \frac{q^2}{2gy_1^2} - \left[y_2 + \frac{q^2}{2gy_2^2}\right] \text{ — (1)}$$

$$= \frac{q^2}{2g}\left[\frac{1}{y_1^2} - \frac{1}{y_2^2}\right] - [y_2 - y_1]$$

$$= \frac{q^2}{2g}\left[\frac{y_2^2 - y_1^2}{y_1^2 y_2^2}\right] - [y_2 - y_1]$$

$$q^2 = \frac{y_1 y_2 [y_1 + y_2] g}{2} \text{ — (1)}$$

$$= \frac{y_1 y_2 [y_1 + y_2] g}{2 \times 2g}\left[\frac{[y_2 - y_1][y_2 + y_1]}{y_1^2 y_2^2}\right] - [y_2 - y_1]$$

$$= (y_2 - y_1)\left[\frac{y_1^2 + y_2^2 + 2y_1 y_2}{4y_1 y_2} - 1\right]$$

$$= [y_2 - y_1]\,\frac{y_1^2 + y_2^2 + 2y_1 y_2 - 4y_1 y_2}{4y_1 y_2}$$

$$= \frac{[y_2 - y_1][y_2 - y_1]^2}{4y_1 y_2}$$

$$= \frac{[y_2 - y_1]^3}{4y_1 y_2} \text{ — (1)}$$

(b.) V = 1 m/s.

y = 0.6 m.

B = 7 m.

$y_c = \left(\dfrac{q^2}{g}\right)^{1/3}$ — (1) $\quad q = V \times y = .6\,m^3/s/m$ — (1)

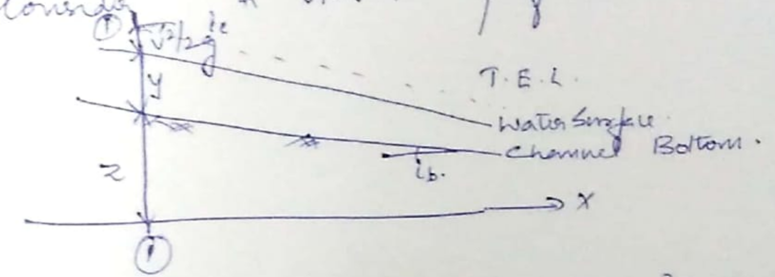
$= \left(\dfrac{.6^2}{9.81}\right)^{1/3} = \underline{0.33\,m}$ — (1)

$y_1 = 0.6\,m.$

$y_1 > y_c \quad \therefore$ hydraulic jump will not occur.

— (2)

5(a) Consider a G.V.F profile.



— (2)

Total Energy @ (1) $= z + y + \dfrac{v^2}{2g}$ — (1)

$$\frac{dE}{dx} = \frac{dz}{dx} + \frac{dy}{dx} + \frac{d}{dx}\left(\frac{Q^2}{B^2y^2 \times 2g}\right)$$

$$= \frac{dz}{dx} + \frac{dy}{dx} + \frac{Q^2}{B^2 \times 2g}\;\frac{-2}{y^3}\;\frac{dy}{dx}.$$

$$= \frac{dz}{dx} + \frac{dy}{dx} - \frac{v^2}{gy}\frac{dy}{dx}.$$ — (1)

$\dfrac{dE}{dx} = -i_e \quad ; \quad \dfrac{dz}{dx} = -i_b$

$$-i_e = -i_b + \frac{dy}{dx}\left[1 - \frac{v^2}{gy}\right]$$

$$\frac{dy}{dx} = \frac{i_b - i_e}{1 - \frac{v^2}{gy}}.$$ — (1)

(b.) $B = 15\,m \quad y = 4\,m. \quad Q = 25\,m^3/s \quad i_b = 1/4000$

$C = 60.$

$v = C\sqrt{R\,i_e}$ — (1)

$v = \dfrac{25}{15 \times 4} = .42\,m/s$ — (1)

$\dfrac{25}{15 \times 4} = 60\sqrt{\dfrac{15 \times 4}{15 + 4 \times 2} \times i_e}$

$i_e = \underline{1.84 \times 10^{-5}}$ — (1)

$$\frac{dy}{dx} = \frac{1/4000 - 1.84 \times 10^{-5}}{1 - .42^2/9.81 \times 4} = \underline{2.33 \times 10^{-4}}$$ — (2)