UNIT-III-

FLOW THROUGH OPEN CHANNELS

[13 MARKS]

THEORIES :- 06 Marks

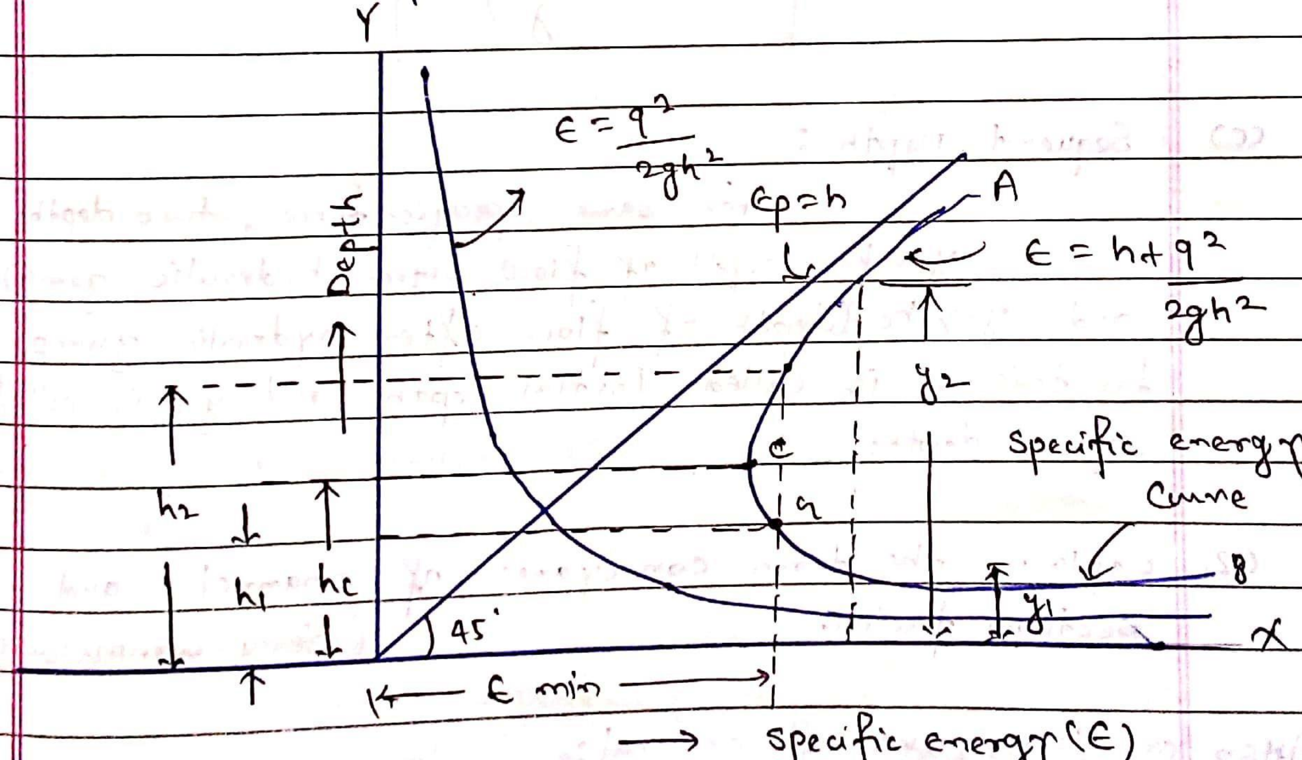
NUMERICALS :- 07 Marks

THEORY :-

01. Define :- (a) Alternate depth
(b) Sequent depth
(c) Critical depth

(Compulsary)

ANS-> (a) Alternate depth :-



(fig: Specific energy curve)

In the specific energy curve the point C corresponds to the minimum specific energy and the depth of flow at C is called critical depth. For any other value of the specific energy, there are two depths, one greater than the critical depth and other smaller than the critical depth. These two depths for a given specific energy are called the alternate depths. These depths are shown h_1 and h_2.

(b) Critical Depths :-

Critical depth is defined as that depth of flow of water at which the specific energy is minimum. This is denoted by 'h_c'.

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

(c) Sequent Depth :-

For same specific force, two depths are possible $y_1 < h_c$ (depth of flow before hydraulic jump) and $y_2 > h_c$ (depth of flow after hydraulic jump). In this y_1 is called Initial depth and y_2 is called as sequent depths.

02. Explain the term conveyance of channel and section factor. [Semi-compulsary]

Ans→ (a) Conveyance of channel:-

$$Q = AV$$

As per Chezy's equation and Mannings eqn

$$Q = AC\sqrt{RS}$$

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

$$\boxed{\therefore Q = A \frac{1}{n} R^{2/3} \sqrt{S}}$$

K is called as conveyance of channel,
It is a measure of carrying capacity of channel
for chezy's

$$K = AC\sqrt{R}$$

For manning's

$$K = A \frac{1}{n} R^{2/3}$$

b) Section factor :-

Using Mannings equations

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

$$AR^{2/3} = \frac{nQ}{\sqrt{S}}$$

The term $AR^{2/3}$ is called as section factor.

$$\boxed{\therefore Z_n = \frac{nQ}{\sqrt{S}}}$$

03. Distinguish between specific force and specific energy in details. (Compulsary)

ANS→ Specific force :-

Specific force is defined as the sum of momentum of flow passing the channel section per unit time per specific weight γ of the liquid and the hydrostatic forces per specific weight γ of the liquid.

Specific Energy :-

Specific energy (E) in a channel section is defined as the energy per unit weight of liquid at any section of a channel measured with respect to channel bottom as the datum.

04. Draw a specific energy diagram and show critical depth, minimum specific energy alternate depth, sub critical flow and super critical flow zones.

[FUTURE]

ANS→ Diagram :- ..... as Que No. 1 (Specific energy Curve)

Specific energy Curve:-

It is defined as the curve which shows the variation of specific energy with depth of flow.

05. What is meant by most economical section of a channel? State the conditions for a trapezoidal section to be most economical and derive.

(Semi-compulsary)

ANS→ Most Economical Section :-

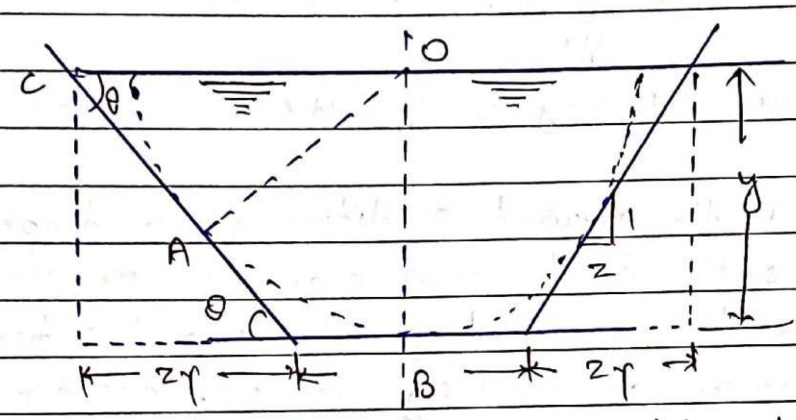
A section of a channel is said to be most economical when the cost of construction of the channel is minimum.

Most economical section is also called the best section or most efficient section as the discharge, passing through a most economicals section of channel for a given cross-sectional area (A), slope of the bed (i) and a resistance coefficient is maximum.

$$\boxed{\therefore Q = k \frac{1}{\sqrt{P}}}$$ where, $k = AC\sqrt{Ai}$ = Constant

[hydraulically most efficient section = most economical section]

Trapezoidal Section :- (Derive)



(Fig. Trapezoidal section)

For a trapezoidal channel section, of bottom width B, depth of flow y and side slope z horizontal to 1 vertical, following expression for wetted area A and wetted perimeter P can be written,

$$A = (B + zy) \times y \quad \text{—— (i)}$$

$$P = B + 2y\sqrt{1+z^2} \quad \text{—— (ii)}$$

from equation (i)

$$B = \frac{A}{y} - zy$$

Substituting the value of B in eq.n (ii) it becomes,

$$P = \frac{A}{y} - zy + 2y\sqrt{1+z^2} \quad \text{—— (iii)}$$

Assuming area A and side slope z to be constant,

Eq.n (iii) Differentiate w.r.t y

$$\frac{dP}{dy} = -\frac{A}{y^2} - z + 2\sqrt{1+z^2} = 0$$

$$\text{or} \quad \frac{A}{y^2} + z = 2\sqrt{1+z^2}$$

Substituting the value of A from eqⁿ (i)

$$\frac{(B+zy)y}{y^2} + z = 2\sqrt{1+z^2}$$

or $$\frac{B+2zy}{2} = y\sqrt{1+z^2} \quad \text{-----} \quad (iv)$$

Eqⁿ (iv) is the required condition for a trapezoidal channel section to be most economical or most efficient. It shows that for a trapezoidal channel section to be most economical or most efficient half the top width must be equal to one of the sloping sides of the channel.

The hydraulic radius R can be expressed as

$$R = \frac{A}{P}$$

$$R = \frac{(B+zy)y}{B+2y\sqrt{1+z^2}}$$

Substituting the values of B from eqⁿ (iv), we get

$$R = \frac{(2y\sqrt{1+z^2} - 2zy + zy)y}{2y\sqrt{1+z^2} - 2zy + 2y\sqrt{1+z^2}}$$

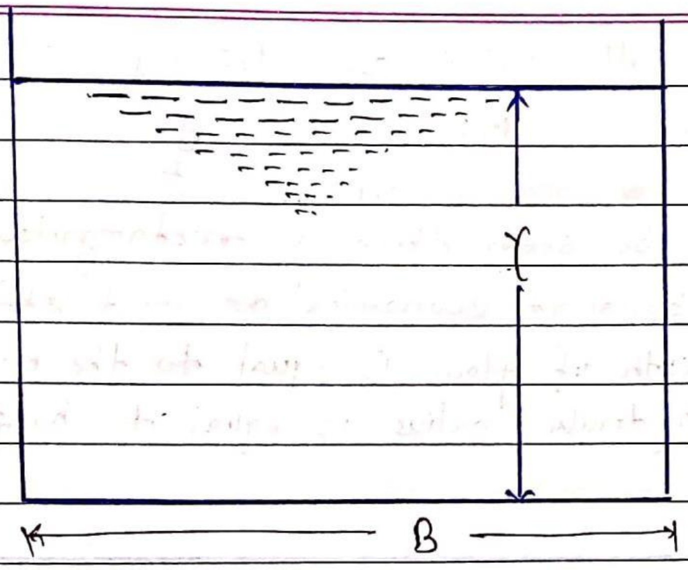
or $$R = \frac{y}{2}$$

Thus it can be seen that for a trapezoidal channel section to be most economical or most efficient the hydraulic radius must be equal to half depth of flow.

06. Derive the conditions for most economical rectangular Section.

[Compulsary]

ANS→ Derive :-



(fig: rectangular channel section)

For a rectangular channel section of bottom width B and depth of flow y, following expressions for wetted area A and wetted perimeter P can be written as

$$A = By \quad \text{——— (i)}$$
$$P = B + 2y \quad \text{——— (ii)}$$

from eq^n(i),

$$B = \frac{A}{y}$$

Substituting the value of B in eq^n(ii), we get

$$P = \frac{A}{y} + 2y \quad \text{——— (iii)}$$

Assuming the area A to be constant, eq^n(iii) diff. w.r.t y

$$\frac{dP}{dy} = -\frac{A}{y^2} + 2 = 0$$

or $$A = 2y^2 = By$$

$$B = 2y$$

or $$y = \frac{B}{2} \quad \text{——— (iv)}$$

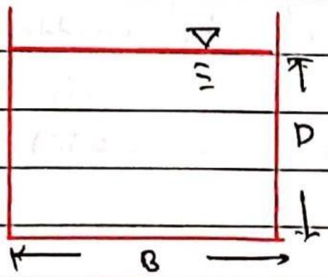
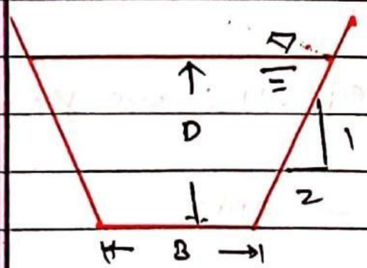
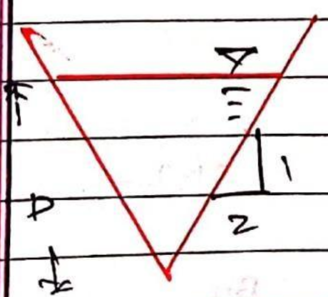
Also hydraulic radius $R = \frac{A}{P} = \frac{By}{B+2y}$

Substituting the value of $B = 2y$

$$R = \frac{2y^2}{2y + 2y} = \frac{y}{2}$$

Thus it can be seen that a rectangular channel section will be most economical or most efficient when either the depth of flow is equal to the half the bottom width, or hydraulic radius is equal to half the depth of flow.

FORMULA TABLE

Types	Area (A)	Perimeter (P)	Hydraulic radius R
	$A = B \times D$	$P = B + 2D$	$R = \frac{BD}{B+2D}$
	$A = (B + ZD)D$	$P = B + 2D\sqrt{Z^2+1}$	$R = \frac{(B+ZD)D}{B+2D\sqrt{Z^2+1}}$
	$A = ZD^2$	$P = 2D\sqrt{Z^2+1}$	$R = \frac{ZD^2}{2D\sqrt{Z^2+1}}$

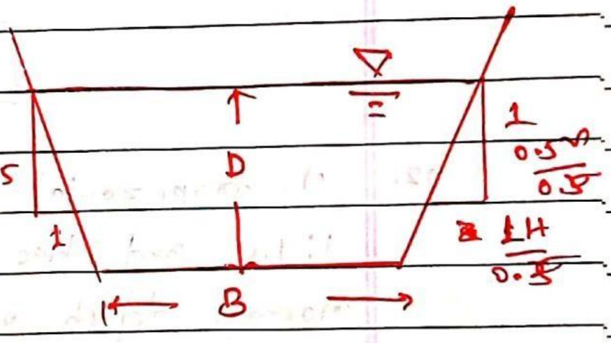
NUMERICALS :-

TYPE-I. [Compulsary]

[Based on Trapezoidal channel, Determine Dimension] Rectangular, [OR Design the Section] [7 MARKS]

01. A trapezoidal channel carries a discharge of 2.5 m³/sec if the bed slope is $\frac{1}{5000}$ and sides of channel slope 1 H : 0.5 V. Design most economical channel section, assuming mannings $n = 0.02$.

Sol^n → Given data, $Q = 2.5\ m^3/sec,\ n = 0.02$



$S = \frac{1}{5000}$

1H : 0.5V

but $z : 1$ $\quad$ $z = 0.5$

$\frac{1}{0.5} H = \frac{0.5\ V}{0.5}$

$2H = 1V$

$\boxed{\therefore z = 2}$ $\quad$ $z = \cancel{0.5}$ $\quad$ $z = 2$

for most economical channel section

$$\frac{B + 2zD}{2} = D\sqrt{z^2+1}$$

$$\frac{B + 2\times 2D}{2} = D\sqrt{2^2+1}$$

$$\frac{B+4D}{2} = D \times 2.236$$

$$B + 4D = 4.47D$$

$$B = 4.47D - 4D$$

$$\therefore B = 0.47D \quad \text{—— (i)}$$

Now,

$$Q = Av$$

$$Q = (B+zD)D \times \frac{1}{n} (R)^{2/3} (S)^{1/2}$$

$$\Rightarrow 2.5 = (0.470D + 2 \times D) D \times \frac{1}{0.02} \left(\frac{D}{2}\right)^{2/3} \left(\frac{1}{5000}\right)^{1/2}$$

$$\boxed{\therefore D = 1.35 m}$$

Put $D = 1.35$ eq^n (i)

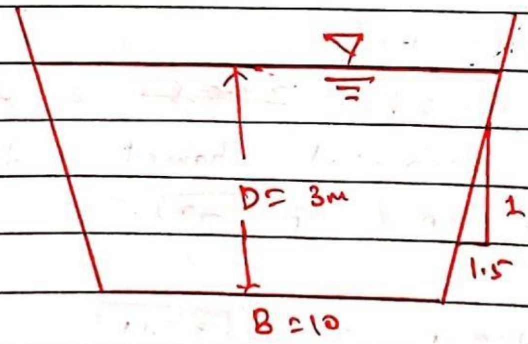
$$B = 0.47 \times D$$

$$B = 0.47 \times 1.36$$

$$\boxed{\therefore B = 0.64 m}$$

02. A trapezoidal channel of 10m width having side slope 1:1.5 and has to carry discharge of 150 m³/sec with normal depth of flow 3m, determine the bed slope take mannings coefficient = 0.013.

Sol^n →



Given data,
$Q = 150 \, m^3/sec$
$n = 0.012$
$z = 1.5$

To find :- $S = ?$

(i) Area $(A) = (B+zD) \cdot D$

$$A = (10 + 1.5 \times 3) 3$$

$$\boxed{\therefore A = 43.5 \, m^2}$$

(ii) $P = B + 2D\sqrt{Z^2+1}$

$P = 10 + 2 \times 3\sqrt{1.5^2+1}$

$\boxed{\therefore P = 20.816\,m}$

(iii) $R = \dfrac{A}{P} = \dfrac{43.5}{20.816}$

$\boxed{\therefore R = 2.089\,m}$

(iv) $Q = A \times V$

$Q = 43.5 \times \dfrac{1}{n} \times R^{2/3} \times S^{1/2}$

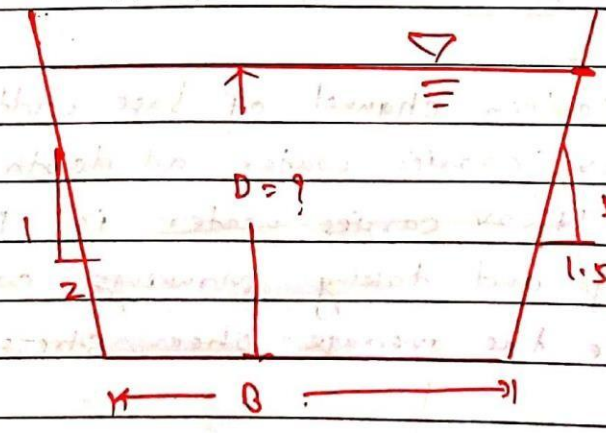
$\Rightarrow 150 = 43.5 \times \dfrac{1}{0.013} \times (2.089)^{2/3} \times S^{1/2}$

$S = \cancel{0.00064}\ 7.52 \times 10^{-4}$

$\boxed{\therefore S = 1 \text{ in } 1559.61} = 1 \text{ in } 1329.78.$

03. A trapezoidal channel having bottom width 4m has to carry dischage of 10m3/sec at bed slope of 1/2000 with side slope 1:1.5. Determine normal depth of flow taking Manning's constant = 0.016.

Soln→



Given data,

$Z = 1.5$

$B = 4m$

$Q = 10\,m^3/sec$

$S = \dfrac{1}{2000}$

(i) $A = (B + 2D) \times D$

$A = (4 + 1.5 \times D) \times D$

$\boxed{\therefore A = 4D + 1.5D^2}$

(ii) $P = B + 2D\sqrt{2^2 + 1}$

$P = 4 + 2D\sqrt{1.5^2 + 1}$

$\boxed{\therefore P = 4 + 3.6D}$

(iii) $R = \dfrac{A}{P}$

$R = \dfrac{4D + 1.5D^2}{4 + 3.6D}$

$\boxed{R = \dfrac{(4D + 1.5D^2)}{4 + 3.6D}}$

(iv) $Q = A \times V$

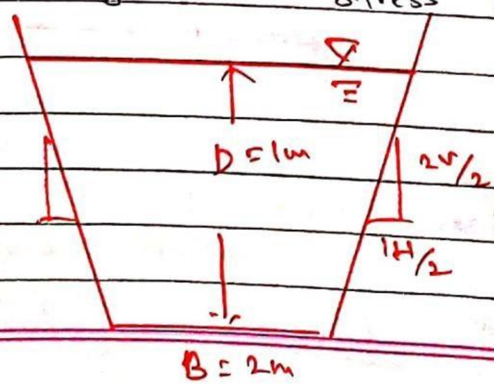
$Q = A \times \frac{1}{n} \times R^{2/3} \times S^{1/2}$

$\Rightarrow 10 = 4D + 1.5D^2 \times \dfrac{1}{0.016} \times \left[\dfrac{(4D + 1.5D^2)}{4 + 3.6D}\right]^{2/3} \times \left(\dfrac{1}{2000}\right)^{1/2}$

$\boxed{\therefore D = 1.439 \text{ m}}$

04. An earthen channel of base width 2m and side slope 1H:2V carries water at depth of 1m. If the bed slope ~~1H:2V carries water~~ is 1/625; calculate the discharge and taking Mannings constant N = 0.013. Also calculate the average shear stress boundaries.

Soln→



Given data,: V:H

1:0.5

$\therefore z = 0.5$

$S = 1/625$

$N = 0.013$

To find :- (a) $Q = ?$

(b) $\tau_0 = ?$

(i) $A = (B+zD)D$

$A = (2+0.5\times D)D$

$A = (2+0.5\times 1)\times 1$

$\boxed{\therefore A = 2.5 m^2}$

(ii) $P = B+2D\sqrt{z^2+1}$

$P = 2+2\times 1\sqrt{0.5^2+1}$

$\boxed{\therefore P = 4.23 m}$

(iii) $R = \frac{A}{P}$

$R = \frac{2.5}{4.23}$

$\boxed{\therefore R = 0.59 m}$

(iv) $Q = AV$

$Q = 2.6\times\frac{1}{0.013}\times(0.59)^{2/3}\times\left(\frac{1}{625}\right)^{1/2}$

$\boxed{\therefore Q = 5.41 m^3/sec}$

(v) Shear stress, τ_0

$\tau_0 = w.R.S$

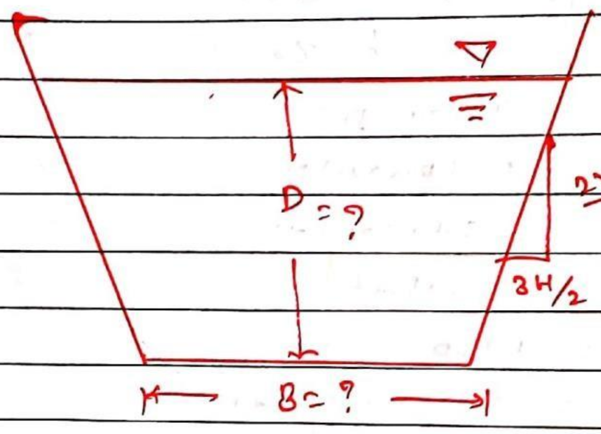
$\tau_0 = 9810.0.59\times(1/625)$

$\boxed{\therefore \tau_0 = 9.26 N/m^2}$

For most economical trapezoidal S/C conditions
(i) $\frac{B+2zD}{2} = D\sqrt{z^2+1}$
(ii) $R = D/2$ (iii) $z = \frac{1}{\sqrt{3}}$ consider (if not given)

05. An economical channel of trapezoidal section having side slope 3H:2V to carry flow of 10 m³/sec on longitudinal slope of 1/5000, the channel is to be lined for which the friction coefficient N = 0.012, determine dimensions of channel and area of lining per km length.

Solⁿ



Given data, 3H : 2V

$\therefore z = 1.5$

$Q = 10 \text{ m}^3/\text{sec}$

$S = \frac{1}{5000}$

$N = 0.012$

To find:- (a) Dimension of channel (B and D)
(b) Area of lining

(a) For most economical trapezoidal section

$$\frac{B+2zD}{2} = D\sqrt{z^2+1}$$

$$\frac{B+2\times1.5\times D}{2} = D\sqrt{1.5^2+1}$$

$$\frac{B+3D}{2} = D\times1.80$$

$$B+3D = 3.60D$$

$$B = 3.60D - 3D$$

$$\therefore B = 0.60D \quad \text{---- (i)}$$

[Earthen Channel = Trapezoidal Channel]

(b) $A = (B+2D)\times D$

$A = (B+1.5D)\times D$

(c) $Q = A\times V$

$Q = (B+1.5D)\times D \times \frac{1}{n} \times (R)^{2/3} \times (S)^{1/2}$

$\Rightarrow 10 = (B+1.5D)\times D \times \frac{1}{0.012} \times \left(\frac{D}{2}\right)^{2/3} \times \left(\frac{1}{5000}\right)^{1/2}$

$\Rightarrow 10 = (0.60D+1.5D)\times D \times \frac{1}{0.012} \times \left(\frac{D}{2}\right)^{2/3} \times \left(\frac{1}{5000}\right)^{1/2}$

$\boxed{\therefore D = 2.00m}$

Put $D = 2.00m$ in eqn(i)

$B = 0.60\times D$

$B = 0.60\times 2.00$

$\boxed{\therefore B = 1.20m}$

(d) Area of lining $=$ Perimeter $\times L$

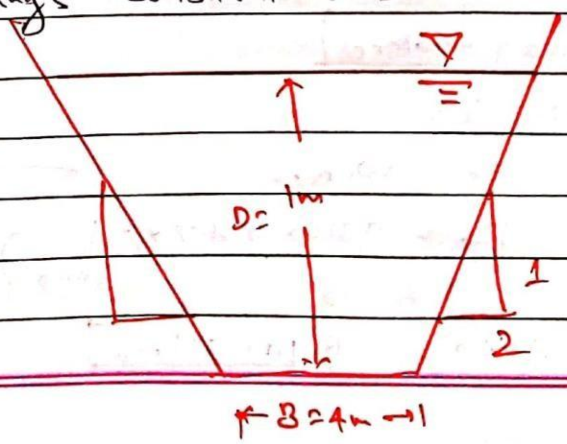
$= B+2D\sqrt{Z^2+1} \times 1000$

$= 1.20+2\times 2\sqrt{1.5^2+1} \times 1000$

$\boxed{\therefore A = 8411 m^2}$

S 2016 06. An earthen channel with a base width 4m and side slope 1:2 carries water with a depth of 1m, if the slope of the bed of the channel is 1:1000 ; find the discharge and the average shear stress at the channel boundary. Assume mannings constant 0.03.

Soln →



Given data,

$D = 1m$

$B = 4m$

$S = 1/1000$

$N = 0.03$

$z = 2$

To find :- (a) $Q = ?$

(b) $\tau_0 = ?$

(i) $A = (B + zD) \times D$

$A = (4 + 2 \times 1) \times 1$

$\boxed{\therefore A = 6\ m^2}$

(ii) $P = B + 2D\sqrt{z^2+1}$

$P = 4 + 2 \times 1\sqrt{2^2+1}$

$\boxed{\therefore P = 8.47 m}$

(iii) $R = \frac{A}{P}$

$R = \frac{6}{8.47}$

$\boxed{\therefore R = 0.708}$

(iv) $Q = A \times V$

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

$Q = \frac{6 \times 1}{0.03} \times \left(\frac{1}{1000}\right)^{1/2} \times (0.708)^{2/3}$

$\boxed{\therefore Q = 5.024\ m^3/sec}$

(v) Shear stress, τ_0

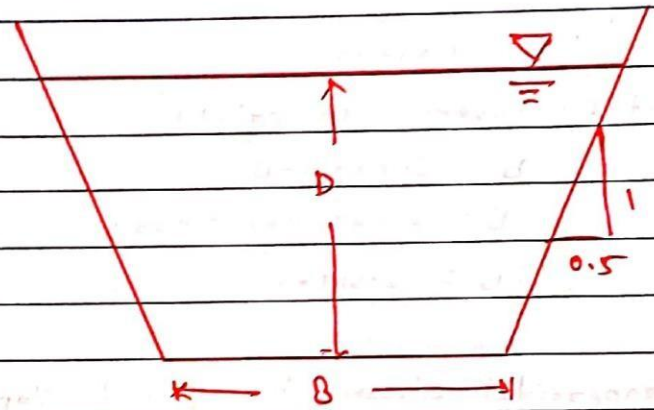
$\tau_0 = w \cdot R \cdot S$

$\tau_0 = 9810 \times 0.708 \times \left(\frac{1}{1000}\right)$

$\boxed{\therefore \tau_0 = 6.945\ N/m^2}$

W/2015 07. A trapezoidal channel carries a discharge of 4.0 m^3/sec. Design the most efficient if the channel, side slope 1:0.5 bed slope 1/5000 and Rugosity coefficient 0.0225.

Sol^n →



Given data: $Q = 4.0\ m^3/sec$

$z = 0.5$

$S = \frac{1}{5000}$

$N = 0.0225$

(a) for most economical or most efficient section.

$$\frac{B + 2zD}{2} = D\sqrt{z^2+1}$$

$$\frac{B + 2 \times 0.5 \times D}{2} = D\sqrt{0.5^2+1}$$

$$\frac{B + 1 \times D}{2} = D \times 1.118$$

$$B + D = 2.236D$$

$$\therefore B = 2.236D - D \quad \text{——— (i)}$$

(b) $A = (B + zD) \times D$

$A = (B + 0.5D) \times D$

(c) $Q = Av$

$$Q = (B + 0.5D) \times D \times \frac{1}{n} \times (R)^{2/3} \times (S)^{1/2}$$

$$\Rightarrow 4.0 = \frac{(B+0.5D)\times D \times 1}{0.0225} \times \left(\frac{D}{2}\right)^{2/3} \left(\frac{1}{5000}\right)^{1/2}$$

$$\Rightarrow 4.0 = (2.36D - D + 0.5D) \times D \times \frac{1}{0.0225} \times \left(\frac{D}{2}\right)^{2/3} \times \left(\frac{1}{5000}\right)^{1/2}$$

$$\boxed{\therefore D = 1.886\ m}$$

Put $D = 1.886m$ in equ(i)

$$B = 2.236D - D$$

$$B = 2.236 \times 1.886 - 1.886$$

$$\boxed{\therefore B = 2.519\ m}$$

W 2014

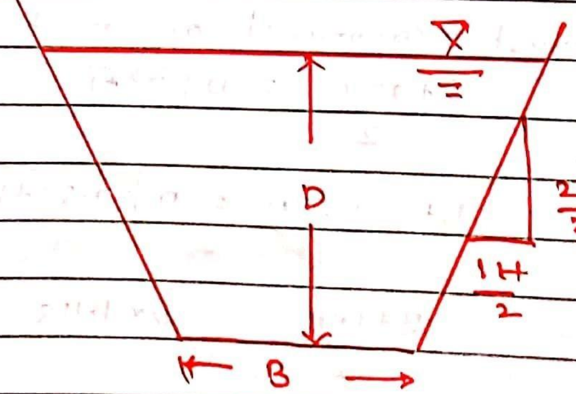
08. A trapezoidal channel having bed slope and side slop of 1:1500 and 1H:2V respectively. The area of section is $40m^2$. If chezy's constant (C) = 60.

Determine:

(a) The dimension of the cross-section if is most economical.

(b) Discharge of the most economical section.

Solⁿ →



Given data, $S = 1/1500 = i$

$A = 40m^2$

$C = 60$

$z = 0.5$

(a) for the most economical section

$$\frac{B+2zD}{2} = D\sqrt{z^2+1}$$

$$\frac{B + 2\times0.5D}{2} = D\sqrt{0.5^2+1}$$

$$\frac{B + 1D}{2} = 1.118D$$

$$B + 1D = 2.236D$$

$$B = 2.236D - 1D$$

$$\therefore B = 1.236D \quad \text{——— (i)}$$

(b) $A = (B+2D)\times D$

$\Rightarrow 40 = (1.236D + 0.5D)\times D$

$$\boxed{\therefore D = 4.80 m}$$

Put $D = 4.80$ m in eqn (i)

$$B = 1.236\times D$$

$$B = 1.236\times 4.80$$

$$\boxed{\therefore B = 5.932 m}$$

(c) Discharge for most economical section,

$$m = \frac{D}{2}$$

$$m = \frac{4.80}{2}$$

$$\boxed{\therefore m = 2.40 m}$$

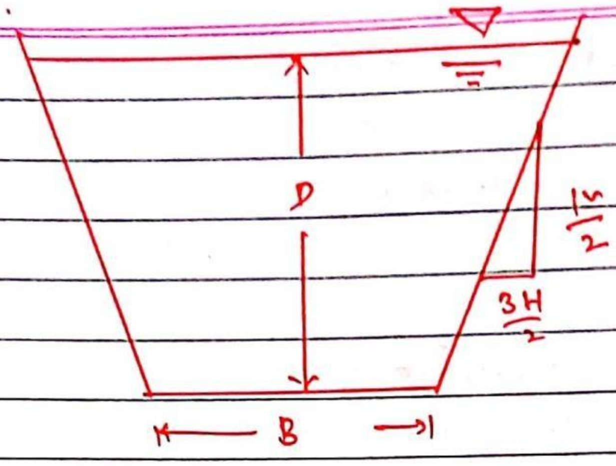
$\therefore$ Discharge $= AC\sqrt{mi}$ --- $i = s$

$$Q = 40\times60\sqrt{\frac{2.40\times1}{1500}}$$

$$\boxed{\therefore Q = 96 \ m^3/sec}$$

W 2013 Q9. A trapezoidal channel is to be designed to carry a discharge of 2.5 m^3/sec. Design the most economical section; for a bed slope of 1 in 1200 and side slope as 3H : 1V. use Chezy formula with the value of Chezy's constant C = 56.

Sol^n →



Given data,

$$Q = 2.5 \, m^3/sec$$

$$z = 3$$

$$S = 1/1200 = i$$

$$c = 56.$$

(a) for the most economical s/c

$$\frac{B + 2zD}{2} = D\sqrt{z^2+1}$$

$$\frac{B + 2 \times 3 \times D}{2} = D\sqrt{3^2+1}$$

$$\frac{B + 6D}{2} = D \times 3.16$$

$$B + 6D = 6.324 \times D$$

$$B = 6.324D - 6D$$

$$\therefore B = 0.324D \text{ ---- (i)}$$

(b) $A = (B + zD) \times D$

$A = (B + 3 \times D) \times D$

$\therefore A = (B + 3D) \times D$

(c) $m = \dfrac{D}{2}$

(d) $Q = AC\sqrt{mi}$ ———— $i = s$

$$\Rightarrow 2.5 = (B + 3D) \times D \times 56 \sqrt{\frac{D}{2} \times \frac{1}{1200}}$$

$$\Rightarrow 2.4 = (0.324D + 3D) \times D \times 56 \times \sqrt{\frac{D}{2} \times \frac{1}{1200}}$$

$$\boxed{\therefore D = 0.8321 \text{ m}}$$

Put $D = 0.8321$ in eqn (i),

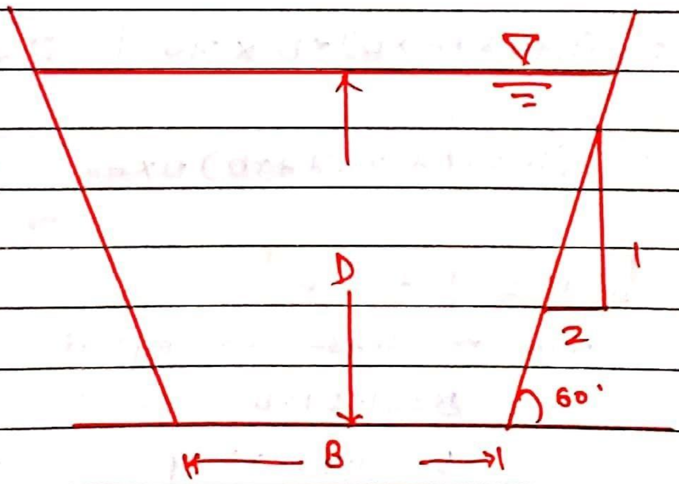
$$B = 0.324 \times D$$

$$B = 0.8321 \times 0.324$$

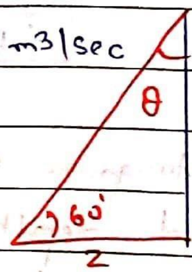
$$\boxed{\therefore B = 0.269 \text{ m}}$$

S/2013 10. A trapezoidal channel having side slopes 60° with horizontal conveys a discharge of $12 \, m^3/sec$. The bed slope of channel is 1 in 800. Find the bottom width and depth of flow for most economical condition. Assume chezy's constant = 70.

Soln →



Given data, $S = \frac{1}{800} = i$, $Q = 12 \, m^3/sec$



$C = 70$

$\theta = 30^\circ$

$\tan 30^\circ = \frac{z}{1}$

$z = \tan 30^\circ$

$z = 0.577$

(a) for the most economical section

$$\frac{B+2zD}{2} = D\sqrt{z^2+1}$$

$$\frac{B+2\times 0.577\times D}{2} = D\sqrt{0.577^2+1}$$

$$\frac{B+1.154\times D}{2} = 1.154D$$

$$B+1.154D = 2.309D$$

$$\therefore B = 1.159D \text{ ---- (i)}$$

(b) $A = (B+zD)\times D$

$\therefore A = (B+0.577\times D)\times D$

(c) $Q = AC\sqrt{mi}$ $\quad m = \frac{D}{2}, \quad i = s$

$$\Rightarrow 12 = (B+0.577\times D)\times D\times 70\sqrt{\frac{D}{2}\times\frac{1}{800}}$$

$$\Rightarrow 12 = (1.159D+0.577\times D)D\times 70\sqrt{\frac{D}{2}\times\frac{1}{800}}$$

$$\boxed{\therefore D = 1.732\text{ m}}$$

put $D = 1.732$ in eqn (i)

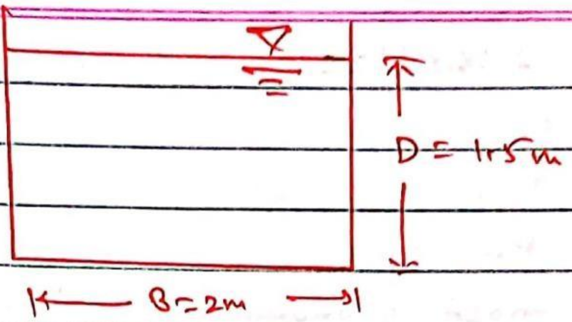
$B = 1.159\times D$

$B = 1.732\times 1.159$

$$\boxed{\therefore B = 2.007\text{ m}}$$

W 2016 11. A rectangular channel cross section having base width of 2m and depth of flow 1.5m. Bed slope is 1in 2000 is to be converted into most economical trapezoidal cross section with side slope 1:15; so as to carry same discharge with same bed slope. Determine dimension of trapezoidal section Take N = 0.016.

Sol^n →



Given data, $S = 1/2000$

$N = 0.016$

(a) $A = B \times D$

$A = 2 \times 1.5$

$\boxed{\therefore A = 3 m^2}$

(b) $P = B + 2D$

$P = 2 + 2 \times 1.5$

$\boxed{\therefore P = 5 m}$

(c) $R = \frac{A}{P}$

$R = \frac{3}{5}$

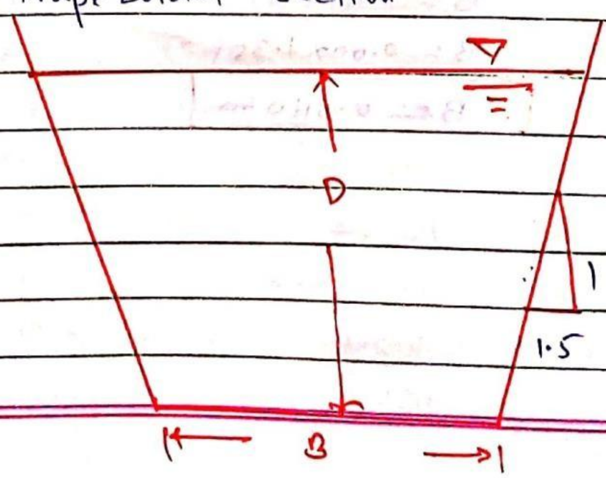
$\boxed{\therefore R = 0.6 m}$

(d) $Q = A \times V$

$Q = 3 \times \frac{1}{0.016} (0.6)^{3/2} \times (1/2000)^{1/2}$

$\boxed{\therefore Q = 2.98 \; m^3/sec}$

Now; for Trapezoidal Section



$Q = 2.98\ m^3/sec$

$B = ?$

$D = ?$

$z = 1.5$

(a) For most economical section,

$$\frac{B + 2zD}{2} = D\sqrt{z^2+1}$$

$$\frac{B + 2\times1.5\times D}{2} = D\sqrt{1.5^2+1}$$

$$\frac{B+3D}{2} = D\times 1.80$$

$$B + 3D = 3.60D$$

$$\therefore B = 0.60D \quad ---- (i)$$

(b) $A = (B+zD)\times D$

$A = (B+1.5D)\times D$

(c) $Q = AV$

$$\Rightarrow 2.98 = (B+1.5D)\times D \times \frac{1}{0.016} \times \left(\frac{D}{2}\right)^{3/2} \times \left(\frac{1}{2000}\right)^{1/2}$$

$$\Rightarrow 2.98 = (0.60D + 1.5D)\times D \times \frac{1}{0.016} \times \left(\frac{D}{2}\right)^{3/2} \times \left(\frac{1}{2000}\right)^{1/2}$$

$$\boxed{\therefore D = 1.351m}$$

Put $D = 1.351m$ in eqn(i)

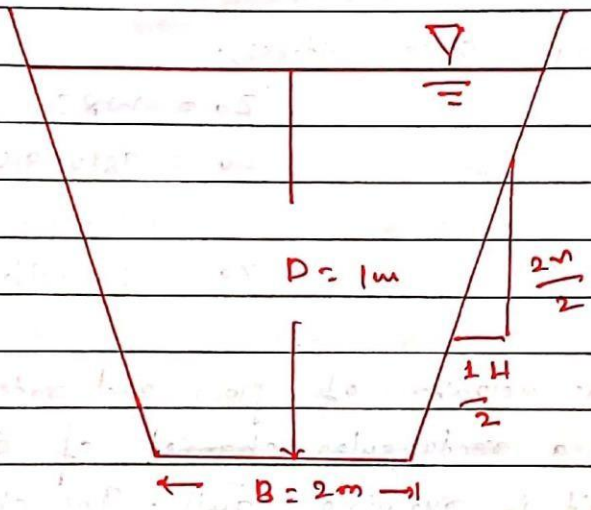
$B = 0.60\times D$

$B = 0.60\times 1.351$

$$\boxed{\therefore B = 0.8110\ m}$$

12. An easthern channel with a base width 2 m and side Slope 1 horizontal to 2 vertical carries water a depth of 1 m. The bed slope is 1 in 625. Calculate the discharge if $n = 0.03$. Also calculate the average shear stress at the channel boundary.

Sol^n



Given data:- $B = 2\ m$

$z = 0.5$

$D = 1m$

$S = 1/625$

$n = 0.03$

To find:- (a) $Q = ?$

(b) $\tau_0 = ?$

$A = (B + zD) \times D$

$A = (2 + 0.5 \times 1) \times 1$

$\therefore A = \cancel{4\ m^2}\ 2.5\ m^2$

$P = B + 2D\sqrt{z^2 + 1}$

$P = 2 + 2 \times 1\sqrt{0.5^2 + 1}$

$\therefore P = 4.236\ m$

$R = A/P = \dfrac{2.5}{4.236} = 0.590$

For ~~rect~~ trapezoidal Section

Design – $R = D/2$

Analysis – $R = A/P$

$$Q = A \times v$$

$$Q = 2.5 \times (S)^{1/2} (R)^{2/3} \times \frac{1}{n}$$

$$Q = 2.5 \times \frac{1}{0.03} \times \left(\frac{1}{625}\right)^{1/2} (0.59)^{2/3}$$

$$\boxed{\therefore Q = 2.344 \ m^3/sec}$$

Average shear stress,

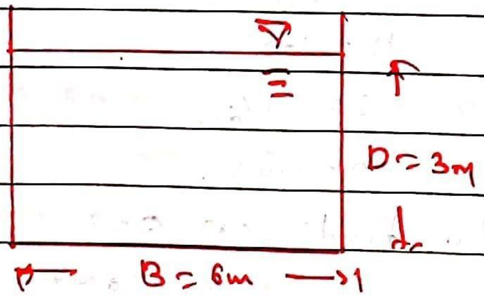
$$\tau_0 = wRS$$

$$\tau_0 = 9810 \times 0.59 \times \frac{1}{625}$$

$$\boxed{\therefore \tau_0 = 9.26 \ N/m^2}$$

13. Find the velocity of flow and rate of flow of water through a rectangular channel of 6m wide 3m deep when it is running full. The channel is having bed slope as 1 in 2000. Take chezy's constant C = 55.

Sol^n →



Given data,

$B = 6m$

$D = 3m$

$S = 1/2000$

$C = 55$

$$A = B \times D$$

$$A = 6 \times 3$$

$$\therefore A = 18 \ m^2$$

$$P = B + 2D = 6 + 2 \times 3 = 12m$$

for rectangular Section for chezy

Design - $m = D/2$

Analysis - $m = A/P$

$R = \frac{A}{P} = \frac{18}{12} = 1.5$

$Q = A \times v$

$Q = 18 \times C\sqrt{mi}$ $\quad i = s \quad$ $m = d/2 \quad \frac{A}{P}$

$v = 55\sqrt{\frac{3}{2} \times 1/2000}$ $\quad m = \frac{A}{P}$

1.5

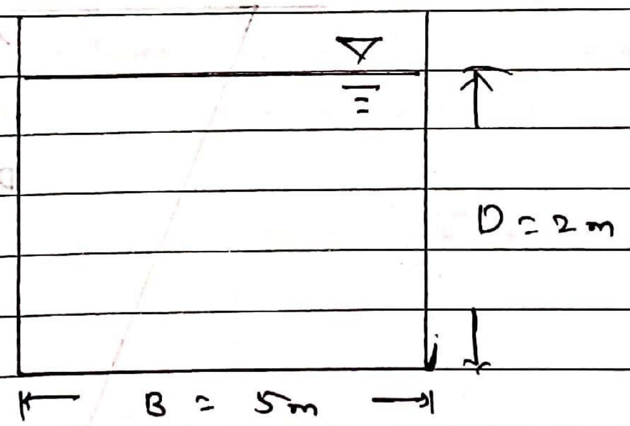
$\boxed{\therefore v = 1.506 \, m/s}$

$Q = 18 \times 1.506$

$\boxed{\therefore Q = 27.11 \, m^3/sec}$

14. Find the slope of the bed of a rectangular channel of width 5m when depth of water is 2m and rate of flow is given as 20 m³/sec. Take chezy's const. c = 50.

Soln →



Given data,
$B = 5m$
$D = 2m$
$C = 50$
$Q = 20 \, m^3/sec$

To find :- $i = s = ?$

$A = B \times D = 5 \times 10 = 10 \, m^2$

$P = B + 2D = 5 + 2 \times 2 = 9m$

$$Q = AC\sqrt{mi}$$

$$m = \frac{A}{P} = \frac{10}{9}$$

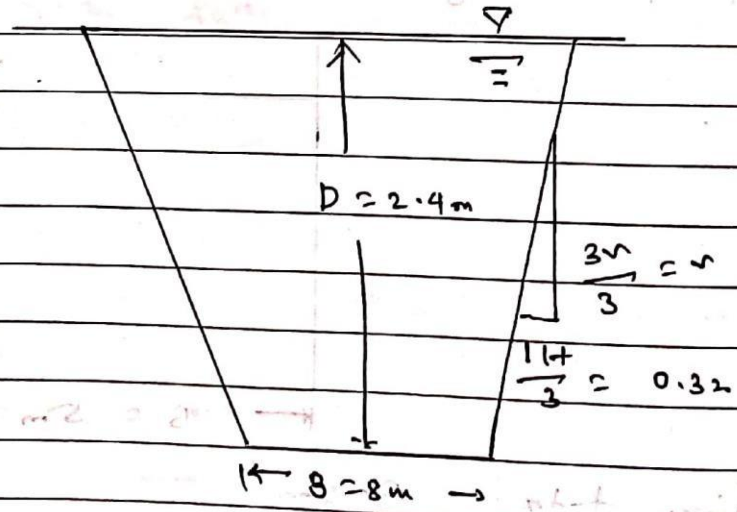
$$m = 1.10$$

$$\Rightarrow 20 = 10 \times 50\sqrt{1.10 \times i}$$

$$\boxed{\therefore i = 1.4545 = \frac{1}{1.4545} = 1 \text{ in } 0.687}$$

15. Find the discharge through a trapezoidal channel of width 8m and side slope of 1 horizontal to 3 vertical. The depth of flow of water is 2.4m and value of chezy's constant, C=50. The slope of the bed of the channel is given 1 in 4000.

Soln→



Given data, $B = 8m$

$Z = 0.32$

$D = 2.4m$

$C = 50$

$i = S = 1/4000$

To Find :- $Q = ?$

$A = (B+ZD) \times D$

$A = (8+0.32\times2.4)\times2.4$

$\therefore A = 21.04\ m^2$

$P = B+2D\sqrt{Z^2+1}$

$P = 8+2\times2.4\sqrt{0.32^2+1}$

$\therefore P = 13.039\ m$

$m = \frac{A}{P} = \frac{21.04}{13.039} = 1.60$

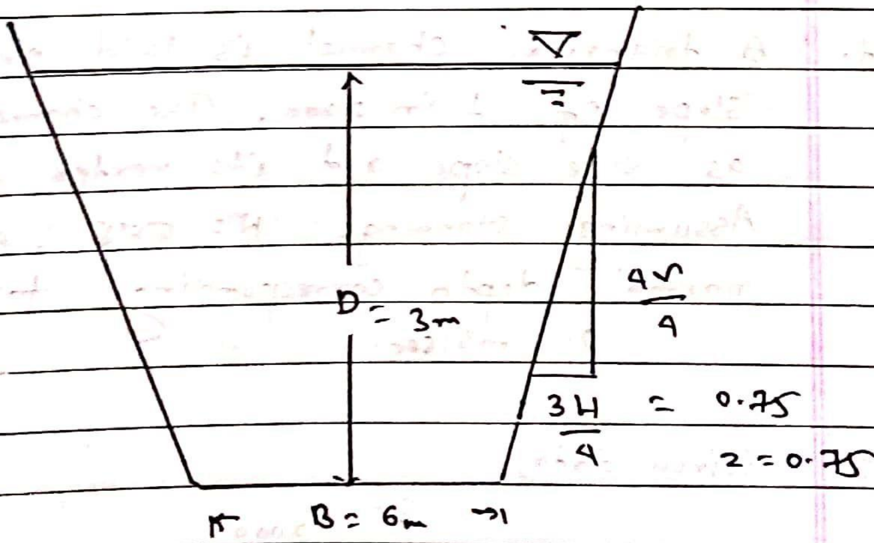
$Q = AC\sqrt{mi}$

$Q = 21.04\times50\sqrt{1.60\times\frac{1}{400}}$

$\boxed{\therefore Q = 21.04\ m^3/sec}$

16. Find the bed slope of trapezoidal channel of bed width 6m, depth of water 3m and side slope of 3 horizontal to 4 vertical, when the discharge through the channel is 30 m3/sec. Take Chezy's Const. C=70.

Sol^n,



Given data;

$D = 3m$

$B = 6m$

$Z = 0.75$

$Q = 30\ m^3/sec$, $C = 70$

To find = $i = ?$

$A = (B+zD)\times D$

$A = (6+0.75\times3)\times3$

$A = 24.75\,m^2$

$P = B+2D\sqrt{z^2+1}$

$P = 6+2\times3\sqrt{0.75^2+1}$

$\therefore P = 13.5\,m$

$m = \frac{A}{P}$

$m = \frac{24.75}{13.5}$

$\therefore m = 1.82$

$Q = AC\sqrt{mi}$

$\Rightarrow 30 = 24.75\times70\sqrt{1.82\times i}$

$i = 1.6474\times10^{-4}$

$\boxed{\therefore i = 1 \text{ in } 6070.171}$

S/2015 17. A triangular channel is laid on a longitudinal bed slope of 1 in 2000. The channel has 1.5 H to 1V as side slope and its vertex downwards. Assuming Mannings N = 0.015, estimate the normal depth corresponding to discharge of 0.4 m3/sec.

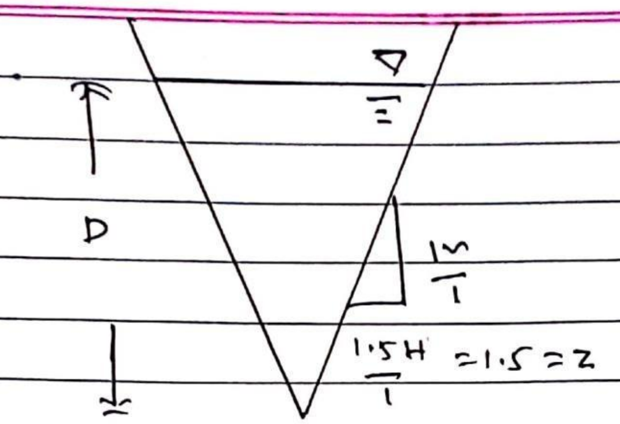
Soln: Given data,

$S = 1/2000$

$z = 1.5$

$N = 0.015$

$Q = 0.4\,m^3/sec$



$Q = A \times v$

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

$A = 2D^2$

$A = 1.5D^2$

For design always $R = \frac{D}{2}$

$m = D/2$

$P = 2D\sqrt{z^2+1}$

$P = 2D\sqrt{1.5^2+1}$

$P = 2D \times 1.80$

$\therefore P = 3.60D$

$R = \frac{1.5D^{\cancel{2}}}{3.60\cancel{D}}$

$R = 0.416D$

$\Rightarrow 0.4 = 1.5D^2 \times \frac{1}{0.015} \times \left(\frac{1}{2000}\right)^{1/2} \left(\frac{\cancel{0.416D}}{D/2}\right)^{2/3}$

$\boxed{\therefore D = 0.6236 \text{ m}}$