Canal Design

Using Kennedy's (1895) theory

$$V_0 = c_1 \cdot y^{c_2}$$

$$\boxed{V_0 = 0.55\, m y^{0.64}} \qquad \text{...(4.}$$

where V_0 = Critical velocity in the channel in m/s.

y = water depth in channel in m

$m = C.V.R$

Table 4.2. Recommended Values of C.V.R. (m)

S.No.	*Type of silt*	*Value of m*
1.	Silt of River Indus (Pakistan)	0.7
2.	Light sandy silt in North Indian Rivers	1.0
3.	Light sandy silt, a little coarser	1.1
4.	Sandy, loamy silt	1.2
5.	Debris of hard soil	1.3

Kutter's Formula

$$V = \left[\frac{\frac{1}{n} + \left(23 + \frac{0.00155}{S}\right)}{1 + \left(23 + \frac{0.00155}{S}\right)\frac{n}{\sqrt{R}}} \right] \sqrt{RS}$$

Manning's Formula

$$V = \frac{1}{n} R^{2/3} \cdot S^{1/2}$$

Chezy's Formula

$$V = C\sqrt{RS}$$

Example 4.6. *Design an irrigation channel to carry 50 cumecs of discharge. The channel is to be laid at a slope of 1 in 4000. The critical velocity ratio for the soil is 1.1. Use Kutter's rugosity coefficient as 0.023.*

Solution. $Q = 50$ cumecs, $\quad S = \dfrac{1}{4000}$

$m = 1.1, \quad n = 0.023$

Use equation (4.19), as, $V_0 = 0.55m \cdot y^{0.64}$

Assume a depth equal to 2 m

$$V_0 = 0.55 \times 1.1 \times (2)^{0.64} = 0.605 \times 1.558 = \mathbf{0.942} \text{ m/sec}$$

$$A = \frac{Q}{V_0} = \frac{50}{0.942} = 53.1 \text{ m}^2.$$

Assume side slopes as $\frac{1}{2}:1\left(\frac{1}{2}H:1V\right)$

Now, $A = y\left(b + y \cdot \frac{1}{2}\right)$

$\therefore$ $53.1 = 2\,(b+1)$

or $26.55 = b + 1$

or $b = 25.55$ m

and $P = b + 2\sqrt{\left(1+\frac{1}{4}\right)} \times y$

or $P = b + 2\,\frac{\sqrt{5}}{2}\,y = 25.55 + \sqrt{5} \times 2 = 30.03$

$R = \frac{A}{P} = \frac{53.1}{30.03} = 1.77$ m.

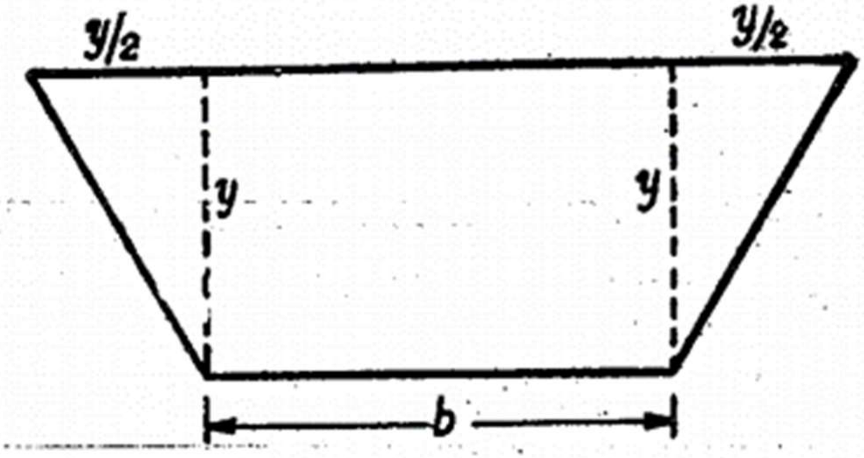

Fig. 4.9.

But, from eqn. (4.20),

$$V = \left[\frac{\frac{1}{n} + \left(23 + \frac{0.00155}{S}\right)}{1 + \left(23 + \frac{0.00155}{S}\right)\frac{n}{\sqrt{R}}} \right] \sqrt{RS}$$

$$\therefore \quad V = \left[\frac{\frac{1}{0.023} + 23 + \frac{0.00155}{1/4000}}{1 + \left(23 + \frac{0.00155}{1/4000}\right)\frac{0.023}{\sqrt{1.77}}} \right] \sqrt{1.77 \times \frac{1}{4000}}$$

$$= \left[\frac{43.5 + (23 + 6.2)}{1 + \frac{29.2 \times 0.023}{1.33}} \right] \left[1.33 \times \frac{1}{63.3} \right]$$

$$= \frac{72.7}{1 + 0.505} \times 1.33 \times \frac{1}{63.3} = \frac{72.7}{1.505} \times 1.33 \times \frac{1}{63.3}$$

$$= 1.016 \text{ m/sec} > 0.942 \text{ ; or } V > V_0.$$

In order to *increase* the critical velocity (V_o),, we have to *increase* the depth. So increase the depth.

Use 3 m depth :

$$V_0 = 0.605 \times (3)^{0.64} = 0.605 \times 2.02 = 1.22 \text{ m/sec.}$$

$$A = \frac{50}{1.22} = 40.8 \text{ m}^2.$$

$$40.8 = 3\left(b + \tfrac{1}{2} \cdot 3\right)$$

or $\quad 13.6 - 1.5 = b = 12.1$ m.

$$P = 12.1 + 2 \times \frac{\sqrt{5}}{2} 3 = 12.1 + 6.72 = 18.82$$

$$R = \frac{A}{P} = \frac{40.8}{18.82} = 2.17 \text{ ; therefore } \sqrt{R} = 1.47.$$

$$V = \frac{43.5 + 29.2}{1 + \frac{29.2 \times 0.023}{1.47}} + \left[1.47 \times \frac{1}{63.3}\right] = \frac{72.7}{1.45} \times 1.47 \times \frac{1}{63.3}$$

$$= 1.16 \text{ m/sec.} < 1.22 \text{ ; or } V < V_0$$

So reduce the depth.

Use 2.5 m depth

$$V_0 = 0.605 \times (2.5)^{0.64} = 0.605 \times 1.797 = 1.087 \text{ m/sec.}$$

$$A = \frac{50}{1.087} = 46$$

$$46 = 2.5\,(b + \tfrac{1}{2} 2.5)$$

$$18.4 - 1.25 = b = 17.15 \text{ m}$$

$$P = 17.15 + \sqrt{5} \times 2.5 = 17.15 + 5.58 = 22.73$$

$$R = \frac{A}{P} = \frac{4}{22.73} = 2.02 \text{ ; therefore } \sqrt{R} = 1.42$$

$$V = \frac{72.7}{1 + \frac{29.2 \times 0.023}{1.42}} (1.42) \left(\frac{1}{63.3}\right) = \frac{72.7}{1.472} \times \frac{1.42}{63.3}$$

$$= 1.1 \text{ m/sec} > 1.087 \text{ ; } V > V_0$$

So increase the depth.

Use 2.7 m depth

$$V_0 = 0.605 \times 1.189 = 1.147$$

$$A = \frac{50}{1.147} = 43.5$$

$$43.5 = 2.8\,(b + \tfrac{1}{2} 2.8)$$

$$15.54 - 1.4 = b = 14.14 \text{ m}$$

$$P = 14.14 + \sqrt{5} \times 2.8 = 14.14 + 6.26 = 20.40$$

$$R = \frac{43.5}{20.4} = 2.13, \text{ therefore, } \sqrt{R} = 1.46$$

$$\therefore \qquad V = \left[\frac{72.7}{1 + \dfrac{29.2 \times 0.023}{1.46}}\right]\left[\frac{1.46}{63.3}\right] = \left[\frac{72.6}{1.46}\right]\left[\frac{1.46}{68.3}\right]$$

$$= 1.148 \text{ m/sec} \approx 1.147 \text{ or } V \approx V_0.$$

Actual velocity V tallies with V_0.

Hence, use the depth equal to 2.7 m and base width 14.14 m. (say 14.2 m) with slopes $\frac{1}{2}$: 1 of trapezoidal section. **Ans.**