

**Kennedy's theory of designing unlined Canals:** Kennedy selected a number of canal sections in the upper Bari-Doab region which did not required any silt clearance for more than 35 years and were supposed to be flowing with non-silting and non-scouring velocity. Kennedy put forward the following facts out of his study.

- The bed of the canal offers frictional resistance to the flow of water, as a result critical eddies (Turbulences) arise from the bottom of the bed. These eddies keep the sediments carried by water in suspension. Some eddies also arise from the sides of the canal, but do not support the sediments. Hence, the sediment supporting capacity is proportional to the bed width of the canal.
- The critical velocity or non-silting and non scouring velocity ( $V_o$ ) is a function of the depth of the flowing water ( $D$ ). It is given by the relationship  $V_o = c m D^n$

Where, 'c' is and 'n' are coefficients suggested by Kennedy for canals of Bari-Doad region. The values of 'c' differs for different materials are

Light Sandy silt       $c = 0.53$

light sandy silt       $c = 0.59$

Sandy loan       $c = 0.65$

Coarse silt       $c = 0.70$

Note: Unless otherwise specified, values of c and n can be taken as  $c = 0.55$  and  $n = 0.64$

Thus, the equation for critical velocity becomes  $V_o = 0.55 m D^{0.64}$ . Where, V represents mean velocity of flow. The value of m also varies with the silt

Types of Silt	Value of 'm'
Silt of Indus rivers	0.7
Light Sandy silt of north India	1.0
Coarse-sandy silt	1.1

Sandy, Loamy silt	1.2
Coarse silt of hard rock	1.3

Note: Unless, otherwise specified  $m = 1.0$

The mean velocity of flow is given by  $V = C\sqrt{RS}$

Where C represents Chezy's constant and is given by

$$C = \frac{23 + (1 + N) + (0.0015 \div S)}{1 + (23 + (0.0015 \div S) \times (N \div \sqrt{R}))}$$

Where, N represents Kutter's Rugosity coefficient,

S represents Bed slope of the canal

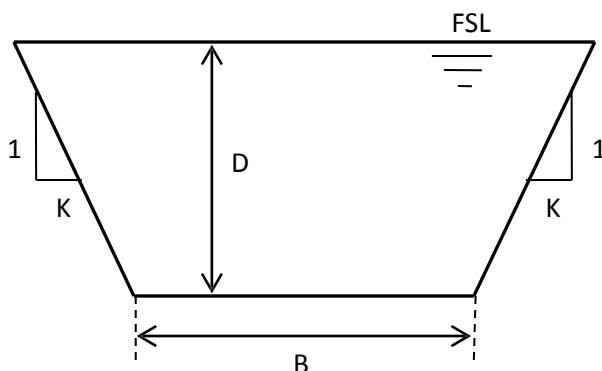
R represents Hydraulic mean radius and is given by  $R = A/P$

Where A is cross sectional area of canal and P is wetted perimeter.

When a canal is designed by Kennedy's method it is required that  $V_o$  is equal to V.

i.e., Critical velocity ratio  $m = 1$

Note: The cross section for an irrigation canal is assumed as a trapezoidal channel as follows.



Cross Sectional Area of flow  $A = BD + KD^2$

Wetted Perimeter  $P = B + 2D\sqrt{1 + K^2}$

### Kennedy's procedure for designing unlined canals:

In designing the required canal section, the following equations are adopted.

$$Q = A V_o$$

$$V_o = 0.55 m D^{0.64}$$

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

$$C = \frac{23+(1+N)+(0.0015\div S)}{1+(23+(0.0015\div S)\times(N\div\sqrt{R}))}$$

Knowing the different quantities such as

1. Discharge (Q)
2. Rugosity coefficient (N) (if the value of  $N$  is not specified, it is assumed as 0.025)
3. Critical velocity ratio (m)
4. Bed slope (S) or B/D ratio the properties of the canal such as cross sectional area of flow, hydraulic mean radius, mean velocity of flow are determined.





### **Case 1: When bed slope 'S' is given**

1. For the given discharge (Q) assume a trial value of the depth of flow (D)

For different values of discharge (Q) the trial values of depth of flow (D) are given as follows.

Q(m <sup>3</sup> /s)	0.283	0.708	1.416	2.832	7.079	14.158	28.317	56.634
D(m)	0.49	0.66	0.84	1.04	1.43	1.73	1.98	2.26

2. Calculate  $V_o$  from  $V_o = 0.55 m D^{0.64}$
3. Determine A from  $Q = A V_o$
4. Knowing D and A calculate the Bed width B
5. Knowing B and D calculate the wetted perimeter P
6. Knowing A and P calculate hydraulic mean radius R
7. Calculate mean velocity of flow from the equation  $V = C\sqrt{RS}$ .
8. If critical velocity ratio is equal to 1 ( $m=1$ ), then the assumed value of D is correct.
9. If not revise the depth 'D'.

### **Case-2: When B/D ratio is given**

1. Let  $B/D = x$        $B = D x$
2. Calculate cross sectional area in terms of D  $A = B D + K D^2$
3. Calculate critical velocity  $V_o$  in terms of D by substituting in  $V_o = 0.55 m D^{0.64}$
4. Substituting for A and  $V_o$  in  $Q = A V_o$  D can be determined.
5. Knowing D, A and B calculate P and R
6. Calculate  $V_o$  from equation  $V_o = 0.55 m D^{0.64}$
7. Assuming a trial value for S, Calculate Chezy's constant from equation

$$C = \frac{23 + \frac{1}{N} + \frac{0.0015}{S}}{1 + \left( \frac{23 + \frac{0.0015}{S}}{N} \right) \sqrt{R}}$$

8. Calculate mean velocity of flow from equation  $V = C\sqrt{RS}$
9. Calculate critical velocity ratio  $m$ . If  $m = 1$  the bed slope provided is adequate.
10. If not, revise the bed slope  $S$ .

Note: The trial values of bed slope  $S$  are assumed depending upon the discharge ( $Q$ ) as follows.

Q (m <sup>3</sup> /s)	0.283	0.708	1.416	2.832	7.079	14.158	28.317	56.634
S (1 in__)	3333	3636	4000	4444	4444	5000	5000	5714

Draw backs in Kennedy's theory

1. Kutters equation is used for determining the mean velocity of flow and hence the limitations of kutter's equation are incorporated in Kennedy's theory.
2. The significance of B/D ratio is not considered in the theory
3. No equation for the bed slope has been given which may lead to varied designs of the channel with slight variation in the bed slope.
4. Silt charge and silt grade are not considered. The complex phenomenon of silt transportation is incorporated in a single factor are called critical velocity ratio.
5. The value of  $m$  is decided arbitrarily since there is no method given for determining its value.
6. This theory is aimed to design only an average regime channel.
7. The design of channel by the method based on this theory involves trial and error which is quite cumbersome.

## Problems

1. Design and sketch an irrigation channel to carry 5 cumec. The channel is to be laid on a slope of 0.2m per kilometer. Assume  $N=0.025$  and  $m=1$

Solution:

1. Assume a trial depth  $D$  equal to 1.0m



$$2. V = V_o = 0.55 \text{ m D}^{0.64}$$

$$= 0.55 \times 1.0 \times 1.0^{0.64}$$

$$3. \text{Area} = Q = A V_o$$

$$A = Q/V = 5/0.55 = 9.09 \text{ m}^2$$

$$4. A = B D + K D^2$$

$$= 9.09 = B \times 1.0 + 1.0^2/2$$

$$B = 8.59 \text{ m}$$

$$5. \text{Perimeter} = P = B + D \sqrt{5}$$

$$8.59 + 1.0 \sqrt{5} = 10.83 \text{ m}$$

$$R = A/P = 9.09/10.83$$

$$= 0.84 \text{ m}$$

6. Mean velocity flow

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

$$C = \frac{23 + \frac{1}{N} + \frac{0.0015}{S}}{1 + \left( \frac{23 + \frac{0.0015}{S}}{N} \right) \sqrt{R}}$$

$$R = 0.84 \text{ m}, S = 0.2/1000, N = 0.0225$$

$$C = 42.85$$

$$V = 42.85 \sqrt{0.84 (0.2/1000)}$$

$$= 0.555 \text{ m/s}$$

7. Ratio of velocities found in step 6 and step 2

$$= 0.555/0.55 = 1.009 = 1.0$$

Hence assumed  $d$  is satisfactory.

**2. Determine the dimensions of the irrigation canal for the following data B/D ratio = 3.7, N= 0.0225, m=1.0 and S= 1/ 4000 side slopes of the channel is ½ H : 1V. Also determine the discharge which will be flowing in the channel.**

Solution:  $B/D = 3.7$

$$B = 3.7D$$

For the channel with side slopes of 1/2H : 1V

$$R = \frac{D + \left(\frac{D^2}{2}\right)}{D + D\sqrt{5}} = 0.708D$$

From Kennedy's equation ,

$$V_o = 0.55 m D^{0.64}$$

$$V_o = 0.55 D^{0.64}$$

$$C = \frac{23 + \frac{1}{N} + \frac{0.0015}{S}}{1 + \left(23 + \frac{0.0015}{S}\right) \frac{N}{\sqrt{R}}}$$

Equating the two values of V, we get

$$0.55 D^{0.64} = 0.975 D^{1/2} / (1 + 0.781 D^{-1/2})$$

$$0.55 D^{0.64} + 0.4296 D^{0.14} = 0.9795 D^{1/2}$$

Solving the above equation by trial and error , we get

$$D = 1.0m$$

$$B = 3.7m$$

$$V = 0.55m/s$$

$$A = B D + D^2/2$$

$$A = 4.2m$$

$$Q = A x V = 4.2 x 0.55$$

$$= 2.31 \text{ cumes}$$