Design of Irrigation Channels

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IRRIGATION AND HYDRAULIC STRUCTURES

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Assumptions of Kennedy

1. Vertical component of eddies support the silt particles.
2. The silting power of a channel depends upon its velocity, which controls the eddies.
3. The silt transporting power depends upon its depth.
4. The silt transporting power of a channel is independent of bed width.

Kennedy:

1. Arbitrary fixed the ratio B/D.
2. Used Chazys and Kutter Equations to find V.
3. N = 0.0225.

The equations chosen by Kennedy are:

1. Q = AV
2. $V = C\,(RS)^{1/2}$ ---- Chazys equation.

$$c = \frac{\frac{1}{n} + (23 + \frac{0.00155}{s})}{1 + (23 + \frac{0.00155}{s})\frac{n}{\sqrt{R}}}$$

MKS system

$$c = \frac{41.65 + \frac{0.00281}{s} + \frac{1.811}{n}}{1 + \frac{n}{\sqrt{R}}(41.65 + \frac{0.00281}{s})}$$

FPS system

3. $V_o = 0.546mD^{0.64}$ MKS system

Following Data Should be Known:

1. Design Discharge (Q)
2. Slope (S).
3. Rugosity coefficient: n.
4. C.V.R = m = V/Vo .

Kennedys Theory

- R.G. Kennedy studied straight reaches of upper Bari Doab canal which are stable for 30 years.
- $V_o = CD^n$

Where Vo is critical velocity (non-silting or non-scouring)

C is constant depends upon quantity of silt.

Sediment is kept in suspension solely by the vertical component of eddies.

- Weight of sediment vertically acts downwards.
- Vertical component of eddies acts upwards.
- Result: the sediment is in suspension.
- $V_o = 0.84\ D^{0.64}$ FPS system
- $V_o = 0.546\ D^{0.64}$ MKS system, D is depth.
- $V_o = 0.546m\ D^{0.64}$ where $m = V/V_o$ = critical velocity ratio (C.V.R), depends upon silt grade.
- V = critical velocity for all sizes of sediment, Vo is Vcr for upper Bari Doab canal only.

Kennedy Procedure for Canal Design

Step 1. Assume the trial value of D and put in eqn. 1 and determine $V_o = 0.546mD^{0.64}$

Step 2. In Eqn. 1: Q =AV

A = Q/V

A = BD + D^2/2

P = B + D $5^{1/2}$

For assumed D determine B

Find R = A/P

Kennedy Procedure for Canal Design

Step 3. Substitute the value of R in eqn. 2 (Kutters and Chazys Eqn.) to obtain V which will be the actual velocity for assumed dimensions.

Step 4. If the velocity worked out from Eqn.2 agrees with that of obtained with the Eqn. 3 (Kennedeys Eqn.). Then the assumed depth is correct. Other wise repeat the procedure with changed value of D.

Lacey's Theory

- According to Kennedy, a channel is regime (No silting, No scouring) but according to Lacey even though channel with no silting or scouring may actually be not in regime.
- He differentiated between initial regime and final regime but this theory is applicable to final regime.

Lacey's Theory

INITIAL REGIME

When only bed slope of channel changes but the cross section remains same then also no silting or scouring take place. But this is rare.

FINAL REGIME

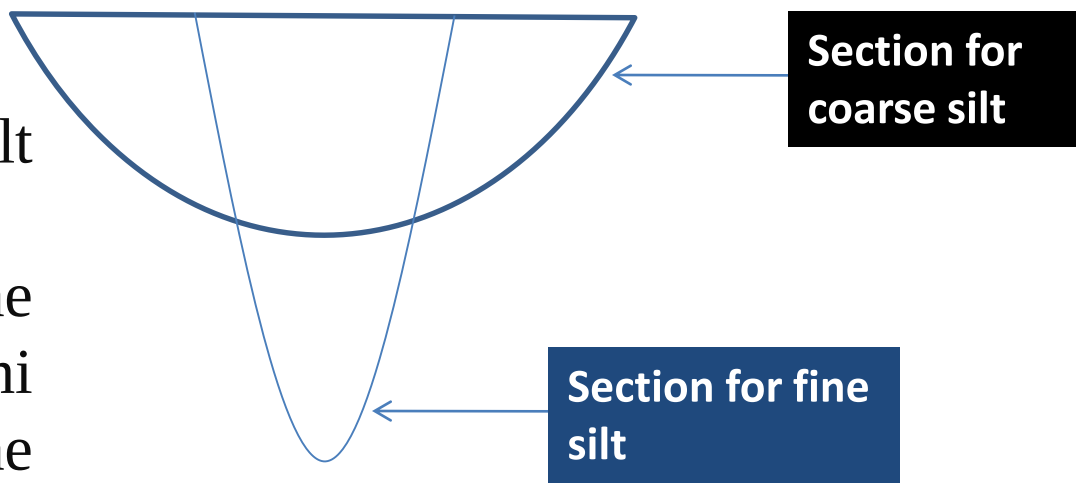
If all the parameters (perimeter, depth and slope) have equally free to vary and adjust according to discharge and silt grades then the channel is said to have final regime.

Lacey's Theory

In final regime the cross section assumes semi-ellipse shape.

Coarser the silt flatter the ellipse.

Finer the silt the section is semi circle (greater the depth)



Lacey's Theory

The channel is said to be regime when the following conditions are satisfied:

1. The channel is flowing in unlimited, in-coherent alluvium of same character (grade).

2. Silt grade and silt charge is constant.

3. Q is constant

Lacey’s Theory

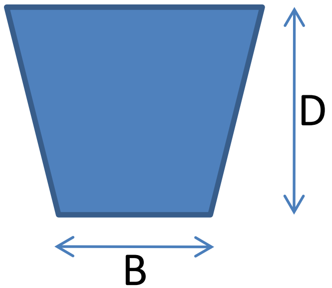
- Lacey argued that silt is supported by the eddies generated from bottom as well as sides so he considered “R” as variable instead of D.

- Lacey: Grain size is important. He introduced Lacey’s silt factor F.

Design Procedure by Lacey

1. Calculate velocity

$$V_m = \left[\frac{Qf^2}{140}\right]^{1/6}$$



Where; $f = 1.76\ M^{0.5}$

f = Lacey's silt factor

Q = Cumecs

M= Mean dia in 'mm'

2. Work out $R = (5/2) * (V^2/f)$

$A = BD + 0.5*D^2$

$P = B + D* 5^{1/2}$

Design Procedure by Lacey

- Compute

$$P = 4.75\sqrt{Q}$$

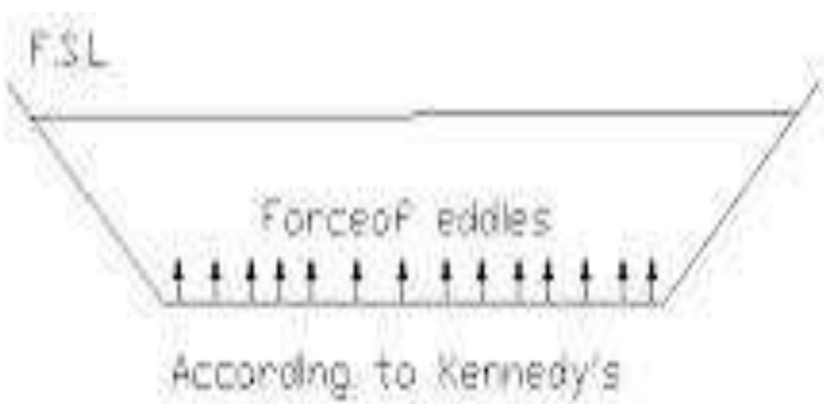
- Compute

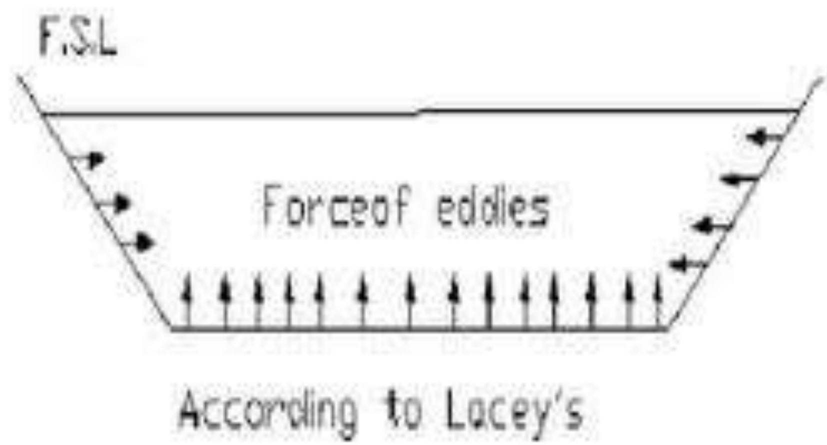
$$S = \frac{f^{5/3}}{3340Q^{1/6}}$$

Comparison of Lacey's and Kennedy Theories

1. Both (K & L) considered that the vertical eddies are responsible for holding silt in suspension. But Kennedy neglected the eddies generated by sides.

Lacey considered the sides (so he included R instead of D).





Comparison of Lacey's and Kennedy's Theories

2. Kennedy: All channels which are not silting or scouring are in regime. But Lacey differentiated between initial and final regime.

3. Lacey: Grain size is important.

$$\text{Silt factor } F = 1.76 * M^{0.5}$$

Designing of Non Erodible(Lined) Channels

The initial dimensions of a channel are determined by uniform flow or Manning's formula. But final dimensions are determined on the basis of

A. Hydraulic efficiency
B. Empirical rule of the best section
C. Practicability & economy

Factors Considered in The Design

1. Kind of material to find n.
2. Minimum velocity.
3. Maximum velocity:
4. Bed Slopes
5. Side Slopes
6. Free board

Factors Considered in The Design

1. **Kind of material** is important to find the roughness coefficient of channel.

2. **Minimum velocity:**

It is 2-3 ft/sec, non silting velocity to prevent aquatic growth.

3. **Maximum velocity:**

Upto 8 ft/sec, more than the above value, the lining blocks are pulled away by moving water.

4. **Bed slopes:**

It depends upon topography and energy head required for flow of water.

5. **Side slopes:**

It depends upon the material forming the channel section

	H		V
e.g. Earth with lime stone	1	:	1
Earth with concrete lining	½	:	1

Factors Considered in The Design

Free Board

Distance between top of channel to maximum water surface. It should prevent waves. It should be 5-13 % of depth.

U.S.B.R $$F = \sqrt{cy}$$

F= free board in ft

y=depth in ft

C = 1.5 ---- 20 cft

C = 2.5 ---- 300 cft

Best section: Max Q for Min P

Factors Considered in The Design

Best section Of hexagon	A	P	R	T	Z=sectional Factor
Trapezoid	$\sqrt{3}y^2$	$2\sqrt{3}y$	y/2	$\frac{4}{3}\sqrt{2}y$	$\frac{3}{2}y^{2.5}$
Rectangle	$2y^2$	4y	y/2	2y	$2y^{2.5}$

Design Steps For Erodible Channel

1. Collect all the information and estimate n & s.
2. Compute section factor $AR^{(2/3)} = nQ/1.486S^{0.5}$
3. Substitute the values of A & R

From

$A = (b+zy)y$

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

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

& solve for y (depth) by assuming b & z.

Design Steps For Erodible Channel

Assume different values for b and z and different dimensions of y are obtained.

Final dimension is based on hydraulic efficiency and practicability.

4. If best hydraulic section is required, directly substitute for A and R for best section.

e.g. Trapozoid

$R = y/2$

$A = (3)^{0.5}\, y^2$

5. Check for minimum permissible velocity
6. Add proper free board to depth

Balancing Depth

For a given cross-section of channel, there can be only one depth, for which a balance between cutting and filling will occur. This depth is known as balancing depth.

This can be computed by equating the areas of cutting and filling.

Types of Lining

1. Hard Surface Type Lining

a) Cement concrete lining
b) Pre-cast concrete lining
c) Brick- burn clay lining
d) Shot-crete lining
e) Asphalt concrete lining
f) Stone masonry lining

Types of Lining

2. <u>Burried and Protected Type Membrane Lining</u>

a) Sprayed in place asphalt membrane lining
b) Pre- fabricated
c) Synthetic rubber and plastic film membrane lining
d) Bentonite-clay membrane lining

Types of Lining

3. Earth type lining

a) Compacted earth lining
b) Soil cement lining

4. Porous type lining, Boulder and brick lining

Thank You