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# IRRIGATION ENGINEERING

[BTAI 2201]

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# Lacey's Theory

According to Lacey's theory, there is a relationship between velocity,  $V$  & hydraulic mean radius/scour depth,  $R$  in the form

$$V = R^{1/2}.$$

As a measure of silt grade, Lacey introduced a silt factor,  $f$  & he proposed an equation

$$V = K \quad (\text{Eq.9.31})$$

where  $K$  is a constant. The value of  $K$  proposed is  $K =$

$$\sqrt{f R}$$

Hence Eq. (9.31) in SI unit can be written as:

$$\sqrt{\frac{2}{5}}$$



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$$V = \sqrt{\left(\frac{2}{5} f R\right)}$$

$$\text{Hence, } f = \frac{5 V^2}{2 R} \quad (\text{Eq.9.33})$$

$$f = 1.76 m_r^{1/2} \quad (\text{Eq.9.34})$$

**where  $m_r$  is average particle size, mm**



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He also proposed the following relationship between area,  $A$  vs. velocity,  $V$ :

$$A f^2 = 140 V^5 \quad (\text{Eq.9.35})$$

Lacey's regime flow equation is:

$$V = 10.8 R^{\frac{2}{3}} S^{\frac{1}{3}} \quad (\text{Eq. 9.36})$$

**Eqns. (9.32, 9.35 and 9.36) are called as Lacey's fundamental equations from which other flow equations are derived**



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$$V = \left( \frac{Q f^2}{140} \right)^{\frac{1}{6}}$$

**(Eq. 9.37)**

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

**(Eq. 9.38)**

$$S = \frac{f^{3/2}}{4980 R^{1/3}}$$

**(Eq. 9.39)**

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

**(Eq. 9.40)**



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Eqns. (9.39 and 9.40) are called as Lacey's regime slope equation.

$$Q = \left( \frac{f^{5/3}}{3340 x S} \right)^6 \quad \text{(Eq. 9.40)}$$

**Eqns. (9.39 and 9.40) are called as Lacey's regime slope equation.**



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# Lacey's design procedure

Step I. Calculate the silt factor.

Step II. Find out velocity,

Step III. Find out the cross sectional area,  $A = \frac{Q}{V}$

Step IV. Find out the wetted perimeter,

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

Step V. Find out base width,  $B$  and depth,  $D$  of the channel section since area & wetted perimeter are known.



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Step VI. Calculate  $R$  as

$$R = \frac{5 V^2}{2 f}$$

Step VII. Also calculate  $R$  as ratio of  $A$  and  $P$ . Both the values of  $R$  should be same which serves as a check from step I to V.

Step VIII. Find out the slope,

$$S = \frac{f^{3/2}}{4980 R^{1/3}}$$





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**or as**

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



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**Design a channel section to carry a full supply discharge of 30 cumecs having side slope 0.5 :1 & mean diameter of silt particle is 0.33 mm.**

Silt factor,  $f = 1.76 \sqrt{0.33} = 1.0$

**Mean velocity,**

$$V = \left( \frac{Q f^2}{140} \right)^{\frac{1}{6}}$$
$$\left( \frac{30 \times 1^2}{140} \right)^{\frac{1}{6}} = 0.773 \text{ m/sec}$$



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$$A = Q/V = 30/0.773 = 38.8 \text{ m}^2$$

$$\text{Wetted perimeter, } P = 4.75 \sqrt{Q}$$

$$= 4.75 \sqrt{30} = 26 \text{ m.}$$

**Since side slope is 0.5:1, base width**

**& depth are  $B$  and  $D$  respectively**

$$\text{Area, } A = B D + \frac{D^2}{2}$$

$$\text{wetted perimeter, } P = B + D \sqrt{5}$$



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Hence,

$$D = \frac{P - \sqrt{P^2 - 6.944 A}}{3.472}$$

$$= \frac{26 - \sqrt{26^2 - 6.944 \times 38.8}}{3.472} = 1.67 \text{ m}$$



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$$B = P - D \times \sqrt{5} = 26 - 1.67 \times \sqrt{5} = 22.6 \text{ m.}$$

$$\mathbf{R = Area/wetted perimeter = 38.8/26 = 1.49 \text{ m}}$$

$$\mathbf{Again, R = \frac{5V^2}{2f} = \frac{5 \times 0.773^2}{2 \times 1} = 1.49 \text{ m}}$$

**Since values of  $R$  by both methods are same, calculation is checked.**



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

$$\frac{1^{5/3}}{3340 \times 30^{1/6}} = 1/5900 = 0.017 \text{ percent}$$

**So, B = 22.6 m, D = 1.67 m, & S = 0.017%**



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## Drawbacks in Lacey's Theory:

Concept of true regime is theoretical & cannot be achieved practically.

Various equations are derived considering silt factor  $f$  which is not at all constant.

Concentration of silt is not taken into account.

Silt charge & silt grade are not clearly defined.

Equations are empirical & based on available data from a particular type of channel which may not be true for other channels.

Characteristics of regime channel may not be same for all cases.

Lacey did not take into account silt left in channel by water that is lost in absorption which is as much as 12 to 15 percent of the total discharge of the channel.

Lacey introduced semi ellipse as ideal shape of a regime channel which is not correct.



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**THANK YOU**