Ex: Design a lined canal of trapezoidal section by sizing it using Best hydraulic section approach. The canal slope 0.0016, the side slope is 1:2, discharge is 15 m^3/s. The lining material is asphalt.

Sol.

the optimum ratio of $\frac{B}{y}$ is consider here in using eq ④ page (18).

$$\frac{B+2Zy}{2} = y\sqrt{Z^2+1} \Rightarrow B = 2y\sqrt{Z^2+1} - 2Zy$$

$$B = 2y(\sqrt{Z^2+1} - Z)$$

$$\therefore \frac{B}{y} = 2(\sqrt{Z^2+1} - Z)$$

$$= 2(\sqrt{5} - 2)$$

$$= 0.47 \Rightarrow B = 0.47y$$

$$A = By + Zy^2$$

$$= 0.47y^2 + 2y^2$$

$$= 2.47y^2$$

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

$$= 0.47y + 2y\sqrt{5}$$

$$= 4.942y$$

$$R = \frac{A}{P} = \frac{2.47y^2}{4.942y} = 0.5y$$

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

By using table in page 15, $n = 0.016$ for asphalt

$$15 = \frac{1}{0.016} 2.47y^2 (0.5y)^{2/3} (0.0016)^{1/2}$$

$$15 = 3.89y^2 \Rightarrow y = 1.96\,m$$

$$B = 0.47(1.96) = 0.92\,m$$

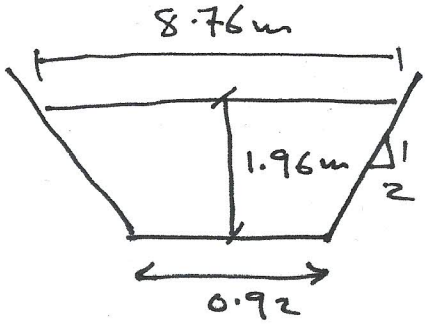
$$Fr = \frac{V}{\sqrt{gy}}$$

$$= \frac{15/9.488}{\sqrt{9.81(1.96)}}$$

$$= 0.36 < 0.6 \quad \therefore \text{O.K}$$

$A = 2.47(1.96)^2$

$= 9.488\,m^2$



2- Design of stable alluvial canal

تصميم القنوات المائية المستقرة

After some information about the canal are available, one can consider the Lacey's Method to design the alluvial canals according to the following eq:-

1- Silt factor معامل الغرين $f = 1.76\sqrt{d_{mm}}$ ——— ①

d: median size of sediment in mm.

2. $V = 10.8\, R^{2/3} S^{1/3}$ ——— ②

V: velocity in m/s, R: hydraulic radius in m

3. $P = 4.75\sqrt{Q}$ ——— ③

P is wetted parameter in (m), Q is discharge (m^3/s)

4. $R = 0.48\left(\frac{Q}{f}\right)^{1/3}$ ——— ④

5. $S = 0.0003\frac{f^{5/3}}{Q^{1/6}}$ ——— ⑤

Lacey also obtained that:

$$V = \frac{1}{Na} R^{4/3} S^{1/2} \quad \text{——— ⑥}$$

Na is rugosity coefficient, and

$$Na = 0.0225\, f^{1/4} \quad \text{——— ⑦}$$

Derivation of Lacey equations for regime canals
اشتقاق معادلات ليسي للقنوات المتوازنة (المستقرة)

essential eqs are:

$$V = \sqrt{\frac{2}{5}}\sqrt{Rf} \quad \text{—— (8)}$$

$$Af^2 = 140\,V^5 \quad \text{—— (9)}$$

هذه هي المعادلات الاساسية

$$V = 10.8\,R^{2/3}\,S^{1/2} \quad \text{—— (2)}$$

اما المعادلات التكميلية فهي :

from eq (1) $\quad f = \frac{5V^2}{2R}$ —— (a)

sub (a) into eq (9) yields :

$$A\left(\frac{5V^2}{2R}\right)^2 = 140\,V^5 \qquad \text{[multiplied both sides by V]}$$

$$Q\left(\frac{5V^2}{2R}\right)^2 = 140\,V^6$$

$$\frac{25}{4}\frac{Q}{R^2} = 140\,V^2$$

$$\frac{25}{4}\frac{Q}{(A/P)^2} = 140V^2 \Rightarrow P^2 = \frac{560}{25}Q \quad \text{—— (b)}$$

$$P = 4.75\sqrt{Q} \quad \text{—— (3)}$$

From eq (b)

$$\left[P^2 = \frac{560}{25}VA\right] \div A^2 \Rightarrow \left\{\frac{P^2}{A^2} = \frac{560}{25}\frac{V}{A} = \frac{1}{R^2}\right\} * AR$$

$$\frac{A}{R} = \frac{560}{25}VR \Rightarrow P = \frac{560}{25}VR$$

$$4.75\sqrt{Q} = \frac{560}{25}VR \quad \text{—— (c)} \qquad \text{sub eq (8) into eq (c)}$$

$$4.75\,Q^{1/2} = \frac{560}{25}\sqrt{\frac{2}{5}}\,f^{1/2}R^{3/2} \Rightarrow R = 0.48\left(\frac{Q}{f}\right)^{1/3} \quad \text{—— (4)}$$

By eliminating V from both eq(8) and eq(2) and equating them, one can get:

$$\sqrt{\frac{2}{5}}\sqrt{fR} = 10.8\, R^{2/3} S^{1/3}$$

or

$$S = \left(\frac{\sqrt{0.4}}{10.8}\right)^3 f^{3/2} / R^{1/2}$$

Recalling R from eq(4) to obtain:

$$S = \frac{0.0002\, f^{3/2}}{R^{1/2}} \quad \text{——} \quad (4)$$

$$S = 0.0003\, \frac{f^{5/3}}{Q^{1/6}} \quad \text{——} \quad (5)$$

from eq(2):

$$V = \frac{10.8\, R^{2/3} S^{1/2}}{S^{1/6}}$$

but from eq (4): $S^{1/6} = \dfrac{0.242\, f^{1/4}}{R^{1/12}}$

$$V = \frac{44.6\, R^{3/4} S^{1/2}}{f^{1/4}}$$

or $\boxed{V = \frac{1}{Na} R^{3/4} S^{1/2}}$ —— (6) $\quad Na = 0.0925\, f^{1/4}$ —— (7)

Ex 1: Design a stable canal that carrying discharge of 30 m^3/s by Lacey's method, assuming $f = 1.0$.

Sol.

from eq ③

$$P = 4.75\sqrt{Q} = 4.75\,(30)^{1/2} = 26.02\ m$$

from eq ④

$$R = 0.48\left(\frac{Q}{f}\right)^{1/3} = 0.48\,(30)^{1/3} = 1.49\ m$$

from eq ⑤

$$S = 3*10^{-4}\,(1)^{5/3}/(30)^{1/6} = 1.702\times10^{-4}$$

from eq ②

$$V = 10.8\,R^{2/3}S^{1/3} = 10.8\,(1.49)^{2/3}\,(1.702*10^{-4})^{1/3}$$
$$= 0.781\ m/s$$

choose the shape of canal, say it is trapezoidal in shape, the side slope Z can be selected as 1 (generally observed in alluvial canal)

وهنا هو فرق بالجدول في صفحة (9) لاختيار Z حيث ان التربة الطينية الثقيلة تعتبر من الرتب

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

$$P = B + \sqrt{2}\,y = 26.02$$

or $B = 26.02 - 1.42\,y$ ——— ⓐ

$$A = By + zy^2 = By + y^2$$

since $R = \frac{A}{P} \Rightarrow A = RP = 26.02 * 1.49 = 38.77\ m^2$

$By + y^2 = 38.77$ ——— ⓑ [sub eq ⓐ in ⓑ]

$26.02\,y - 1.42\,y^2 + y^2 = 38.77$

$0.42\,y^2 - 26.02\,y + 38.77 = 0$

$y = 1.53\ m$ $\quad B = 23.84\ m$

$y = 60.4\ m$ ترفض ↑ give negative value in eq a

Ex 2: An irrigation canal is to be designed for discharge 50 m^3/s, adopting the available ground slope of 1.5×10^{-4}. The river bed material has median size of 2 mm. Design the canal and recommend the size of coarser material to be excluded or ejected from the canal for efficient functioning.

Sol.

$$f = 1.76\sqrt{d} = 1.76\sqrt{2} = 2.49$$

$$S = 0.0003\,(2.49)^{5/3}/(50)^{1/6} = 7.15 \times 10^{-4}$$

هنا الميل هوا كبر بكثير من ميل الارض المعطى بالسؤال

$\therefore$ take $S = 1.5 \times 10^{-4}$

The median size of sediment can be determined by computing new value of f for $S = 1.5 \times 10^{-4}$

$$1.5 \times 10^{-4} = 0.0003\, f^{5/3}/(50)^{1/6} \Rightarrow f = 0.976$$

$$\therefore d = \left(\frac{0.976}{1.76}\right)^2 = 0.3\,mm$$

Therefore material > 0.3 mm will have to be removed for efficient functioning of the canal.

$$R = 0.48\left(\frac{50}{0.976}\right)^{1/3} = 1.78\,m$$

$$P = 4.75\sqrt{50} = 33.59\,m$$

$$P = B + \sqrt{2}\,y = 33.59 \quad \text{— (a)}$$

$$A = By + y^2 = PR = 33.59\,(1.78)$$

for $Z = 1$

$$By + y^2 = 59.89 \quad \text{— (b)}$$

sub a in b yields:

$$33.59y - \sqrt{2}y^2 + y^2 - 59.89 = 0$$

$$0.42y^2 - 33.59y + 59.89 = 0$$

$y = 1.82$ m or $y = 78.2$

$B = 31.1$ m

نهمل لان تعطي B سالب