Type of irrigation canals

- lined canal القنوات المبطنة (Rigid boundary) — [designed by section factor method, trial method and best hydraulic section]
- unlined canal القنوات الغير مبطنة
  - Stable alluvial canal, non-alluvial canal — [designed by Lacey's method]
  - alluvial canal — [Designed by tractive force method]

Rigid boundary canals :

the surface of the canal is lined. The quantity of silt transported by such remains more or less the same as that entered the canal at its head. In such canals, relatively high velocity of flow is permitted which does not allow the silt to get deposited.

The nonalluvial canals :

are excavated in non-alluvial soils such as loam, clay ... etc. Generally, there is no silt problem in these canals and they are relatively stable.

The alluvial canals :

are excavated in alluvial soils, such as silt. The silt content may increase due to scouring of bed and sides of the canal. انجرافات بسبب السرعه العاليه

في المحاضرة السابقة تم شرح طريقة section factor method لتصميم القنوات المبطنة (lined canal) ويتم في هذه المحاضرة تكملة طرق تصميم هذه القنوات.

ان كمية الطمي (Silt) المنقولة عبر هذا النوع من القنوات تعتبر مستقرة اي ان كمية الطمي الداخلة والخارجة من القناة هي نفسها. حيث ان سرعة الجريان يجب ان تكون ذات قيمة بحيث تمنع ترسب الطمي لذا ينصح بأن تكون اكبر من V_{min} وكالآتي :

Limitation of velocity in lined canal

① Velocity **with** sedimentation basin at the head of the system

$$V_{min} = 0.33\, Q^{0.2} \quad (m/s)$$

② velocity without sedimentation basin at the head of the system :

$$V_{min} = 0.5\, Q^{0.2} \quad (m/s)$$

يتم اعتماد هذه المعادلات لايجاد V_{min} و V_{max} بدلاً من الجدول في ص ١٢ النقطة الخامسة لذا تعتبر هذا الجدول ملغي

ولمنع اي انهيار لطبقة التبطين ينصح بأن تكون اقصى سرعة للجريان $V_{max} \leq 2\, m/s$. بصورة عامة فان السرعة $(0.7-1)\, m/s$ تكون كافية لمنع ترسب الطمي ومنع نمو النباتات داخل القناة.

Maning coefficient "n"

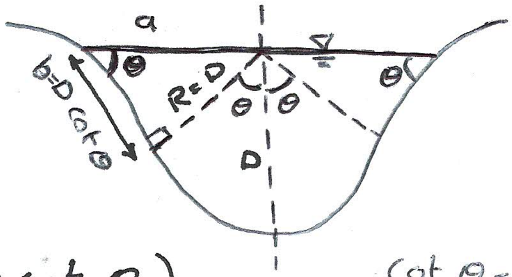
Material of lining	Maning's n
cement concrete	0.013 – 0.022
Bricks lining	0.014 – 0.017
Asphalt	0.013 – 0.016
Wood planed clean	0.011 – 0.013
concrete lined, excavated rock	0.017 – 0.027

Cross-section of lined canal

For Practicle design, sime-circular section is not used, thus the trapezoidal + traingular with rounded edges are used to increase the hydraulic radius R.

1- Traingular section:

The radius of the bottom is equal to the depth of water (D)
The angle of the center is 2θ.



$$A = \pi D^2 (2\theta / 2\pi) + 2(\tfrac{1}{2} D D \cot\theta)$$

$$\boxed{A = D^2 (\theta + \cot\theta)}$$

$\cot\theta = \frac{b}{D}$

$b = D \cot\theta$

$$P = 2D\cot\theta + 2\pi D (2\theta / 2\pi)$$

$$P = 2D(\theta + \cot\theta)$$

Ex/ Design a lined canal to carry 50 cumecs, Assuming $S = \frac{1}{8100}$, $n = 0.015$, $z = 1$

Sol.

$$\theta = \tan^{-1}\frac{1}{1} = 45^\circ = \frac{\pi}{4}$$

[لتحويل الزاويه من درجه (o) الى
$\theta_{rad} = \theta^\circ * \frac{\pi}{180}$ (rad)]

$$A = D^2 \left(\frac{\pi}{4} + \cot\frac{\pi}{4}\right)$$
$$= 1.785 D^2$$

$$P = 2D\left(\frac{\pi}{4} + \cot\frac{\pi}{4}\right)$$
$$= 3.57D$$

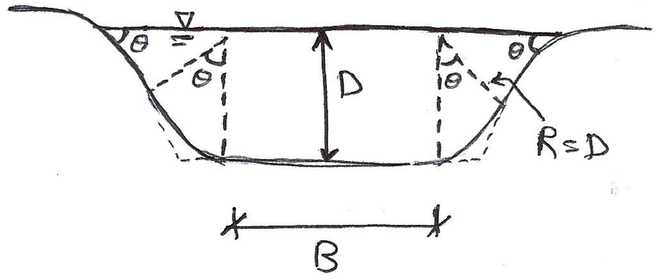
from maning formula: $Q = \frac{1}{n} A R^{2/3} S^{1/2}$

$$50 = \frac{1.785 D^2}{0.015} \left(\frac{1.785 D^2}{3.57 D}\right)^{2/3} \left(\frac{1}{8100}\right)^{1/2}$$

$$D = 4.64 \text{ m}$$

2- Trapezoidal section

$A = BD + 2(\frac{1}{2} D\, D\cot\theta) + \pi D^2 (2\theta / 2\pi)$



$$\boxed{A = BD + D^2(\theta + \cot\theta)}$$

$$\boxed{P = B + 2D(\theta + \cot\theta)}$$

EX. Design a lined canal of discharge 120 m^3/s. The permissible velocity of flow is taken as 2 m/s. Assume side slope 1:1 and n = 0.018 whereas the slope of the canal is 1/3000.

Sol.

$$A = \frac{Q}{V} = \frac{120}{2} = 60\ m^2$$

$$R = \left(\frac{nV}{\sqrt{s}}\right)^{3/2} = \left(\frac{0.018(2)}{\sqrt{1/3000}}\right)^{3/2} = 2.77\ m$$

$$P = \frac{A}{R} = \frac{60}{2.77} = 21.66\ m$$

Now:

$$A = BD + D^2(\theta + \cot\theta)$$

$$60 = BD + 1.785 D^2 \quad \text{— (a)} \qquad \text{where } \theta = \pi/4$$

$$21.66 = B + 3.57 D$$

$$\text{or } B = 21.66 - 3.57 D \quad \text{— (b)} \qquad \text{sub in (a)}$$

$$60 = 21.66 D - 3.57 D^2 + 1.785 D^2$$

$$D^2 - 12.13 - 33.61 = 0$$

D = 4.28 m, B = 6.38 m

or

D = 7.85 m, B = 1.5 m — it is too small similar to triangular section.

٢- مقطع القناة الاكثر اقتصاديا — Most Economical section of channel

من معادله manning او chezy تكون سرعه الجريان في اقصاها اذا كانت قيمه $(R = \frac{A}{P})$ في اقصاها . حيث بثبوت مساحه مقطع الجريان يكون نصف القطر الهيدروليكي R في اقصى قيمه له عندما يكون الطول المبلل $\bar{P}$ اقل ما يمكن .

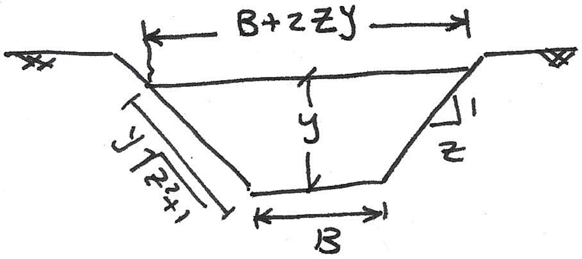
على فرض مقطع الجريان شبه منحرف (trapezoidal)

$$A = (B + Zy)y \quad \text{——} \; ①$$

$$\frac{A}{y} = B + Zy$$

$$B = \frac{A}{y} - Zy \quad \text{——} \; ②$$

$$P = B + 2y\sqrt{Z^2+1} \quad \text{——} \; ③$$



وبالتعويض عن قيمه B من معادله ② في معادله ③ ينتج

$$P = \left(\frac{A}{y} - Zy\right) + 2y\sqrt{Z^2+1}$$

وكما بينا في اعلاه يكون المقطع اقتصادي عندما يكون المحيط المبتل اقل ما يمكن

$$\therefore \frac{dP}{dy} = 0$$

$$\text{or} \quad \frac{d}{dy}\left[\frac{A}{y} - Zy + 2y\sqrt{Z^2+1}\right] = 0$$

$$-\frac{A}{y^2} - Z + 2\sqrt{Z^2+1} = 0 \qquad [\text{since } Z \text{ is constant}]$$

$$\frac{A}{y^2} + Z = 2\sqrt{Z^2+1}$$

وبالتعويض عن قيمه A من معادله ① ينتج

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

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

$$\therefore \boxed{\frac{B+2Zy}{2} = y\sqrt{Z^2+1}} \quad \text{——} \; ④$$

يعني : Half of top width = one of the sloping side

for hydraulic Radius $R = \frac{A}{P}$:

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

وبتعويض معادله ④ في معادله المحيط المبتل ينتج

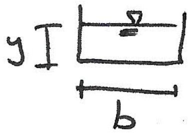
$$P = B + B + 2yZ = 2(B + Zy)$$

$$\therefore \quad R = \frac{(\cancel{B+Zy})\,y}{2(\cancel{B+Zy})} = \frac{y}{2} \qquad \boxed{R = \frac{y}{2}}$$

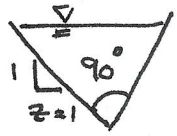
The hydraulic radius equals half of the flow depth مهم!

Conditions for economic section

1- Rectangular $\quad y = \frac{B}{2}$
The depth is half of the width



2- Triangular : side slope $(Z\,H : 1\,V)$ $Z = 1$ $\quad$ angle $= 90^\circ$



3- Trapezoidal : $\quad \frac{B}{2} + Zy = y\sqrt{1+Z^2}$

4- Circular: $\quad y = 0.938\,D$ $\quad$ (for maximum Q with Manning's eq.)

(H.w) Derive an economic section for rectangular channel.

EX: Design an open drain carrying discharge of $(3\ m^3/s)$, the permissible velocity $(1\ m/s)$ and side slope 1:2 assume chezy Coef. $(C = 55)$. Use economical section.

Sol.

$Q = V \cdot A$

$A = \frac{3}{1} = 3\ m^2$

$P = b + 2y\sqrt{1+Z^2} = b + 2y\sqrt{5}$

$R = \frac{A}{P} = \frac{3}{b + 2y\sqrt{5}}$

$R = \frac{y}{2}$ [since we are design using economic section]

$\therefore \quad \frac{3}{b + 2y\sqrt{5}} = \frac{y}{2} \quad \Rightarrow \quad 6 = by + 2y^2\sqrt{5}$

$A = by + Zy^2$

$3 = by + 2y^2 \quad \Rightarrow \quad by = 3 - 2y^2$ $\quad$ sub in $\quad \Rightarrow \quad 6 = 3 - 2y^2 + 4.472\,y^2$

$\therefore \boxed{y = 1.101\ m}$

$\therefore b = 0.527\ m$

$V = C\sqrt{RS}$ $\qquad R = \frac{y}{2} = 0.55\ m$ $\qquad \therefore \quad 1 = 55\,(0.55)^{1/2} \cdot S^{1/2}$

$S = 6 * 10^{-4}\ m/m$