* Part-2

⇒ Lined Canals

→ India - 2nd largest irg land

→ irg water - 1st - lined

→ unlined - 25-50% seepage loss - wastage

- Thus, lined canals are built

→ Lining - adding impermeable layer to edges of trench

→ ~~There are other reasons too~~

advantages of Lining

1. Seepage of Control
   - seepagage losses ↓↓
   - lined canal cost = 2-2.5 (unlined canal)
   - capital expenditure → justified by ↓ percolation

S. No.	Type of Lining	Int. rate of seepage in cumecs per million m² of wetted area before lining	Stabilised rate of seepage in cumecs per million m² of wetted area after lining
1.	Unlined	7.4	3.4
2.	(30 x 15 x 5) cm tiles using cement mortar (cement : sand) (1:3)	0.17	0.009
3.	10 cm thick cement cct (1:3:6) (Cement : Sand : brick ballast)	0.13	0.007
4.	10 cm thick cement lime cct (1:5:12:24) (Cement : Lime : surkhi : brick ballast)	0.40	0.13

2. Increase in channel capacity
   - capacity ↑ - smooth surface + less resistance to flow
     - flow fast - ↑ vel. - more H_2O transferred
       vel ∝ capacity
   - channel capacity ∝ $\frac{1}{\text{reqd. channel section}}$

- lined channel - less dimensions & less earthwork

3. Prevention of Water logging
- uncontrolled seepage ⇓ ↑ water table - near GL
  - brings up alkali salts - land becomes unfit
  - ~~thus~~ (land) - unfit land | - ↑ WT - water logging
- lining - × water logging
- ex → Punjab

4. Increase in Command Area
- steeper gradients - ↑ high - ↑ vel. permit - ↓ eroding
- flat slopes - × silting on ~~lined~~ channel - more areas in command

5. Reduⁿ in maintenance Cost
- in unlined canals,
  → periodical removal of silt
  +
  → minor repairs
  +
  → removal of weeds
  ⇓
  → ↑↑ maintenance cost
- in lined canals,
  → × need bcz ↓↓ erosion
  +
  → × need bcz adequate lining is tough & robust
  → plants flow down themselves due to ↑ vel.
  ⇓
  → ↓↓ maintenance cost

6. Elimination of Flood Dangers
- small breaches in unlined canal - lead to washing of embankment
- lined canals - cct lining - × danger

⇒ Design of Lined Irg Channels

→ lined canal – vel of flow uniform
→ economical distribution
→ sharp curves – avoided – ↓ vel. + ↑ high walls – Cost ↑

– Channel Cross-sections

(a) Triangular channel section
– small discharges
– increase $\frac{A}{P}$ ratio – corners rounded

→ central depth = radius = y

→ Area $= \pi y^2 \cdot \frac{\theta}{\pi} + 2 \times \frac{1}{2} y \cdot y \cot\theta$

$= y^2\theta + y^2 \cot\theta$

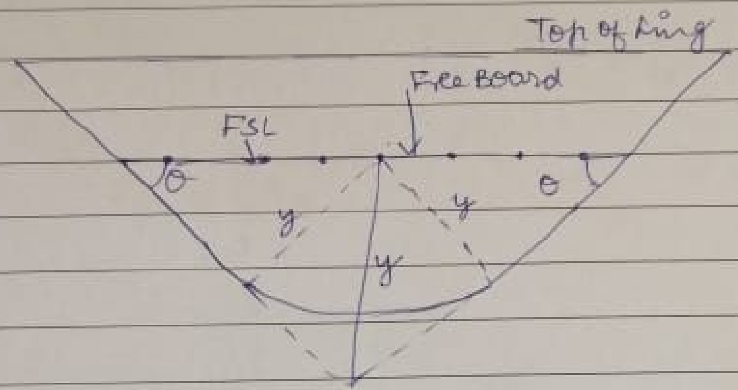
$$A = y^2[\theta + \cot\theta]$$

→ Perimeter $= 2\pi y \times \frac{\theta}{\pi} + 2 \times y \cot\theta$

$$P = 2y[\theta + \cot\theta]$$

→ Hydraulic mean depth (R) $= \frac{y^2(\theta + \cot\theta)}{2y(\theta + \cot\theta)}$

$$\boxed{R = \frac{y}{2}}$$



(b) Trapezoidal Channel Section
– large discharges

→ Area $= By + 2\left(\pi y^2 \cdot \frac{\theta}{2\pi}\right) + 2\left(\frac{1}{2} y \cdot y \cot\theta\right)$

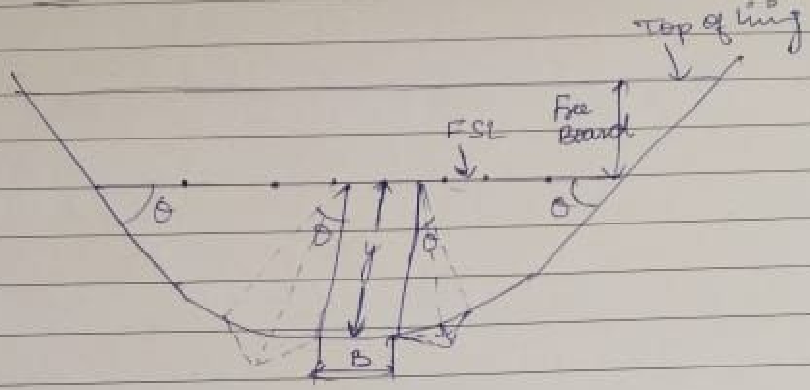
$= By + \theta y^2 + y^2 \cot\theta$

$$\boxed{A = y\left[B + y\theta + y\cot\theta\right]}$$

→ $P = B + 2\left(2\pi y \cdot \frac{\theta}{2\pi}\right) + 2\left(y \cot\theta\right)$

$$\boxed{P = B + 2y\theta + 2y\cot\theta}$$

$$R = \frac{A}{P} = \frac{y\left[B + y\theta + y\cot\theta\right]}{B + 2y\cot\theta + 2y\theta}$$



⟹ Types of Lining

Lining

- Hard surface Lining
  - Cast insitu cct lining
  - Shotcrete lining
  - Brick lining
  - Asphaltic cct lining
  - Boulder Lining
- Earth type Lining
  - Compacted earth lining
  - Soil Cement Lining

⇒ Requirements of Good Lining

(1) Economy
- int cost + maintenance cost → cost↓ or economical
- availability of material, labours, machinery, etc.

(2) Structural Stability
- lining must withstand subsoil water pressure behind lining of subgrade.
- also, withstand effect due to local cavity formation.

(3) Durability
- able to withstand natural wear & tear
- such as vel of water, rain, frost, sunshine, action of salts etc.
- also, withstand effects due to cattle traffic, weed, etc.

(4) Repairability
- repair should be easy & economical
- brick lining can be easily repairable.

(5) Impermeability
- If permeablity ↑ – seepage losses ↑
- " ↓ – " " ↓ – needed

(6) Hydraulic Efficiency
- ~~do~~ reduces with time
- surface lining - erodes → capacity decreases - eff ↓
- Cement plastered brick lining is used.

(7) Resistance to erosion
- sediment load damage lining by abrasion
- cement cct & stone boulder linings are used.

⟹ Factors responsible for Selection of lining

(1) Size & Importance of canal
- small canal - little equipment & machinery, used rarely
- large canal - large " " " + stronger linings

(2) Canal Slopes & Alignments
- steeper slopes → high velocities - stronger linings

type of lining	Safe limiting Vel. (m/s)
1. boulder lining	1.5
2. Burnt clay tile	1.8
3. Cement cct lining	2.7

(3) Climate of the Area
- ↑ temp variations / frosts take place
- higher quality lining is used.

(4) Availability of material
- material abailable is a distinct factor for choice of lining
- nearly available material is preferred
  - ↓ cost

(5) Init. Expenditure
- annual benefit cost ratio ⇒ max - economical
  - initial cost ↑ but longer life
- If initial cost ↑↑ - then other ↓ cost linig is used
  - benefit cost ratio ↓