Design of Cross Drainage Works

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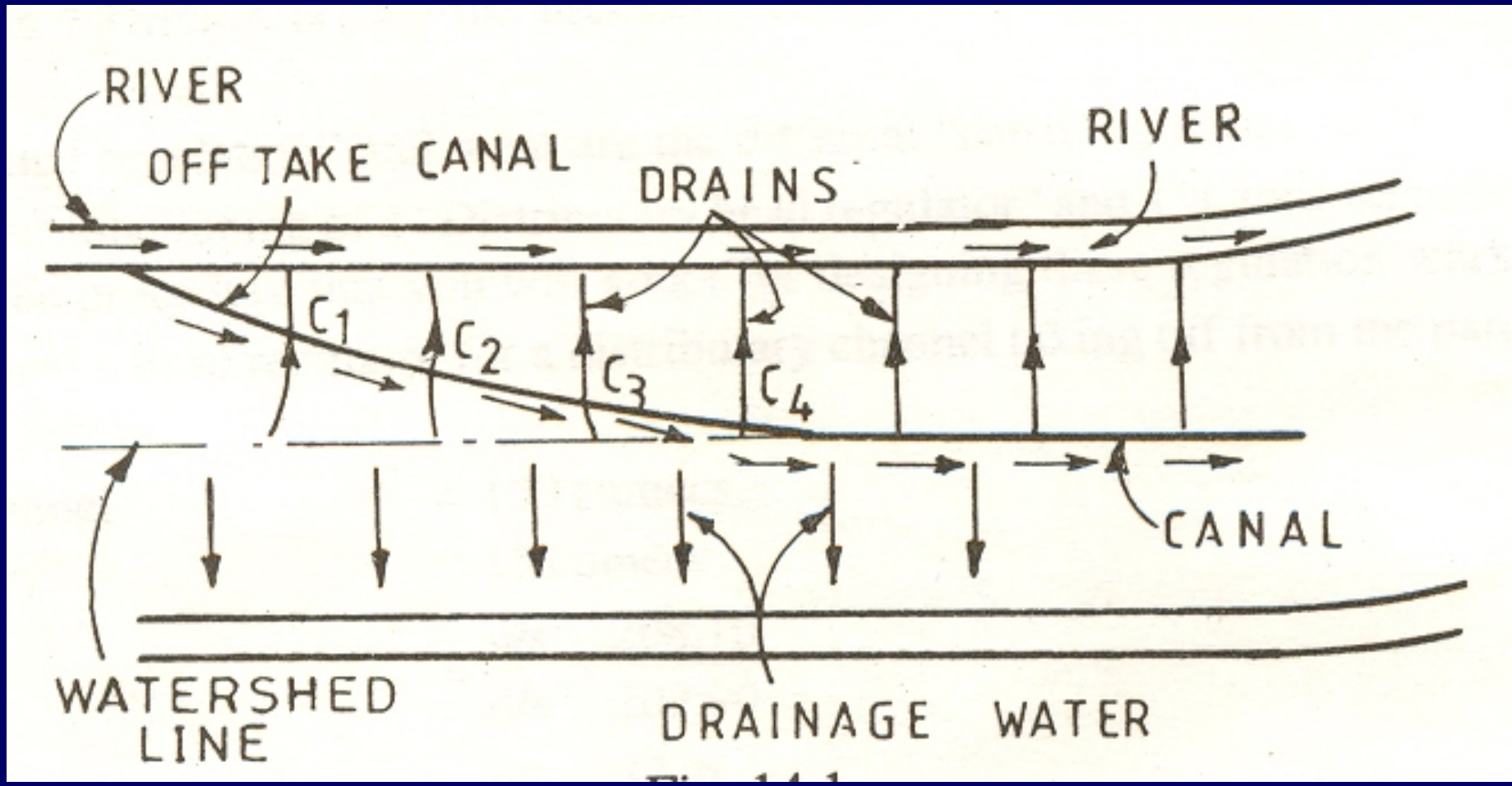
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Necessity of a CD works



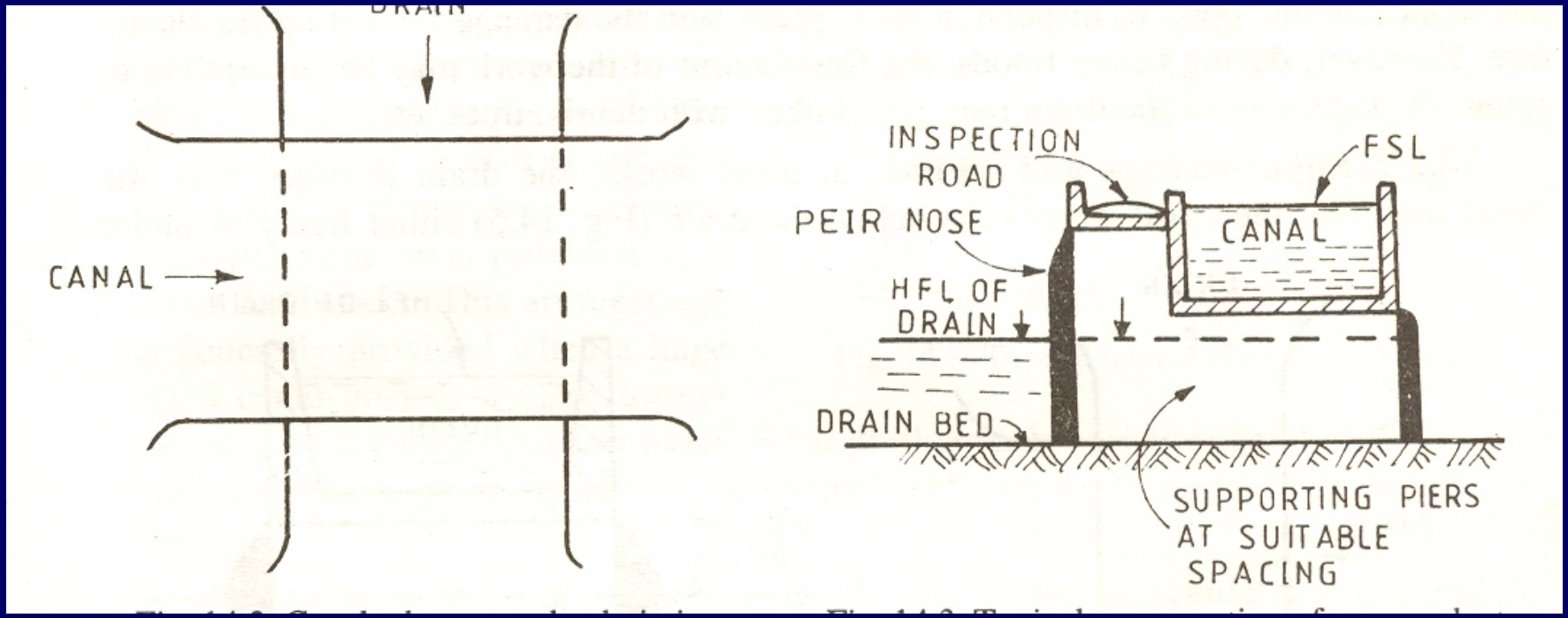
Necessity of a CD works

- A cross drainage work is a structure which is constructed at the crossing of a canal and a natural drain so as to dispose off drainage water without interrupting the continuous canal supplies.
- In whatever way the canal is aligned, such cross drainge works become unavoidable.
- In order to reduce the CD works, the artificial canals are generally aligned along the ridge line called watershed.
- A cross drainage work is generally a costly construction and must be avoided as far as possible.

Classification of CD works

- By passing the irrigation canal over the drainage, through
  - (i) Aqueduct
  - (ii) Syphon aqueduct
- By passing the drainage over the canal, through
  - (i) Super passage
  - (ii) Syphon
- By passing the drainage through the canal so that the drainage and irrigation water are intermixed. This is affected by
  - (i) Level crossing (ii) an inlet and outlet

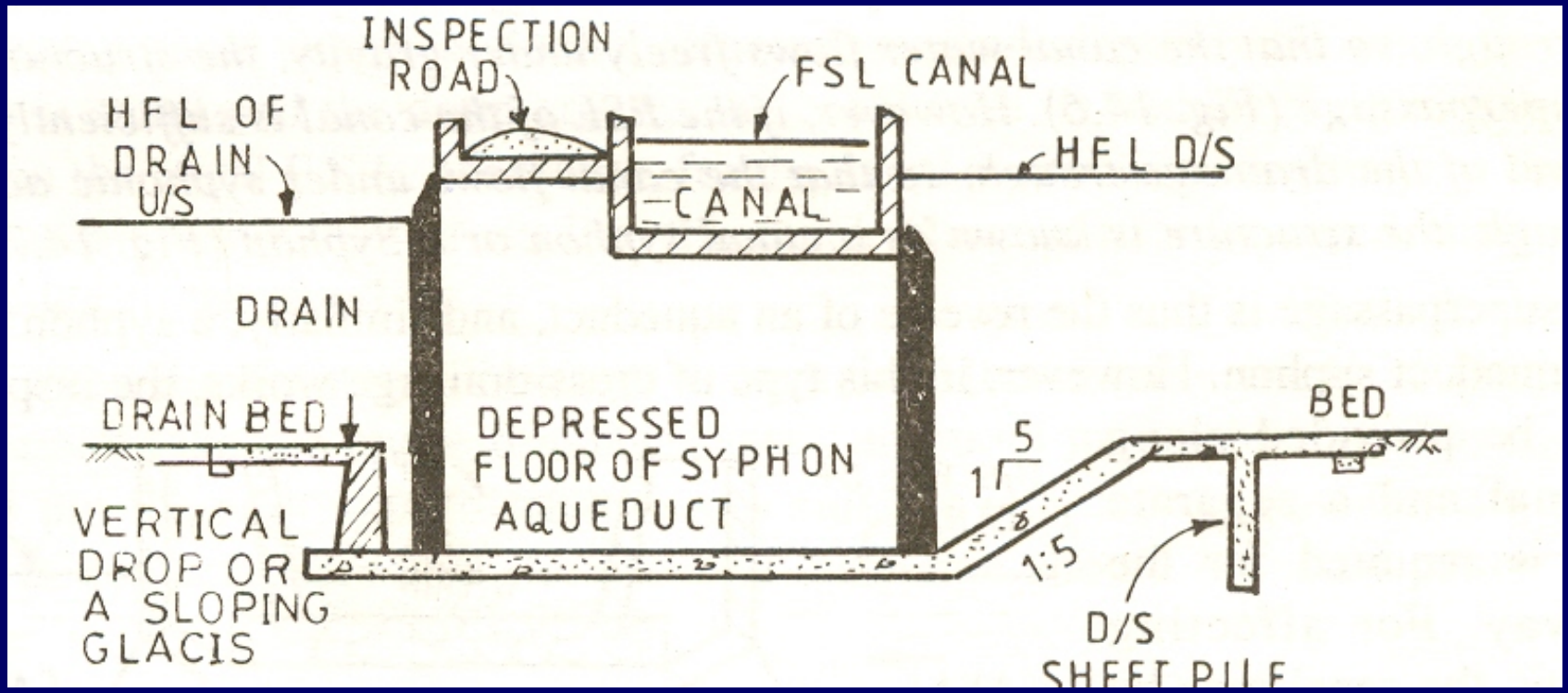
Classification of CD Works



Aqueduct

- BL of canal is above the highest flood level of drain.
- May be constructed across a stream having rocky or boulder bed.

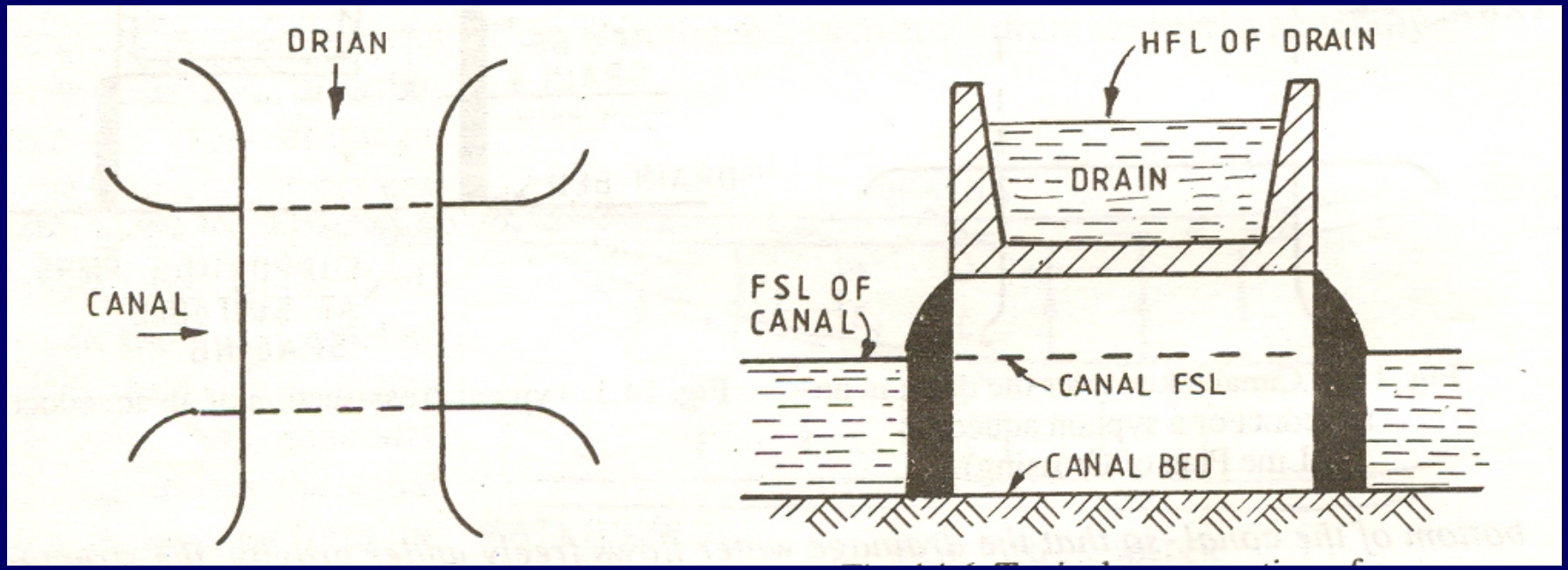
Classification of CD Works



Syphon aqueduct

- To limit the stream velocity it may sometimes be essential to regrade or depress the drainage bed.

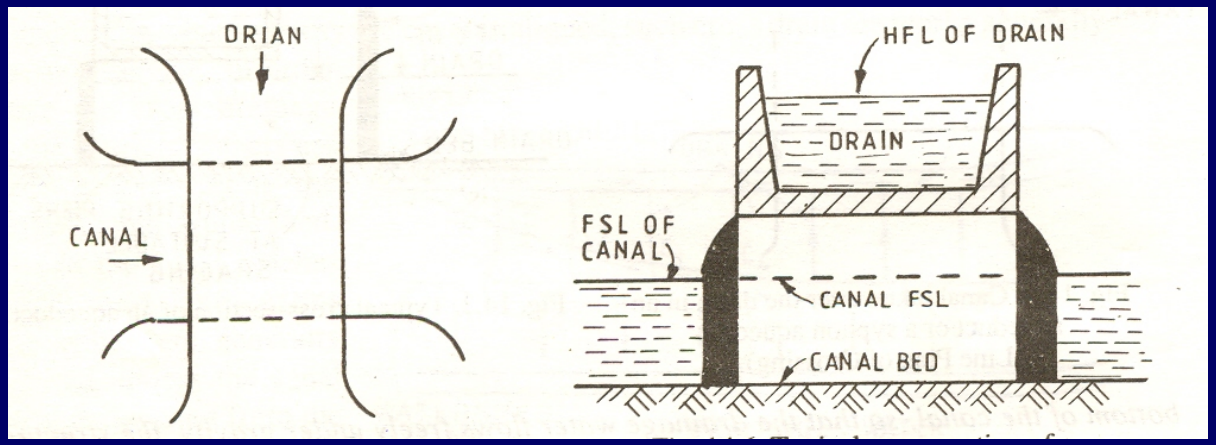
Classification of CD Works



Super-passage

- There should be sufficient clearance available between the FSL of the canal and underside of the drainage trough.

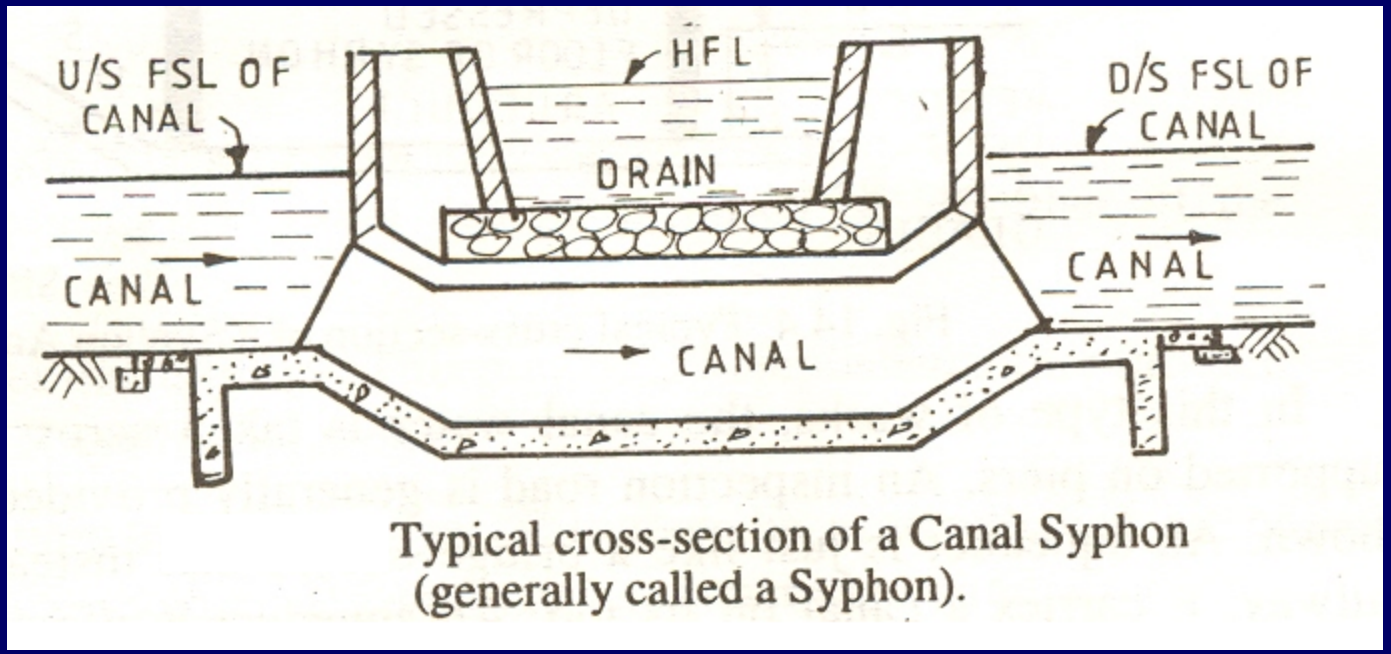
Classification of CD Works



Super-passage

- In this case it is usually not possible to provide an inspection road along the canal.
- At the crossing, the canal road is detoured and separate bridge is provided for the roadway.
- For affecting economy, both the canal and the drainage trough may be flumed.

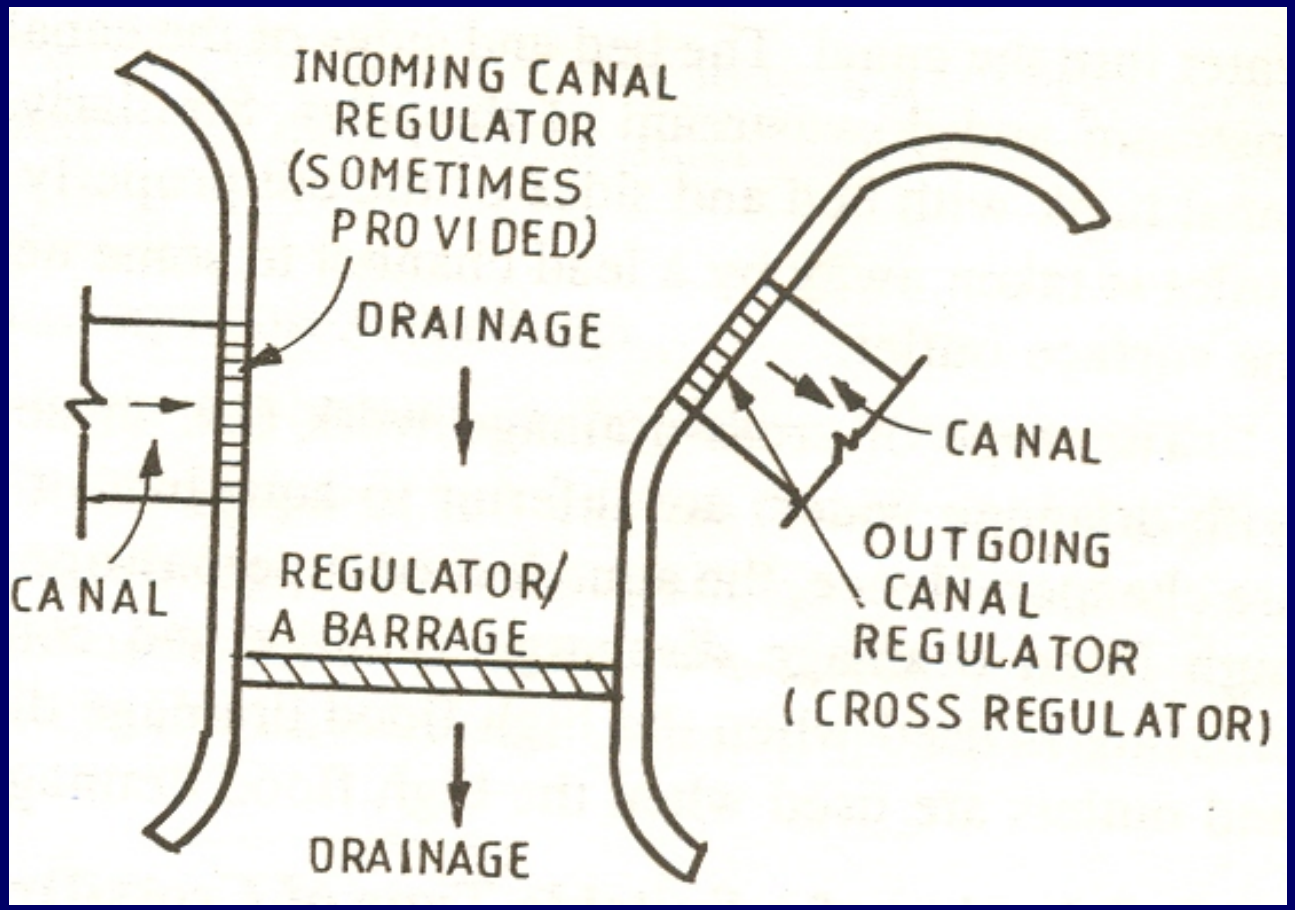
Classification of CD Works



Typical cross-section of a Canal Syphon
(generally called a Syphon).

Syphon

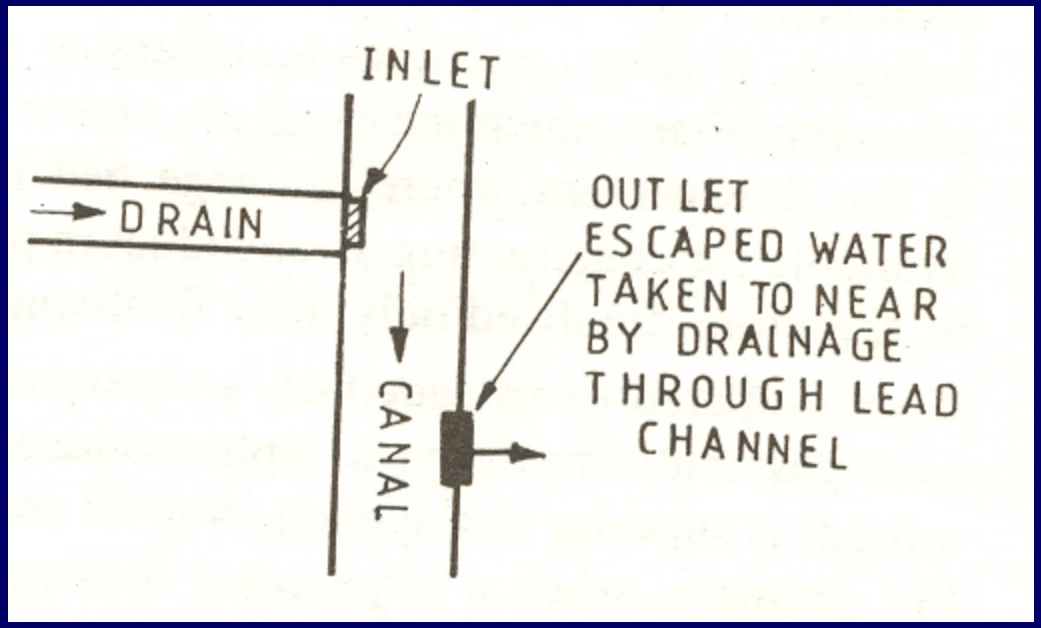
Classification of CD Works



Level Crossing

It is provided when a canal and drainage approach each other practically at the same level.

Classification of CD Works



Inlet and outlet

- An inlet is simply an open cut or a pipe in a canal bank to admit drainage water into the canal.
- An inlet may be provided for a small drainage if its bed level is higher than the canal FSL, provided it des not carry heavy silt.
- If drainage water admitted into the canal is discharged at a suitable site opposite the inlet or on downstream, the arrangement is called an inlet and outlet.
- Inferior to an aqueduct or super passage and performance has not been satisfactory.

Selection of suitable type of CD works

- The relative bed and high water levels of the canal and the drainage, and their relative discharges primarily dictate the type of CD work most suitable for a particular location.
- If bed level of canal is well above the high flood level of a drain then Aqueduct
- If reverse Super passage
- When the canal has small discharge compared to the drain, it is taken below the latter by constructing the syphon against a syphon aqueduct, which is constructed when the drain with smaller discharge is taken below a large canal.

Selection of suitable type of CD works

- In practice, however, relative economic of various alternatives are considered after taking the following into account.

(i) Canal alignment and topography of the drain,

(ii) Foundation strata,

(iii) Ground water table and dewatering requirements,

(iv) Permissible loss of head in canal,

(v) Sediment characteristics of the drainage and its regime condition.

Design of CD works

- Design of CD works
- Hydraulic design - Surface flow
  - Sub-surface flow

Main features of design with regard to Surface flow

(i) Design discharge

(ii) Determination of water way of drain

(iii) Affluxed HFL of the drain

(iv) Head loss through the CD works

(v) Fluming of contraction of canal water way,

(vi) Uplift pressure on the trough and the floor.

Design of CD works

- Design of CD works
- Hydraulic design - Surface flow
  - Sub-surface flow

Main features of design with regard to Sub-Surface flow

(i) The uplift pressure of the percolating water acting on the bottom of the floor

(ii) The exit gradient and hence safety of structure against piping.

Design of CD works

Design discharge

for small CD works

1 in 25 years flood

1 in 50 years flood

For major CD works

1 in 100 years flood

- In case of important structures, an additional margin of safety is provided in the foundation design, and fixation of freeboard to take care of the unexpected and unforeseen nature of flood intensities.

Design of CD works

Determination of water way of drain

- Lacey's regime parameter $P = 4.75 \sqrt{Q}$

  (i) In plain (where silt factor is about 1), it is generally economical to keep the water way 1 to 2 times Lacey's water way.

  (ii) In boulder reach of the river, the water way ranging from 0.25 to 0.9 time Lacey's water way.

  (iii) However, in the boulder reach of the river, the water way on Lacey's formula has no significance.

  (iv) In actual practice, the most economical water way is dictated by the allowable afflux and the discharge intensity per metre run.

Design of CD works

Determination of water way of drain

Dominant discharge – ½ to 2/3 of maximum flood discharge

Or 1 in 5 years frequency flood

- The most important aspect is the velocity through the vintage.
- The water way should be so fixed that during the dominant flood, the velocity generated through the vintage should be enough to scour the material collected in the vintage but during the design flood, it should not be so excessive so as to damage the works, or cause excessive scour around piers etc.
- In alluvial reach, minimum velocity of about 1 m/s during dominant flood but should be limited between 2 to 3 during design flood.

Design of CD works

Determination of water way of drain

- In boulder strata, the minimum velocity during dominant flood should be about 3 m/s but should not exceed 6 m/s

Above considerations may necessitate substantial reduction in the Lacey's water way between 60% to 80%.

Design of CD works

Affluxed HFL of the drain

Affluxed HFL may be determined by Mlesworth formula

$$h = \left(\frac{v^2}{17.85} + 0.0152 \right) \left(\left(\frac{A}{a} \right)^2 - 1 \right)$$

where, h = afflux (m)

V = velocity of unobstructed stream (m/s)

A = the unobstructed area of stream (m^2)

a = area of the obstructed sectional area of stream (m^2)

Design of CD works

Discharge and head loss through CD works

- Aqueduct

  Sufficient freeboard (difference between afflux HFL of the drain and bottom level of canal trough)

  ≈ normally 0.6 m

- Super passage

  when barrels are provided, a freeboard of 0.25 m in case of canal and 0.5 m in case of nala is usually considered adequate.

Design of CD works

Discharge and head loss through CD works

- Syphon and Syphon aqueduct – Unwin's formula

$$h = (1 + f_1 + f_2 \frac{L}{R}) \frac{V^2}{2g}$$

$$f_2 = (a + \frac{b}{R})$$

L = length of barrel (m)

R = Hydraulic mean depth in the barrel (m)

V = velocity of flow (m/s)

f_1 = coefficient for loss of head at entry taken as 0.505 for an unshaped mouth, 0.08 for bell mouth

a, b = are given for different materials (of the surface of the barrel)

Design of CD works

Discharge and head loss through CD works

- Syphon and Syphon aqueduct – Unwin's formula

Note: The height of the barrel shall not be kept less than 2 m from the consideration of manual clearing of deposits therein.

Design of CD works

Fluming of contraction of canal water way

- It is usual to flume the canal upto 75% of its bed width
- It has to be assumed that velocity and loss of head is within permissible limits.
- Minimum transition of 2:1 on u/s and 3:1 on d/s side
- Normally 3:1 on u/s and 5:1 on d/s side
- Usually done after model studies.
- Generally, the normal earthen canal section is trapezoidal while the flumed pucca canal section is rectangular.
- It is also not necessary to keep the same depth in the normal and flumed sections.

Design of CD works

Fluming of contraction of canal water way

- Channel transitions – to provide a smooth change from one stage to other so as to avoid sudden transition and the formation of eddies.
- Methods

  Mitra's method of transition (when water depth remains constant)

  Chaturvedi's method of design transition (when water depth remains constant)

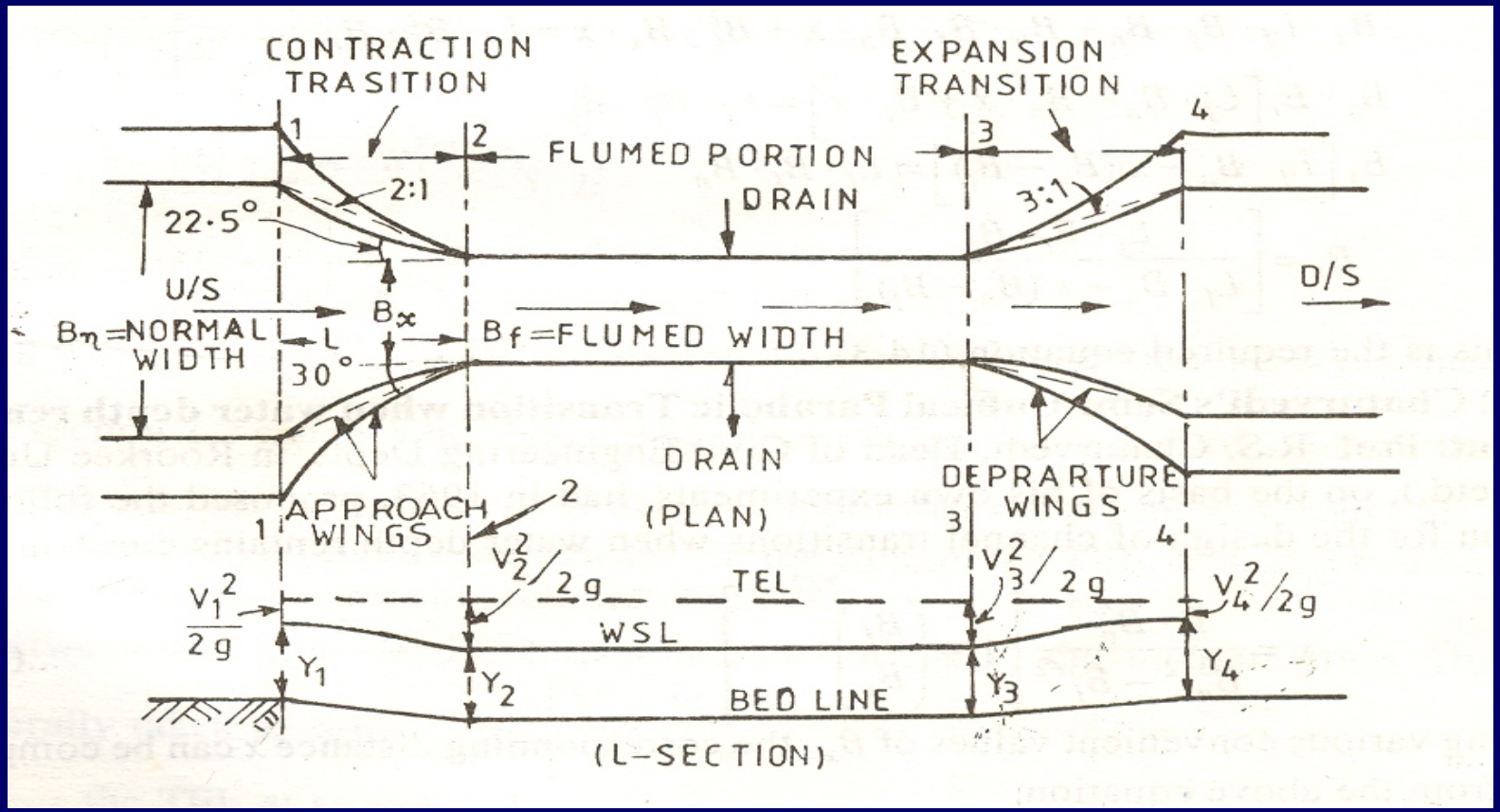
  Hind's methods of design of transition (when water depth may or may not vary).

Design of CD works

Fluming of contraction of canal water way

- Channel transitions –

  Mitra's method of transition (when water depth remains constant)



Design of CD works

$$B_x = \frac{B_n B_f L_f}{L_f B_n - (B_n - B_f)x}$$

The rate of chnage of velocity per unit length of transition reamins constant throughout the transition.

$$\frac{V_f - V_x}{x} = \frac{V_f - V_n}{L_f}$$

since Q and y are constant

Design of CD works

Uplift pressure on the trough and the floor

