R.C.Patel College Of Engineering & Polytechnic, Shirpur

Department of Civil Engineering

Course Title- Water Resource Engineering **Course Code -** 315314

Programme Name -Civil Engineering **Semester-** Fifth

Unit	Title	COs	Learning hours	R Level	U Level	A Level	Total Marks
V	Diversion Headwork and Canals	CO5	08	00	08	06	14

Unit 5 : Diversion Headwork and Canals.

5.1 Weirs

Defination → A weir is a structure constructed across a river or stream to raise the water level on the upstream side and divert water into an irrigation canal.

Main functions of a weir

1) Raises water level on the upstream side
2) Diverts water into an irrigation canal
3) Helps maintain the required water level at the canal entrance.
4) Controls the flow of water.
5) Can help in measuring discharge when designed as a measuring weir.
6) Protects the canal from receiving water at an unsuitable low level.

Diversion Headwork

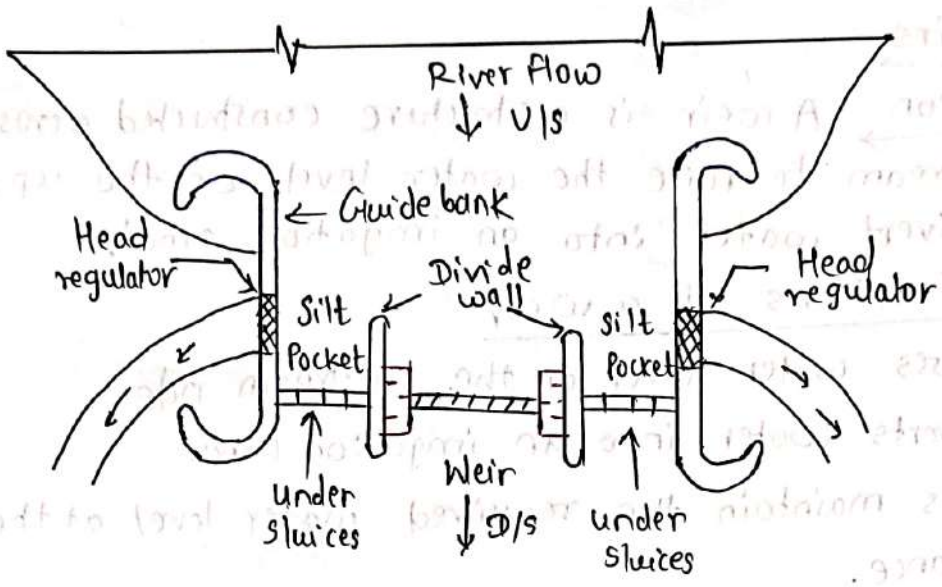
A diversion head work is a structure constructed across a river so as to raise water level on upstream side so that it can be diverted towards canal.

- If the storage on upstream of diversion head work is significant, it is called storage weir.

Ideal site for diversion Headwork

1. Good foundation should be available.
2. The overall cost should be less.
3. Proper approach way should be nearby site.
4. The site should be such that weir can be aligned at right angle to the diversion of water in the river.
5. On the upstream side where water is retained, should not include costly land.

Layout of diversion Head Work



Layout of diversion Weir

A diversion head work consist of following component:

1) Weir (barrage)
2) Under sluice
3) Fish ladder
4) Divide Wall
5) Canal head regulator
6) Silt excluder
7) Guide bank
8) marginal bunds.

Types of Weir

Weirs are classified as follows:

1) Gravity Weir 2) Non-gravity weir.

1) Gravity weir →

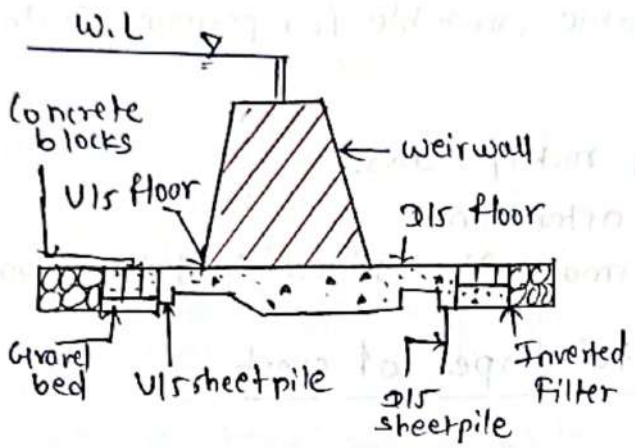
When the weight of weir balances uplift pressure caused by the head of water seeping below weir it is called gravity weir.

2) Non gravity weir →

In non gravity weir the uplift pressure is largely resisted by weight of concrete slab with the weight of divide piers.

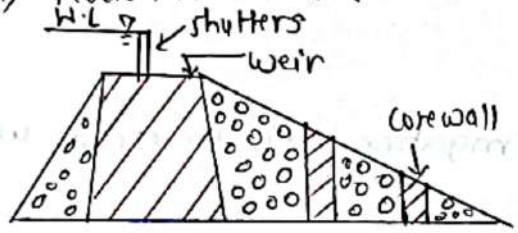
Gravity weirs are further divided into following types:

i) Vertical drop weir:



- Weir consist of horizontal floor and masonry crest with vertical or nearly vertical downstream face and shutters are provided at the crest.
- Most of storage is done by raised crest.

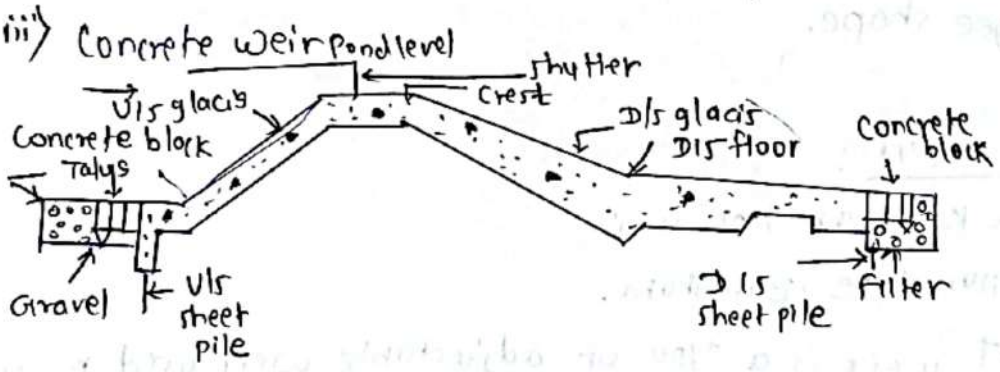
ii) Rock Fill weir:



It is also called dry stone slope weir

It is suitable for fine sandy foundation stone are mainly used for construction of such type of weir and hence requires large quantities of stone.

iii) Concrete weir



These are suitable for permeable foundations. In such weirs sheet piles are provided on both upstream and downstream floors, in order to destroy the energy of water.

Classification according to material of construction

1. Masonry weir

Constructed using stone masonry or brick masonry.

- strong and durable.
- suitable where masonry material is easily available.

2. Concrete weir:
constructed using cement concrete.
Advantages → strong, durable, suitable for permanent structures.

3. Rock fill weir.
Constructed mainly using rocks/ stones.
Advantages → - simple construction
- Useful for small streams and irrigation works.

classification according to shape of crest

1. sharp-crested weir
It has a thin/sharp crest.
Mainly used for measurement of discharge.

2. Broad crested weir
It has a wide crest
It is commonly used in irrigation and diversion works.

3. Ogee weir
The crest has a smooth curved profile, generally following an ogee shape.

K.T Weir:

K.T = Kolhapur type weir.
Kolhapur type Bandhara.

A K.T weir is a type of adjustable weir used mainly on small rivers and streams to store water after the monsoon and raise the water level for irrigation.
- It is particularly associated with Maharashtra and is commonly constructed across small rivers or streams.

Components of KT Weir

1. Piers : Piers are vertical masonry/ concrete supports constructed across the river.
Function → Support the needles
Divide the weir into openings
Provide grooves for fixing needles

2. Openings: Openings are provided between two adjacent piers.
- Allow flood water to pass during the monsoon.
- Reduce obstruction to river flow.

3. Grooves: Vertical grooves are provided on the sides of the piers.
The wooden needles are placed inside these grooves,
- To hold the needles firmly in position.

4. Wooden Needles: Wooden needles are removable rectangular members placed between the piers.
Typical dimensions given in the Maharashtra irrigation reference are approximately.
Length = 2m, Height = 15cm, thickness = 5 cm.

5. Foundation: A strong foundation is provided below the piers and floor.
- Transfers load safely to the river bed.
- Prevents settlement, Provides stability.

6. Cut off walls:
Cut off walls are provided below the floor.
- Reduce seepage, Increase seepage path, Prevent piping.

7. Downstream Protection/ Apron:
Protection is provided on the downstream side.
- Prevents erosion, protects the river bed from high velocity water.

Construction of K.T Weir

1) selection of site
2) Foundation Preparation
3) Construction of piers
4) Providing Grooves
5) Construction of floor
6) Providing Needles
7) Storage of water
8) Removal of Needles before floody

" Piers + Grooves + Needles = K.T Weir"

5.2 Barrages

Defination → A barrage is a hydraulic structure constructed across a river to raise the water level and divert water into an irrigation canal.

- The main difference from an ordinary weir is that a barrage has gates/shutters over most or all of its waterway openings. These gates can be operated to control the flow and maintain the required upstream water level.

Purposes →

1) To raise the upstream water level
2) To divert water into irrigation canals
3) To control river flow
4) To pass flood water safely
5) To maintain required pond level
6) To regulate sediment.

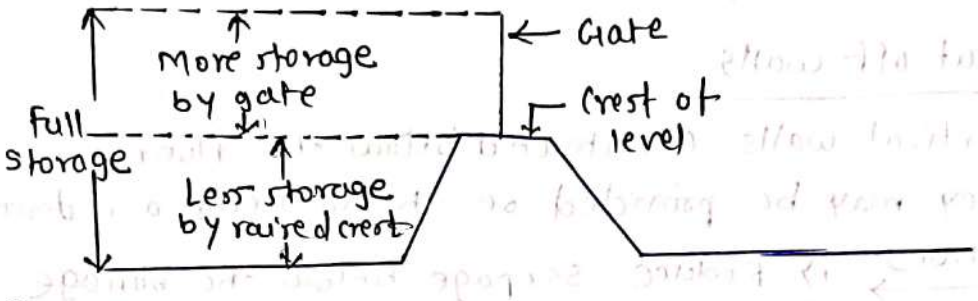
Functions →

1) Body of barrage: To raise the water level on u/s side.
2) Upstream Apron: To protect main body of barrage during floods
3) Upstream curtain wall: To reduce uplift pressure.
4) Crest wall: To raise water level and divert the water Canal.
5) Gate/shutter: During the floods, the gates are raised to clear off the high flood level, enabling the high flood to pass downstream with maximum afflux.

Components →

1. Barrage bays
2. Piers
3. Gates/shutters
4. U/S & d/s glacis
5. Cut off walls
6. Upstream impervious floor
7. Downstream impervious floor/apron
8. Stilling basin

9. Energy dissipators
10. Divide wall
11. Fish ladder
12. Breast wall
13. Under sluices
14. Guide banks
15. Afflux bunds.



1. Barrage Bays

A barrage bay is the opening through which river water passes.
Several bays are provided side by side across the river.

Function → i) Provides passage for river water
ii) Allows flood discharge to pass
iii) Gates are provided in the bays to control the flow.

2. Piers

Piers are vertical structures provided between two adjacent barrage bays.

Functions → i) support the gates
ii) Divide the barrage into different bays.
iii) Provide support for gate operating machinery.
iv) Provide bridge/ roadway support in some barrages.

3. Gates/ shutters

Gates are movable barriers installed in the barrage bays.

Function → To control the quantity of water passing through the barrage.

4. Barrage floor

The barrage floor is the horizontal base on which the piers and gater are supported.

Functions → i) supports the barrage structure,
ii) Provides a smooth passage for water.
iii) Protects the foundation from flowing water.
iv) Helps resist uplift pressure.

5. Cut off walls

Vertical walls constructed below the floor.
They may be provided on the upstream and downstream sides.

Functions → i) Reduce seepage below the barrage
ii) Increase the seepage path.
iii) Prevent piping
iv) Protect the foundation.

6. Impervious floor

An impervious floor is provided below the barrage.
It is made of relatively impermeable material such as concrete.

Function → i) Reduces seepage
ii) Protects the foundation.
iii) Helps maintain stability of the barrage

7. Glacis

A glacis is a sloping surface provided on the upstream or downstream side of the barrage floor.

Function → i) Provides a smooth transition to the downstream side.
ii) Helps control the flow.
iii) Works with the stilling basin for energy dissipation.

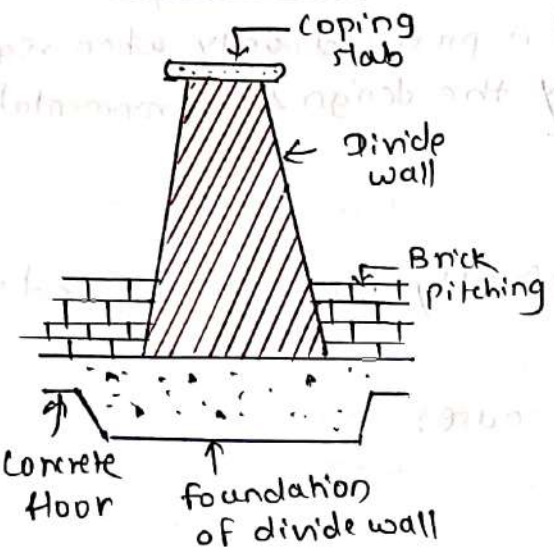
8. Stilling Basin - Provided on the downstream side.
- Main purpose to reduce the energy & velocity flowing water.

9. Canal head Regulator:

The canal head regulator is provided at the entrace of irrigation canal.

Functions → i) It regulates discharge
ii) To regulate the supply of water entering in canal.
iii) To controls the entry of silt into canal.
iv) To prevents the river flood entering the Canal.

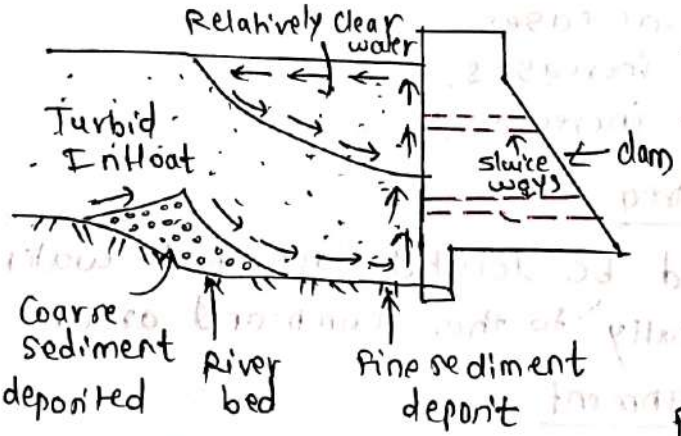
10. Divide wall



- A divide wall is a wall constructed longitudinally between the barrage and the canal / under sluice arrangement.
- It separates different flow zones

Functions → i) Separates the under sluice portion from the main barrage portion
ii) Helps guide the flow.
iii) Helps control sediment movement
iv) Provides a calm approach to the canal head regulator.

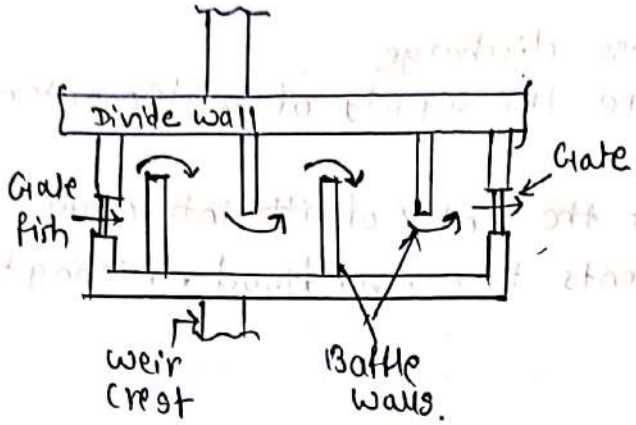
11. Under sluices



- Under sluices are low level gated openings provided near the canal head regulator.
- They are also called scouring sluices in many irrigation works.

Functions → i) Remove deposited silt.
ii) maintain a clear approach near the canal head.
iii) Pass excess water
iv) Help control sediment deposition.

12. Fish ladder



a)

- A fish ladder is provided where necessary to allow fish to move from the downstream side to the upstream side of the barrage.

function → i) Provides a passage for fish.

ii) Reduces obstruction to aquatic life caused by the barrage.

- It is provided only when required by the design & environmental condns

Location of Barrage →

1. Suitable River Bed:

The river bed should preferably have a strong and stable foundation.

A week foundation can cause:
- Excessive settlement
- seepage
- structural problems.

2. Suitable River width:

If river is extremely wide:
- Barrage length increases.
- Number of bays increases.
- construction cost increases.

3. Near Irrigable Area

The barrage should be located such that water can be diverted economically to the command area.

4. Suitable Canal Alignment

The canal should be able to take off from the barrage at a suitable location and alignment.

5. Stable River Banks.
6. Minimum obstruction to flood flow.
7. Minimum shifting of River course.

Differentiation Between Weir & Barrage.

Weir	Barrage.
1) Initial cost weir is low	1) Initial cost of barrage is high
2) Area of submergence is more due to large afflux.	2) Area of submergence less due to less afflux.
3) water level control comparatively less control over upstream water level.	3) water level control provides better control of upstream water level.
4) It is difficult to inspect and repair.	4) These provides better facilities for inspection & repair of various structure.
5)	
5) Roadway is not possible across river.	5) Road way can be provided across the river.
6) Storage of water is done by crest and very little by or nil portion of water is by gate.	6) In barrage most of water storage is done by shutter & very less or nil portion of water is by crest.

5.3 Canals

Definition → A canal is a man made open channel constructed to carry water from a source such as a river, reservoir, barrage or weir to agricultural fields or other required locations.

(OR) A canal is an artificial channel constructed to convey water from one place to another.

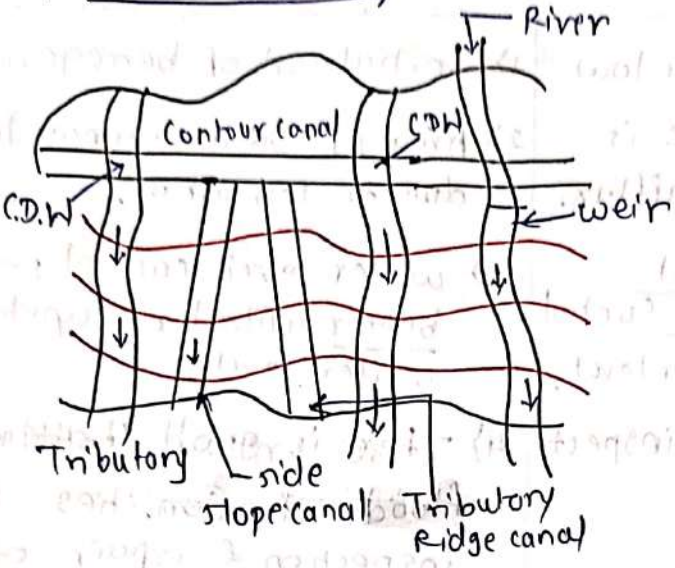
Canal Alignment →

Canal alignment is the location of the centre line of canal in plan and fixing it on the ground.

- The alignment should be such that it has minimum cross drainage work and it should be such that cutting and filling of soil will balance.

Classification of canals based on alignment

1) Contour canal →



- A contour canal is a canal constructed approximately parallel to the contour lines of the ground.
- A contour line joins points having the same elevation.
- The canal generally follows the natural slope of the land.

Cross drainage work.

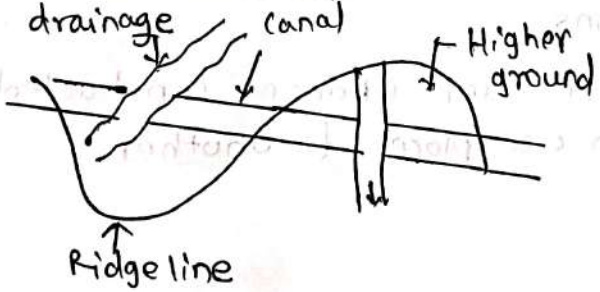
Advantages →

i) suitable in hilly areas
ii) In contour canals longitudinal slope is given to enable water to flow by gravity.
iii) Can carry water over a long distance.

Disadvantages →

i) Natural drainage streams may cross the canal.
ii) Can irigate only one side.

2) Ridge Canal →



- A ridge canal is a canal constructed approximately along the ridge or water-shed line of an area.
- A ridge is a comparatively high line separating two drainage areas.

Advantages →

i) Economical
ii) No cross drainage required
iii) It can irigate on both sides.

3) side long /or side slope

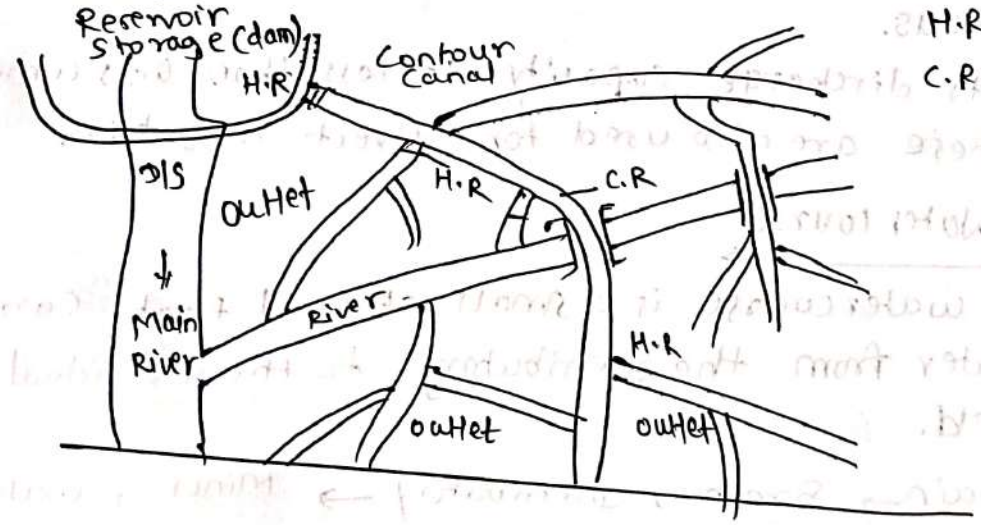
A side slope canal is constructed approximately along the side slope of a valley, usually at right angles or nearly right angles to the contours depending on the terrain and canal alignment.

- These types of canals are not intercepted by cross drainage work.
- The canal has to be designed carefully so that;
  i) It has the required bed slope
  ii) Water flows safely.
  iii) Excessive cutting or filling is avoided.

Canal Network →

Parts of canal system:

1) Main canal
2) Branch canal
3) Major distributor
4) Minor distributor
5) Water course
6) Head work.



1) Main canal →

- The main canal is the the largest canal in an irrigation system.
- It carries water from the; Reservoir, Barrage, weir. to the irrigation network.

characteristics → i) Largest discharge
ii) Large dimensions
iii) Usually does not directly supply individual farms.
iv) supplies water to branch canals and distributaries.

2) Branch canal →
- A branch canal takes water from the main canal.
- It carries water toward different parts of the Command area.

characteristics → i) Smaller than the main canal.
ii) carries less discharge.
iii) supplies distributaries.

3) Major distributory →
A distributory takes water from a main or branch canal and distributes it to a smaller area.

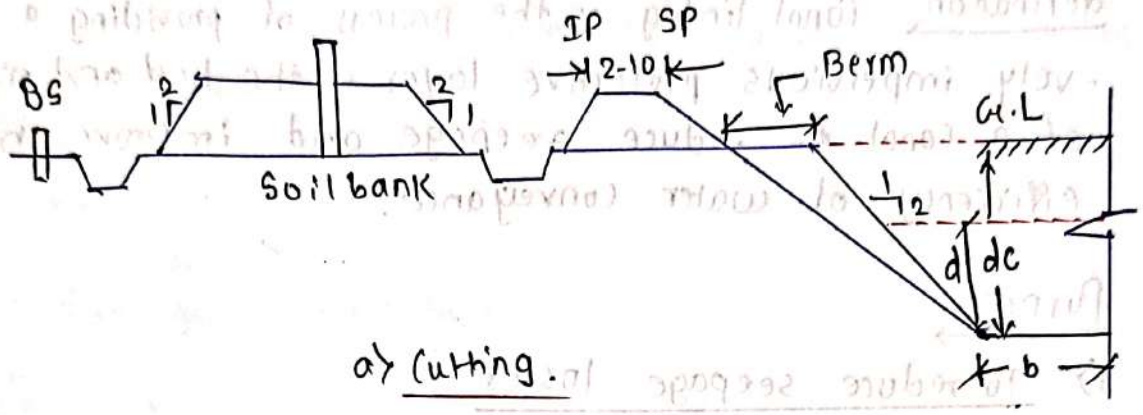
4) Minor distributor →
It carries water to a still smaller area.
- To distribute water closer to individual agricultural areas.
- Its discharge capacity is less than 0.25 cumecs.
These are also used for direct irrigation.

5) Water course →
A watercourse is a small channel that carries water from the distributory to the individual agricultural field.

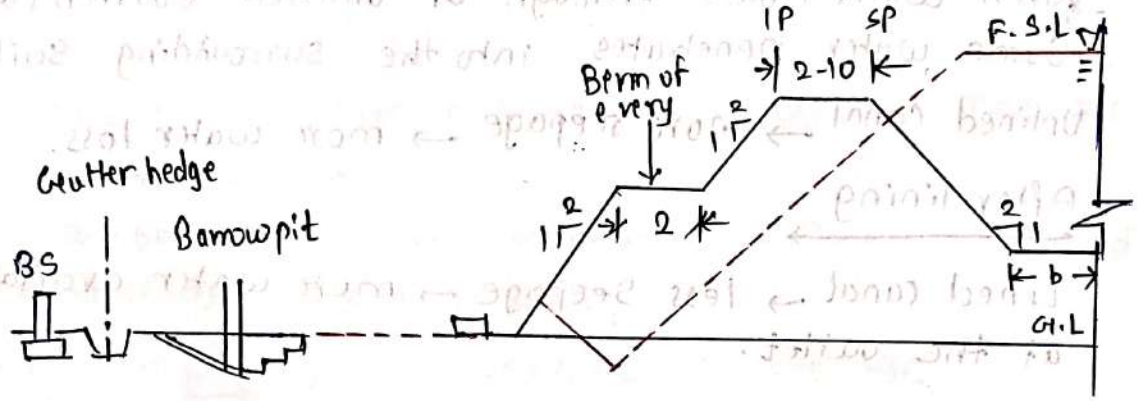
Main → Brach → Distributory → Minor → watercourse → field.

6) Head Work →
The works there are constructed to store, divert and control the river water and regulate the supplied into the canal.

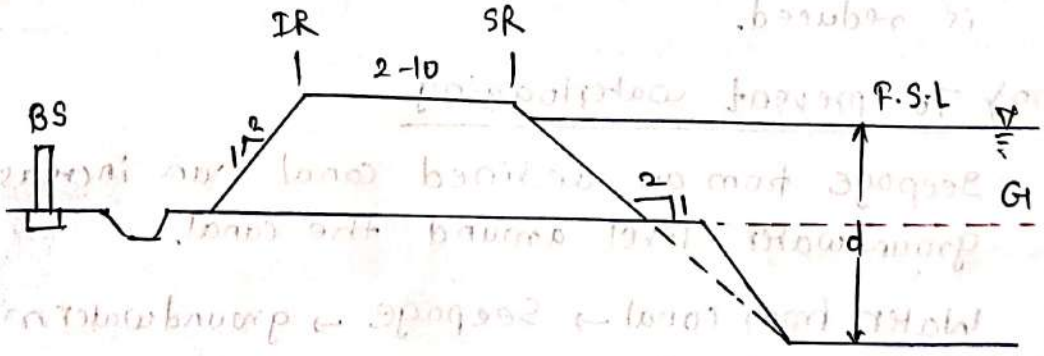
Cross section of canal in, Filling and in Partial Cutting and Filling :



a) Cutting.



b) In Filling



c) In partial cutting and filling.

5.5 Canal lining:

- A canal is an artificial channel constructed to carry water from a river, reservoir, dam or other source to agricultural fields, industries or other locations.

definition → Canal lining is the process of providing a relatively impervious protective layer on the bed and sides of a canal to reduce seepage and improve the efficiency of water conveyance.

Purpose →

1) **To reduce seepage losses**

- When water flows through an unlined earthen canal, some water penetrates into the surrounding soil.

Unlined canal → more seepage → more water loss.

- After lining →

Lined canal → less seepage → more water available at the outlet.

2) **To increase the water carrying capacity**

- A properly finished lining provides a smooth surface.
- Because of the smooth surface, resistance to water flow is reduced.

3) **To prevent waterlogging**

Seepage from an unlined canal can increase the groundwater level around the canal.

Water from canal → seepage → groundwater rises → waterlogging.

4) **To prevent growth of weeds**

weeds, unwanted vegetation can grow along the bed and sides. from this obstruct water flow.

5) To prevent erosion of the canal section

Fast flowing water can erode the bed and sides of an earthen canal.

6) To reduce maintenance.

An unlined canal generally requires frequent maintenance because of,

- Weed growth
- erosion
- Silting
- damage to side slopes.

Construction material used in canal lining :

1) Cement or lime Concrete lining :

The lining which is done by Concrete is called as Concrete lining.

- A concrete layer is constructed over the prepared Canal bed and side slopes.

Advantages → i) Good reduction in seepage
ii) Strong and durable
iii) Smooth surface
iv) Less maintenance.

disadvantages → i) Initial construction cost can be high.
ii) Cracks may develop if construction and joints are not properly provided.

2) Brick lining :

Bricks can be used for lining the bed and sides of canals.

- Bricks are generally laid over a prepared surface using mortar.

Advantages → i) Bricks may be locally available
ii) construction is relatively simple.

Disadvantages → i) Joints can allow some seepage.
ii) Quality depends strongly on brick and mortar.

3) Stone masonry lining

- Stone masonry lining is constructed using stones joined with cement mortar.
- It may be useful where good quality stones are easily available.

Advantages → i) Strong and durable.
ii) Good resistance to erosion.
iii) Useful in areas where stones are locally available.

Disadvantages → iv) Construction is comparatively labour-intensive.
ii) Surface may not be as smooth as concrete.

4) Cement Mortar lining

- A relatively thin layer of cement mortar can be applied over a prepared canal surface.
- It is generally used where a comparatively thin protective and seepage reducing layer is required.

Advantages → i) Simple construction
ii) Smooth surface.
iii) Less thickness than concrete lining.

Disadvantages → i) Comparatively less resistant to major structural damage.
ii) Cracking can cause seepage.

5) Shotcrete lining

- In shotcrete lining slurry of cement mortar is forced under pressure through nozzle on the surface of canal.
- It is also used for resurfacing old lined surface Thickness of this lining varies from 3.5cm to 5cm.

6) Asphaltic lining

- In this lining asphalt cement is used with sand and gravel.
- It provides smooth flexible surface the only drawback of this lining is it absorb heat and encourages weeds growth causing rapid deterioration.

7) Precast Concrete block lining

Concrete blocks are carted in factories are used to Prepare bed, it has high durability hydraulic efficiency the thickness of such lining may vary from 5 to 6.5cm.

Advantages Canal lining :

1) Reduction in seepage: The biggest advantage is the reduction of water loss through the canal bed and sides.
2) Increased irrigation efficiency: More water reaches the intended command area, so the efficiency of the irrigation system improves.
3) Prevention of waterlogging: Reduced seepage helps control excessive rise of groundwater.
4) Prevention of weed growth: Hard lining greatly reduces the growth of unwanted vegetation.
5) Less erosion: The canal bed and sides are protected from erosion caused by flowing water
6) Less maintenance: lowered maintenance required
7) Higher velocity of flow: A smooth lining reduces hydraulic resistance, allowing water to flow at a higher permissible velocity, subject to design Considerations.
8) Better control of canal water: Seepage and erosion are reduced, it operates efficiently.

5.6 Cross drainage works:

Definition → A cross drainage work is a structure provided at the intersection of an irrigation canal and a natural drainage channel to carry the canal water and drainage water safely across each other.

Classification or Types

The various cross drainage work are as follows:

1) Aqueduct
2) Super passage
3) Level crossing
4) Inlet and outlet.

1) Aqueduct →

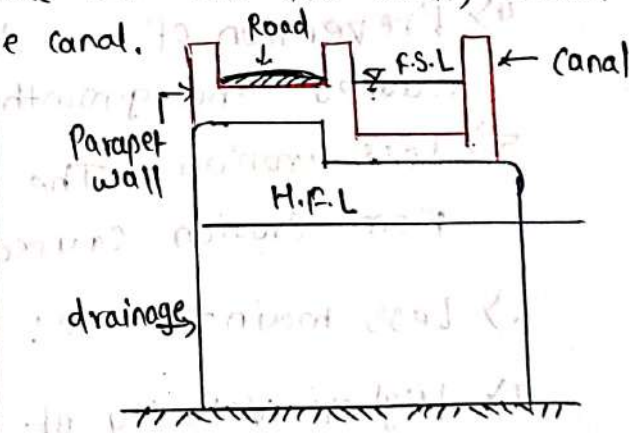
An aqueduct is a cross drainage structure in which the canal is carried over the drainage channel and the drainage water passes below the canal.

Canal over the drain = Aqueduct.

- canal bed is considerably above the HFL of the drain

HFL = High flood level.

- This provides enough space for the the drain water to pass freely below the canal.

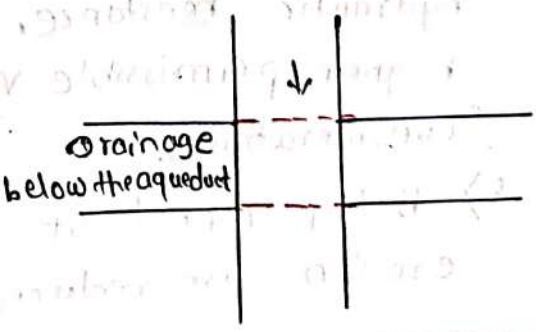


Advantages →

i) Canal water remains separate from drainage water.

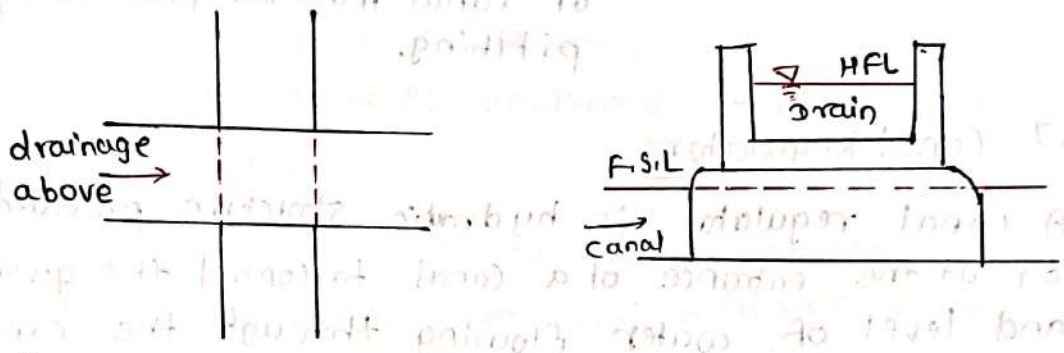
ii) Drain can pass freely below the canal.

iii) Drainage does not interface with canal operation under normal conditions.



2) Super passage:

- A super passage is a cross drainage work in which the drainage channel is carried over the canal.
- Drain over canal = super passage.
- The drainage bed is considerably higher than the canal.
- The drain can pass over the canal by gravity.
- The main object of super passage is to take stream discharge safely across canal and at higher level.

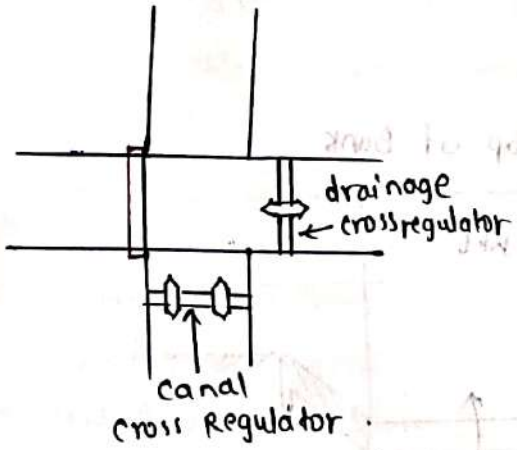


Advantages
i) Drainage water flows naturally by gravity.
ii) Simple hydraulic arrangement compared with siphon arrangement.

3) Level crossing

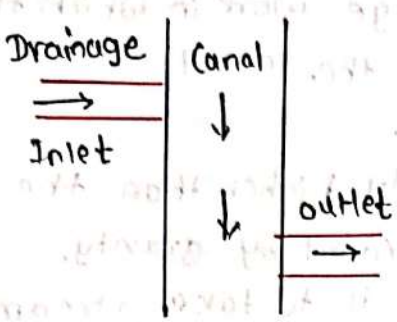
A level crossing is a cross drainage arrangement in which the canal and drainage channel meet approximately at the same level, and their flows are controlled by suitable regulators.

- Canal and drain at nearly the same level = Level crossing.



Advantages
i) Simple arrangement for suitable site conditions
ii) Economical for small drains.
iii) Suitable when canal and drain are at nearly the same level.
iv) Flow can be controlled using regulators.

4) Inlet and outlet



- Inlet admits water of stream into the canal and it flows mixed with canal water and then excess discharge is allow to pass through outlet.
- The capacity of inlet and outlet must be same and sides and beds of canal must be protected by stone pitching.

5.7 Canal Regulators

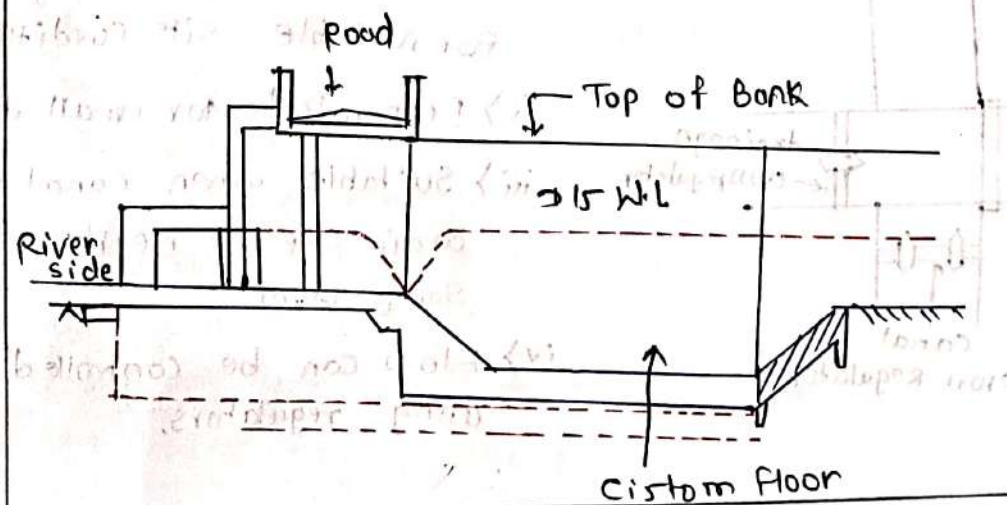
A canal regulator is hydralic structure provided across or at the entrance of a canal to control the quantity and level of water flowing through the canal.

Regulators generally consist of:

i) opening or water passage.
ii) Gates
iii) Piers
iv) Abutments
v) operating mechanism
vi) floor
vii) Upstream and downstream protection works.

Two Types

1) Head Regulator:



- A head regulator is a regular constructed at the head or entrance of a canal or distributory, where water is diverted from a river, reservoir, main canal or another canal.
- A head regulator controls the quantity of water entering a canal or distributory.

Functions → i) controls discharge
ii) Maintains water level
iii) Controls silt entry
iv) Prevents unwanted entry of water.

2) Cross Regulator →

- A cross regulator is a structure constructed across a canal to control the water level and discharge in the canal.
- A cross regular is provided across a canal to control the water level upstream and regulate the flow downstream.

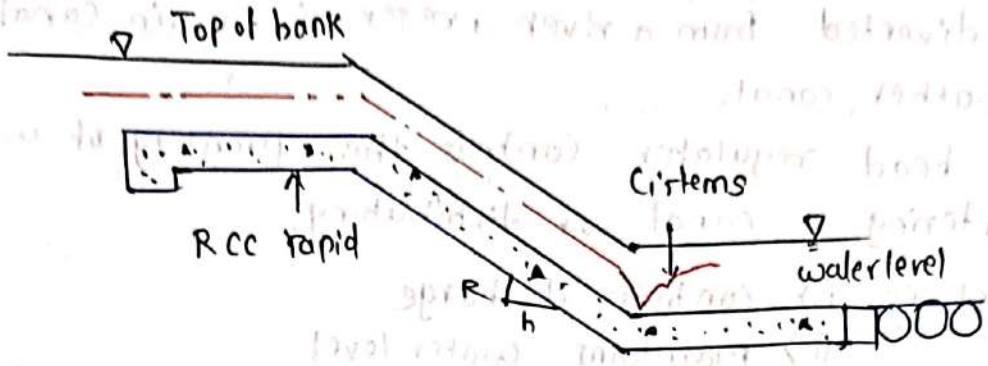
functions → i) Maintains required upstream water level.
ii) Controls canal discharge
iii) Helps in distribution of water
iv) Facilities canal maintenance.

Canal Escape →

- A canal escape is a structure provided to remove excess water from a canal and discharge it safely into a natural drain, river or other suitable location.
- Sometimes the canal receives more water than it can safely carry.

This happen because of:
i) Heavy Rainfall
ii) Sudden increase in water supply.
iii) Flood conditions
iv) Reduction in irrigation demand
v) Emergency conditions.

Canal Falls and Rapids:

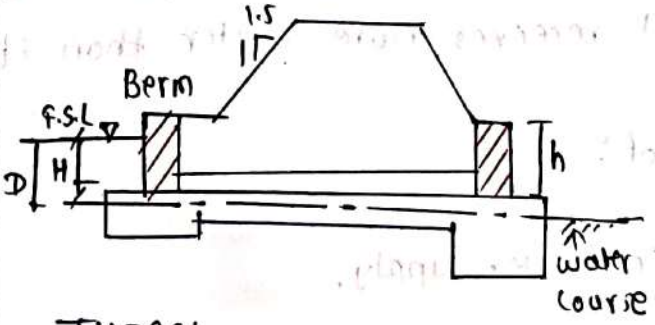


- A canal falls is a hydraulic structure provided in a canal when the natural ground slope is steeper than the permissible canal bed slope.
- High velocity can cause – i) Erosion
  ii) scouring
  iii) damage to the canal bed & sides.

Function → i) Reduces canal bed level
ii) Controls excessive velocity
iii) Dimipate energy
iv) Maintains proper canal slope.

Canal outlets →

- A canal outlet is a small hydraulic structure that takes water from a canal and supplies it to a watercourse, field channel or agricultural area.
- A canal outlet is a structure provided to deliver a controlled quantity of water from a canal to the field channel.



functions →
i) Supplies irrigation water
ii) Controls discharge
iii) Maintains equitable distribution.

Types:
1) Non Modular outlet: Simple opening or pipes.
2) Semimodular outlet: Flexible outlet
3) Modular outlet : Rigid modular, constant flow.

References →

1) Punmia B.C. ⟶ Irrigation and Water power Engineering.

2) Sharma R.K ⟶ Irrigation Engineering

3) Textbook ⟶ diagrams.

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ASSIGNMENT QUESTIONS

1. Compare Weir with barrage with respect to cost, afflux, maintenance, sketch.
2. Draw a layout of diversion head works with component parts.
3. State three advantages and disadvantages of canal lining.
4. Explain with the neat sketch components of Canal regulators: i) Head regulator ii) Escape and Fall.
5. Define canal lining and state material used for canal lining.
6. Suggest the suitable type of CD-work and draw sketch under each situation.
   i) Canal bed level and Nala bed level are same.
   ii) Canal bed level is above HFL of Nala.
   iii) Canal bed level is above FSL of canal
7. Explain construction and operation of KT weir.
8. Classify canals according to alignment and position in canal network.
9. Design economical section of canal suitable for following case.
   i) Discharge = 1.2 cumec
   ii) Coefficient of rugosity = 0.02
   iii) Canal in full cutting with side slope = 1.5 : 1.
   iv) Longitudinal bed slope = 1 in 2000.
10. Design a most economical canal section to carry a discharge of 5 m3/s. with bed slope of 1:2000 lined with concrete. Take N = 0.0012 and side slope 1:1.
11. Explain the advantages of Barrage w.r.t. i) Cost ii) Silting iii) Flood control Area of submergence
12. Describe in brief with neat sketch i) Aqueduct ii) Super passage iii) Level crossing.
13. Draw the cross section of canal in embankment and partial cutting and embankment.
14. Explain types of canal lining materials.