

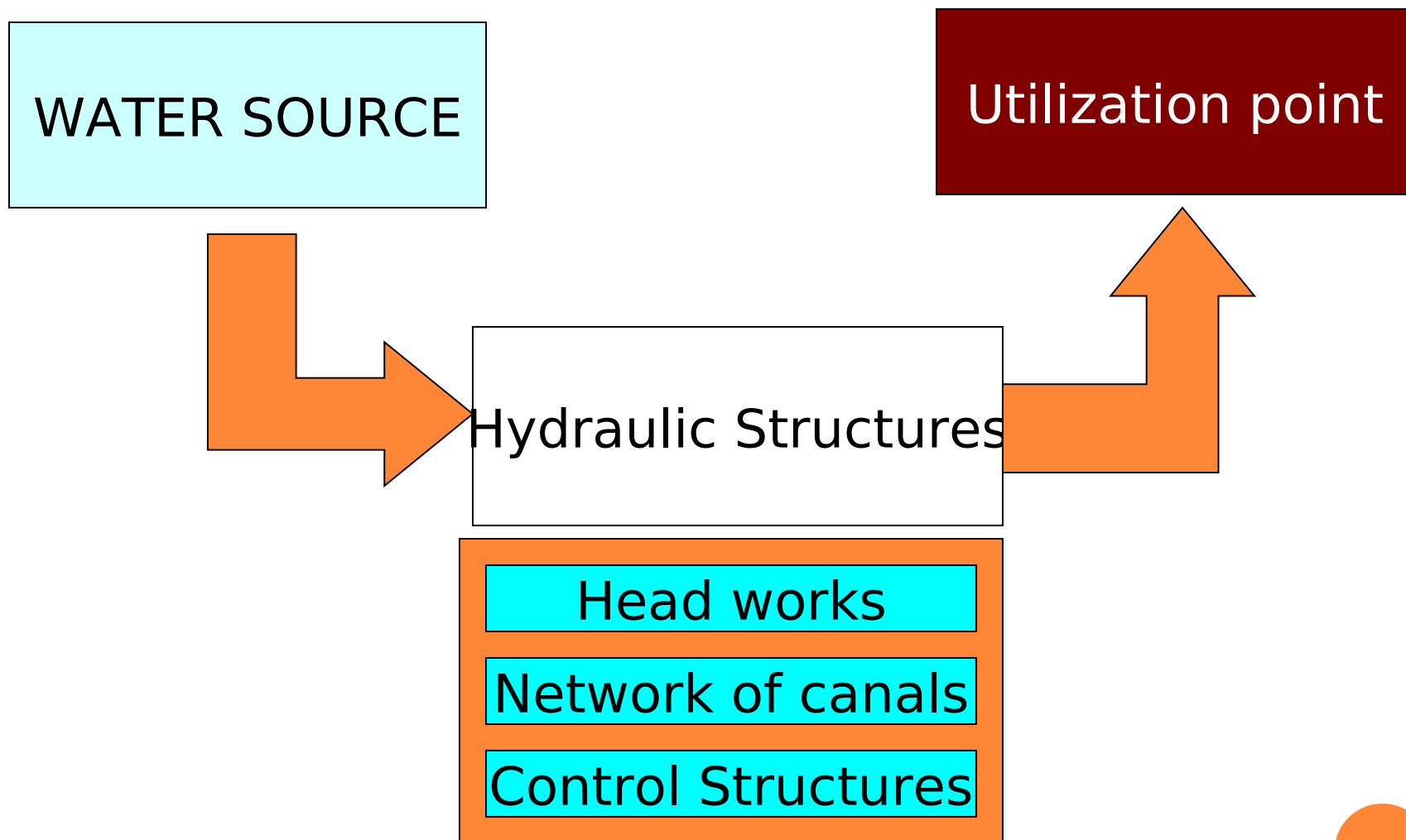
Chapter

3

DIVERSION HEAD



General:



Introduction

- Any **hydraulic structure** which **supplies** water to the off-taking **canal/conveyance structure** is called a **headwork**.
 - Headwork may be
 1. Storage headwork.
 2. Diversion headwork.
 - A Storage headwork comprises the construction of a dam on the river. It **stores** water during the period of **excess supplies** and **releases** it when **demand overtakes** available supplies.
- A **diversion headwork** serves to **divert** the required supply to canal from the river

Introduction

- **Headwork:** structures and hydro-mechanical equipment located at the upstream end of a water diversion system
- **Diversion works:** structures and hydro-mechanical equipment designed to divert and control the required discharge from the river. Eg. Dam, wier, barrage

In general;

- River diversion headwork is constructed at the head of the canal to divert the river water towards the canal, so as to ensure a regulated continuous supply of silt-free water with a certain minimum head into the canal.
- It usually provides a small storage capacity.

PURPOSES OF DIVERSION HEADWORK

- ✓ It raises the water level in the river so that the commanded area is increased
- ✓ It regulates the supply of water into the canal
- ✓ It provides storage of water for a short period
- ✓ It controls the entry of silt into the canal
- ✓ It reduces the fluctuations in the level of supply in the river.

SELECTION OF ACTUAL SITE FOR CANAL HEAD WORKS

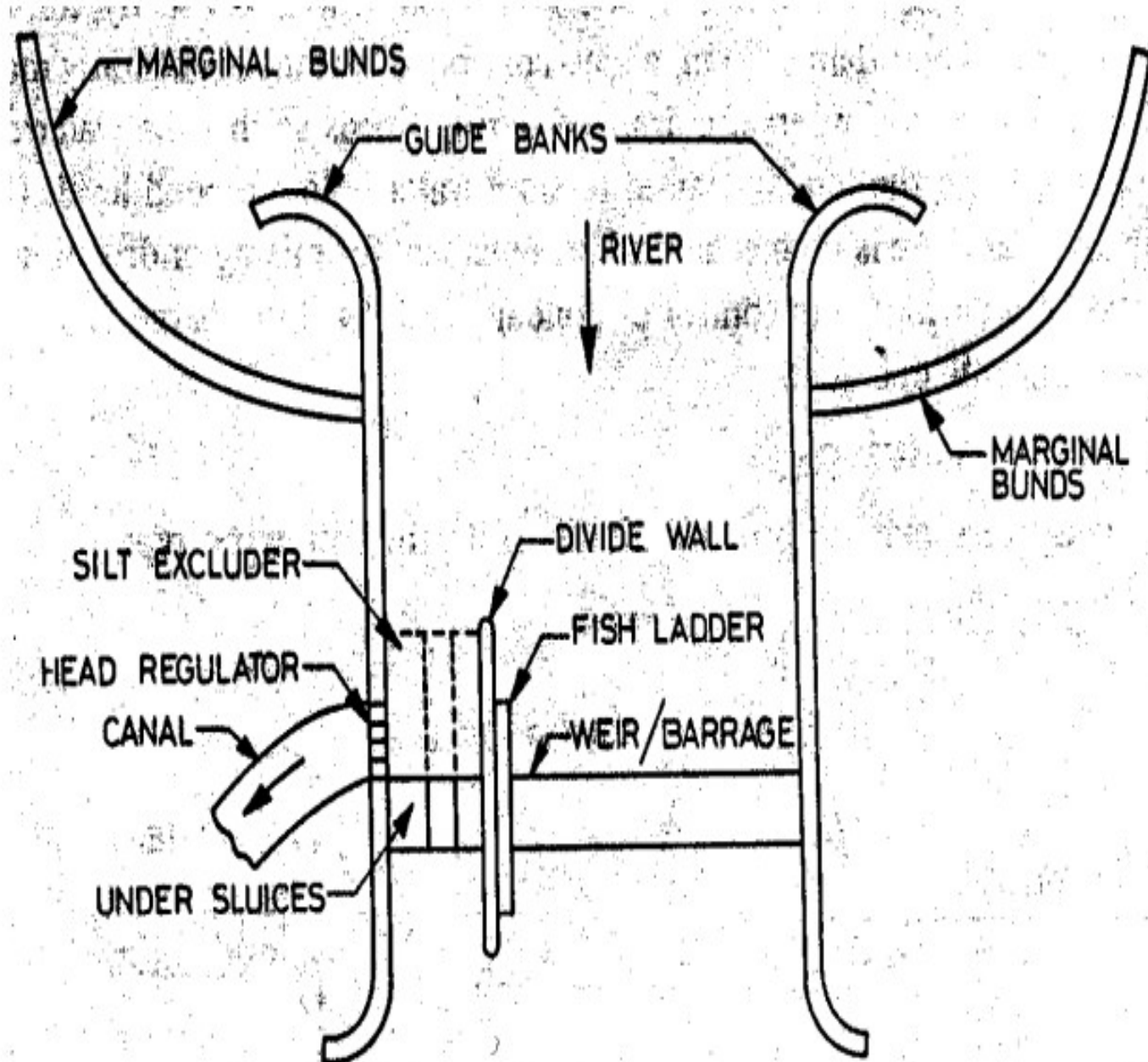
- As far as possible a narrow, straight, well defined channel confined b/n banks not submerged by the highest flood.
- It should be possible to align the off taking canal in such a way that the command of its area is obtained without excessive digging.
- The material of construction such as stone, sand, etc. should be available in the vicinity of the site.
- The site should be accessible by road. And there should be (enough) workers available in the vicinity of project site.

Diversion Headwork -Components

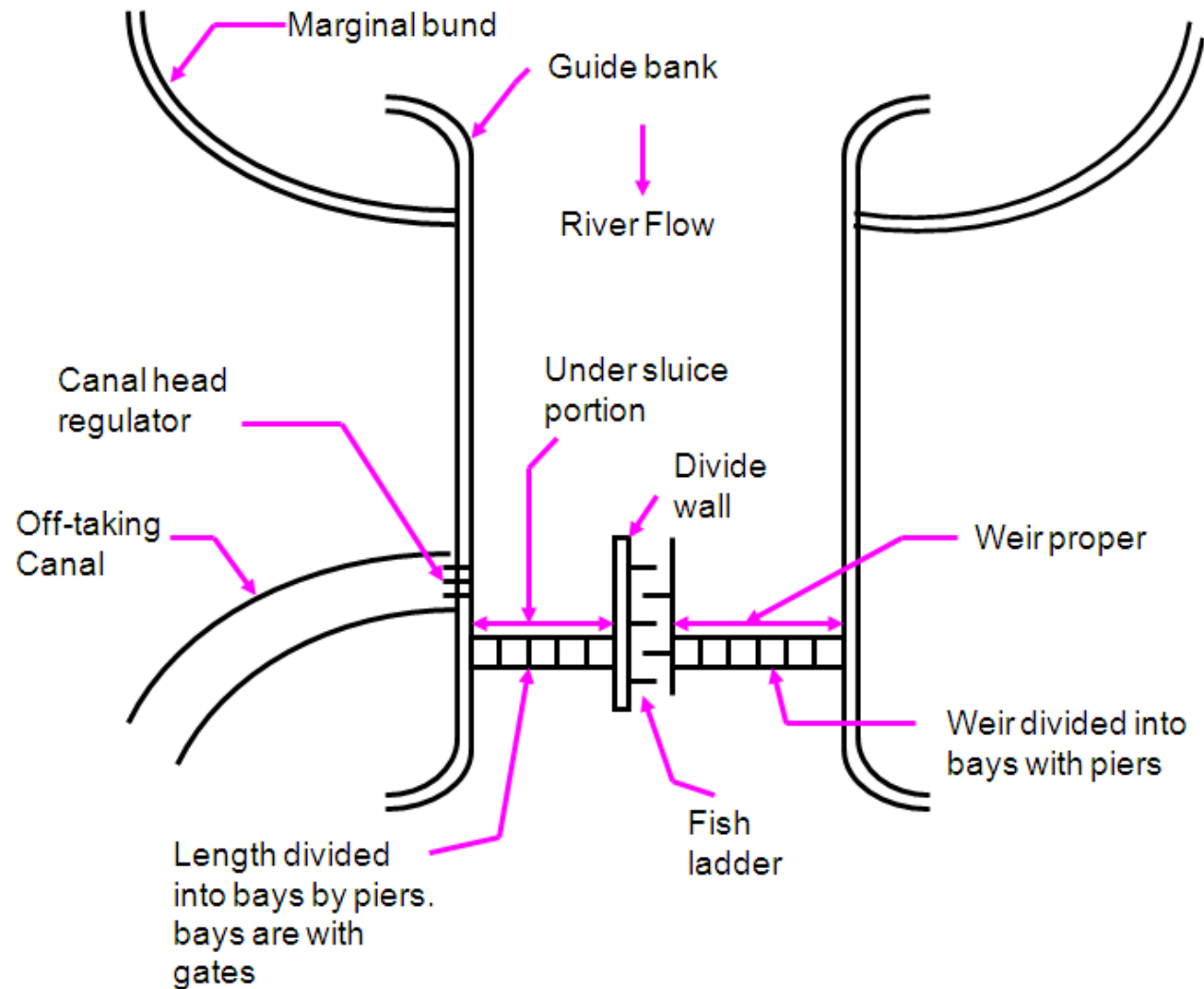
A typical diversion weir consists of:

1. Weir proper
 2. Under sluices
 3. Divide wall
 4. River training works –marginal bunds, guide banks, etc.
 5. Fish ladder
 6. Canal head regulator
 7. Ancillary works – gates/shutters, etc.
 8. Silt regulation works/silt excluder
- 
- The diagram shows a red curly bracket on the left side of the first three list items (1. Weir proper, 2. Under sluices, 3. Divide wall). To the right of the bracket is a yellow rectangular box containing the text 'Main components'.
- Main components

TYPICAL LAYOUT OF DIVERSION HEADWORK



Diversion Head Work - Components



Typical Layout of a diversion head work

1. Weir and barrage

- ✓ If the major part or the **entire ponding** of water is achieved by a raised **crest** and a **smaller or nil** part of it is achieved by the **shutters** then this barrier is known as a **weir**. on the other hand **most of the ponding** is done by **gates** and a **smaller or nil** part of it is done by the raised **crest** then this barrier is known as **barrage**. **Weirs and barrages are permanent river diversion works** and are relatively **low dams** constructed across a river to **raise the river level** sufficiently, to **divert** the flow in full/ in part into a supply canal or conduit for the purpose of **irrigation, power generation, domestic and industrial uses, etc**

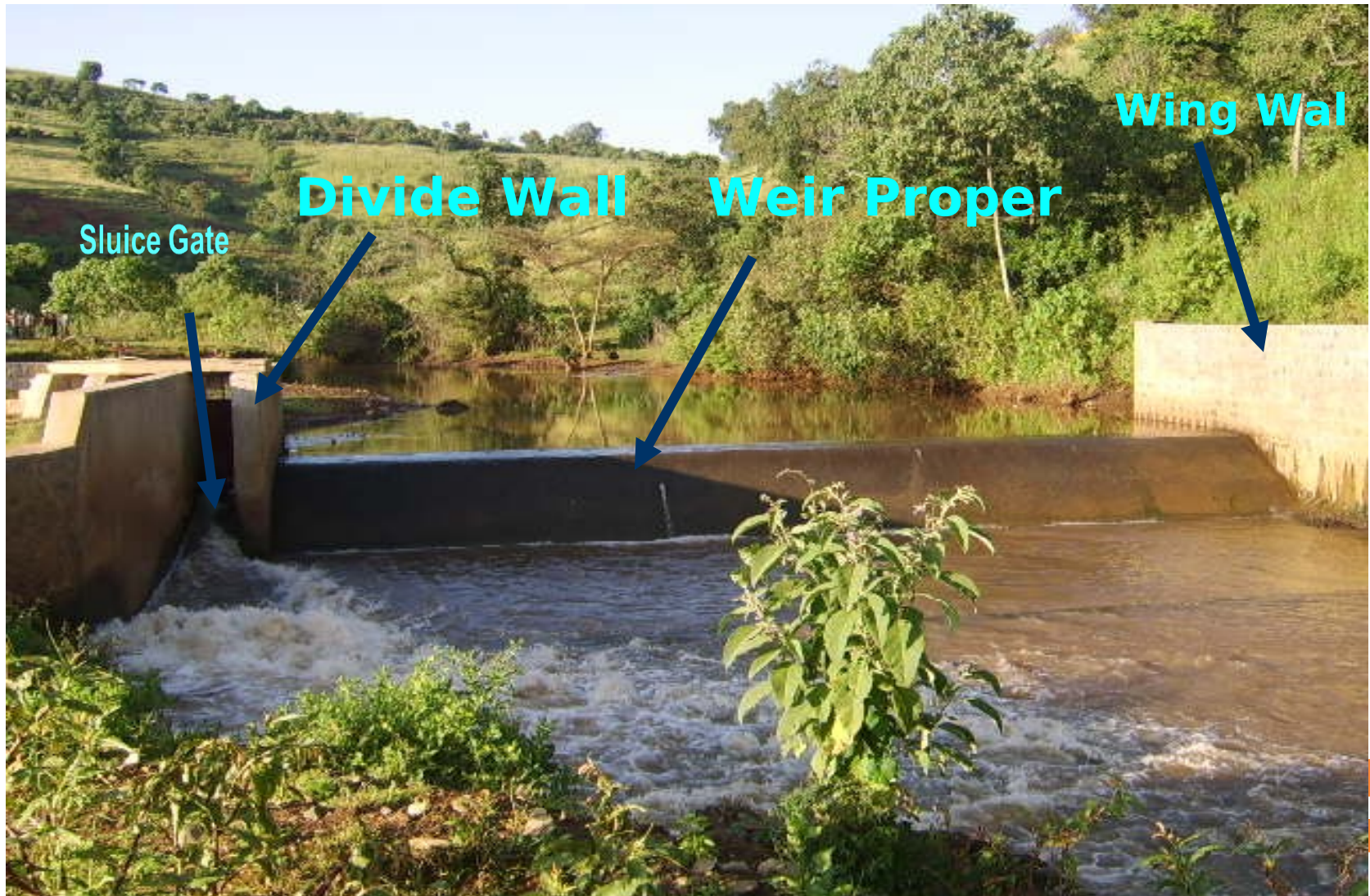
1. Weir and barrage

- ✓ *Weirs are with or without gates, whereas barrages are always gate controlled.*

The Purpose is:

- To obstruct and divert the river flow into the canal
- To raise the water level in the river locally at the canal take-off point and helps in maintaining gravity flow Thus, reduces excessive cutting of the canal in the head ditch.
- To reduce the fluctuation in the water level of the river
- To enable diversion of silt-free water into the canal system

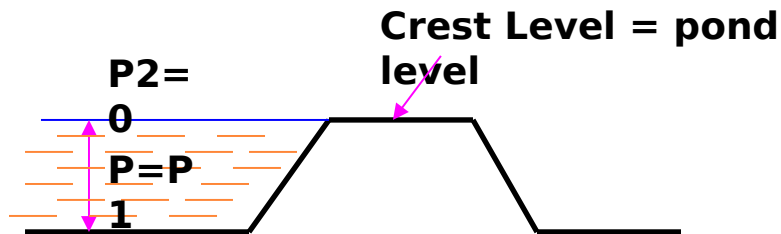
WEIR PROFILE



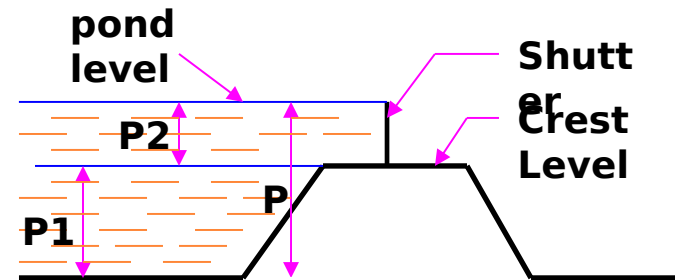
Barrage without raised crest



Weir and Barrage:



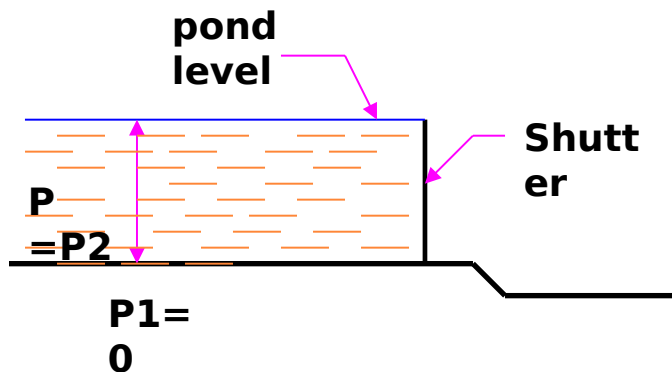
a) Without shutter



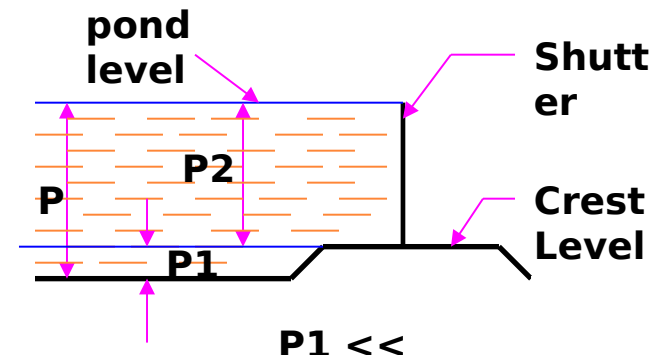
$$P_1 \gg P_2$$

b) With shutter

Weir



a) Without crest



$$P_1 \ll P_2$$

b) With crest

Barrage

Key: P = total ponding ; P_1 = Ponding by crest; P_2 = Ponding by shutter

Weir and Barrage:

Weir

- ❑ Most of the ponding of water is by a raised crest
- ❑ Has a small shutter or none
- ❑ The afflux during high flood is high
- ❑ Less control of river flow at times of flood.
- ❑ Not possible to construct road way
- ❑ Relatively cheap

Barrage (shuttered weir)

- ❑ Most of the ponding is by gates
- ❑ Has a small crest or none
- ❑ The afflux during high flood is nil or minimum
- ❑ A better control of river flow by manipulating gates
- ❑ a road way can be constructed
- ❑ Relatively expensive

BARRAGE

A weir maintains a constant pond level on its upstream side so that the water can flow into the canals with the full supply level.

- ✓ If the difference between the pond level and the crest level is less than 1.5 m or so, a weir is usually constructed.
- ✓ On the other hand, if this difference is greater than 1.50 m, a gate-controlled barrage is generally more suitable than a weir.
- ✓ In the case of a weir, the crest shutters are dropped during floods so that the water can pass over the crest.
- ✓ During the dry period, these shutters are raised to store water up to the pond level.
- ✓ Generally, the shutters are operated manually, and there is no mechanical arrangement for raising or dropping the shutters.
- ✓ On the other hand, in the case of a barrage, the control of pondage and flood discharge is achieved with the help of gates which are mechanically operated.

ADVANTAGES AND DISADVANTAGE OF WEIR

Weirs

- *Advantages*

- **The initial cost of weirs is usually low.**

- *Disadvantages*

- **There is a large afflux during floods which causes large submergence**
- **Because the crest is at high level, there is great silting problem.**
- **The raising and lowering of shutters on the crest is not convenient. Moreover, it requires considerable time and labor.**
- **The weir lacks an effective control on the river during floods.**

BARRAGE - ADVANTAGES AND DISADVANTAGES

Barrages

- Advantage

- The barrage has a **good control on the river during floods**. The out flow can be easily regulated by gates
- The **afflux during floods is small** therefore the submerged area is less
- There is a **good control over silt entry** in to the canal
- There is a **good control over flow conditions**
- There are **better facilities for inspection & repairs** of various structures.
- It is possible to **provide a roadway across the river at** a relatively small additional cost.

- Disadvantage

- The **initial cost** of the barrage is quite high



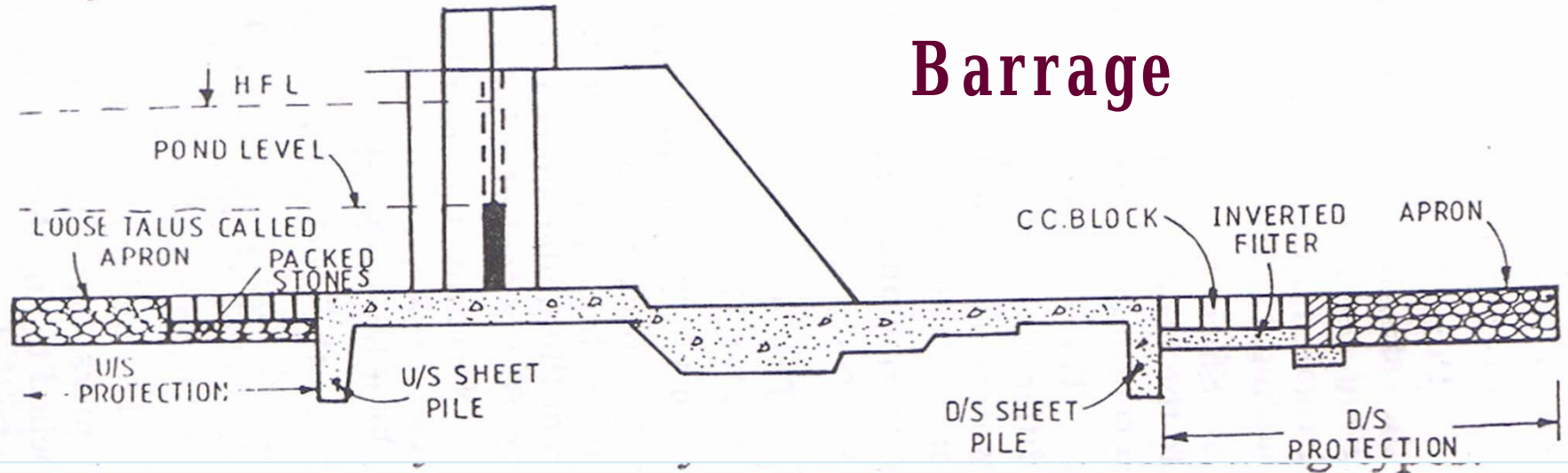
Small
weir

Small
barrage

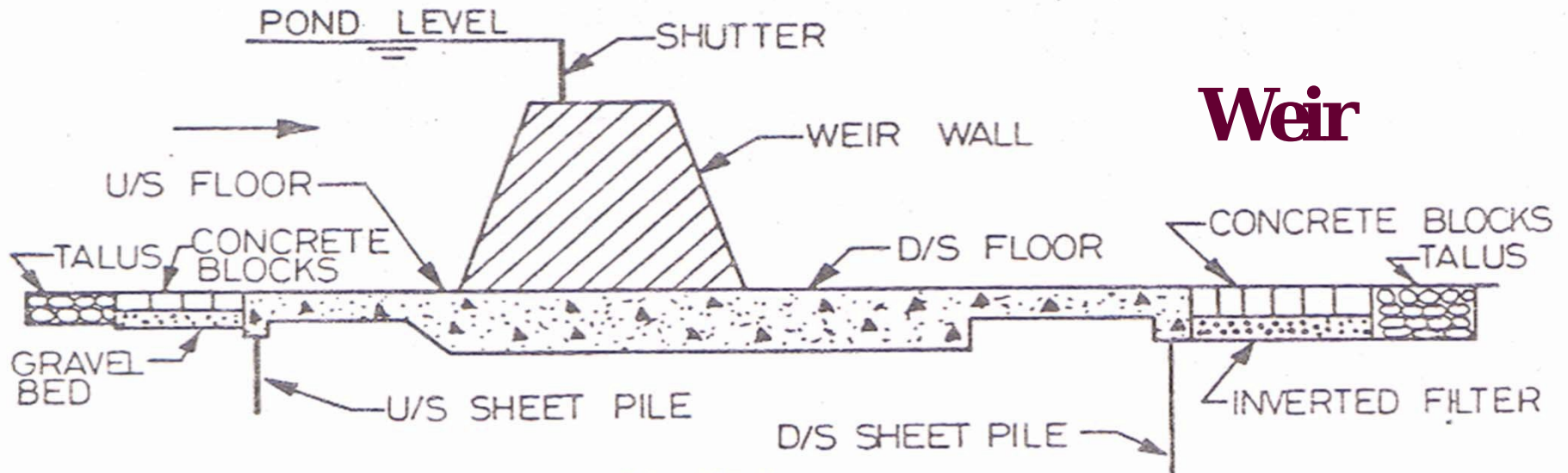


WEIR AND BARRAGE

Barrage



Weir



TYPES OF WEIR

- ❖ Vertical drop weirs
- ❖ Rock fill weirs.
- ❖ Concrete glacis or sloping weirs

VERTICAL DROP WEIRS

- Wall type structure on a horizontal concrete floor.
- Shutters are provided at the crest, which are dropped during floods so as to reduce afflux.
- Water is ponded upto the top of the shutters during the rest of the period.
- Vertical drop weirs were quite common in early diversion headworks, but these are now becoming more or less obsolete

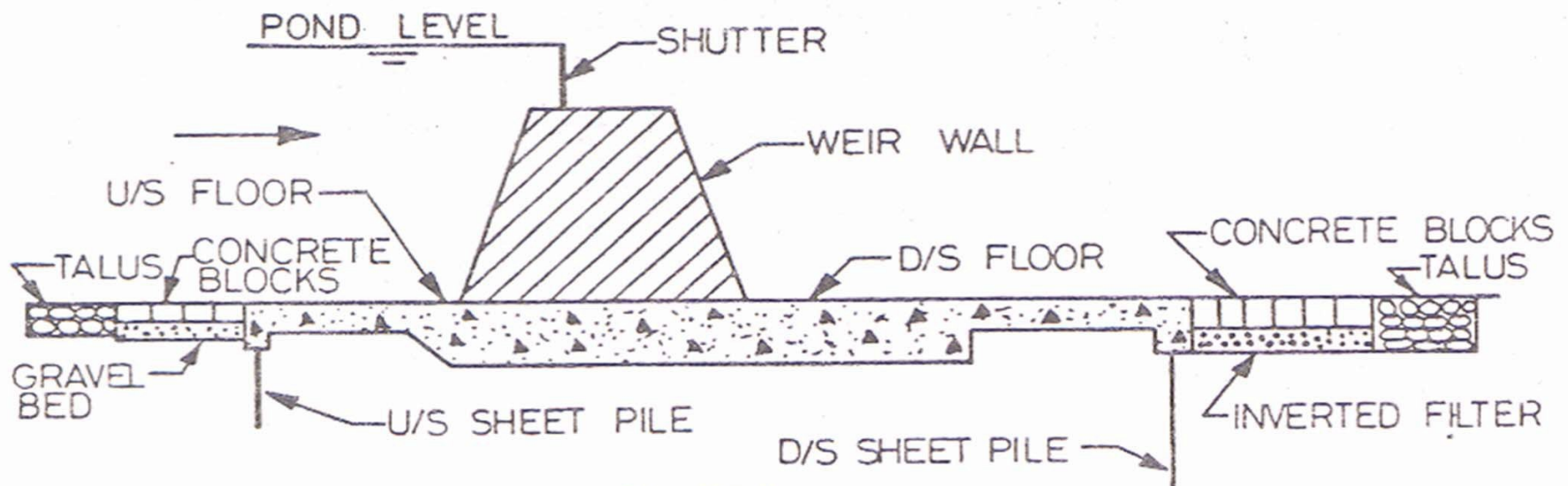
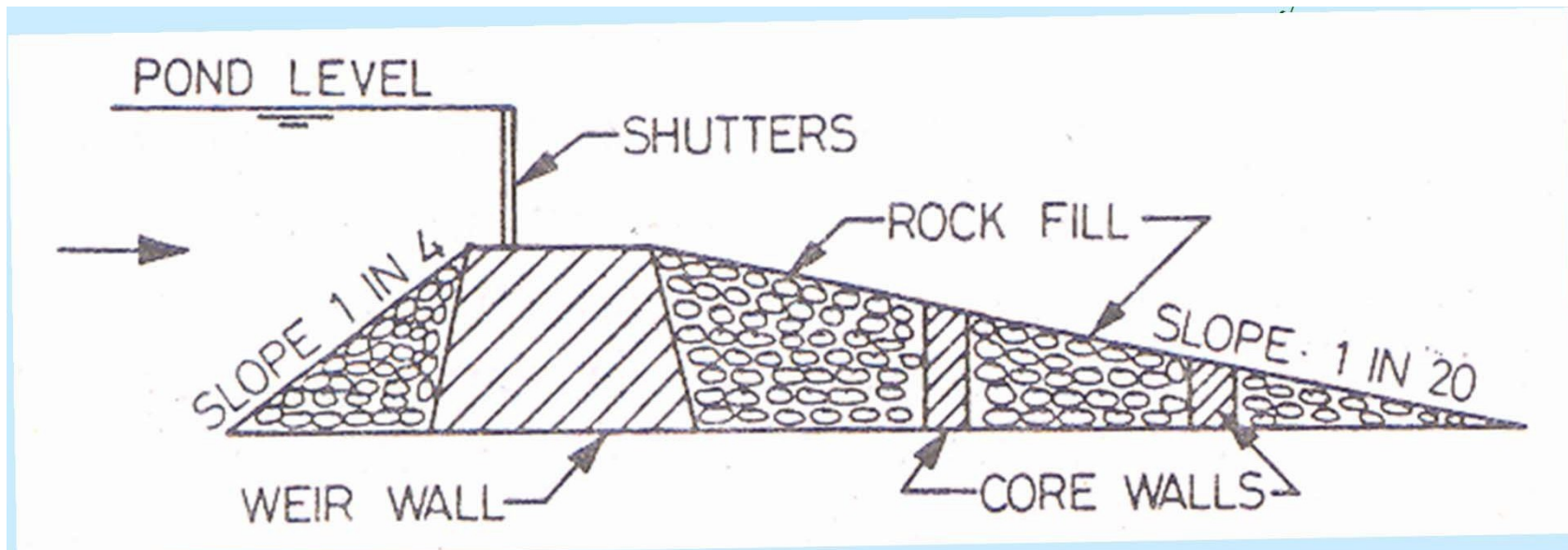


Fig. 17.2

ROCK FILL WEIRS

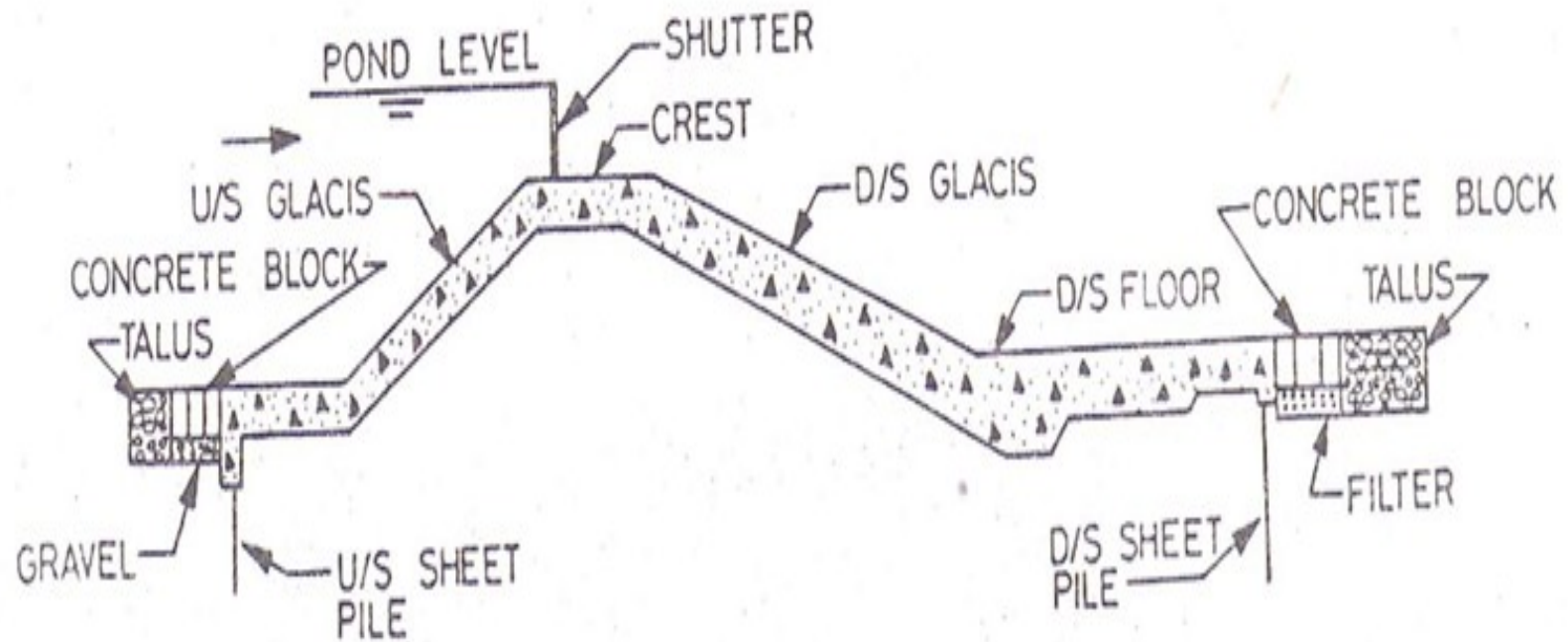
- In a rockfill type weir, there are a number of core walls. The space between the core walls is filled with the fragments of rock.
- A rockfill weir requires a lot of rock fragments and is economical only when a huge quantity of rockfill is easily available near the weir site.
- It is suitable for fine sand foundation. The old Okhla Weir across the Yamuna river is a rockfill weir.
- Such weirs are also more or less obsolete these days



SLOPING/GLACIS WEIRS

- Concrete sloping weirs (or glacis weirs) are of relatively recent origin.
- The crest has glacis (sloping floors) on u/s as well as d/s. There are sheet piles driven upto the maximum scour depth at the u/s and d/s ends of the concrete floor.
- Sometimes an intermediate pile is also driven at the beginning of the u/s glacis or at the end of d/s glacis
- The main advantage of a sloping weir over the vertical drop weir is that a hydraulic jump is formed on the d/s glacis for the dissipation of energy.
- Therefore, the sloping weir is quite suitable for large drops

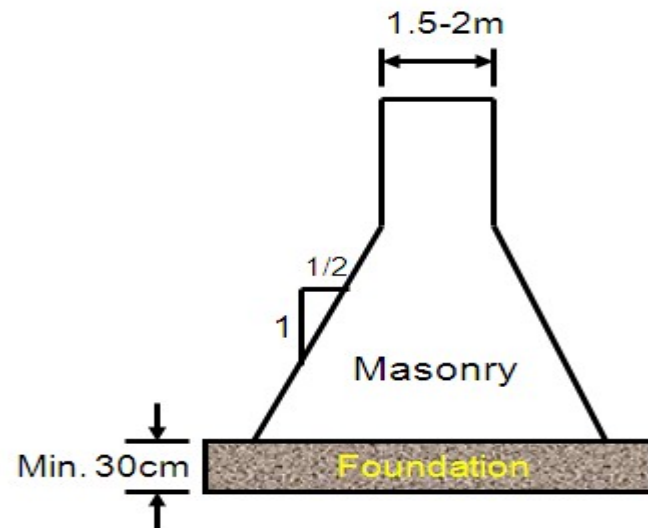
SLOPING/GLACIS WEIRS



Diversion Head Work - Components

1. Divide wall ...

- a long solid wall which **divides** the river water into two portions – the **weir proper** and the **under sluice portion**.
- Divide wall **constructed** of **stone masonry or concrete**.
- **Top width** usually varies from **1.5 to 2m**
- Extends from the **weir body** to a little beyond the length of the **head regulator**



Diversion Head Work - Components

2. Under sluice portion...

- a portion from which the main canal takes off water
- helps to reduce turbulence of flow near the canal head regulator.
- crest of the under sluice is made lower than the crest of the canal head regulator to divert silt free water.
- sluices controlled by gate to remove silt deposited in front of the head regulator.

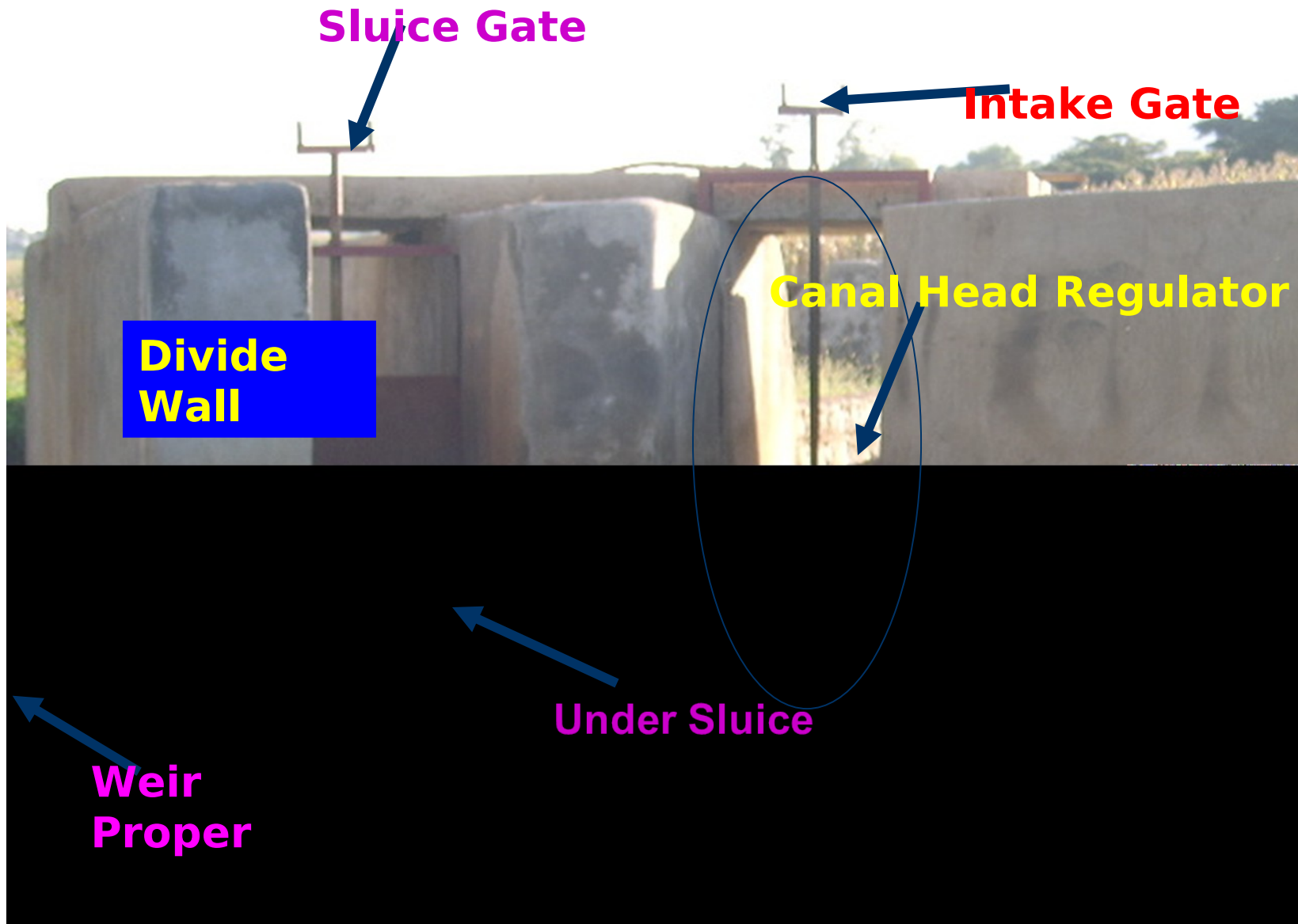
3. silt excluder:- to clean the silt deposition to the downstream so that only clear water enters into the canal through head regulator.

4. Head Regulator...

- a structure constructed at the entrance of the canal take off.
- used as a meter for measuring discharge.
- regulates and prevents excessive silt entry.

5. Fish ladder:- a structure provided for allowing free passage to the fishes, if present in the river.

COMPONENTS OF WEIR





**Temporary
Diversion**



Wing Wall

Divide Wall

Weir Proper

End Sill

**D/S Launching
Apron**



Divide Wall

Weir Proper

U/S Launching Apron

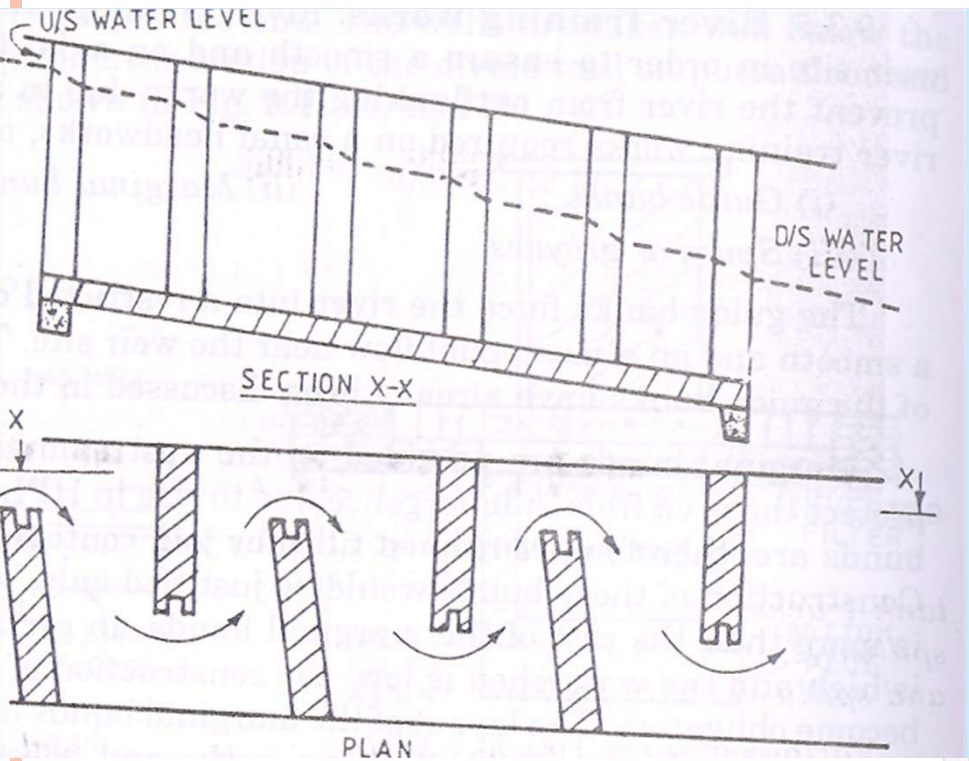
Under Sluice



PROFILE OF BARRAGE

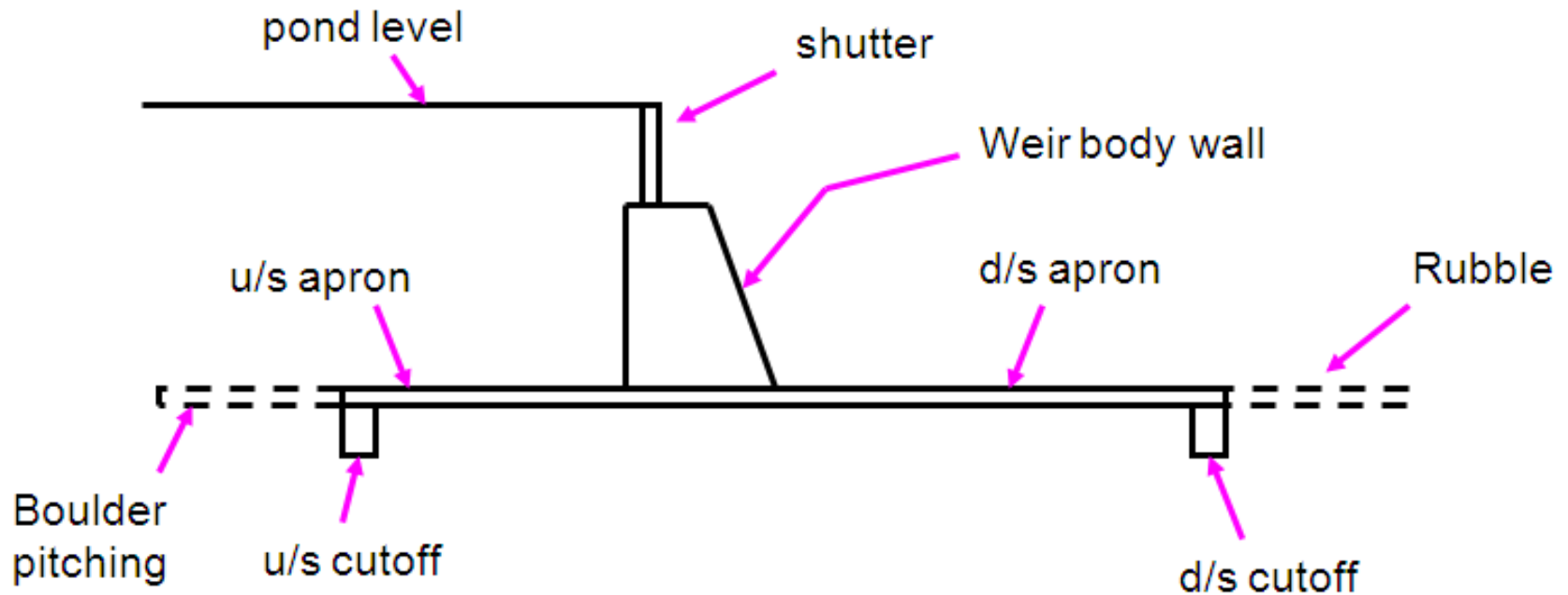


FISH LADDER



Diversion Head Work - Design

- It is essential to know various parts of a weir before actually designing it.



Typical structural components of a weir

Diversion Head Work - Design

- **Weir Design:** The data required for design are:
 - Maximum flood discharge in the river.
 - stage-discharge curve
 - Cross-section of the river
 - Soil properties at the bed of the river
 - Pond level
- **Design considerations:**
 - *Piping or undermining* ...hollow formation due to excessive percolation of water below the foundation.
 - *Failure due to uplift*...failure/rupture of apron, if not strong when the percolated water exerts excessive upward pressure

Diversion Head Work - Design

- Design Methods (Seepage Theories)

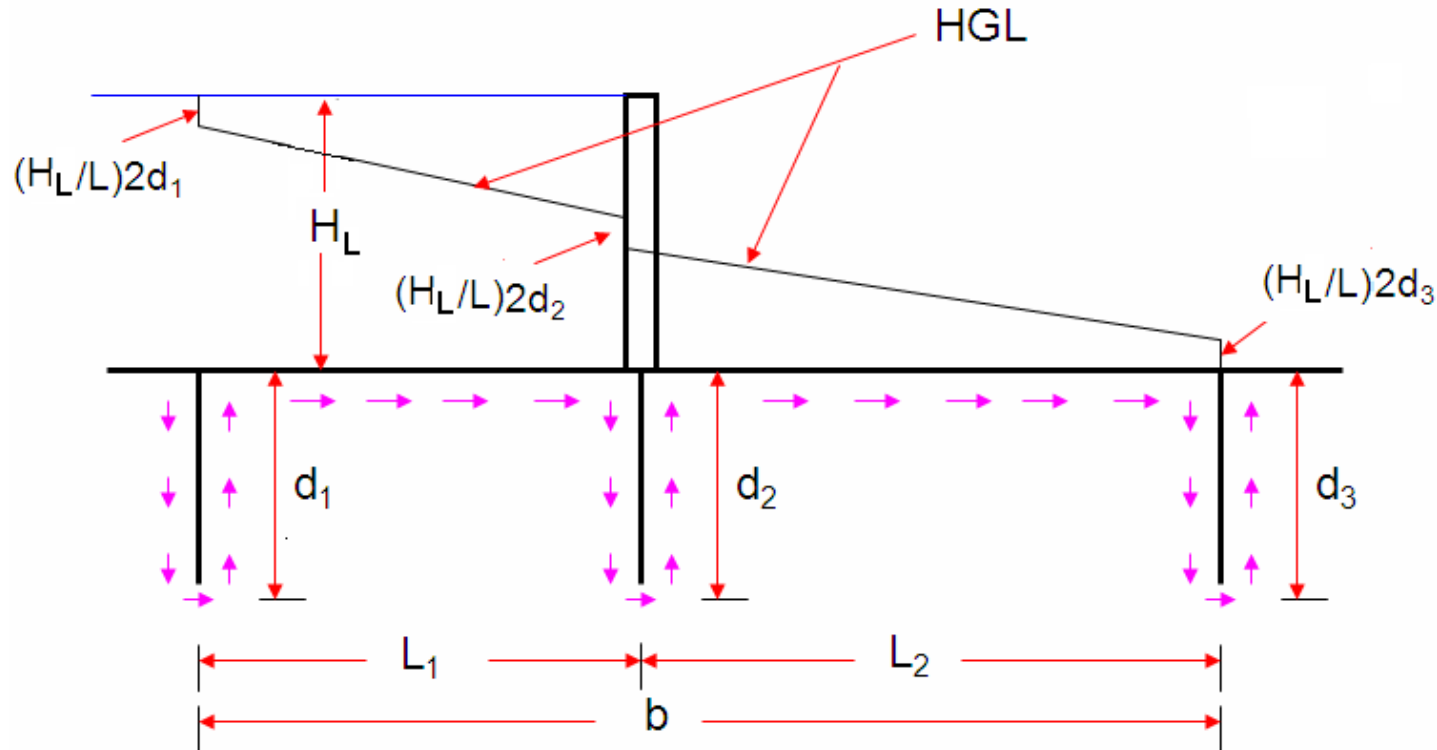
1. Bligh's Creep theory
2. Lane's creep theory
3. Khosla's creep theory

1. Bligh's Creep theory ... It states about

- The percolating water follows the outline of the foundation of the structure creep length, L .
- No distinction between horizontal and vertical creep.
- The loss of head is proportional to the length of the creep ...the hydraulic gradient, G .

Creep length, L ... the total length covered by the percolating water till it emerges out at the downstream end.

Diversion Head Work - Design



- Creep length, $L = b + 2d_1 + 2d_2 + 2d_3$
- Head loss per unit length or **hydraulic gradient**, $G = H_L/L$
- Head losses equal to $(H_L/L)2d_1$, $(H_L/L)2d_2$ and $(H_L/L)2d_3$ will occur respectively in the planes of **three vertical cutoffs**.

Diversion Head Work - Design

Lane's Creep theory ...

- The **horizontal creep** is **less effective** in reducing uplift (or in causing loss of head) than the **vertical creep**.
- He suggested a **weightage factor of 1/3** for the **horizontal** creep against the vertical creep. i.e.
$$L = 2d_1 + 1/3L_1 + 2d_2 + 1/3L_2 + 2d_3$$
- It is an **improvement** over **Beligh's** but not **rationalized**.
Not used anywhere.

Khosla's Creep theory....

The **seeping water does not creep along the bottom contour of the**

floor but moves along stream lines which is represented for steady seepage in homogenous soil by the Laplace equation as:

$$\frac{d^2\phi}{dx^2} + \frac{d^2\phi}{dy^2} = 0$$

Where, ϕ = flow potential = Kh ; K = permeability and h = residual head

THANK YOU

