

**IRRIGATION STRUCTURES – 1**

CHAPTER 8

**Diversion Head Works**

The works, which are constructed at the head of the canal, in order 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, are known as *diversion heads works*.

**Objective of Diversion Head Works**

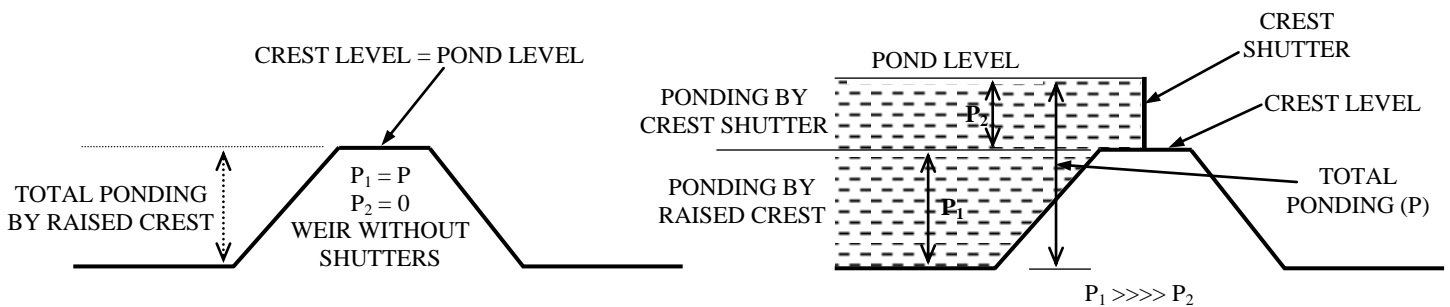
- ✓ To rise the water level at the head of the canal.
- ✓ To form a storage by constructing dykes (embankments) on both the banks of the river so that water is available throughout the year
- ✓ To control the entry of silt into the canal and to control the deposition of silt at the head of the canal
- ✓ To control the fluctuation of water level in the river during different seasons

**Selection of Site for Diversion Head Works**

- At the site, the river should be straight and narrow
- The river banks should be well defined.
- The valuable land should not be submerged when the weir or barrage is constructed.
- The elevation of the site should be much higher than the area to be irrigated.
- The site should be easily accessible by roads or railways.
- The materials of construction should be available in vicinity of the site.
- The site should not be far away from the command area of the project, to avoid transmission loss.

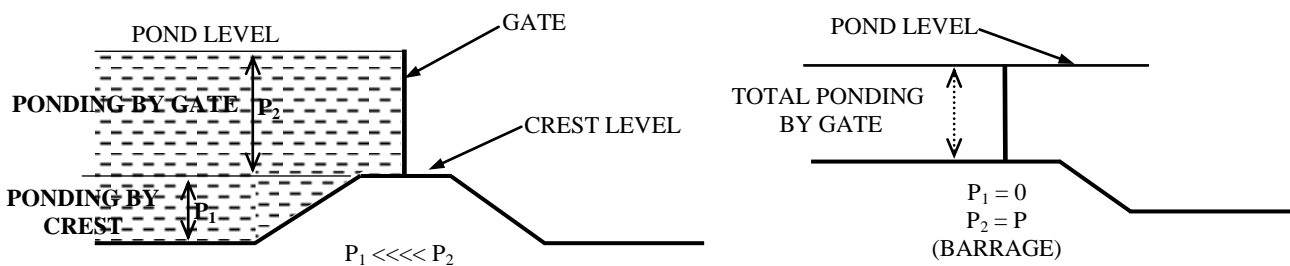
**Weir and Barrage**

- It is a barrier constructed across the river to raise the water level on the upstream side of the obstruction in order to feed the main canal.
- The ponding of water can be achieved either only by a raised crest across the river or by a raised crest supplemented by gates or shutters, working over the crest.



(a) Fig: Weir without shutters

(b) Fig: Weir with shutters

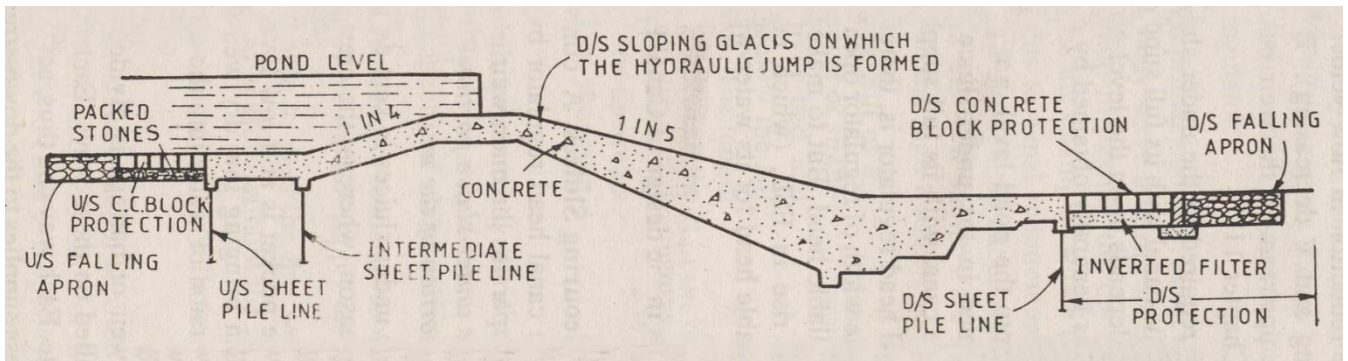


(c) Fig: Barrage with a small raised crest

(d) Fig: Barrage without any raised crest

## Weir

- If the major part or the entire ponding of water is achieved by a raised crest and a smaller part or nil part of it is achieved by the shutters, then this barrier is known as a *weir*.



**Fig: A typical cross-section of a modern concrete weir**

## Gravity and Non-gravity weirs:

When the weight of the weir (i.e. its body and floor) balances the uplift pressure caused by the head of the water seeping below the weir, it is called a gravity weir.

On the other hand, if the weir floor is designed continuous with the divide piers as reinforced structure, such that the weight of concrete slab together with the weight of divide piers keep the structure safe against the uplift then the structure may be called as a non-gravity weir.

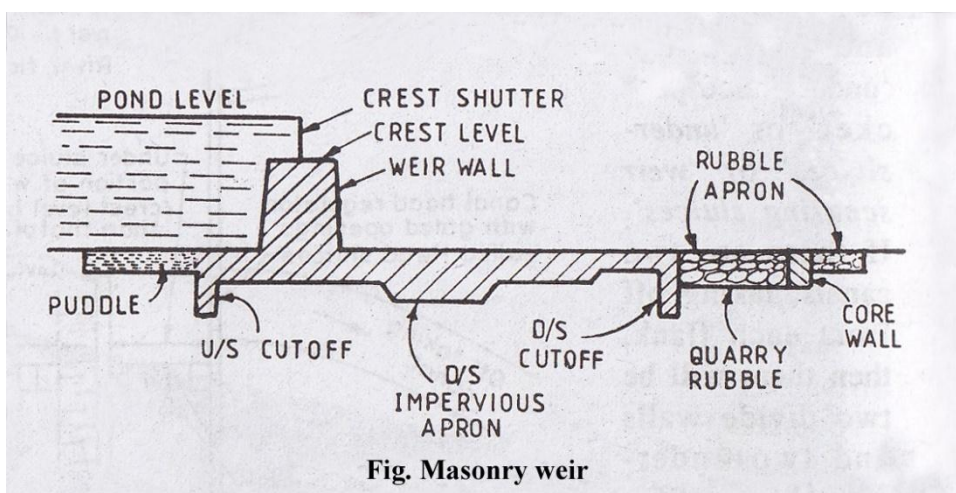
- In the latter case, RCC is to be used in place of brick piers
- Considerable savings may be obtained, as the weight of the floor can be much less than what is required in gravity weir.

## Types of weirs

- Masonry weirs with vertical drop
- Rock-fill weirs with sloping aprons
- Concrete weirs with sloping glacis

## Masonry weirs with vertical drop

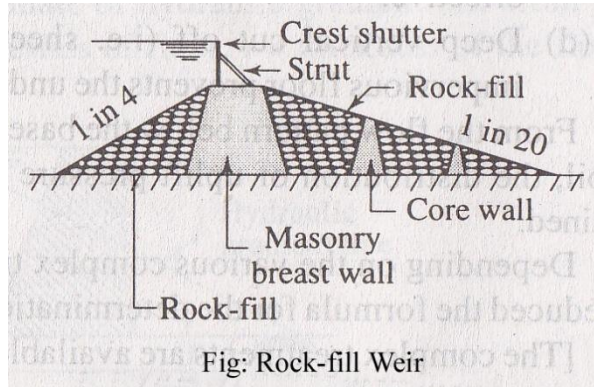
Masonry weir wall is constructed over the impervious floor. Cut-off walls are provided at both ends of the floor. Sheet piles are provided below the cut off walls. The crest shutters are provided to raise the water level, if required. The shutters are dropped down during flood. The masonry weir wall may be vertical on both face or sloping on both face or vertical on downstream face and sloping in upstream face.



**Fig. Masonry weir**

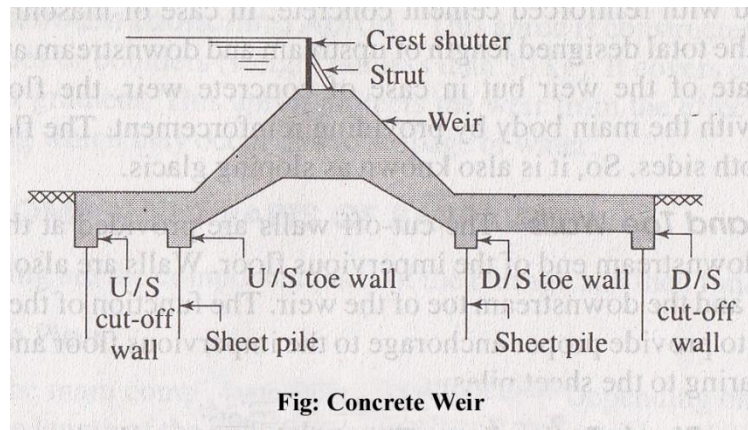
### Rock-fill weirs with sloping aprons

It consists of masonry breast wall which is provided with adjustable crest shutter. The upstream rock-fill portion is constructed with boulders forming a slope of 1 in 4. The boulders are grouted with cement mortar. The downstream sloping apron consists of core walls. The intermediate spaces between the core walls are filled up with boulders maintaining a slope of 1 in 20. The boulders are grouted properly with cement mortar.



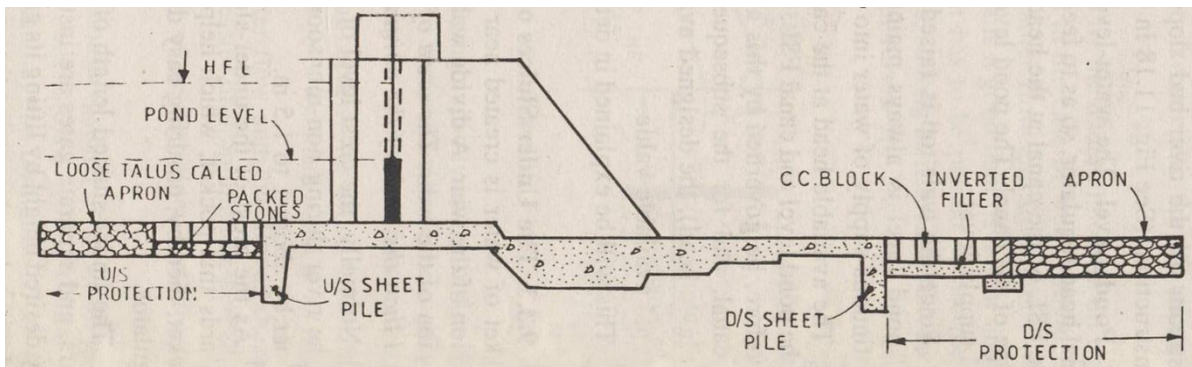
### Concrete weir

Now-a-days, the weir is constructed with reinforced cement concrete. The impervious floor and the weir are made monolithic. The cut off walls are provided at the upstream and downstream end of the floor and at the toe of the weir. Sheet piles are provided below the cut-off walls. The crest shutters are also provided which have dropped down during the flood.



### Barrage

- If most of the ponding is done by gates and a smaller or nil part of it is done by the raised crest, then the barrier is known as a **barrage** or a **river regulator**.



### **Afflux:**

- The rise in the highest flood level (HFL) upstream of the weir due to construction of the weir across the river is called.
- In case of weir, the afflux caused during high floods is quite high. But in case of a barrage, the gates can be opened during high floods and the afflux will be nil or minimum.

### **Choice between a weir and a barrage**

The choice between a weir and a barrage is largely governed by cost and convenience in working.

- A shuttered weir will be relatively cheaper but will lack the effective control possible in the case of a barrage.
- A barrage type construction can be easily supplemented with a roadway across the river at a small additional cost. Barrages are almost invariably constructed now-a-days on all important rivers.

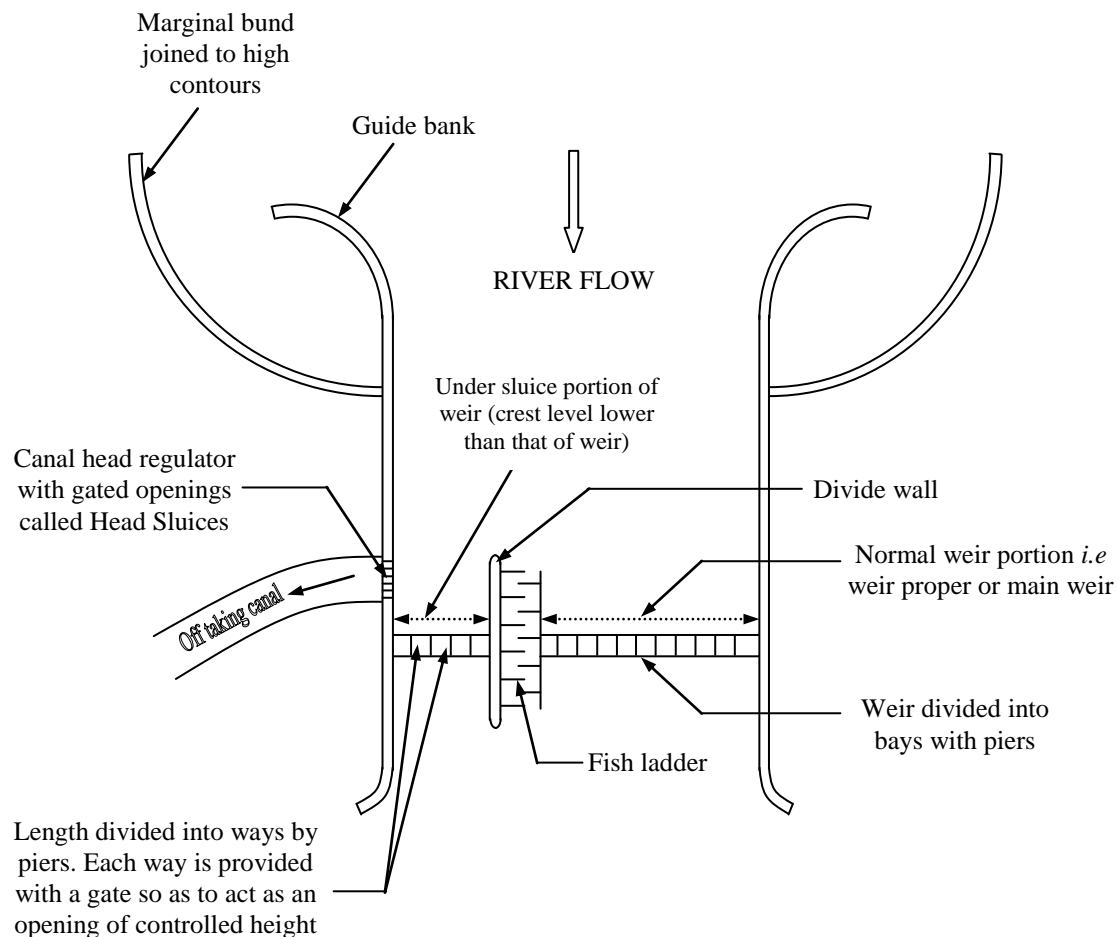
### **Difference between Barrage and Weir**

<b>SL</b>	<b>Barrage</b>	<b>Weir</b>
(a)	Low set crest	High set crest
(b)	Ponding is done by means of gates	Ponding is done against the raised crest or partly against crest and partly by shutters
(c)	Gated over entire length	Shutters in part length
(d)	Gates are of greater height	Shutters are of smaller height, 2 m
(e)	Gates are raised clear off the high floods to pass floods	Shutters are dropped to pass floods
(f)	Perfect control on river flow	No control of river in low floods
(g)	Gates convenient to operate	Operation of shutters is slow, involve labour and time
(h)	High floods can be passed with minimum afflux	Excessive afflux in high floods
(i)	Less silting upstream due to low set crest	Raised crest causes silting upstream
(j)	Longer construction period	Shorter construction period
(k)	Silt removal is done through under sluices	No means for silt disposal
(l)	Road and/or rail bridge can be constructed at low cost	Not possible to provide road-rail bridge
(m)	Costly structure	Relatively cheaper structure

### **Layout of a Diversion Head Works and its components**

A typical layout of a canal head-works is shown in figure below. *Such a head-works consists of:*

- Weir proper
- Under-sluices
- Divide wall
- River Training works
- Fish Ladder
- Canal Head Regulator
- River Training Works e.g. Guide bank, Marginal bunds, spur and groyne etc.
- Shutters and Gates
- Silt Regulation Works



**Fig: Typical layout of diversion head-works**

■ **Weir Proper:**

It is a barrier constructed across the river. It aims to raise the water level in order to feed the canal.

■ **Under-sluices:**

The under sluices are the openings provided at the base of the weir or barrage. These openings are provided with adjustable gates. Normally, the gates are kept closed. The crest of the under-sluice portion of the weir is kept at a lower level (1 ~ 1.5 m) than the crest of the normal portion of the weir. The suspended silt goes on depositing in front of the canal head regulator. When the silt deposition becomes appreciable the gates are opened and the deposited silt is loosened with an agitator mounting on a boat. The muddy water flows towards the downstream through the scouring sluices. The gates are then closed. But, at the period of flood, the gates are kept opened.

***The main functions of under-sluices are:***

- To maintain a well defined deep channel approaching the canal head regulator.
- To ensure easy diversion of water into the canal through the canal head regulator even during low flow.
- To control the entry of silt into the canal
- To help scouring and of the silt deposited over the under-sluice floor and removing towards the downstream side.
- To help passing the low floods without dropping the shutters of the weir.

■ **The divide wall:**

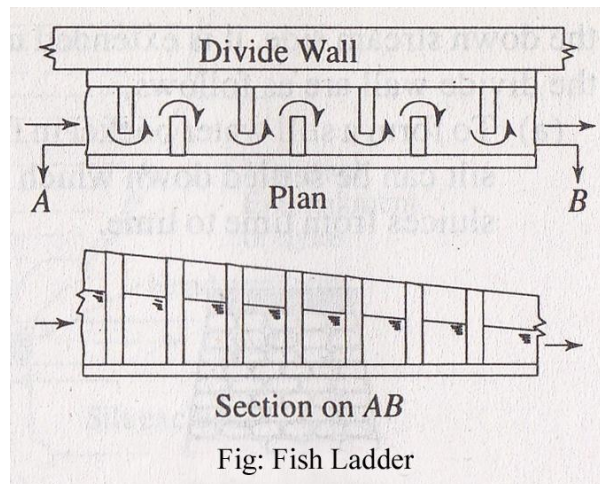
- The divide wall is a masonry or concrete wall constructed at right angle to the axis of the weir.
- The divide wall extends on the upstream side beyond the beginning of the canal head regulator; and on the downstream side, it extends upto the end of the loose protection of the under-sluices.
- The divide wall is a long wall constructed at right angles in the weir or barrage, it may be constructed with stone masonry or cement concrete. On the upstream side, the wall is extended just to cover the canal head regulator and on the downstream side, it is extended up to the launching apron.

**The main functions of the divide walls:**

- It separates the ‘under-sluices’ with lower crest level from the ‘weir proper’ with higher crest level.
- It helps in providing a comparatively less turbulent pocket near the canal head regulator, resulting in deposition of silt in this pocket and, thus, to help in the entry of silt-free water into the canal.
- It helps to keep cross-current, if any, away from the weir.

**Fish Ladder**

- It is device by which the flow energy can be dissipated in such a manner as to provide smooth flow at sufficiently low velocity, not exceeding 3 to 3.5 m/s.
- A narrow opening including suitable baffles or staggering devices in it is provided adjacent to the divide wall.
- The fish ladder is provided just by the side of the divide wall for the free movement of fishes. Rivers are important source of fishes.
- There are various types of fish in the river. The nature of the fish varies from type to type. But in general, the tendency of fish is to move from upstream to downstream in winters and from downstream to upstream in monsoons. This movement is essential for their survival. Due to construction of weir or barrage, this movement gets obstructed, and is detrimental to the fishes.
- In the fish ladder, the fable walls are constructed in a zigzag manner so that the velocity of flow within the ladder does not exceed 3 m/sec
- The width, length and height of the fish ladder depend on the nature of the river and the type of the weir or barrage.

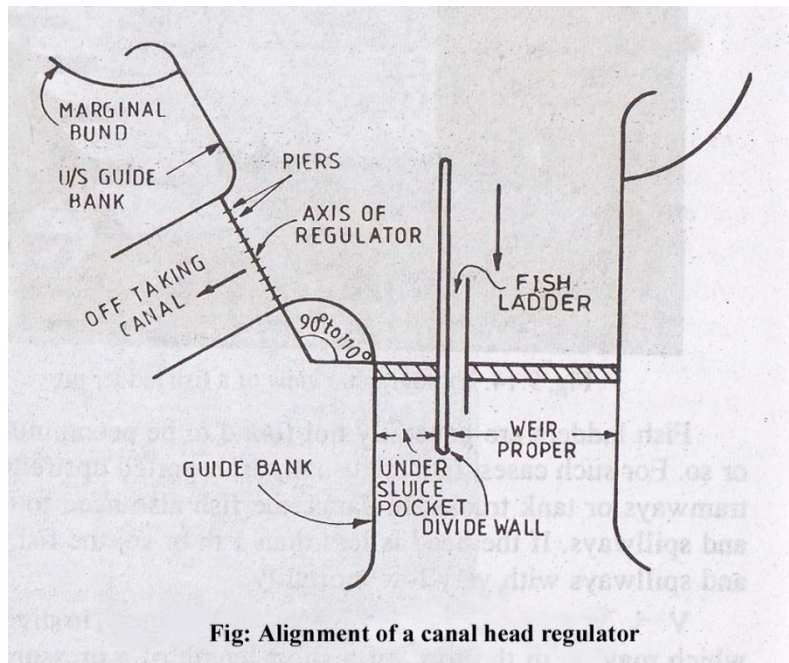


**Canal Head Regulator or Head sluices**

A structure which is constructed at the head of the canal to regulate flow of water is known as canal head regulator. It consists of a number of piers which divide the total width of the canal into a number of spans which are known as bays. The piers consist of number tiers on which the adjustable gates are placed. The gates are operated form the top by suitable mechanical device. A platform is provided on the top of the piers for the facility of operating the gates. Again some piers are constructed on the down stream side of the canal head to support the roadway.

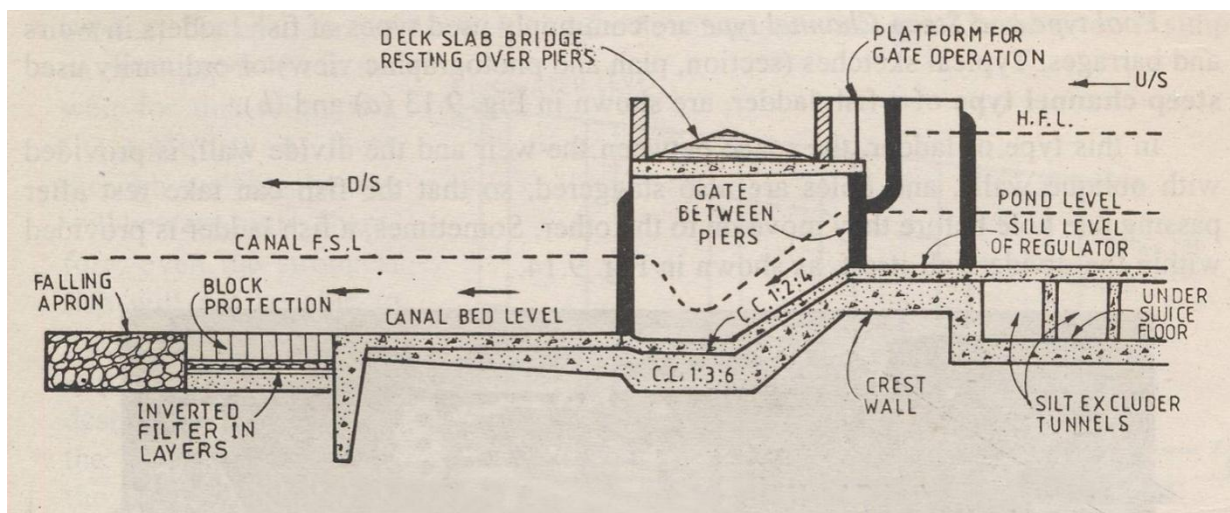
**Functions of Canal Head Regulator:**

- It regulates the supply of water entering the canal
- It controls the entry of silt in the canal
- It prevents the river-floods from entering the canal



The water from the under-sluice pocket is made to enter the regulator bays, so as to pass the full supply discharge into the canal. The maximum height of these gated openings, called head sluices will be equal to the difference of Pond Level and Crest Level of the regulator.

- ✓ The entry of silt into the canal is controlled by keeping the crest of the head regulator by about 1.2 to 1.5 meters higher than the crest of the under-sluices.
- ✓ If a silt-excluder is provided, the regulator crest is further raised by about 0.6 to 0.7 meter.
- ✓ Silt gets deposited in the pocket, and only the clear water enters the regulator bays.
- ✓ The deposited silt can be easily scoured out periodically, and removed through the under-sluice openings.



**Fig: A typical section through a Canal Head Regulator (CHR)**

### ■ River Training Works

River training works are required near the weir site in order to ensure a smooth and an axial flow of water, and thus, to prevent the river from outflanking the works due to a change in its course.

*The river training works required on a canal headwork are:*

- (a) Guide banks
- (b) Marginal bunds
- (c) Spurs or groyne

### (a) Guide Bank

When a barrage is constructed across a river which flows through the alluvial soil, the guide banks must be constructed on both the approaches to protect the structure from erosion.

*Guide bank serves the following purposes:*

- ✓ It protects the barrage from the effect of scouring and erosion.
- ✓ It provides a straight approach towards the barrage.
- ✓ It controls the tendency of changing the course of the river.
- ✓ It controls the velocity of flow near the structure.

### (b) Marginal Bunds

The marginal bunds are earthen embankments which are constructed parallel to the river bank on one or both the banks according to the condition. The top width is generally 3 m to 4 m. The side slope on the river side is generally 1.5: 1 and that on the country side is 2:1.

*The marginal bunds serve the following purposes:*

- ✓ It prevents the flood water or storage water from entering the surrounding area which may be submerged or may be water logged.
- ✓ It retains the flood water or storage water within a specified section.
- ✓ It protects the towns and villages from devastation during the heavy flood.
- ✓ It protects valuable agricultural lands.

### (c) Spurs or groynes

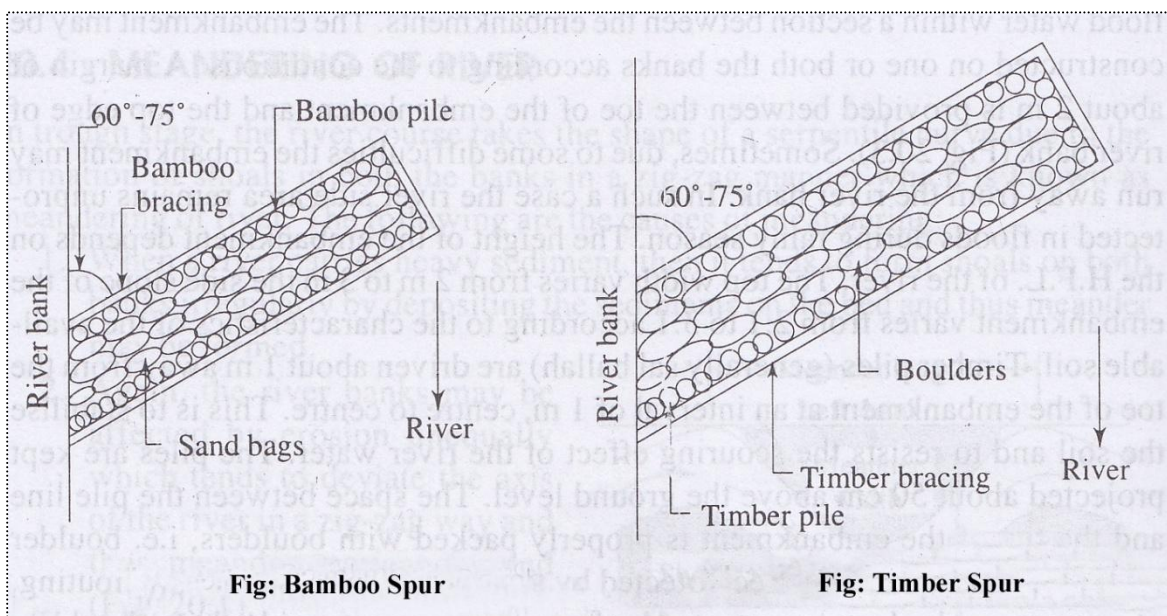
#### (i) Spurs

These are temporary structures permeable in nature provided on the curve of a river to protect the river bank from erosion. These are projected from the river bank towards the bed making angles  $60^\circ$  to  $75^\circ$  with the bank of the river. The length of the spurs depends on the width of the river and the sharpness of the curve. The function of the spurs is to break the velocity of flow and to form a water pocket on the upstream side where the sediments get deposited. Thus the reclamation of land on the river bank can be achieved.

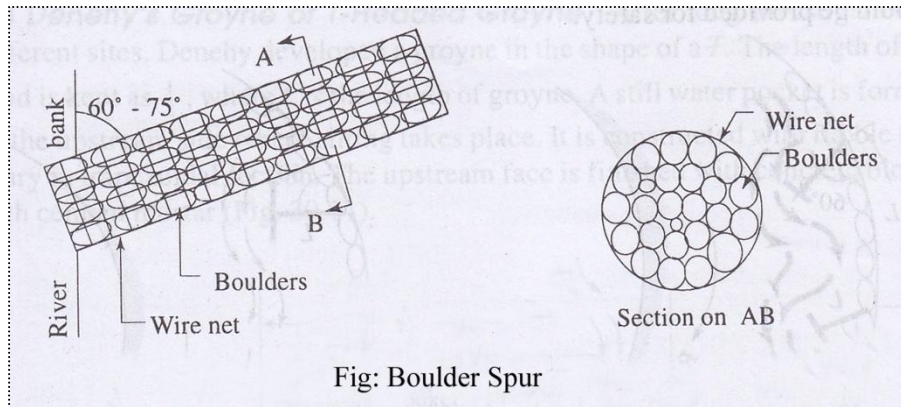
*The spurs may be of the following types:*

- (a) Bamboo Spur
- (b) Timber Spur
- (c) Boulder Spur

- (a) **Bamboo Spur:** In this type of spur, a box like compartment is prepared by driving bamboo piles at 15 cm centre to centre. The piles are secured by bamboo bracings. The hollow space is filled up with sand bags. It is permeable in nature and water can seep through its body. This type of spur is suitable for small rivers. This is purely temporary and requires repair work every year. The length of bamboo piles depends on bed condition.



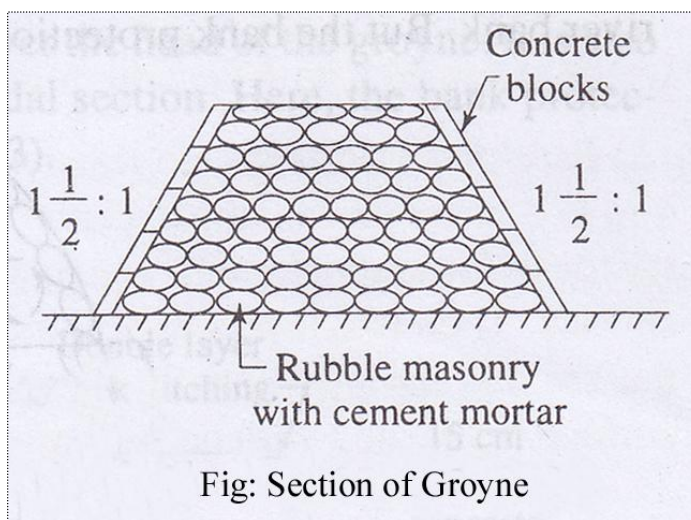
- (b) **Timber Spur:** In this type, a box like compartment is prepared by driving timber piles at 15 cm to 30 cm centre to centre. The piles are secured by wooden bracings. The hollow space is filled up by boulders. This spur is permeable but stable. This is recommended for bi rivers with high velocity of flow. The length of the timber piles depend on bed condition.
- (c) **Boulder Spur:** In this type of spur, boulders are enclosed in G.I wire net in circular shape. The boulder should be heavy, varying from 30 kg to 50 kg and the wire net should be made of 4 mm diameter G.I wires. It is laid from the river bank towards the bed making an angle of  $60^{\circ}$ - $75^{\circ}$  with the bank. This type of spur is recommended for the rivers where velocity of flow is very high.



**(ii) Groynes**

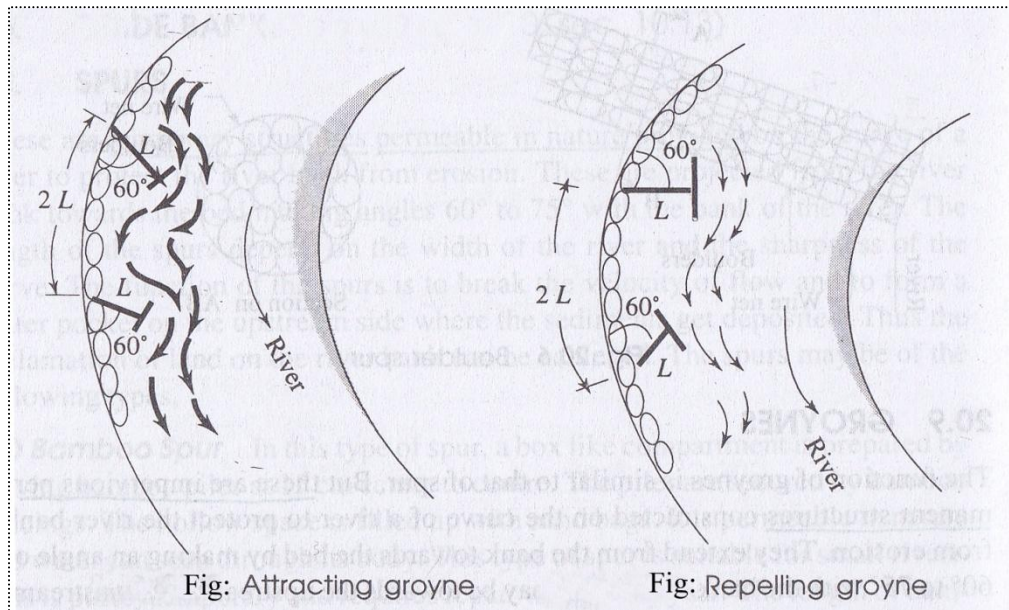
The function of groynes is similar to that of spur. But these are impervious permanent structures constructed on the curve of a river to protect the river bank from erosion. They extend from the bank towards the bed by making an angle of  $60^{\circ}$  to  $75^{\circ}$  with the bank. The angle may be towards the upstream or downstream. Sometimes, it is made perpendicular to the river bank. These are constructed with rubble masonry in trapezoidal section and the surface is finished with stone pitching or concrete blocks.

- The stone pitching or the concrete blocks are set with rich cement mortar.
- The length of the groyne depends on the width and nature of the river.
- The top width varies from 3 m to 4 m. The side slope may be  $1\frac{1}{2}$ : 1 or 2:1.
- The groynes are provided in series throughout the affected length of the river bank.
- The spacing between the adjacent groynes is generally kept as  $2L$ , where  $L$  is the length of the groyne.
- These are recommended for the river where the permanent solution of erosion control is extremely necessary.



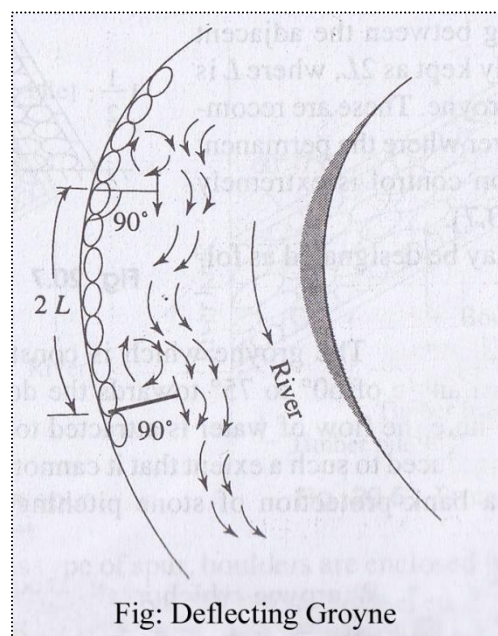
**The groynes may be designated as follows:**

- (a) **Attracting Groyne:** The groyne which is constructed obliquely to the bank by making an angle of 60 to 75° towards the downstream is known as attracting groyne, here the flow of water is attracted towards the bank, and the velocity of flow is reduced to such a extent that it can not cause any erosion to the bank. However, a bank protected of stone pitching is provided for safety.



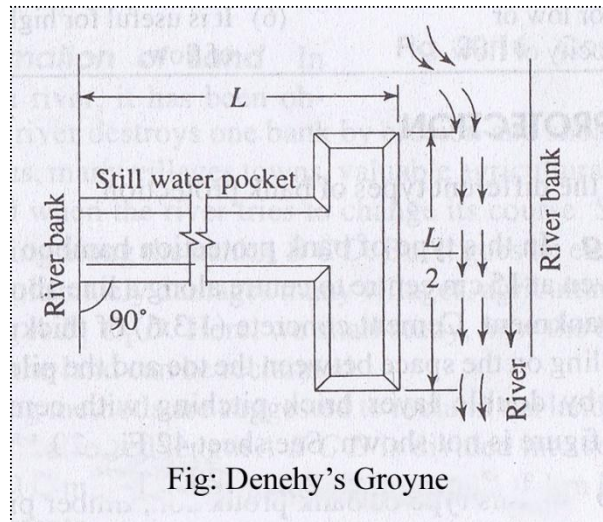
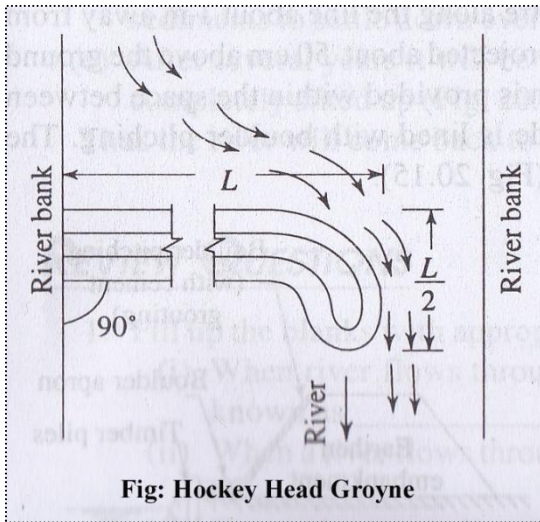
- (b) **Repelling Groyne:** A groyne which is aligned towards upstream at an angle of 60° to 75° with the river bank is known as repelling groyne. A still water pocket is formed on the upstream where silting takes place. Here, the bank protection is not necessary, because the flow of water does not touch the bank and there is no effect of erosion on the bank. But still boulder pitching should be provided for safety.

- (c) **Deflecting Groyne:** The groyne which is constructed perpendicular to the river bank is known as deflecting groyne. Here the flow of water is deflected from bank by the perpendicular obstruction i.e. groyne. The flow of water follows an undulating path just outside the head of the groyne. An eddy current is formed on the upstream side of the groyne. This eddy current will not affect the river bank. But the bank protection is provided for safety.



**Modification of Groyne:**

- (a) **Denehy’s Groyne or T-Headed Groyne:** After long investigation in different sites, Denehy developed a groyne in the shape of a T. The length of the head is kept as  $\frac{1}{2}L$ , where L is the length of groyne. A still water pocket is formed on the upstream side where silting takes place. It is constructed with rubble masonry in trapezoidal section. The upstream face is finished with concrete blocks with cement mortar.
- (b) **Hockey Head Groyne:** Another development is hockey head groyne. Here, the head of the groyne is curved towards the downstream in the shape of a hockey stick. It behaves like an attracting groyne. But it allows the water to flow smoothly over the head of the groyne. It is also constructed with rubble masonry in trapezoidal section. Here, the bank protection by stone pitching is necessary.



**Comparison between spur and groyne**

	<b>Spur</b>	<b>Groyne</b>
(1)	It is a temporary structure.	It is a permanent structure.
(2)	It is permeable.	It is impermeable.
(3)	It is constructed with bamboo pile, timber pile, sand bag, boulders etc.	It is constructed with rubble masonry with cement mortar.
(4)	It requires repair works.	It does not require any repair work.
(5)	It is recommended for small rivers.	It is recommended for large rivers.
(6)	It is useful for low or medium velocity of flow	It is suitable for high velocity of flow.

**■ Shutters and Gates:**

Functions of shutters and gates are:

- They maintain pond level.
- They raise water level during low flow.

**Pond Level**

The water level required in the under-sluice pocket upstream of the Canal Head Regulator, so as to feed the canal with its full supply, is known as Pond Level.

The FSL of the canal at the head depends upon the level of the irrigated areas and the slope of the canal.

$$\text{Pond Level} = \text{Canal FSL} + 1.0 \text{ to } 1.2 \text{ m}$$

■ **Silt Regulation works**

The entry of silt into a canal, which takes off from a head works, can be reduced by constructed certain special works, called silt control works.

*These works may be classified into the following two types:*

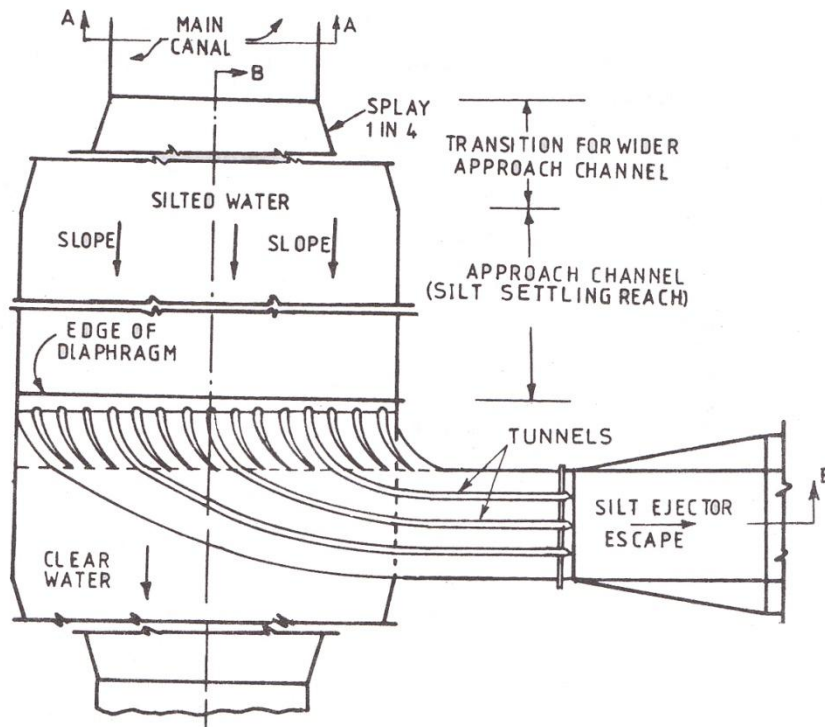
- (a) Silt Excluders
- (b) Silt Ejectors

**(a) Silt Excluders**

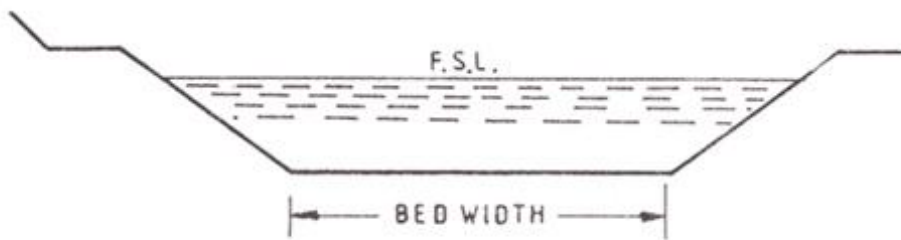
Silt excluders are those works which are constructed on the bed of the river, upstream of the head regulator. The clearer water enters the head regulator and silted water enters the silt excluder. In this type of works, the silt is, therefore,, removed from the water before in enters the canal.

**(b) Silt Ejectors**

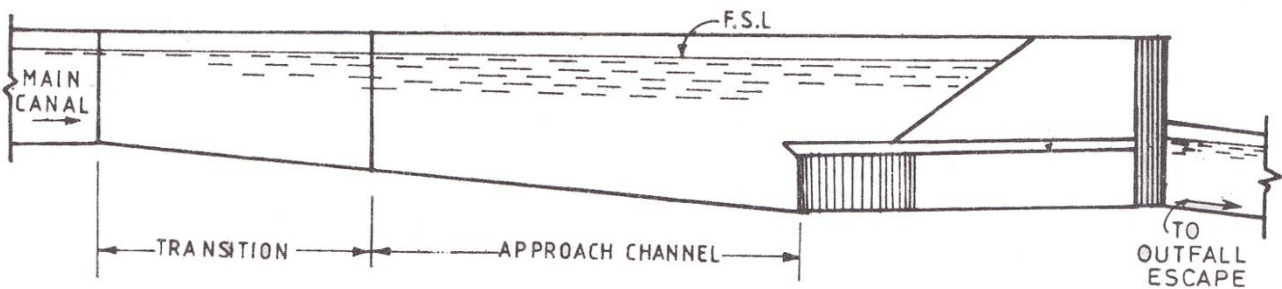
Silt ejectors, also called silt extractors, are those devices which extract the silt from the canal water after the silted water has traveled a certain distance in the off-take canal. These works are, therefore, constructed on the bed of the canal, and little distance downstream from the head regulator.



**Fig: Plan of Silt Ejector**



**Fig: Section A-A  
(Main Canal)**



**Fig: L-section along tunnel  
(Section B-B)**