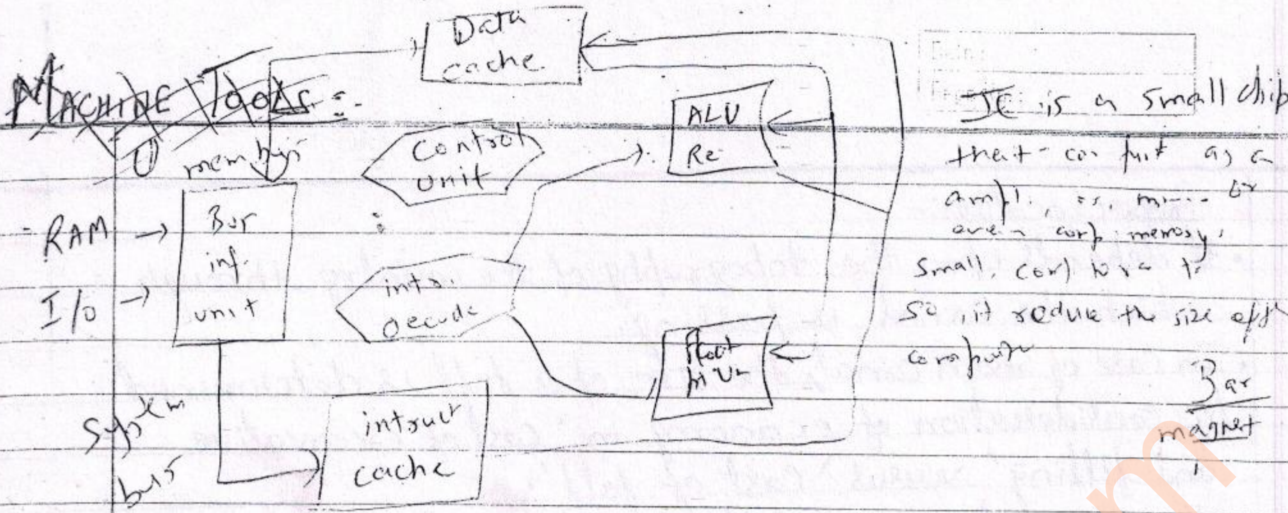


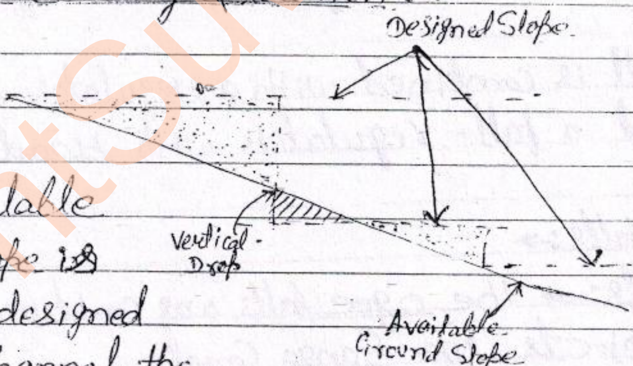
Irrigation Engineering - I

Section - A

Unit - I

Regulation Works

* Canal falls - Necessity & location :→



Whenever the available natural ground slope is steeper than the designed bed slope of the channel, the difference is adjusted by constructing vertical falls or drops in the canal bed at suitable intervals.

Such a drop in a natural canal bed will not be stable and, therefore, in order to retain this drop, a masonry structure is constructed. Such a pucca structure is called a canal fall or a canal drop.

Proper Location:-

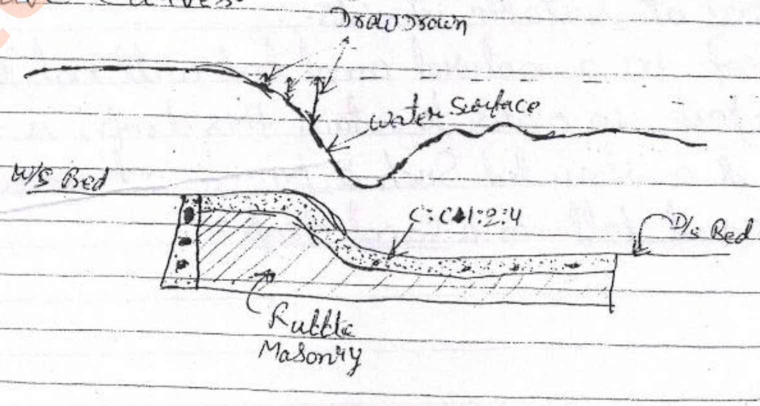
- It depends upon the topography of the country through which the canal is passing.
- In case of main canal, the site of a fall is determined by consideration of economy in 'cost of excavative and filling' versus 'cost of fall'.
- The excavation and filling on two sides of a fall should be tried to be balanced, because the unbalanced earthwork is quite costly.
- In case of branch canals and distributary channels, the falls are located with consideration to commanded area.
- The location of the falls may also be influenced by the possibility of combining it with a bridge, regulator, or some other masonry work, since such combinations often result in economy and better regulation.

When a fall is combined with a regulator and a bridge, it is called a fall-regulator with road bridge.

Types of falls:->

1) Ogee falls:-> The ogee falls was constructed in olden days on projects like Ganga Canal.

- The water was gradually led down by providing convex and concave curves.



The performances of such an ogee fall was found to have the following major defects:

(i) There was heavy draw-down on the upstream side, resulting in lower depths, higher velocities and consequent bed erosion. Draw-down would also affect the supply in a distributary, situated just upstream of fall.

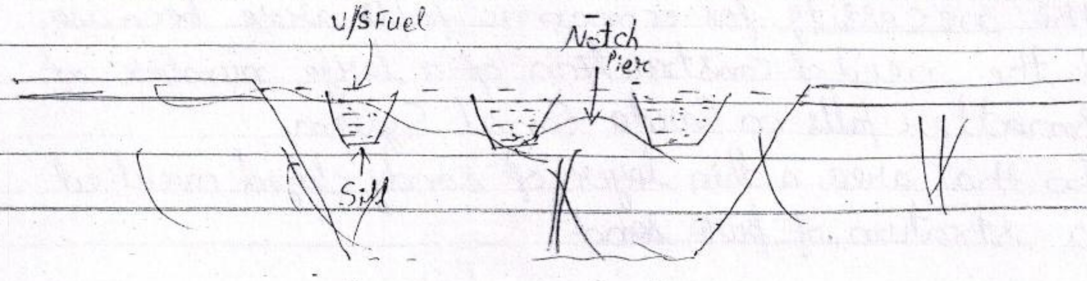
(ii) Due to smooth transition, the kinetic energy of the flow was not at all dissipated, causing erosion of downstream bed and banks.

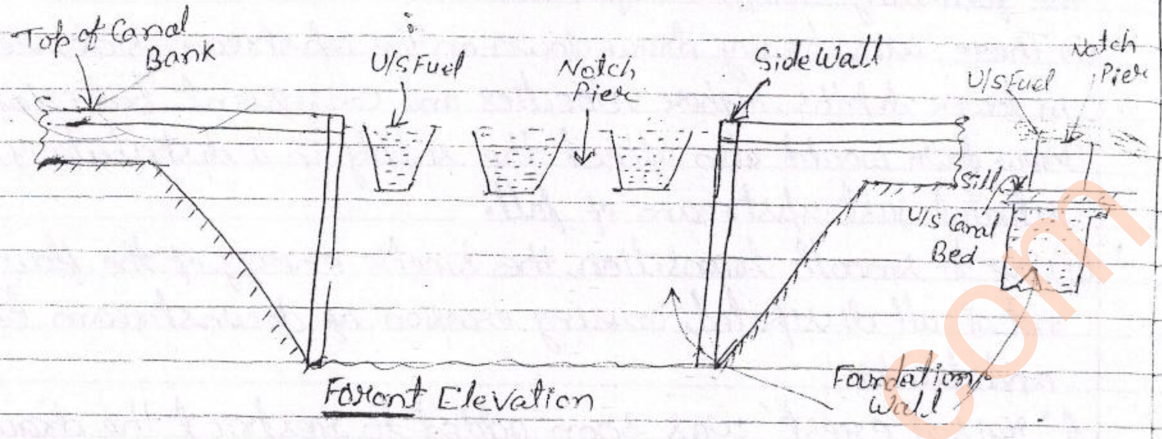
A 'raised crest' was soon added to restrict the drawdown and a long protection was provided on the downstream side. Later, it was converted into a much better type of fall, called a 'vertical Impact type'.

2) Rapids:→ In Western Yamuna Canal, long rapids at slopes of 1:15 to 1:20 (i.e. gently sloping glacis) with boulder facings were provided. They work quite satisfactorily, but were very expensive, and hence became absolete.

3) Trapezoidal Notch falls:→

The trapezoidal notch fall was designed by Ried in 1984. It consists of a number of trapezoidal notches constructed in a high-crested wall across the channel with a smooth entrance and a flat circular lip projecting downstream from each notch to spread out the falling jet. These falls remained quite popular, till simpler, economical and better modern falls were developed.





Front Elevation

4) Well type falls or Cylinder falls or Syphon Well Drops:→

- This type of a fall consists of an inlet well with a pipe at its ~~location~~ bottom, carrying water from the inlet well to a downstream well or a cistern.
- The downstream well is necessary in the case of falls greater than 1.8m and for discharges greater than ~~0.29 cm~~ 0.29 ~~cm~~. cumecs.
- This type of falls are very useful for affecting larger drops for smaller discharges.
- They are commonly used as tail escapes for small canals, or where high levelled smaller drains do out fall into a low levelled bigger drain.

5) Simple Vertical Drop Type and Sarda Type Falls:→

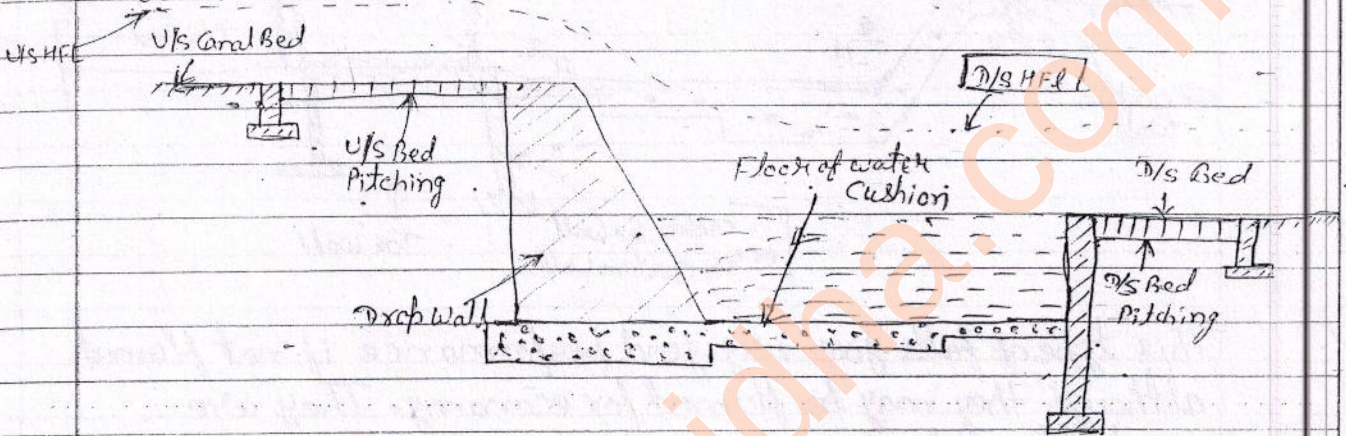
- A raised crest fall with a vertical impact was first of all introduced on Sarda Canal System in U.P., owing to its economy and simplicity.
- The necessity for economic falls arose because of the need of construction of a large number of smaller falls on Sarda Canal System.

In that area, a thin layer of sandy clayed overlied a stratum of pure sand.

upstream - बहाव के विरूद्ध
downstream - प्रवाह की ओर
Crest - शिखर, ढाल

- In this type of a high crested fall, the nappe impinges into the water cushion below.

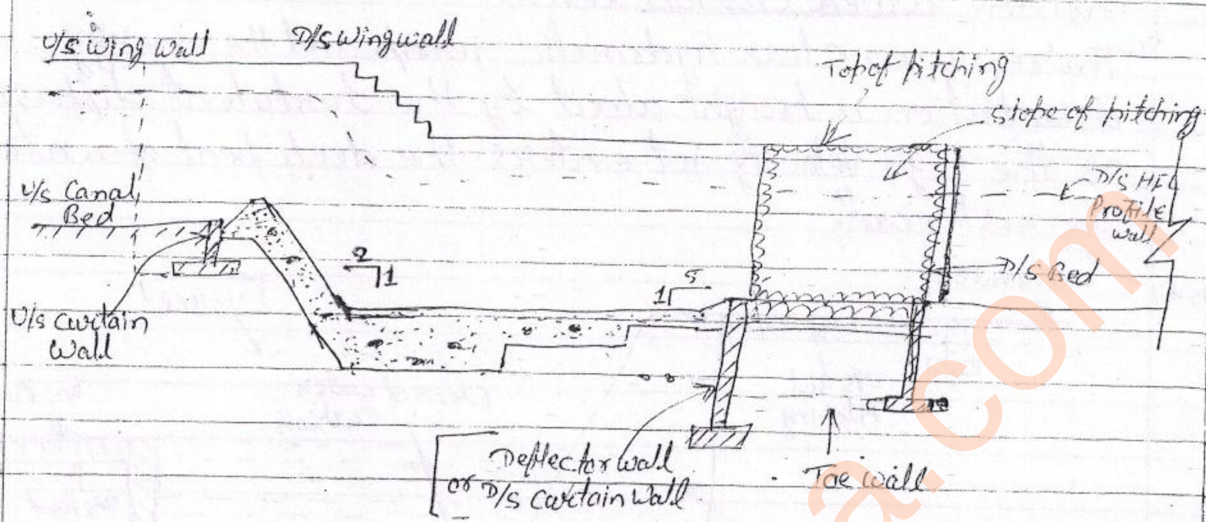
"There is no clear hydraulic jump and the energy dissipation is brought about by the turbulent diffusion, as the high velocity jet enters the deep pool of water downstream."



- Sarda type fall is a high crested fall, and if the discharge in the Canal varies (50 to 100%), the water will head up to on the upstream side at low discharges.
- The reach upstream of the crest will silt in the d/s discharge, there may be a tendency of scouring on D/S, so as to make up the silt loss.
- Hence, this type of fall is not quite suitable for canals in which discharges varies within a wide range.
- A trapezoidal notch fall, although costlier than Sarda type or glacis type fall, is free from such troubles and, therefore, preferred for canals where the discharge is very small and also varies over a wide range.

6) Straight Glacis Fall:→ In this type of a modern fall, a 'straight glacis' (generally sloping 2:1) is provided after a 'raised crest'.

- The hydraulic jump is made to occur on the glacis, causing sufficient energy dissipation.



This type of falls give very good performance if not flumed, although they may be flumed for economy. They are suitable upto 60 cumecs discharge and 1.5 m drop.

7) Inglis Fall or Baffle Falls:→ A straight glacis type fall when added with a baffle platform and a baffle wall, was developed by Inglis, and is called 'Inglis Fall' or 'Baffle Fall'. They are quite suitable for all discharges and for drops of more than 1.5 m. They can be flumed easily as to affect economy.

Design of a Sarda Type Fall:→

Based on the recommendation of Bahadarabad Research station, are given below:—

(a) Length of the Crest:— Since fluming is not permissible in this type of falls, the length of the crest is kept equal to the bed width of the canal. Sometimes, for further future expansion, the crest length may be kept equal to (bed width + depth).

(b) Shape of the crest :→

A rectangular crest with both faces vertical has been suggested for discharges under 14 cumecs. The top width is kept equal to $0.55\sqrt{d}$ and the minimum base width is kept equal to $\frac{h+d}{G}$ (Take G = 2 for masonry), where d is the height of the crest above the downstream bed level and h is the head over the crest.

For discharges over 14 cumecs, a trapezoidal crest with top width equal to $0.55\sqrt{H+d}$ with upstream side slope of 1:3 and downstream side slope of 1:8 is adopted.

(i) ~~For~~ Rectangular Crest for Sarda Type fall:

Q = upto a max. of 14 cumecs

B_t = Top width of Crest = $0.55\sqrt{d}$

$$\text{Base Width} = \frac{h+d}{2}$$

$$Q = 1.84 \cdot L H^{3/2} \left(\frac{H}{B_t}\right)^{1/6}$$

(ii) Trapezoidal Crest :

Q = for 14 cumecs and over

B_t = Top width of Crest = $0.55\sqrt{H+d}$

~~Base Width =~~ $Q = 1.99 \cdot L H^{3/2} \left(\frac{H}{B_t}\right)^{1/6}$

(c) Crest Level :→

The following discharge formula is used to determine the height of the crest

$$Q = C_d \cdot \sqrt{2g} \cdot L \cdot H^{3/2} \left(\frac{H}{B_t}\right)^{1/6}$$

where,

$C_d = 0.415$ for rectangular crest

$= 0.45$ for trapezoidal Crest

L = Length of the Crest
B_t = Top width of crest

Height of the crest above bed = $y-h$
= $y-H$ (assuming $h=H$ i.e. neglecting velocity of approach)

where y is the normal depth of channel (upstream)

(d) Upstream Wing Wall:→
For trapezoidal crest, the upstream wing walls are kept segmental with radius equal to 5 to 6 times H and subtending an angle of 60° at centre, and then carried tangential into the berm. The foundation of the wing walls are laid on the impervious concrete floor itself.

For rectangular crest (i.e. discharge less than 14 cumecs), the approach wings may be splayed straight at an angle of 45°.

(e) Upstream Protection:→
Brick pitching in a length equal to upstream water depth may be laid on the upstream bed, sloping towards the crest at a slope of 1:10.

(f) Upstream Curtain Wall:→ $1\frac{1}{2}$ brick thick upstream curtain wall is provided, having a depth equal to $\frac{1}{3}$rd of water depth.

(g) Downstream Protection:→ The d/s bed may be protected with dry brick pitching, about 20 cm thick resting on 10 cm thick ballast. The length of the d/s pitching is given by ~~the~~ 3 times the depth of downstream water, whichever is more. The pitching may be provided b/w two or three curtain walls.

$L_c = 5\sqrt{H \cdot H_L}$ H = Head of water over the crest = (u/s TEL − crest level)

$X = \frac{1}{4}(H \cdot H_L)^{2/3}$

where, L_c = length of the cistern (m)

X = cistern depression below the d/s bed (m)

Design of a Straight glacis fall :→

1) Cistern Element :—

- In a Glacis type fall, the kinetic energy of water is dissipated by the formation of a hydraulic jump on a sloping glacis.
- E_{f2} measured below d/s TEL, determines the level of the point of jump formation.
- Theoretically, the cistern should be provided at the point.
- The depth of cistern is increased by 25% of E_{f2} in order to ensure the formation of jump on the sloping glacis itself under varying conditions of head.

2) Crest Length :→

- Glacis fall may be unflumed; and in that case, the crest length shall be equal to the bed width of the canal.
- They can be flumed also; and in that case, they are generally provided with a regulator and a bridge. Such a fall is used as a meter and is called a meter fall.
- The fluming may be limited to the following percentage of bed width. This is called fluming ratio.

3) Crest Width :→

- A narrow crest, i.e. a sharp crest, provides a higher coefficient of discharge and thus a greater discharging capacity than that for a broad crest.
- A narrow crest is therefore preferred because it is economical, as it reduces the cost of the crest longitudinally and transversely.
- However, the disadvantage of a narrow crest is that it does not ensure a constant coefficient of discharge for varying heads.
- Hence, if the fall is to be used as a meter, it must not be provided with a narrow crest, and a broad crest of minimum thickness 2.5H is adopted.

Date:
Page No.:

- But for an unflumed ordinary fall, a narrow crest of width = $\frac{2}{3}H$ is generally adopted.

4) Discharge Formula:—

Discharge is given by

$$Q = C \cdot (L - 0.1n \cdot H) H^{3/2}$$

where, n = No. of end contractions = Twice the no. of bays

C = 1.7 for broad ~~test~~ crest
= 1.84 for sharp crest

5) Crest level:→ Crest level is given by

Crest level = U/s TEL − H

where, U/s TEL = U/s FSL + Velocity head

- If the ht. of the crest works out to be more than 0.4 times the upstream water depth, the fall may be flumed or fluming ratio increased, so as to increase H and to lower the crest.

6) Upstream Protection:→

- No upstream protection is ~~refe~~ required for an ordinary unflumed fall.
- However, for a flumed fall, dry bricks pitching on edge may be laid both in bed and sides for a length equal to U/s water depth (in a slope of 1:10 in the bed).

7) Downstream Protection:→

- With the provision of a deflector wall, no d/s bed pitching is provided, and only side slope pitching is provided for a length equal to 3 times the d/s water depth and should rest on a toe wall.

anchor – सहारा देना, लंगर करना

Roughening Devices or Energy Dissipators :→

1) Friction Blocks :→

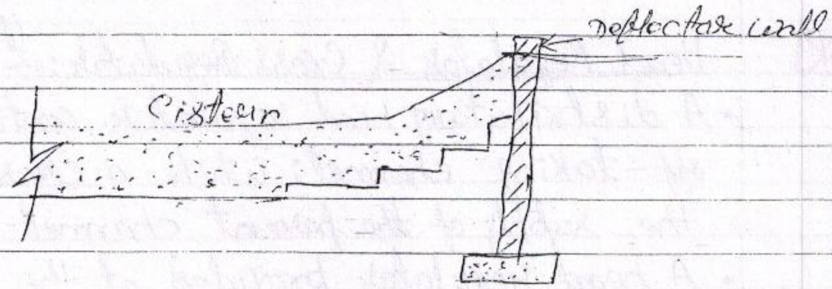
- These are the most simple and useful of all such devices.
- They consist of rectangular concrete blocks securely anchored into the floor.
- Their height is approx. 1/4 th water depth. The spacing between the blocks is about twice the height of the blocks.

2) Glacis Blocks :→

- A single row of blocks called Glacis blocks and of the same dimensions as friction blocks may be provided just at the d/s toe of the glacis, in case of flumed falls with drop more than 2 m.
- It helps in reducing turbulence in flow, which in turn, reduces wave wash, thus ensuring uniform flow.

3) Biff Wall or Deflector wall :→

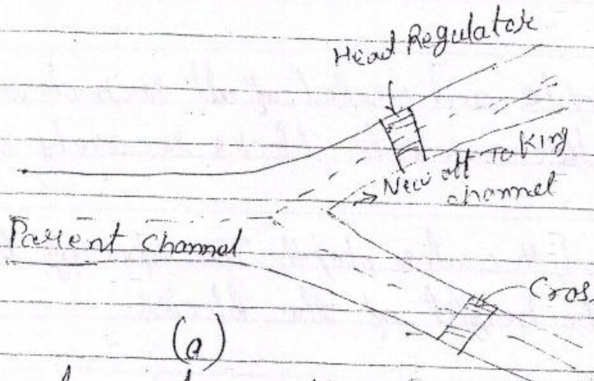
- A deflector wall of height approx. $\frac{1}{10}$ th of water depth may be provided at the downstream end of concrete floor (in case with d/s cutoff).



Off-take alignment :→

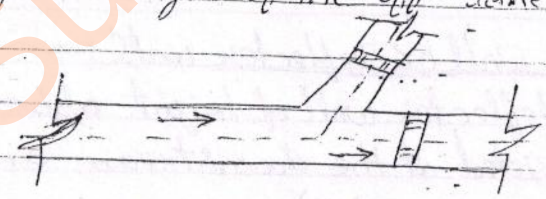
- When a branch channel takes off from the main channel (called Parent channel), the off-take alignment must be carefully designed.
- The best ideal alignment is: When the off-taking channel makes zero angle with the parent channel initially and then

separate out in transition.



(a)

- The transition will have to be properly designed so as to avoid accumulation of silt jetty.
- As an alternative to the transition both the channels should make an angle with the parent channel upstream of the off-take.
- When the parent channel has to be carried straight the edge of the canal rather than the centre line should be considered in deciding the angle of the off-take. as in fig. (b).



(b)

Head Regulator & Cross Regulator:→

- A distributary head regulator controls the supply of the off-taking channel; while a cross-regulator controls the supply of the parent channel.
- A head regulator provided at the head of the off-taking channel, controls the flow of water entering this new channel.
- While a cross-regulator may be required in the main parent channel d/s of the off-taking channel, and is operated when necessary so as to head up water on its U/s side, thus to ensure the required supply in the off-taking channel even during the periods of low flow in the main channel.

The main functions of a head regulator are:-

(i) To regulate or control the supplies entering the off-take channel.

(ii) To control silt entry into the off-take channel.

(iii) To serve as a meter for measuring discharge.

The main functions of cross-regulator are:-

(i) To efficiently control the entire Canal Irrigation System.

(ii) When the water level in the main channel is low, it helps in heading up water on the U/s and to feed the off-take channels to their full demand in rotation.

(iii) They help in absorbing fluctuations in various sections of the canal system, and in preventing the possibilities of breaches in the tail reaches.

(iv) They are often combined with a road bridge, so as to carry the road which may cross the irrigation channel near the site of the cross regulator. It is also usually combined with a fall, when it is called a fall-regulator.

Silt Control Devices:→

- The entry of silt into a canal, which takes off from a Head-Works, can be reduced by constructing certain special works called silt control works. Classified into two types:-

(a) Silt Excluders, and (b) Silt Ejectors

(a) Silt Excluders:→

- ~~Also called silt extractors,~~
- These are those works which are constructed on the bed of the river, u/s of the head regulator.
- The clearer water enters the head regulators and the silted water enters the silt excluder.
- In this type of works, the silt is, therefore, removed from the water before it enters the canal.

(b) Silt Ejectors:→

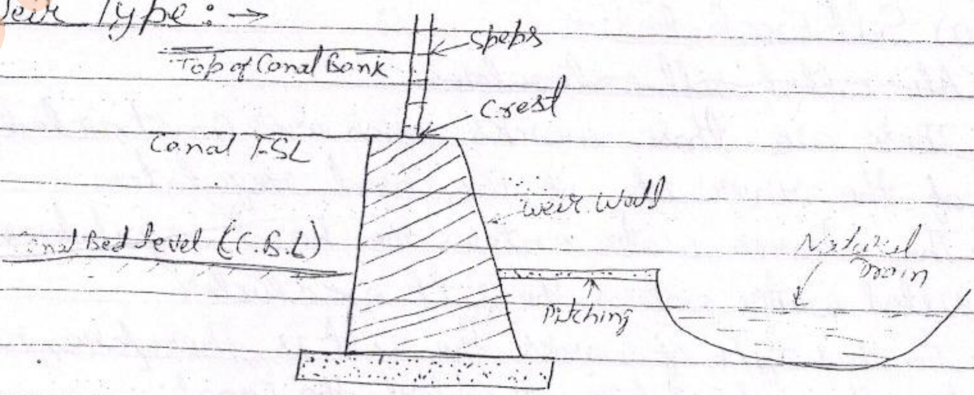
- Also called Silt Extractors, are those devices which extract the silt from the Canal-Water after the silted water has travelled a certain distance in the off-take Canal.
- These works are, therefore, constructed on the bed of the Canal, and a little distance d/s from the head regulator.

Canal Escapes:→

- An escape is a side channel constructed to remove surplus water from an irrigation channel into a natural drain.
- The water in the irrigation channel may become surplus due to some mistake, or difficulty in regulation at the head, or due to excessive rainfall in upper reaches.
- In order to avoid damage due to reduction or stopping the supplies from the head works, some immediate action is required, and this is achieved by means of an 'Escape' generally called a 'Surplus Water escape'.

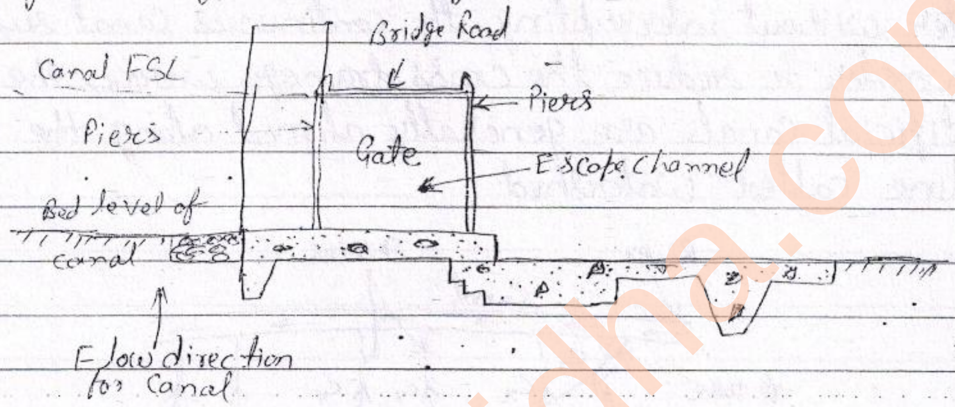
Types:-

(i) Weir Type:→



• Also known as 'Tail Escape'
• In this type, the crest of the weir wall is kept at R.L. equal to Canal FSL.
• When water level rises above FSL, it gets escaped.

(ii) Regulator type (Sluice type):→



• In this type, the sill of the escape is kept at canal bed level and the flow is controlled by gates.
• These type of escapes are preferred these days, as they give better control and can be used for completely emptying the Canal.

The weir type escape may, however, be provided at the tail end of the canal and is useful in maintaining the Required FSL in the tail reaches of the canal. This escapes is then called tail escape.

The regulator type escape may, however, be constructed for the purpose of scouring off excess bed silt deposited in the head reaches, from time to time. In that case, it is known as a scouring escape.