UNIT-3

Diversion Head-Works

Diversion Head works:-

Any hydraulic structure which supplies water to the off Taking canal is called a headwork. Headwork may be divided into Two classes:

1. Storage Headwork
2. Diversion Headwork

A storage headwork comprises the construction of dam across the river. It stores water during the period of excess supplies in the river and releases it when demand overtakes available supplies.

A Diversion Headwork serves to divert the required supply into the canal from the river. A diversion Head work serves the following purposes.

1. It rises the water level in the river so that the commanded area can be increased.
2. It regulate the Intake of water into the canal
3. It control the silt entry into the canal
4. It reduces the fluctuation in the level of supply in the river
5. It stores water for tiding over small periods of short supplies.

Weir:— The weir is a solid obstruction put across the river to raise its water level and diverts the water in to the Canal. If a weir also stores water for tiding over small period of short supplies. it is called a storage weir. The main difference between a storage weir and dam is only in height and the duration in which the supply is stored. A dam stores the supply for a Comparitively longer duration.

Weirs are classified into Two heads depending upon the criterion of the design of their floors.

① Gravity dam ② Non Gravity dam.

Depending A Gravity weir is one in which the uplift pressure due to the seepage of water below the floor is resisted entirely by the weight of the floor.

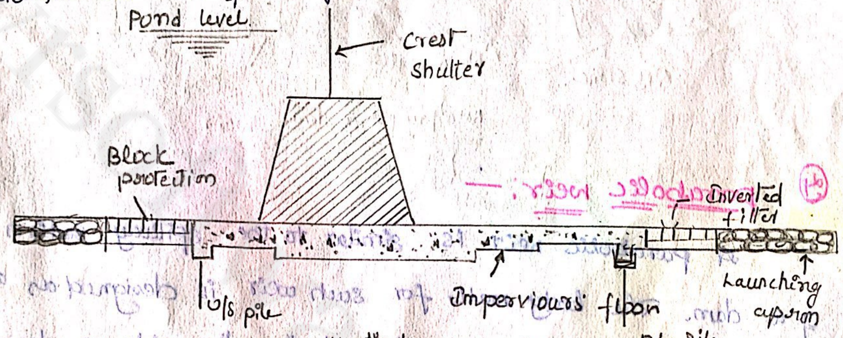
In non Gravity Type, the floor thickness is kept relatively less, and the uplift pressure is largely resisted by the bending action of the reinforced Concrete floor.

Depending upon the material and Certain design feature; can be further divided into.

1. vertical drop weir
2. Masonry or Concrete slope weir
3. Dry stone slope weir
4. parabolic weer.

① Vertical drop weir:—

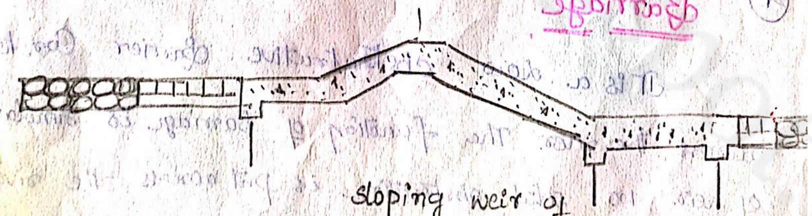
A vertical drop weir consists of a vertical drop wall or crest wall, with or without crest gates. At the upstream and downstream ends of the impervious floor, cutoff piles are provided. To safeguard against scouring action, launching aprons are provided both at upstream downstream ends of the floor.



Vertical drop weir

② Masonry or concrete sloping weir:—

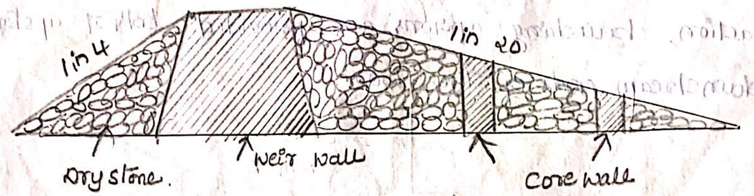
Weirs of this type are of recent origin. They are suitable for soft sandy foundations and are generally used where the difference in weir crest and downstream river bed is limited to 3 metres. when water pressure such a weir hydraulic Jump is formed on the sloping glacis



Sloping weir of Concret

③ Dry stone slope weir: —

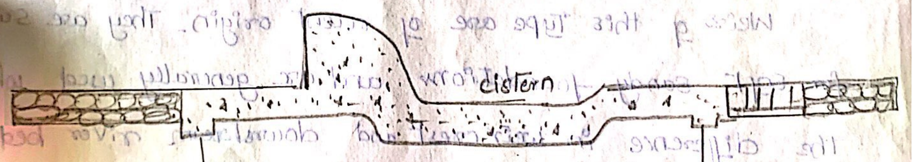
A Dry stone weir or a rockfill weir consists of a body wall (weir wall) and U/s and d/s rockfills laid in the form of glacis with a few intervening core walls



Masonry dry stone weir

④ parabolic weir: —

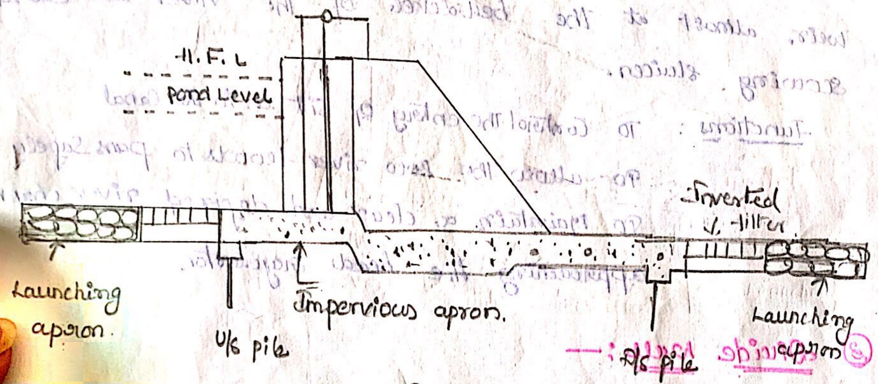
A parabolic weir is similar to the spillway section of a dam. The body wall for such weir is designed as a low dam. A cistern provided at the d/s side to dissipate energy



Parabolic weir

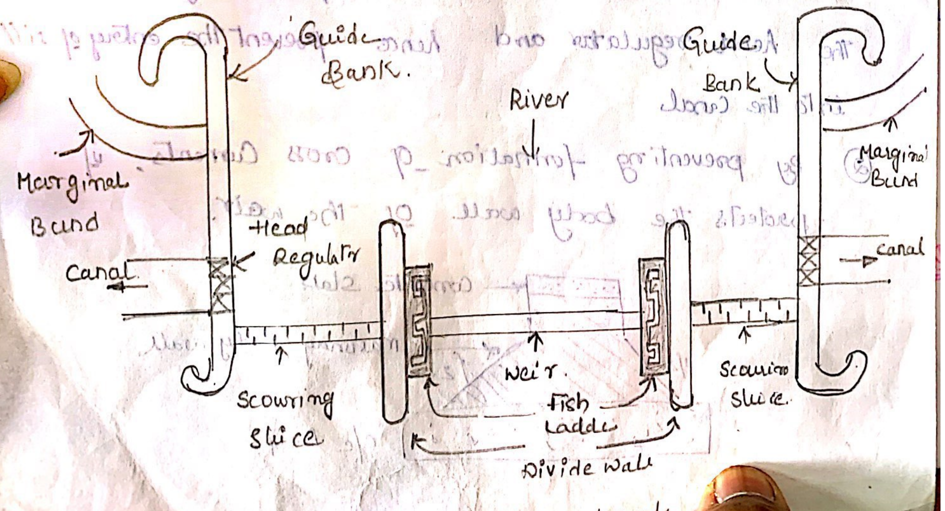
Barriage

It is a low obstructive barrier constructed across the river. The function of barriage is similar to that of weir. no solid obstruction is put across the river but heading up of water is effected by gates alone. Gates are provided on the crest of the barrier and they are housed in the grooves made in the the piers and abutment. The piers are also constructed on the crest and supporting a platform used for lifting and lowering by the gates. Thus the flow is perfectly controlled by gates. Due to this, there is less silting and better control over the levels. However barriages are much more costlier than the weirs.



Barrage

(*) Layout of Diversion Head works :-



Diversion Head work

① **Weir** :- A masonry structure, Constructed across the river with or without shutters is called weir.

Function :- It Can raise the water to the Desired Level.

② **Scouring Sluice** :-

The openings provided in the body wall of the weir, almost at the bed level of the river are Called scouring sluices.

Functions : To Control the entry of silt in to the Canal

To allow the low river floods to pass Safely

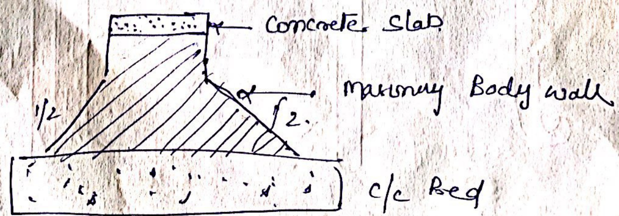
To Maintain a clear and defined river channel approaching the head regulator.

③ **Divide wall** :-

A long solid wall Constructed perpendicular to the axis of weir between the Scouring sluice and the fish ladder ~~is~~ Called Divid wall. It Divide the channel into two Components.

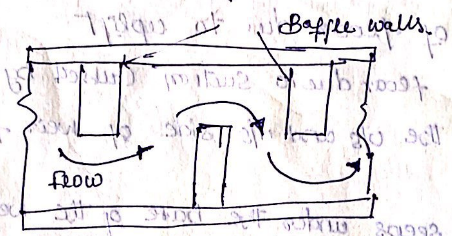
Function :- It Can Create a still pond very near to the head regulator and hence prevent the entry of silt into the Canal

② By preventing formation of cross Currents, it protects the body wall of the weir.



4. Fish ladder :—

A passage provided just by the side of the divide wall for the movement of fish from u/s & d/s or vice versa is called fish ladder.



5. Head Regulator :—

A structure constructed at the head of the canal to regulate the supply of water in to the canal is called "Head Regulator"

Functions

1. It is used as a measuring device.
2. It does not allow flood water to enter the canals.

6. Guid Banks :—

Guid Banks are provided on either side of the Diversion Head works in alluvial soils for a smooth non tortous approach to the division Head works to prevent the river from outflanking the work.

7. Marginal Bands :—

Marginal embankment are provided on either Bank of the river u/s of Diversion head works in alluvial soil to protect the land and property which is likely to be submerged during ponding of water during floods.

Causes of failure of weir :—

A weir may fail due to the following reasons.

(i) piping

(ii) Rupture of floor due to uplift

(iii) Rupture of floor due to suction caused by standing wave

(iv) scour at the u/s and d/s side of weir floor.

1) Piping : —

water seeps under the base of the weirs founded on permeable soils. when the flow line emerge out at the d/s end of the impervious floor of the weir. The hydraulic gradient or the exit gradient may exceed a certain critical value for the soil. in that case, the surface soil starts boiling and is washed away by percolating water. with the removal of surface soil, there is further concentration of flow lines into the resulting depression and still more soil is removed.

Remedies :— piping providing sufficient length of the impervious floor so that path of percolating is increased and the exit gradient is decreased.

② providing pile at d/s end.

② Rupture of floor due to uplift :

If the weight of floor is insufficient to resist the uplift pressure, the floor may burst and effective length of impervious floor is thereby reduced.

Remedies :— 1. providing impervious floor of sufficient length

2. providing impervious floor of appreciat thickness of various point.

3. providing pile at the d/s end. so that the uplift pressure to the d/s is reduced.

③ Rupture of floor due to suction caused by standing wave

The standing wave or Hydralic jump formed at d/s of the weir causes suction which also acts in the direction of uplift pressure. If the floor thickness is insufficient it may fail by rupture.

Remedies :→ 1. providing additional thickness of floor to counterbalance the extra pressure due to the standing wave.

2. Constructing the floor thickness in one concrete mass instead of in masonry layers.

④ Scour on the u/s & d/s of the weir :–

when the natural waterway of a river is contrated, the water may scour the bed both at upstream & downstream of the structure. The scour holes so formed may progress towards the structure.

Remedies ① Taking the piles at u/s & d/s ends of the impervior floor much below the calculated scour level.

⊛ Design of Impervious floor for subsurface flow

we have alredy seen that the subsurface flow or the foundation seepage may cause harm in 2 ways.

1. piping (or) uplift.

1. Bligh's creep theory :—

The design of impervious floor, or the apron is directly dependent on the possibilities of percolation in the porous soil on which the apron is built.

Bligh's assumes as an aproximation that the hydraulic slope or gradient is constant througout the impervias length of the apron. He further assumed the percolating water to creep along the contact of the base profile of the apron with the subsoil.

He designated the length of the Travel as the creep length, which is sum of the horizontal as well as vertical length of creep..

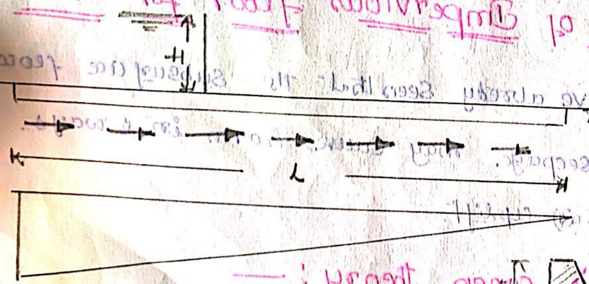
Bligh's asserted that no amount of sheet piling or another cut off could ever stop the percolation unless the cut off extends up to the impermeable soil strata.

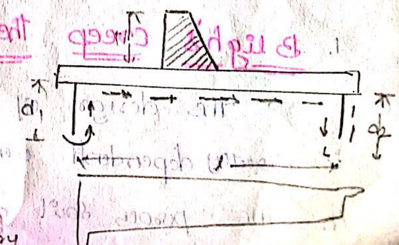
Thus according to the Bligh's theory, the Total creep length L for the case

$$L = l.$$

In the fig the Total creep length

$$L = 2d_1 + l + 2d_2.$$





Bligh's Creep Theory

This means that in calculating length of creep the (6)
depth of every cutoff is multiplied by the coefficient 2.

If H is the total loss of head, the loss of head per unit length of creep. (c) would be

$$C = \frac{H}{2d_1 + l + 2d_2} = \frac{H}{L}$$

Coefficient of creep

Type of soil	value of $C = 1/c$
1. light sand and mud	18
2. Fine micous sand	15
3 Coarse grained sand	12
4 Boulders or shingle gravel mixed	5 to 9.

Design Criteria: —

① Safety against piping: — The length of creep should be sufficient to provide a safe hydraulic gradient according to the type of the soil.

Thus, the safe creep length is given by

$L = CH$

C = coefficient of creep.

② Safety against uplift pressure

Let h' be uplift pressure head at any point of the apron

The uplift Pressure $= wh'$ →①

If t = thickness of the floor at the point

ρ = specific Gravity of the floor material.

Then downward force (resisting force) per unit area

$= t w \rho$ → ②

Equating ① & ② we get

$wh' = t w \rho$

$h' = t\rho$

$h' - t = t\rho - t = t(\rho - 1)$

$t = \frac{h' - t}{\rho - 1} = \frac{h}{\rho - 1}$

h = ordinate of the hydraulic-gradient line measured above the top of the floor providing a factor of safety of 4/3 we have

$t = \frac{4}{3} \frac{h}{\rho - 1}$

① problem

fig shows the section of a hydralic structure founded on sand. Calculate the average hydralic gradient. also find the uplift pressure at points 6 and 12, 18 m from the u/s end of the floor. and find the thickness of the floor at these points. Taking $\rho = 2.24$.

Sol Total length of creep $= (2\times6) + 22 + 2\times8 = 50$

$2l_1 + d_1 + 2l_2$

Hydralic gradient $= \frac{4}{50} = \frac{1}{12.5}$

(i) uplift pressure at a point A, 6 m from u/s.

length of creep upto A $= (6\times2 + 6) = 18m$

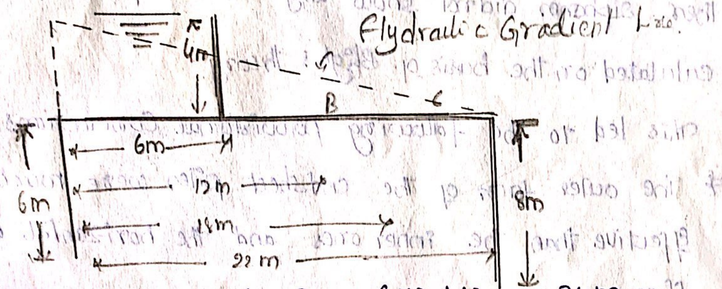
unbalanced head $h_1 = 4\left(1 - \frac{18}{50}\right)$

$4\left(1 - {}^{l}/_{L}\right)$

uplift pressure $wh' = 9.81 \times 2.56 = 25.11\ kN/m^2$

Thickness $t = \frac{4}{3}\frac{h_1}{\rho - 1} = \frac{4}{3} \times \frac{2.56}{2.24-1} = 2.76m$

(2) uplift pressure at point B, 12m from u/s.



length of creep upto B = $6 \times 2 + 12 = 24m$.

unbalanced head $h_2 = 4\left(1 - \frac{24}{50}\right) =$

$= 2.08m$

uplift pressure $= wh_2 = 9.81 \times 2.08 = 20.4\ kN/m^2$

Thickness $t = 4/3 \frac{h_2}{\rho - 1} = \frac{4}{3} \frac{2.08}{2.24-1} = 2.23\ m.$

(3) uplift pressure at point C, 18m from u/s.

length of creep upto C $= (6 \times 2) + 18 = 30m$

unbalanced head $h_3 = 4\left(1 - \frac{30}{50}\right) = 1.6m$

uplift pressures $wh_3 = 9.81 \times 1.6 = 15.7\ kN/m^2$

Thickness $t = 4/3 \frac{h_3}{\rho - 1} = 4/3 \times \frac{1.6}{2.24-1}$

$= 1.72km.$

(b) Khosla's theory :—

Some siphon's on upper chinab canal designed on Bligh's theory gave trouble. Actual pressure measurements made with the help of pipes inserted in the floors of these siphons did not show any relationship with the pressure calculated on the basis of Bligh's theory.

This led to the following provisional conclusions by Khosla.

⇒ The outer faces of the end sheet piles were much more effective than the inner ones and the horizontal length of the floor.

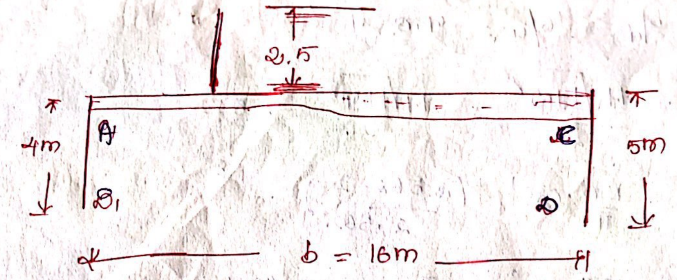
⇒ The intermediate piles of smaller in length than the outer one were ineffective except for the local redistribution of pressure.

⇒ undermining of the floor started from Tail end. If the hydraulic Gradient at exit was more than the critical gradient for the particular soil.

⇒ It was absolutely essential to have a ~~relationship~~ reasonably deep vertical cutoff at d/s end to prevent undermining.

problem :—

(1) An impervious floor of weir on permeable soil is 16m long and has sheet piles at both the ends. The upstream pile is 4m ~~long~~ deep and d/s pile is 5m deep. The weir creates a net head of 2.5m. Neglecting the thickness of the weir floor. Calculate the uplift pressure at the junctions of inner faces of the pile with the weir floor. by using Khosla theory.



1) pressure at point E

$$\phi_E = \frac{100}{\pi}\cos^{-1}\left(\frac{\lambda-2}{\lambda}\right).$$

b = 16.
d = 5.

$$\alpha = b/d = \frac{16}{5}$$

$$= 3.2$$

$$\lambda = \frac{1+\sqrt{1+\alpha^2}}{2} = \frac{1+\sqrt{1+(3.2)^2}}{2} = 2.176.$$

$$\phi_E = \frac{100}{\pi}\cos^{-1}\left(\frac{2.176-2}{2.176}\right)$$

$$= \frac{100}{\pi}\, 85°35' \times \frac{\pi}{180} = 47.42\ \%$$

Let us now apply corrections for interference of u/s pile

$$c = -19\sqrt{\frac{D}{b}}\left(\frac{d+D}{b}\right)$$

d = 5m   D = 4m   b′ = 16m

$$c = -19\sqrt{\frac{4}{16}}\left(\frac{5+4}{16}\right) = -5.34\%.$$

$$\phi_E = 47.42 - 5.34 = 42.08\ \%.$$

$$P_E = 0.4208 \times 2.5 = 1.052\,m$$

(2) pressure at point A :-

$$\phi_A = \frac{100}{\pi}\cos^{-1}\left(\frac{\lambda-2}{\lambda}\right).$$

$\alpha = b/d = 16/4 = 4$

$$\beta = \frac{1+\sqrt{1+\alpha^2}}{2} = \frac{1+\sqrt{1+4^2}}{2} = 2.562$$

$$\phi_E = \frac{100}{\pi} \cos^{-1}\left(\frac{2.562-2}{2.562}\right)$$

$$= \frac{100}{\pi}\, 77.34^\circ \times \frac{\pi}{180} = 42.96\ \%$$

Let us know apply corrections of d/s pile

$$C = +19\sqrt{\frac{D}{b'}}\left(\frac{d+D}{b}\right)$$

$d = 4\ m$ $D = 5m$ $b' = b = 16m$

$$C = 19\sqrt{\frac{5}{16}}\left(\frac{4+5}{16}\right) = 5.97\ \%$$

$$\phi_A = 42.96 + 5.97 = 48.-\ \%$$

$$P_c = 0.4893 \times 2.5 = 1.2235m$$