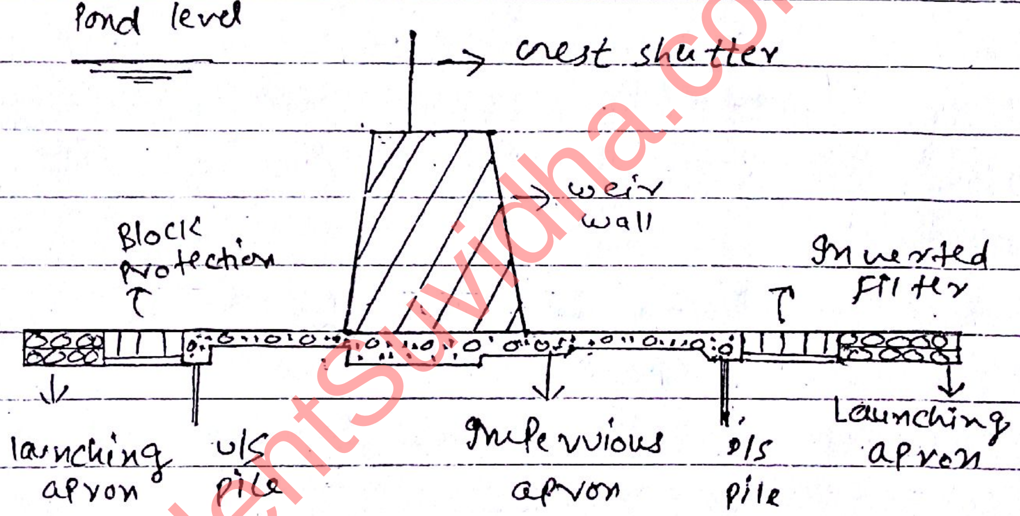
Irrigation Engg. [PIC]

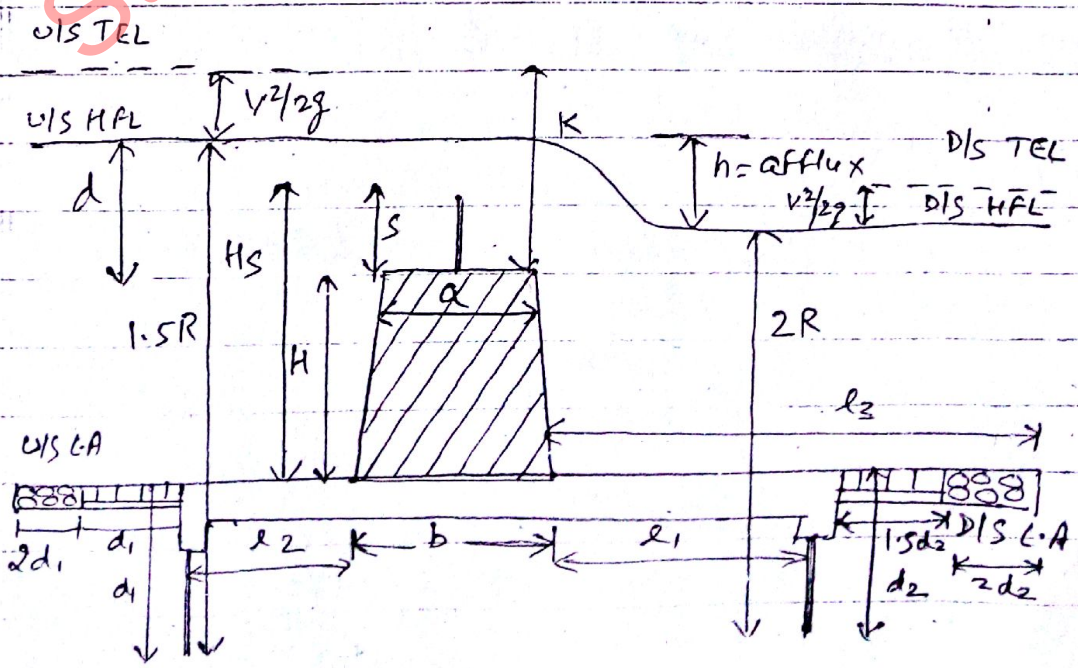
SEC-A UNIT-1 "DESIGN OF WEIR"

(20)

WEIR → The weir is a solid obstruction put across a River to Raise its water level and divert the water into the Canal.



"VERTICAL DROP WEIR"



Design of vertical Drop weir :-

Design Steps :-

1) Hydraulic calculations for fixing various elevations.
2) Design of weir well
3) Design of impervious aprons.
4) Design of inverted filter.

NUM.

Q1 Design a vertical drop weir on Bligh's theory for the following site conditions

a) Max. flood Discharge = 2800 m^3/s
b) HFL before construction = 285 m
c) Min. water level = d/s Bed level = 278 m
d) FSL of canal = 284 m
e) Allowable Afflux = 1m
f) Coff. of creep = 12
g) exit gradient = 1/6

Sol. Step 1 :- "Hydraulic Calculations"

(i) Q = 2800 cumec

$$L = 4.75\, Q^{1/2}$$
$$= 4.75\,(2800)^{1/2}$$
$$= 250\,m$$

∴ L = Length of water way

Now, $q = \frac{Q}{L} = \frac{2800}{250} = 11.2$ cumec/m

(ii) Regime Scour Depth :-

Take f (silt factor) = 1

$R = 1.35 \left(\frac{q^2}{f}\right)^{1/3}$

$= 1.35 \left[\frac{(11.2)^2}{1}\right]^{1/3} = 6.75$ m

Regime velocity (V) $= \frac{q}{R} = \frac{11.2}{6.75} = 1.66$ m/s

vel. Head $= \frac{V^2}{2g} = \frac{(1.66)^2}{2(9.81)} = 0.14$ m

(iii) Water levels :-

Level of d/s TEL = HFL before construction $+ \frac{V^2}{2g}$

$= 285 + 0.14$

$= 285.14$ m

Level of u/s TEL = d/s TEL + Afflux

$= 285.14 + 1$

$= 286.14$ m

u/s HFL = u/s TEL $- \frac{V^2}{2g}$ [From Figure]

$= 286.14 - 0.14$

$= 286$ m

(iv) Discharge over the crest :-

$$q = 1.70\ K^{3/2}$$

$$K = \left(\frac{q}{1.70}\right)^{2/3}$$

$$K = \left(\frac{11.2}{1.70}\right)^{2/3}, \quad K = 3.56m$$

Crest level = u/s TEL − K [From Figure]
= 286.14 − 3.56
= 282.58 m

(v) Pond level = level of Top of gates
= FSL in Canal + Head loss (regulator)
= 284 + 0.5 (say)
= 284.5m

Height of Shutter (S) :-
= Pond level − Crest level
= 284.5 − 282.58
[S = 1.92m]

(vi) Protection against Scour :-

Level of bottom of u/s pile :- [From Figure]
= [u/s HFL − 1.5R]
= 286 − 1.5 (6.75)
= 275.88 m

Level of bottom of D/s pile :-
= [HFL after retrogation − 2R]

$= 284.5 - 2(6.75)$

$= \underline{271 m}$

(vii) Seepage Head :- (H_s)

H_s = R.L of gates crest - R.L of Bed

$= 284.5 - 278$ (given)

$= \underline{6.5 m}$

Height of crest (H)

H = R.L of crest - R.L of Bed

$= 282.58 - 278$

$= \underline{4.58 m}$

Check $H_s = H + S$ (from figure)

$= 4.58 + 1.92 = \underline{6.5 m}$

step 2 Design of weir wall :-

(i) Calculation of Top width (a) :-

d = U/S HFL - crest level

$= 286 - 282.58 = \underline{3.42 m}$

Top width, $a = \frac{d}{\sqrt{\rho}} = \frac{3.42}{\sqrt{2.24}}$

[a = 2.3 m]

From sliding Considerations :-

$$a = \frac{3d}{2\rho} = \frac{3 \times 3.42}{2 \times 2.24} = [2.29\ m]$$

From Practical Considerations :-

$$a = s + 1 = 1.92 + 1 = [2.92 m]$$

Hence, Provide $[a = 3m]$ (greater value)

(ii) Calculation of bottom width (b) :-

- We have to equate overturning Moment (M_o) to Resisting Moment (M_R) in order to calculate b.

$$M_o = \frac{\omega (H+S)^3}{6} = \left[\frac{\omega (Hs)^3}{6}\right]$$

$$= \frac{9.81 (6.5)^3}{6} = 449\ KN\text{-}m \rightarrow (1)$$

(ω = unit wt. of water)

$$M_R = \left[\frac{\omega H \rho}{6} (b^2 + ab - a^2)\right]$$

[assuming u/s face to be vertical]

$$= \frac{9.81 \times 4.58 \times 2.24}{6} [b^2 + 3b - 9]$$

$$= 16.77 [b^2 + 3b - 9] \rightarrow (2)$$

equating ① & ②

$$16.77(b^2+3b-9) = 449$$

$$\Rightarrow \boxed{b = 5m}$$

Step 3 Design of Impervious & Pervious aprons :-

(i) $C = 12$ (given)

$L = C H_s$ (Creep length)

$L = 12(6.5)$

$L = 78\,m$

(ii) $l_1 = 2.21\, C \sqrt{\frac{H_s}{13}}$ [D/s Imp. apron]

$= 2.21(12)\sqrt{\frac{6.5}{13}} = 19m$

(iii) l_2 [U/s Impervious apron]

$l_2 = L - l_1 - (b + 2d_1 + 2d_2)$

d_1 = depth of U/s pile below bed

= Bed level − level of bottom of U/s pile

$= 278 - 276 = 2m$

d_2 = depth of d/s pile below bed

= Bed level − level of bottom of d/s pile

$= 278 - 271 = 7m$

$l_2 = 78 - 19 - (8+4+14) = \underline{36\,m}$

(iii) $l_3 = 18\,C\sqrt{\frac{Hs}{13} \times \frac{q}{75}}$

$= 18(12)\sqrt{\frac{6.5}{13} \times \frac{11.2}{75}} = \underline{54\,m}$

Step 4 Design of Inverted Filter & launching apron :-

$d_1 = 2m$

Length of u/s Block protection $= 2m = d_1$

Provide 1m thick block stones

Length of u/s Talus $= 2d_1$

$= \underline{4m}$

Volume of stones $= \sqrt{10}\, d_1 \times 1$

$= \sqrt{10} \times 2 \times 1$

$= \underline{6.28\,m^3}$

Thickness of apron $= \frac{Vol.}{L}$

$= \frac{6.28}{4} \Rightarrow \underline{1.5M}$