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Sec-C

Design of Sarda type fall

Introduction :-

This fall was used for the first time on the Sarda Canal in U.P. and hence named Sarda type fall in which the water falls from the u/s to the d/s of the canal. Large no. of falls with small drops were constructed so as to avoid deep cutting.

Design Procedure :-

In the design of Sarda type fall, following elements are required to be designed ←

1) crest wall
2) cistern
3) Impervious floor.
4) D/s protection
5) U/s approach.

(A) Design of crest wall -

Crest length may be equal to bed width of the canal. To allow for possible future increase in discharge, the length of the crest wall may be kept equal to bed width plus depth.

For discharge upto 14 cumecs, the shape of the crest wall is kept rectangular while .... trapezoidal.

a) Rectangular Crest -

Top width of crest (B) = $0.55\sqrt{d}$.

where

d = height of crest wall above the d/s bed level in m.

Base width of the crest wall $(B_1) = \frac{H+d}{G}$

H = Height of water surface above top of crest wall on u/s side.

G = specific gravity of the material of crest wall and may be equal to 2.

Discharge formula for Rectangular crest is

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

L = Length of crest in m.

b) Trapezoidal crest –

Top width (B) = $0.55\sqrt{H+d}$

Slope of u/s face = 1 in 3.

Slope of d/s face = 1 in 8.

Discharge formula for Trapezoidal crest wall is –

$$Q = 1.99\, L H^{3/2} \left(\frac{H}{B}\right)^{1/6}$$

Determining crest level –

crest level (R.L.) of crest) = u/s F.S.L – H.

P.T.O

Height of crest above bed h

$$= D - H$$

(B) Design of cistern.

The length of the cistern (L_c) and depth of cistern (x) is given by —

$$L_c = 5\sqrt{E \cdot H_L}$$

OR

$$= 5(E \cdot H_L)^{1/2}$$

$$x = \frac{1}{4}(E \cdot H_L)^{2/3}.$$

Where.

H_L = fall or drop in m.

E = Total Energy line.

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(c) Design of Impervious Floor :-

The total length of the Impervious floor is determined by Bligh's theory or By Khosla's theory.

For small and medium falls, Bligh's theory is used while for large falls, Khosla's theory is used.

A min. length which should be provided on D/s side of the crest is given by –

$$l_d = 2(D + 1.3) + H_L$$

D = water depth on d/s side.

However a min. thickness of floor taken should be from 30 cm to 40 cm.

(D) Downstream (D/s) Protection –

The downstream protection consists of following elements –

Bed protection :-

The bed of the channel needs to be protected by providing dry brick pitching 200mm (20 cm) thick laid on 100 mm (10 cm) thick ballast.

P.T.O

Side Protection :-

After the wing walls, the side slopes of the channel are pitched either with one brick on edge or $1\frac{1}{2}$ brick on edge.

Energy Dissipators :-

Energy Dissipators are not provided for small discharges

(E) **U/s Approach :-**

The u/s approach consists of wing walls : for discharge upto 14 cumecs, the wing walls may be splayed, straight at an angle of 45°.

For large discharges, the wing walls are kept segmental with radius equal to 5 to 6 times H and its angle at the centre should be 60°

full supply depth $\frac{u/s}{d/s} = \frac{2m}{2m}$

Numerical

Design a 1.5 m Sarda type fall for a canal having a discharge of 50 cumecs with the following data –

i) full supply level $\frac{u/s}{d/s}$ = $\frac{101.5 \text{ m}}{101.0 \text{ m}}$

ii) Bed level $\frac{u/s}{d/s}$ = $\frac{99.5 \text{ m}}{98.0 \text{ m}}$

iii) Bed width = 80 m.

iv) Side slope = 1:1

Soil – Good loam.

Safe exit gradient – $\frac{1}{4.5}$

Design the floor with khosla's theory –

Sol^n: –

Given values –

Step-I Design of crest wall.

Length of the crest shall be kept equal to bed width of the channel.

∴ Length of the crest (L) = 30 m.

Crest Level —

For falls more than 14 cumecs, trapezoidal crest is provided and the discharge is given by —

$$Q = 1.99\, L H^{3/2} \left(\frac{H}{B}\right)^{1/6}$$

Assuming crest width (B) = 1.0 m.

$$50 = 1.99 \times 30 \times H^{3/2} \times \left(\frac{H}{1.0}\right)^{1/6}$$

$$= 1.99 \times 30 \times H^{3/2} \times \frac{H^{1/6}}{(1.0)^{1/6}}$$

$$H^{5/3} = \frac{50 \times 1}{1.99 \times 30} = 0.84$$

$$H^{5/3} = 0.84$$

$$H = (0.84)^{3/5} = (0.84)^{0.6}$$

$$= 0.90 \text{ m}.$$

$$H = 0.9 \text{ m}.$$

velocity of approach (V_a) = $\frac{\text{Discharge}}{\text{Area}}$

$$= \frac{50}{(30+1.5) \times 1.5}$$

(with slope 1:1)

Depth of water = 1.5 m

Bed width = 30 m.

$$V_a = \frac{50}{31.5 \times 1.5} = \frac{50}{47.25} = 1.06 \text{ m/sec}.$$

velocity Head (h_a) = $\frac{V_a^2}{2g} = \frac{1.123}{2 \times 9.81} = 0.057$ m

U/S T.E.L = U/S F.S.L + velocity head (h_a)

$$= 101.5 + 0.057 = 101.557.$$

R.L. of crest = U/S T.E.L − H

$$= 101.557 - 0.9 = 100.657$$

Hence,

crest level = 100.657 m.

D/s curtain well - $\frac{H_L}{4} + 0.6$

U/s curtain well - $\frac{H_L}{3} + 0.6$

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Step - II

Shape of crest -

width of the crest $(B_t) = 0.55\sqrt{H+d}$

d = Height of the crest above d/s bed.

$= 100.657 - 98.0 = 2.66\ m$

$\because$

$B_t = 0.55\sqrt{0.9+2.66} = 1.03$

say 1.05 m.

keep crest width 1.05 m with u/s slope 1:3 and d/s slope 1:8.

Step - III

U/s Curtain wall -

Max. depth of u/s curtain wall

$\frac{H_L}{3} = \frac{1.5}{3} = 0.5\ m.$

Curtain wall — (i) d/s D/s curtain wall ⇒ Depth = $\frac{\text{water depth}}{4}$

Depth = $\frac{\text{water depth}}{4} + 0.6 = \frac{1.5}{4} + 0.6 = 1.6m$

Provide 0.4 m thick toe wall over 0.3 m foundation concrete and hence total depth = 1.7 m.

Step - IV Design of cistern —

Length of cistern $(L_c) = 5 \cdot \sqrt{H \times H_L}$

$= 5\sqrt{0.9 \times 1.5} = 5.809$

$= 5.9 m$

Depth of cistern $(x) = \frac{1}{4}(H \cdot H_L)^{2/3}$

$= \frac{1}{4}(1.35)^{0.66} = \frac{1.21904}{4}$

$= 0.3 m$ deep.

R.L of cistern =

$98.0 - 0.3$

$= 97.7 m$

Step - V D/s wings :-

The d/s wing walls shall be kept vertical upto a distance of $5 \cdot \sqrt{H \times H_L}$

∵ Length of D/s wings $= 5\sqrt{0.9 \times 1.5} = 5.9 m$

Step - VI D/s pitching —

Length $= 9 + 2 \times H_L$

$= 9 + 2 \times 1.5 = 12 m.$

Exit Gradient $(G_E) = \frac{H}{d} \times \frac{1}{\pi\sqrt{\lambda}}$

(2) U/s curtain wall

Depth = $\frac{\text{water depth}}{3} + 0.6 = 0.67 + 0.6$
$= 1.3m$

Step - VII

Total floor length and exit gradient -

d = Height of crest above d/s bed

= 100.657 - 98.0 = 2.66 m.

d_c = depth of u/s curtain wall
= 1.7 m.

Exit Gradient $(G_E) = \left(\frac{d}{d_c}\right) \times \left(\frac{1}{\pi\sqrt{\lambda}}\right)$

$\frac{1}{4.5} = \left(\frac{2.66}{1.7}\right) \times \frac{1}{\pi\sqrt{\lambda}} =$

$\lambda = 4.5$

$\alpha = \left[(2\lambda - 1)^2 - 1\right]^{1/2}$

$= \left[(2 \times 4.5 - 1)^2 - 1\right]^{0.5} = 8.9$

$b = \alpha \times d_c$

$= 8.9 \times 1.7 = 15.13$ m.

say 16 m.

Max. floor length required in the d/s =

$10.53 D_c + 4.877 - 1.5 H_L$

D_c = critical depth.

$D_c = \left(\frac{q^2}{g}\right)^{1/3}$, $q = \frac{50}{30}$ ~~= 1.67~~

= 1.67 cumec/m.

$D_c =$ ~~1.16~~ $\left(\frac{(1.67)^2}{9.81}\right)^{1/3} = 0.65 m.$

$= 10.53 \times 0.65 + 4.877 - 1.5 \times 1.5$

= 9.471 say 10 m.

Provide 10 m in the d/s and balance 6 m under and u/s of the crest.

Let Bligh's coefficient = 7.

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In Case of Bligh's Theory –

Step – VII

Length of Impervious Floor –

Bligh's coefficient = 7.

Max. Static head =
crest level – D/s bed level
= 100.657 – 98.0 = 2.66 m

Total floor length required = 7×2.66 = 18.62 m.

Min. d/s floor length required –

$L_p = 10.53\, D_c + 4.877 - 1.5\, H_L$

D_c = critical depth

= 9.471 say 10 m.

Provide d/s floor 10m and the balance 8.62 m under the u/s of the crest.

[18.62 – 10 = 8.62 m]