2- Design of a Syphon Well Drop

A syphon well drop, such as shown in Fig.4, is generally adopted for smaller discharges and larger drops. The main features of the design involve determining the size of the inlet well and that of the pipe. Suitable size for the outer well, a proper provision of water cushion at the bottom of the inlet well, the bed and side slope pitchings in the canal upstream as well as downstream for suitable lengths, are also provided. The size of the inlet well and that of the syphon pipe are determined on the following considerations w .r. to Fig. 11.

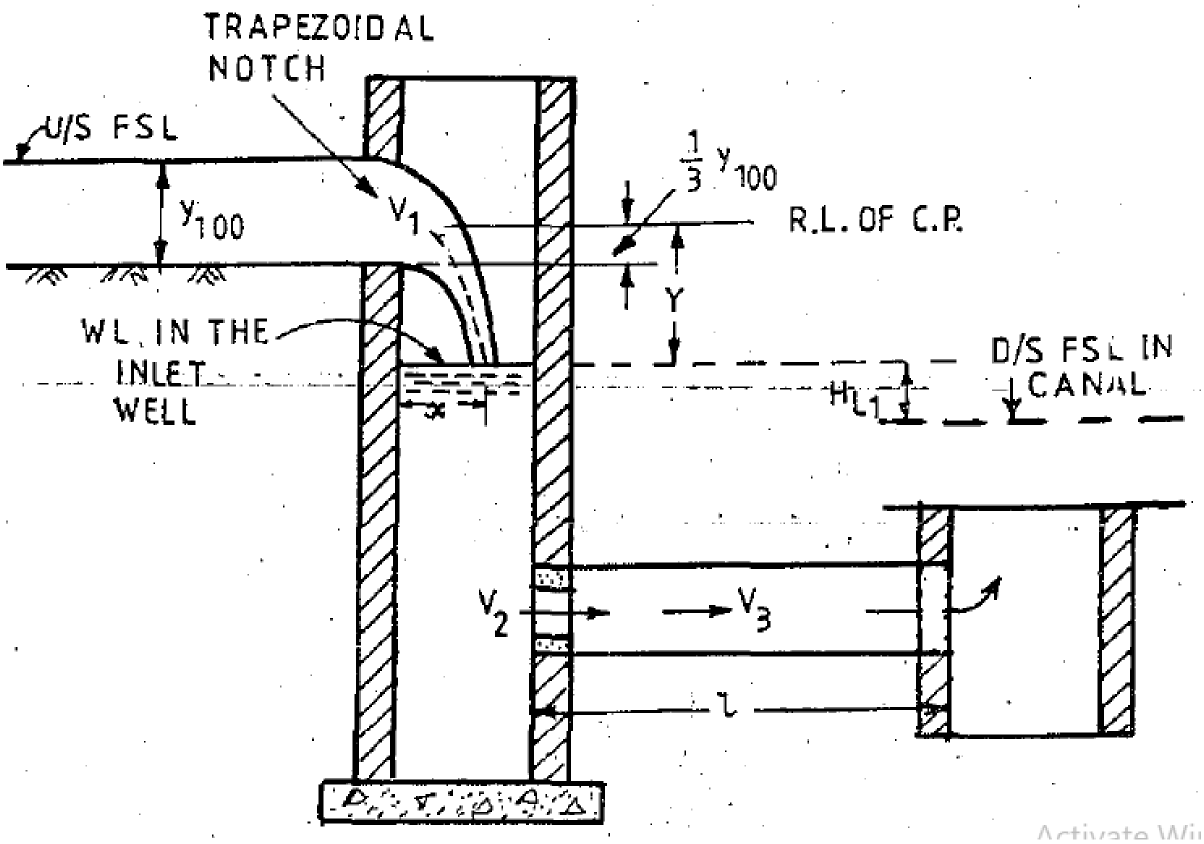

Fig.11

First of all, the size of the trapezoidal notch is determined to pass the designed discharge·by using eq. (12.4) in the same way, as is done for a trapezoidal notch. Then let V1 be the velocity over the notch, V2 be the velocity of entry in the pipe, and V3 be the velocity through the pipe. All these values of velocities can be determined easily as below :

$$V_1 = \frac{\text{Full supply discharge}}{\text{Area of flow over the notch}}$$

$$V_2 = \frac{\text{Full supply discharge}}{\text{Area of opening at entry (for assumed dia of opening)}}$$

$$V_3 = \frac{\text{Full supply discharge}}{\text{Area of pipe (for assumed dia)}}$$

The head loss between the inlet well and the d/s FSL is then given by HL_1 as

$$H_{L_1} = 0.5\,\frac{V_2^2}{2g}\ (i.e.\ \text{loss due to entry}) + \frac{(V_2 - V_3)^2}{2g}\ (i.e.\ \text{the loss due to sudden enlargement}) + \frac{f' L V_3^2}{2gd}\ (i.e.\ \text{the loss in the assumed pipe length } L)$$

$$+ \frac{V_3^2}{2g}\ (\text{loss due to exit}).$$

Knowing all the above values, HL_1 can be determined, and thus the R.L. of water surface inlet well *(i.e. d/s* FSL + *HL)* can be determined.

Now, approximate *R.L.* of the centre of pressure (C.P,) of the trapezoidal waterway through the notch

$$= \text{u/s canal bed level} + \frac{1}{3}\,\text{FSD.}$$

$$= (\text{which can be calculated})$$

Then, the height *(Y)* of the centre of pressure above the water level in the inlet well

$$= \text{R.L. of C.P.} - \text{R.L. of water level in inlet well}$$

$$= (\text{Known})$$

Now using the eq.

$$V_1 = \sqrt{\frac{gX^2}{2.Y}}$$

where X and Y are the coordinates of the jet (issuing from centre of pressure) w.r. t. the water surface level in the inlet well *as fig.12*

$X = V_1\, t$ (after a time t)

$$Y = \frac{1}{2} g t^2$$

or

$$Y = \frac{1}{2} g \cdot \left(\frac{X}{V_1}\right)^2$$

or

$$V_1 = \sqrt{\frac{gX^2}{2y}}$$

$\left[\because \text{using } S = ut + \frac{1}{2} g t^2 \text{ and } u = 0, \text{ we have } S = \frac{1}{2} g t^2\right]$

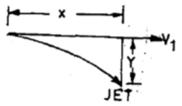

Fig .12

The value of X can be determined. Finally, the dia of the inlet well may be kept at about 1.5 times the value of X. The entire procedure will become more clear when we solve. the following numerical example.

Example .2. Design the salient dimensions of a syphon well drop for the following particulars :
Fall =3.8m , General ground level = + 163.36 m , Full supply depth = 75 cm , Bed level upstream = + 162.83 , Discharge = 1 cumec , Bed width upstream and downstream = 2.4 m

Solution. For a trapezoidal notch, we have the discharge eq. as

$$Q = 2.22 \cdot H^{3/2}\,[l + 0.4\,n\,H]$$

At full supply discharge, we have

$Q_{100} = 2.22\ (y_{100})^{3/2}\ [l + 0.4\ n\ Y_{100}]$

where y_{100} = F.S.D. = 0.75 m , Q_{100}= F.S.Q= 1 cumec

$1 = 2.22\ (0.75)^{3/2}\ [l + 0.4n\ (0.75)]$

$0.71=l+0.3n$ ……(i)

At 50% full discharge, we have

$Q_{50} = 2.22\ y_{50}\ [l + 0.4n\ y_{50}]$

where $y_{50}= 0.66\ y_{100}$

=0.66x0.75

=0.5 m

Q_{50} = 0.5 cumec

0.5 = 2.22 (0.5)312 [l + 0.4n (0.5)]

0.64= l + 0.2 n ….(ii)

Subtracting (ii) from (i) we get

0.07=0.l n

n=0.7

$$2\tan\frac{\alpha}{2}=0.7,\ \text{or}\ \frac{\alpha}{2}=19.3^\circ$$

Substituting this value of n in (ii), we get

l=0.64-0.14=0.50

Hence, provide a trapezoidal notch in the staining of the inlet well, with 0.5 m bottom width and each side inclined to an angle of 19.3° with the vertical.

Now, the width of water (at FSL) flowing over notch

= 0.5 + 0.7 x (0.75) = 0.5 + 0.525 = 1.025 m.

Velocity (V_1) over the notch

$$=\frac{\text{F.S.Q.}}{\text{Area of flow over the notch}}$$

$$=\frac{1}{\frac{0.5+1.025}{2}\times 0.75}\ \text{m/sec}=\frac{1}{0.76\times 0.75}\ \text{m/sec}=1.75\ \text{m/sec}$$

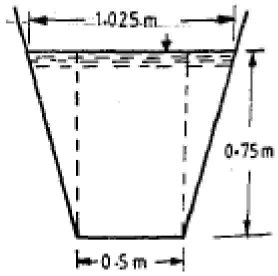

fig .13

Let us now assume that the diameter of the pipe used to be 1 m

Velocity V_3 through the pipe

$$=\frac{1}{\frac{\pi}{4}(1)^2}\ \text{m/sec.}=1.27\ \text{m/sec.}$$

Let us assume that the diameter of the opening at the inlet of pipe be 0.5 m

The velocity of entry into the pipe (V2)

$$=\frac{1}{\frac{\pi}{4}(0.5)^2}\ \text{m/s}=5.1\ \text{m/sec.}$$

Loss of head between the inlet well and the dis FSL is given by Eq.

$$=0.5\cdot\frac{V_2^2}{2g}+\frac{(V_2-V_3)^2}{2g}+\frac{f'\,L\,V_3^2}{2gd}+\frac{V_3^2}{2g}$$

Let us assume that the length of the pipe is kept as 12m and f' =Darcey's coefficient of friction be taken as equal to 0.012, we than have

$$H_{L_1} = 0.5 \times \frac{(5.1)^2}{2 \times 9.81} + \frac{(5.10 - 1.27)^2}{2 \times 9.81} + \frac{0.012 \times 12 \times (1.27)^2}{2 \times 9.81 \times 1.0} + \frac{(1.27)^2}{2 \times 9.81}$$

$$= 0.66 + 0.77 + 0.01 + 0.08 = \mathbf{1.52\ m.}$$

R.L. of the water surface in the inlet well

$$= \text{d/s FSL} + 1.52$$

$$\left[\begin{aligned} \text{d/s FSL} &= \text{u/s FSL} - \text{fall} \\ &= (162.83 + 0.75) - 3.8 = 159.78) \end{aligned}\right]$$

$$= 159.78 + 1.52 = \mathbf{161.30}.$$

Approximate R.L. of the centre of pressure (C.P.) of the trapezoidal waterway through a notch

$$= \text{u/s canal bed level} + \frac{1}{3}\text{FSD}$$

$$= 162.83 + \frac{0.75}{3} = 162.83 + 0.25 = \mathbf{163.08}$$

Height Y of C.P .. above the water level in the inlet well
= 163.08-161.30= 1.78 m.

$$V_1 = \sqrt{\frac{g \cdot X^2}{2Y}}$$

or

$$X = \sqrt{\frac{V_1^2\, 2Y}{g}}$$

$$= \sqrt{\frac{(1.75)^2 \times 2 \times 1.78}{9.81}} = 1.75 \times 0.6 = 1.05\ \text{m.}$$

Now, the dia. of the inlet well may be kept at about 1.5 X, i.e. l.5 x 1.05 = 1.575 m, say 1.6 m. Keep the dia. of the d/s outlet well, as say 1.2 m. Also, provide a water cushion at the bottom of the inlet well. Bed and sides of the channel for suitable lengths on the u/s as well as d/s side are protected by dry brick pitching. The complete details are shown in Fig.14.

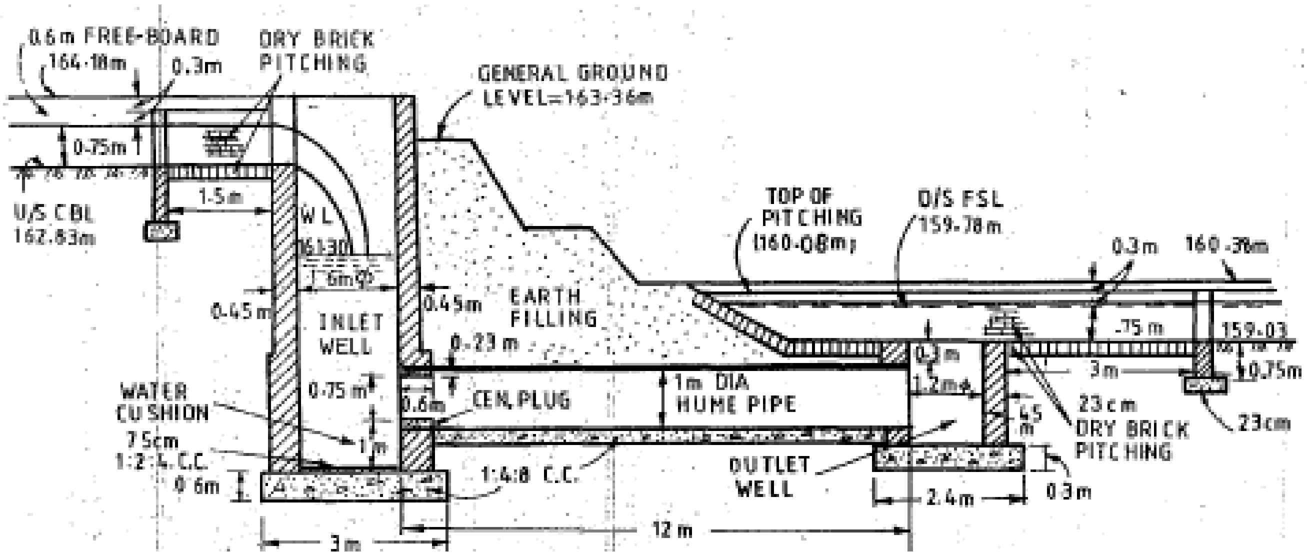

Fig.14