Siphon Spillway:

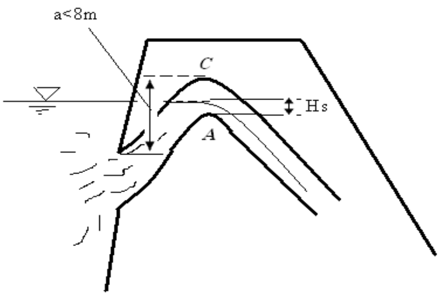
- If a large capacity is not necessary and space is limited, the siphon spillway may be a practical selection.
- Siphon spillway has the advantage that they can automatically maintain water surface elevation within very close limit.

When the water level in the reservoir increases, it seals the air entry trough the mouth of the deprimer mouth. Water spills over the crest of the spillway. Siphonic action is established after the air in the bend over the crest has been exhausted. ***This action is known as priming***. The siphon runs full and water is discharged downstream under siphonic head. During receding flood, when water level has gone down just to the reservoir level, air enters through the mouth of deprimer dome and the siphonic action is broken. This action is called *depriming* of the siphon and is achieved through the deprimer dome.
Depriming is the reverse process of priming. It is the action of the siphon from the air starts entering the siphon through the vents until siphonic action is completely stopped when the air pressure in the siphon equals to atmospheric pressure. Depriming is carried out by providing ***deprimer*** which is a siphon breaker air vent and is provided to break the siphonic action when the reservoir water surface is drawn below it. If an air vent is not provided, siphonic action once initiated would continue till the reservoir level is brought down to the level at inlet which is provided much below normal reservoir level.

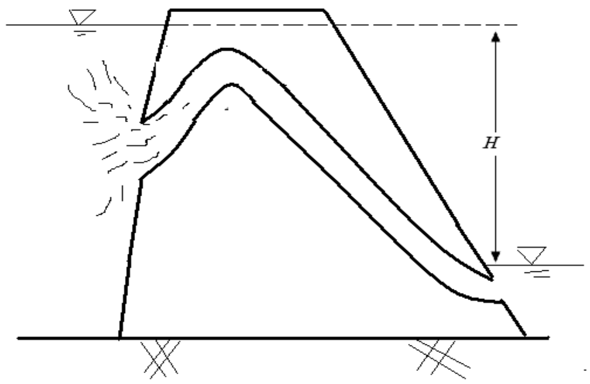
-At low flows, the siphon spillway operates like an overflow spillway with its crest at C.
- At higher flows, after the siphon has primed, discharge is given by:

$$Q = C_d A\sqrt{2gH}$$

Where C_d is a coefficient of discharge that is usually about 0.9.



beginning stage



siphoning stage

Air vent used automatically maintain the water-surface elevation large capacity not needed, good for limited space

* At low flow: it acts like an overflow spillway

* At high flow: the siphon action removes the water thru the structure until reservoir drops to the elevation at the upper lip of entrance

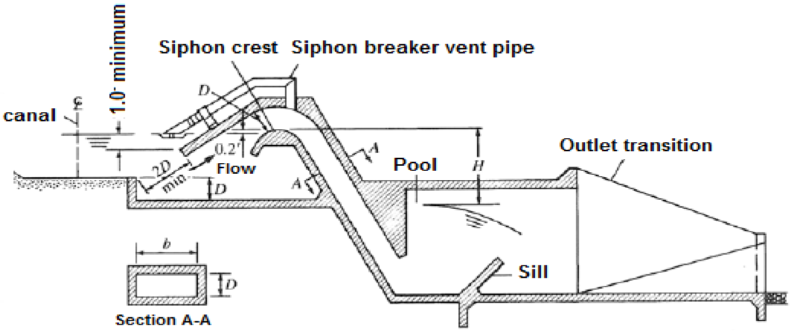
Siphon Behavior:

The portion of the spillway conduit rising above the hydraulic gradient line (HGL) is under negative pressure. Because (HGL) represent zero atmospheric pressure, the vertical distance measured between the (HGL) and the conduit immediately above (HGL) indicate the negative head, $-\frac{P}{\gamma}$, at the location. Point C (highest point in the conduit) is subjected to the maximum negative pressure.

The maximum negative pressure at a spillway crown must not be allowed to decrease below the vapor pressure of water at the temperature measured. Because of the action of cavitations and potentially damaging pressure is created. Because, under ordinary conditions, the atmospheric pressure is equivalent to a 10.34m height of water column, the maximum distance between the (highest point in the siphon) and water surface elevation in the reservoir is limited to **approximately 8m** This difference (2.3m) accounts for the vapor pressure head, the velocity head, and the head losses between the reservoir and highest point in the siphon.

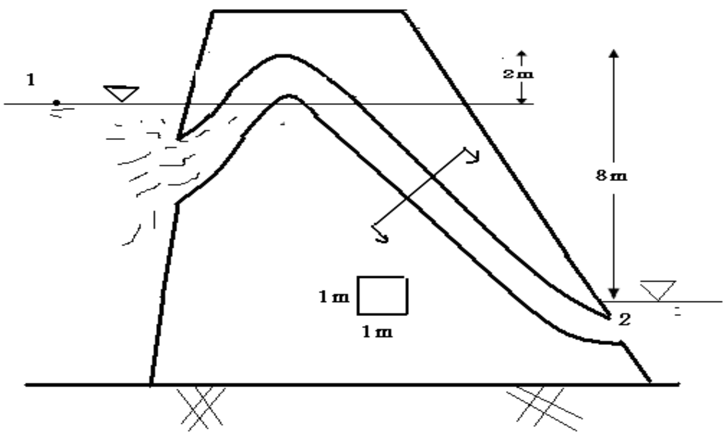
General Specification

Fig. below explains the general specification of siphon spillway.



Profile of a siphon spillway

Example: The rectangular siphon in fig. has a constant cross section 1m*1m and is 40m long, friction factor f=0.025, the inlet coefficient=0.1, the bend losses coefficient=0.8 at the crown, and the exit loss coefficient=1.0. Determine the discharge and the pressure head at the crown? (Assume the length from entrance to crest=10m



Sol: En. Eq. 1&2

$$\frac{p_1}{\gamma}+z_1+\frac{v_1^2}{2g}=\frac{p_2}{\gamma}+z_2+\frac{v_2^2}{2g}+0.1\frac{v_2}{2g}+0.8\frac{v_2}{2g}+0.025(\frac{L}{D})\frac{v_2}{2g}+1.0\frac{v_2}{2g}$$

V1=V2=0 P1/γ=P2/γ=0 Z1=6m, Z2=0 V=siphon velocity

$$6=[1+0.1+0.8+0.025(40/1)]\frac{V^2}{2g}$$

$$V=6.37m/s$$

$$Q=AV=1^2(6.37)=6.37m^3/s$$

En. Eq. 1&C (crown)

$$\frac{p_1}{\gamma}+6+\frac{v_1^2}{2g}=\frac{p_c}{\gamma}+8+\frac{v_c^2}{2g}+0.1\frac{v_c^2}{2g}+0.8\frac{v_c^2}{2g}+0.025(\frac{10}{1})\frac{v_c^2}{2g}$$

$$V_1=0..........,\frac{p_1}{\gamma}=0...........,V_c=V=6.37m/s$$

$$\frac{p_c}{\gamma}=-6.45m$$

Service and Emergency Spillways

-extra spillways provided on a project in rare case of extreme floods (emergency)
-used to convey frequently occurring outflow rates (service)

Conclusions:

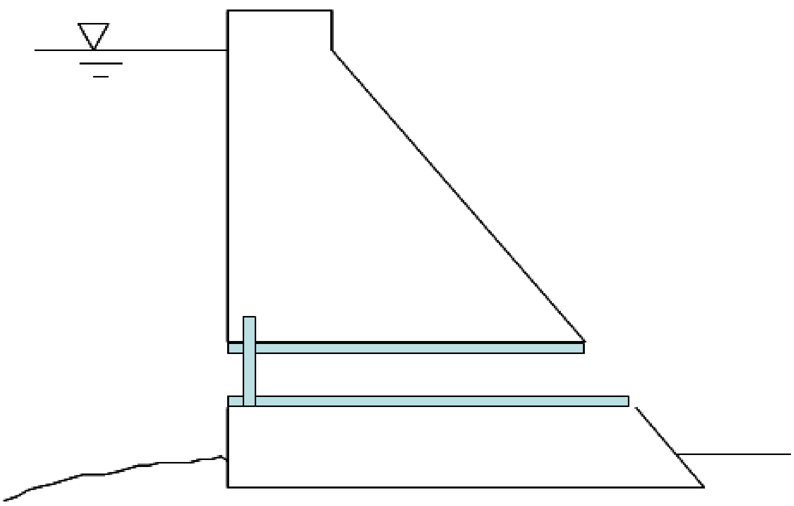
Ogee Spillways	Used in concrete and Masonry dams
Chute Spillways	Used in earthen and rock fill dams
Shaft (Tunnel) Spillways	Used in earthen and rock fill dams
Side Channel and Shaft Spillway	When gorge is very narrow
Siphon Spillway	Almost constant head for design range of discharge

Outlet Work:

The major portion of the storage volume in most reservoirs is below the spillway crest. Outlet works must be provided in order that water can be drawn from the reservoir as needed. This water may be discharged into the channel below the dam or may be transported in pipes or canals to some distant point. Outlet works include:

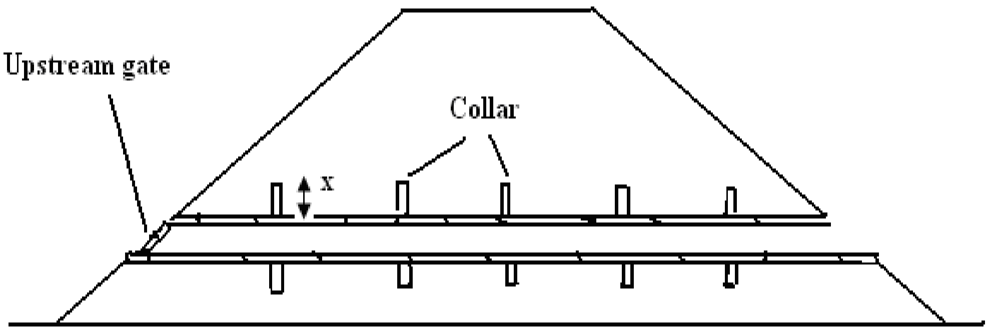
1. **Sluiceways:**

It is a pipe or tunnel that passes through a dam or the hillside at one end of the dam and discharges into the stream below.
Sluiceway for ***concrete dams*** generally passes through the dam.



Sluiceway for a gravity concrete dam.

Sluiceways for earth or rock dams are preferably placed outside the limits of the embankment. If a sluiceway must pass through an earth dam, projecting collars should be provided to reduce seepage along outside of the conduit.



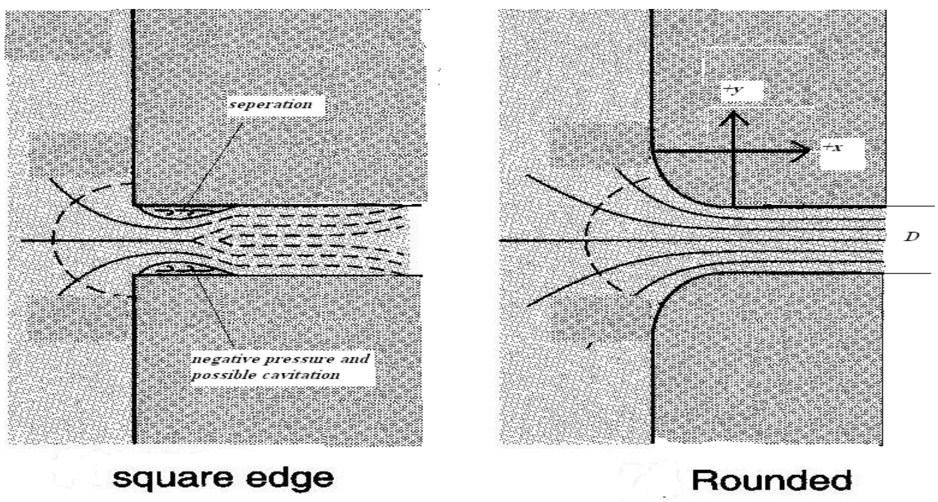
For design purpose :

$$2Nx > 0.25L$$

Where N is the number of collars, and x is the projection of the collars.

Example: determine the height of collars for an earth dam if the length of seepage path is 100m, (assume the available distance between two adjacent collars is 10m?
Sol:
N=(100/10)-1=9
X=(0.25*100)/(2*9)
=1.38m ≈ 1.5m
2(9*1.5)=27>(0.25*100) o.k

- The outlets of most dams consist of one or more sluiceways with their inlets at about minimum reservoir level.
- Large dams may have sluiceways at various levels.
- In most cases a single large-capacity sluiceway may be structurally unsatisfactory, why?
- Sluiceways may be circular or rectangular,
- The interior should be smooth and without projections or cavities which might induce separation of flow boundary of the conduit and cause negative pressure and cavitations.



The equation for circular conduits is:

$$4x^2 + 44.4y^2 = D^2$$

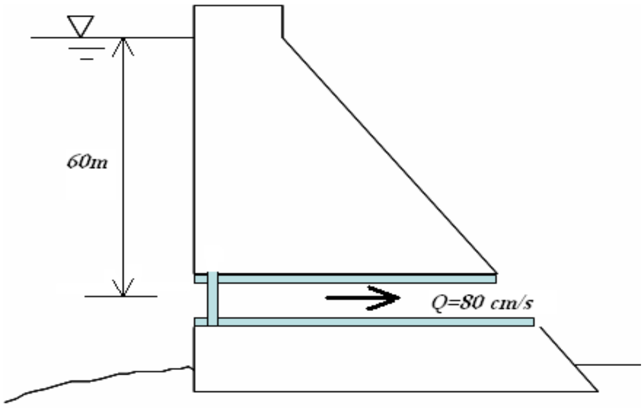
for rectangular conduits is:

$$x^2 + 10.4y^2 = D^2$$

D is the diameter of a circular conduit or the width or height of a rectangular conduit, depending on whether the side or top and bottom curves are being considered.

Example: the sluiceway for a dam discharge 80m^3/s, if the coefficient of discharge from sluiceway is 0.9, and the head above the entrance is 60m, determine the profile of the entrance if:

1. Circular conduit was used,
2. Rectangular conduit was used.



Sol:

Hydraulics of Outlet Works:

- The outlet works of a dam must be designed to discharge water at rates dictated by the purposes of the dam,
- Head losses encountered in outlet conduits include those caused by the trash rack, conduit entrance, friction, gates, valves, and bends,
- Trash rack losses are low, approximately as indicated in table,

Velocity through rack (m/s)	Head losses (m)
0.2	0.01
0.4	0.05
0.5	0.09
0.6	0.13

- Head losses at entrance to a conduit depends on the shape of the entrance and varies from $0.04h_v$ for a bell mouth entrance to $0.5h_v$ for a square-edged opining, where hv is the velocity head in the conduit just downstream from the entrance,
- Head losses caused by conduit friction may be calculated by standard pipe-friction formulas,

$$h_f = f\frac{L}{D}\frac{V^2}{2g}$$

- The discharge formula is,

$$Q = C_d A(2gh)^{0.5}$$

h=the total head at the valve.

Example: Find the discharge through a valve whose outlet diameter is 2m if the pressure just upstream of the valve is 200 kN/m^2 and Cd=0.68?