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Section	**B**
Paper	**Hydraulic Structure**

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Question#1(a)

Reservoir Definition and Efficiency

A reservoir is a man-made structure of large freshwater body of water by enclosing an area that is filled with water. The key difference between a reservoir or lake is that the former is artificial and made by humans, while latter are naturally occurring bodies of water. There are two main types of man-made reservoirs: i) impoundment; ii) and off-stream (also called off-river). Reservoirs can vary in size and be as small as a pond and as big as a large lake [1]. There is so much variability when it comes to reservoirs – they can differ in size, shape and location. the size of the reservoir is governed by the volume of the water that must be stored, which in turn is affected by the variability of the inflow available for the reservoir. A schematic overview of typical reservoir structure with all its components is presented below.

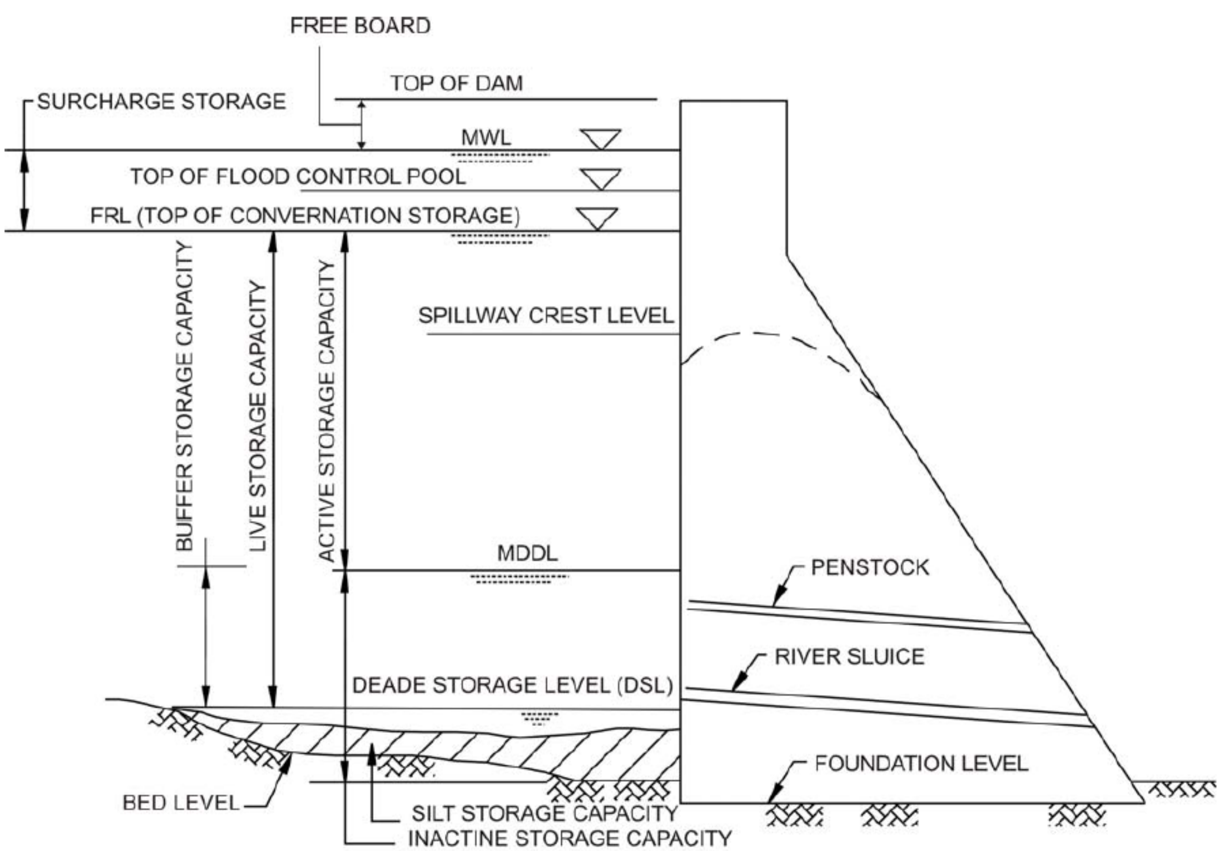


Figure: Schematic overview showing different storage zones for a reservoir

Regarding the reservoir efficiency, circular shaped reservoir makes the most efficient use of materials since it needs a minimum wall length for a given plan area. Part of the water load on the walls is taken in tension by hoop reinforcement. The forces of splashing water against the reservoir body for this reservoir type are transferred more smoothly compared to other reservoirs. As the reservoir size increases crack control becomes more difficult but this design has been used extensively for smaller and medium sized reservoirs.

Question#1(b)

An embankment dam is a large artificial dam. It is typically created by the placement and compaction of a complex semi-plastic mound of various compositions of soil, sand, clay, or rock. It has a semi-pervious waterproof natural covering for its surface and a dense, impervious core. An embankment location is parallel to direction to water flow at a safe distance unlike dam which is placed perpendicular to the flow of water. Embankment dams come in two types: i) earth-filled embankment dam; ii) rock-filled embankment dam.

Rock-filled embankment dams are usually preferred in hilly or mountainous terrain due to their efficiency because the following facts:

a) Large quantities of rock are readily available or excavated in connection with the project.
b) Earth-fill materials or concrete aggregates (for earth dams) are difficult to obtain or require extensive processing in hilly areas.
c) Short construction seasons favor the construction of rock fill dams in such area.
d) These dams provide flexibility to be raised at a later date.
e) The prevailing wet and cold weather conditions in hilly area permits continuous work rock filling that would not permit typica earth or concrete construction.

Other factors that may make use of a rockfill dam advantageous are the ability to place rockfill throughout the winter in cold regions, the possibility of grouting the foundation while simultaneously placing the embankment, and a high degree of seismic stability. In addition, uplift pressures and seepage through the rockfill material do not generally present significant design or operational problems

Question#2

A spillway is a structure used to provide the controlled release of flows from a dam or levee into a downstream area, typically the riverbed of the dammed river itself. In the United Kingdom, they may be known as overflow channels. Spillways ensure that the water does not overflow and damage or destroy the dam. Important parameters considered in design of spillway are:

a) The inflow design flood hydrograph
b) The type of spillway to be provided and its capacity
c) The hydraulic and structural design of various spillway components.
d) The energy dissipation consideration downstream of the spillway.

The topography, hydrology, hydraulics, geology and economic considerations all have significant influence on all these decisions.

There are 9 different types of Spill-ways based on the pertinent feature. These are described in detail below:

A. Free Overfall Spill way

A free overfall spillway (or a straight drop spillway) is a type of spill way in which flow drops straight or freely from crest into the stream bed, sometimes scours occur & thus there is a possibility of formation of a pool. This type of Spillway is suitable for Arch dam.

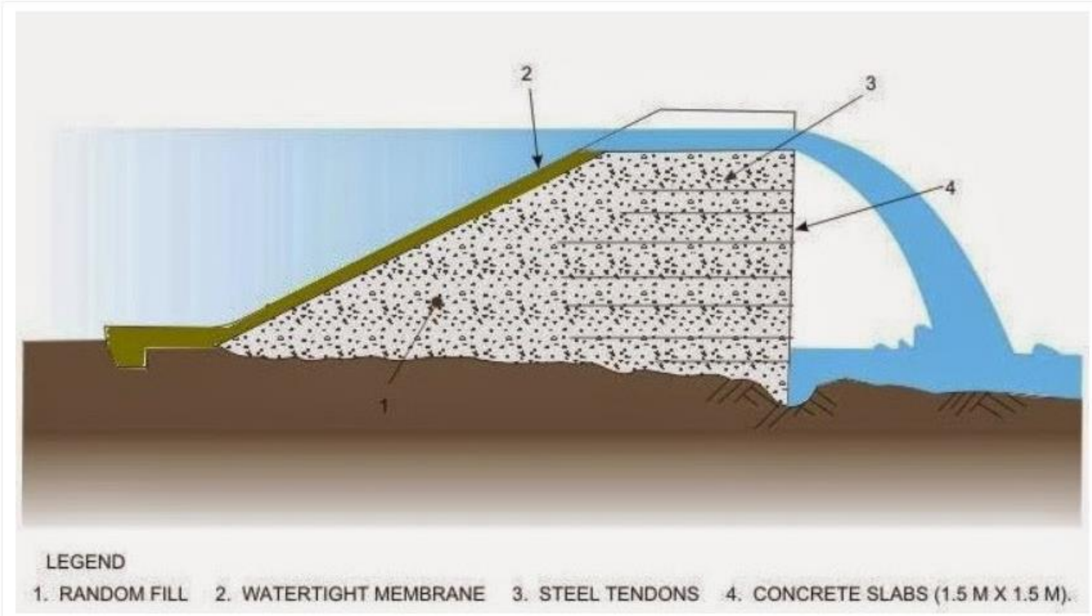


Figure: Free Overfall Spillway

B. Ogee-shaped Spillway:

An Ogee-shaped (or Overflow) Spill way is the most commonly used spillway. It is widely used with gravity dams, arch dams & buttress dams. Several Earth & Rock fill dams are also provided with this type of spillway as a superstructure. An Ogee-shaped Spillway has a control weir of ogee-shaped, which is like the elongated English letter "S". The upper part of the spillway surface matches closely to the profile of the lower nappe of a ventilated sheet of water falling freely from a sharp-crested weir. A typical Ogee spillway is shown below:

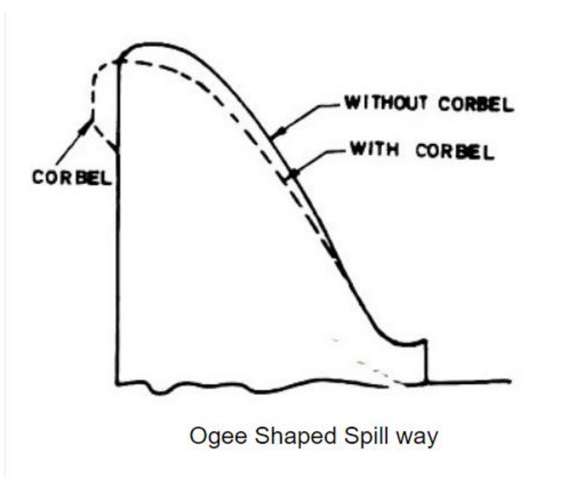


Figure: Schematic for Ogee Spillway

C. Chute Spillway :

A Chute Spillway (or Open Channel Spill way) consist of a open channel , through which the water discharge. For earth dams and rock fill dams a separate spill way is generally constructed in a flank for saddle away from the dam if suitable site exists.

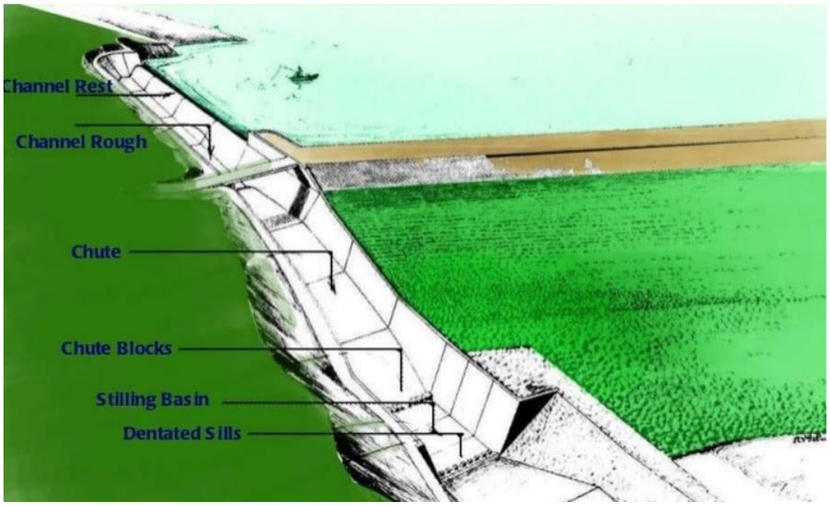


Figure: Chute Spillway

D. Side Channel Spill-way:

In a side channel spill-way, the control weir is placed approximately parallel to the upstream portion of the spill-way discharge. Thus the flow after passing over the crest is carried in a discharge channel running parallel to the crest. The spillway discharge flows over the weir crest and falls into a narrow trough.

Figure: Side Channel Spillway

E. Shaft Spillway:

A Shaft Spill way consist of a horizontal crest & vertical shaft, with its top surface at the crest level of the spillway and its lower end connected to a vertical shaft. The other end of the vertical shaft is connected to a horizontal conduit or tunnel, which extends through or around the dam and carries the water to the river downstream. A shaft spillway is used at the sites where the conditions are not favorable for an overflow or a chute spill-way.

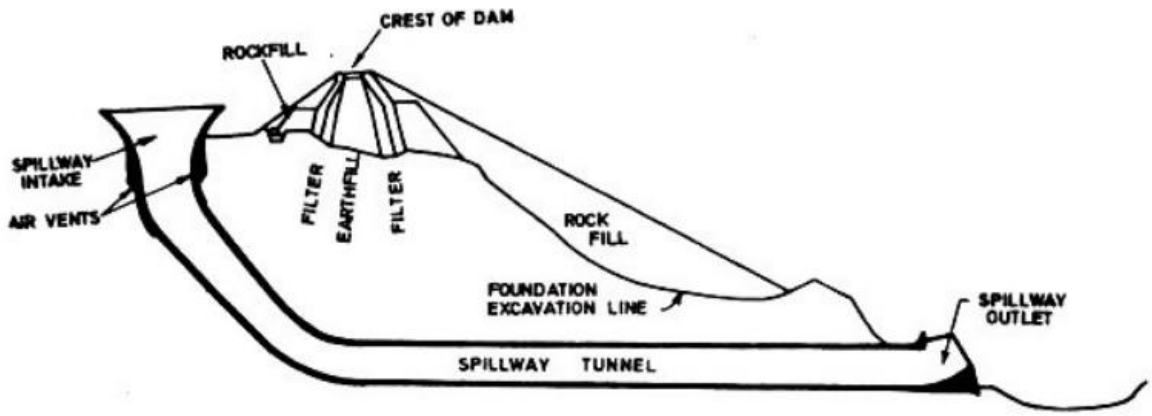


Figure: Shaft Spillway

F. Siphon Spillway:

A Siphon spillway operates on the principle of siphonic action. It is a closed conduit of the shape of an inverted U-tube with unequal legs. It is commonly used in practice. The siphon duct is formed by an air tight RCC cover, called hood over an oggy-shaped body wall made of concrete. The top of the body wall forms the crest of the spill-way and kept at the F.R.L. of the reservoir.

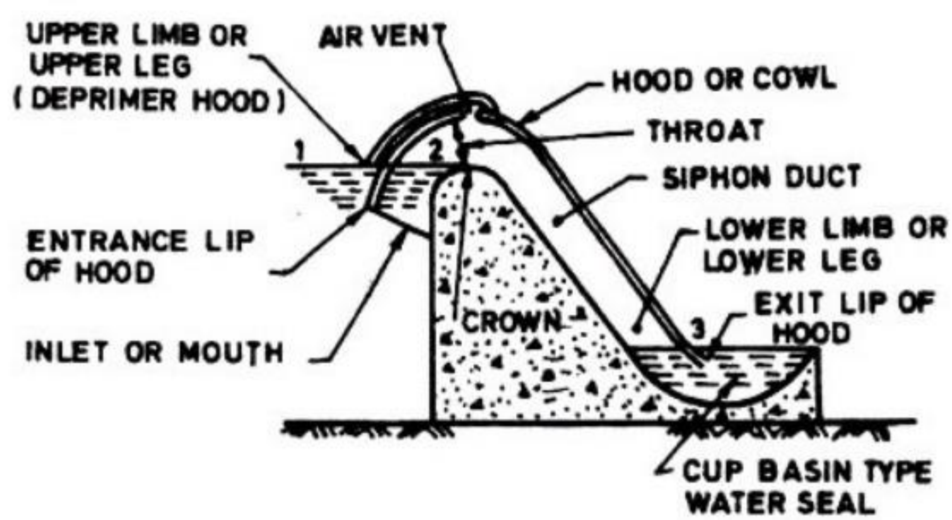


Figure: Siphon Spillway

G. Conduit Spillway:

A conduit Spill-way consist of a closed conduit to carry the flood discharge to the downstream channel . It is constructed in the abutment or under the dam . The closed conduit may take the form of a vertical or inclined shaft, a horizontal tunnel, or a conduit constructed in an open cut and then covered. Such a spill-way is suitable for dam sites in narrow canyons with steep abutments.

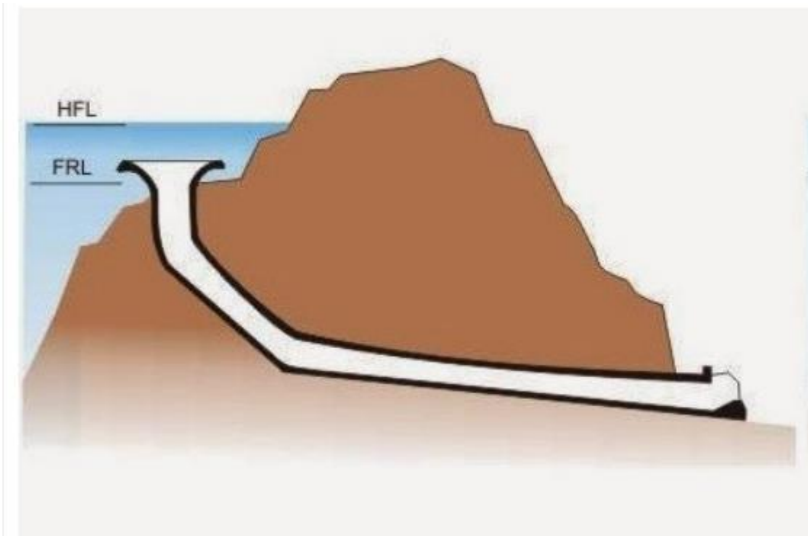


Figure: Conduit Spillway

H. Culvert Spillway:

A culvert spill-way is a special type of conduit or tunnel way in which the inlet is horizontal. Moreover, the profile grade of a culvert type is uniform. It should not be used for drops exceeding 8, because negative pressure may develop along its boundary when it is placed on steep slopes and it runs full.

Consideration of ice impact forces on spillway gates is important during winter and freezing temperature especially below -10^{o}C on operation of a spillway. Large ice pieces from a reservoir or forebay impacting a partially open gate or ice buffeting from return currents and eddies on the downstream gate face may cause significant damage. Chute and Side channel freeway are preferred for extreme winter condition because of their flexibility to avoid formation of ice blocks on spillway surface and easy operations of ice removal during such events.

Assume data

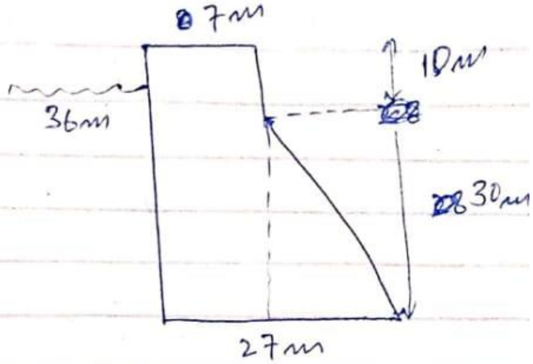
Length = 60 m

$\gamma_m = 2.5 \, KN/m^3$

$\gamma_w = 1 \, KN/m^3$

$h_v = 1.6 \, m$

$\gamma_s = 9 \, KN/m^3$



Sol

Hydrostatic water pressure

$P_H = 0.5 \times \gamma \times h^2$

$= 0.5 \times 1 \times (36)^2$

$P_H =$

Self weight

$W = \gamma_m \times V_{dam}$

$W = 2.5 \times 34800$

$W = 87000 \, KN$

vol of rectangle

$= 7 \times 40 \times 60$

$= 16800 \, m^3$

vol of Triangle

$= \frac{1}{2} bh \times l$

$= \frac{1}{2} \times 20 \times 30 \times 60$

$= 18000 \, m^3$

Total vol = Rect + Triangle

$= 16800 + 18000$

$= 34800 \, m^3$

Uplift

$= \frac{1}{2} \gamma_w h B$

$= \frac{1}{2} \times 1 \times (36)(27)$

Uplift $= 486 \, KN/m$

Silt load

$$P_s = \frac{\gamma_s h^2}{2} \times \frac{1 - \sin\theta}{1 + \sin\theta}$$

$\because \theta = 15^\circ$

Assume $h = 3m$

$$P_s = \frac{9 \times (3)^2}{2} \times \frac{1 - \sin(15)}{1 + \sin(15)}$$

$$\boxed{P_s = 23.84 \ KN/m}$$

Wave

$$P_{wave} = 2.4 \times \gamma_w \times h_{wave}^2$$

$$= 2.4 \times 1 \times (1.6)^2$$

$$\boxed{P_{wave} = 6.144 \ KN/m}$$

$P_{earthquake\ concrete} = \alpha W$ $\because \alpha = 0.2$

$$= 0.2 \times 87000$$

$$\boxed{P_{e\text{-}quake\ on\ concrete} = 17400 \ KN}$$

$$P_{earthquake\ on\ water} = \frac{2}{3} C_e \times h^2$$

$$= \frac{2}{3}(0.63) \times 0.2 \times (36)^2$$

$$= 163.29 \ KN$$