Section-D

Unit-V (Spillway and Energy Dissipations)

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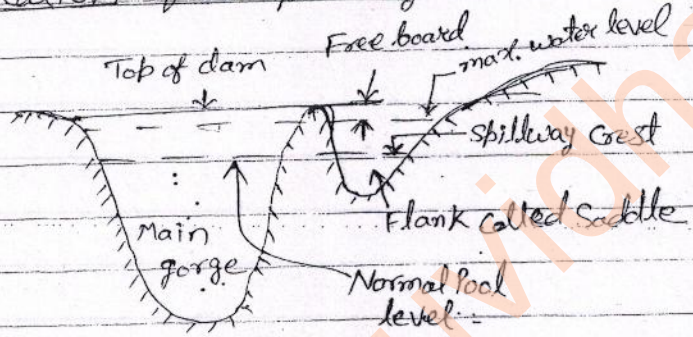
A spillway is a structure constructed at a dam site, for effectively disposal of the surplus water from U/s to d/s.
Spillway is essentially a safety valve for a dam.

Location of a spillway:→



A spillway can be located either within the body of the dam, or at one end of it or entirely away from it, independently in a saddle. If a deep narrow gorge with steep banks, separated from a flank by a hillock with its level above the top of the dam, is available, the spillway can be best built independtly of the dam.
Under such circustances, a concrete or an earthen dam can be constructed across the main valley and a spillway can be constructed independently into the saddle.
Sometimes, a concrete or a masonry dam along with its spillway can be constructed in the main valley, while the flank or flanks are closed by earthen dikes or embankments. The top level of such an embankment is kept at maximum reservoir level.

The materials and designs of these embankments are such that they fail as soon as water overtops them. The secondary safety arrangement is generally provided on large dams especially on earth and rockfill dams, and is known as ~~secondary~~ subsidiary spillway or Emergency spillway or Breaching Section.

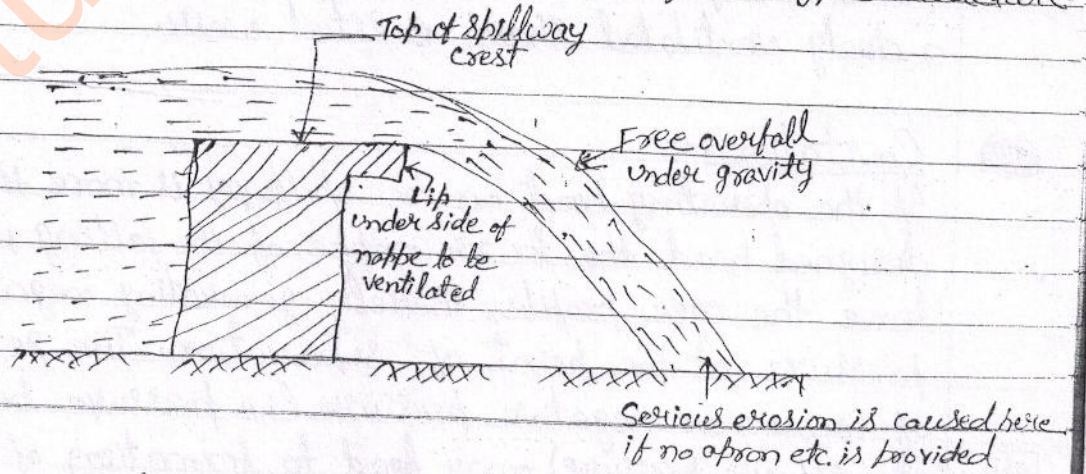
Various types of Spillways:→ Pg. - 842

Depending upon the types of the structure constructed for disposing of the surplus water, the spillways can be of the following major types:

(1) Straight Drop spillway or Overfall Spillway
(2) Overflow Spillway or Ogee Spillway
(3) Chute Spillway or Trough Spillway or open channel Spill.
(4) Side channel Spillway
(5) Shaft Spillway
(6) Syphon Spillway

(1) Straight Drop Spillway or Overfall Spillway

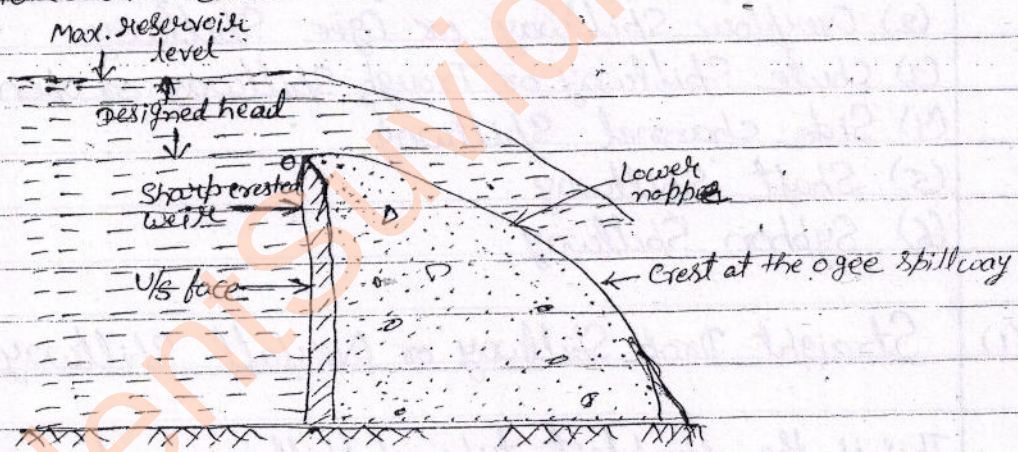
This is the simplest type of spillway and may be constructed on small bunds or on thin arch dams etc. It is a low weir and simple vertical fall type structure.



The d/s face of the structure may be kept vertical or slightly inclined. The water falls freely from the crest under the action of gravity.

(2) Ogee Spillway or Overflow Spillway

Ogee spillway is an improvement upon the free overfall spillway, and is widely used with concrete, masonry, arch and buttress dams. Such a spillway can be easily used on valleys where the width of the river is sufficient to provide the required crest length and the river bed below can be protected from scour at moderate costs.



The profile of this spillway is made in accordance with the shape of the lower nappe of a free falling jet, over a duely ventilated sharp crested weir.

(3) Cavitation:→

If the operating head on the spillway is more than the designed head, the lower nappe of the falling jet may leave the ogee profile, thereby generating negative pressure at the point of separation. The generation of vacuum or negative pressure (i.e. pressure below the atmospheric pressure) may lead to formation of bubbles

or cavities in the water. These cavities or bubbles filled with air, vapour and other gases are formed in a liquid, whenever the absolute pressures of the liquid is close to its vapour pressure, so as to commence evaporation.

Designing the Crest of the Ogee Spillway:-
Theoretically, the adoption of a profile called Bazin's profile, should cause no negative pressures on the crest under designed head. But, in practice, there exists a lot of friction due to roughness on the surface of the spillway. Hence, negative pressure on such a profile seems inevitable. The presence of negative pressure causes the danger of cavitation and sometimes fluctuations of the nappe. Hence, while adopting a profile for the spillway crest, the avoidance of negative pressure must be an objective along with consideration of other factors.
Several standard ogee shapes have been developed by U.S. Army Corps of Engineers at their Waterways Experimental Station (WES). Such shapes are known as 'WES Standard Spillway Shapes. The d/s profile can be represented by the equation

$$x^n = K \cdot H_d^{n-1} \cdot y$$

H_d = design head including velocity head

(8) Chute Spillway or the Trough Spillway:→
Ans→ The trough spillway is the simplest type of spillway which can be easily provided independently and at low costs. It is higher lighter and adaptable to any type of foundations, and hence provided easily on earth and rockfill dams. A chute spillway is

Sometimes known as a waste weir. If it is constructed in continuation to the dam at on end, it may be called as a flank weir. If it is constructed in a natural saddle in a bank of the river separated from the main dam by a high ridge, it is called a saddle weir.
It essentially consists of a steeply sloping a dam abutment or through a flank or a saddle. It leads the water from the reservoir to the d/s channel below. The base for the channel is usually made of reinforced concrete slab, 25 to 50 cm thick.

(4) Side Channel Spillway:→
It differs from the chute spillway in the sense that while in a chute spillway, the water flows at right angles to the weir crest after spilling over it, whereas in a side channel spillway the flow of water after spilling over the crest, is turned by 90° such that it flows parallel to the weir crest (AB).
This type of spillway is provided in narrow valleys where no side flanks of sufficient width to accomodate a chute spillway are available.

(5) Shaft Spillway:→
In a shaft spillway, the water from the reservoir enters into a vertical shaft which conveys this water into a horizontal tunnel which finally discharges the water into the river d/s. For small heights, the shafts may be constructed entirely of metal or concrete, or clay tiles. But for larger heights, reinforced cement concrete may be used.

For smaller heights, no special inlet design is necessary, but on large projects, a flared inlet called morning glory is often used.

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(6) Syphon Spillway :⇒ or Saddle Syphon Spillway It essentially consists of a siphon pipe, one end of which is kept on the u/s side and is in contact with the reservoir, while the other end discharges water on the d/s side.

(a) Tilted outlet Type of a Syphon Spillway when the valley is very narrow and no space is available for constructing a separate spillway, the syphon pipes can be installed within the dam body. An air vent may be kept at normal pool level, while the entry point of the syphon pipe may be kept still lower, so as to prevent the entry of debris, etc in the siphon. The outlet of the siphon may be submerged so as to prevent the entry of the air in the siphon from its d/s end.

(b) Hooded Type of a Syphon Spillway popularly called a Saddle Syphon Spillway or Sphon Spillway :- The construction such a saddle Syphon spillway is more commonly adopted. In this case, a reinforced concrete hood is constructed over an ordinary overflow section of a gravity dam. The inlet and the mouth of this hood, is kept submerged in water, so as to prevent the entry of debris, ice, etc. A small depriming hood is kept above the main hood and both these hoods are connected by an air vent.

uses and

Advantages :→ Pg. -883

(1) Its operation is automatic without any mechanical device.

(2) Discharge occurs at much larger head than in a normal spillway.

(3) Used where large capacities are not required, where space is limited, and where fluctuations of reservoir level have to be maintained within close limits.

Disadvantages and Limitations :→

(1) Construction is expensive, and capacity is limited

(2) It causes sudden apperance of flood water d/s

(3) Large flood debris can sometimes block as to outlet

(4) As the siphon is primed, the flow would result excessive vibrations in the dam body.

(5) There will is a possibility of cavitation for negative pressuries.

(6) Repair and maintenance of siphon spillways are difficult

Energy Dissipators Pg :- 887

(1) Below Overflow Spillway :→

The water flowing over the spillway acquires a lot of kinetic energy by the time it reaches near the toe of the spillway. If arrangements are not made to dissipate this huge kinetic energy of water, and if the velocity of water is not reduced, large scale scour can take place on the d/s side near the toe of the dam and away from it. These arrangements are known as energy dissipation

arrangements or energy dissipators.
In general, the kinetic energy of this super-critical flow can be dissipated in two ways:-
(i) By converting the super critical flow into sub-critical flow by hydraulic jump.
(ii) By directing the flow of water into air and then making it fall away from the toe of the structure.

* Standard Stilling Basins:->
These basins are not simple concrete aprons but are generally provided with auxilliary devices such as chute blocks, sills, baffles walls etc.. These devices can help in dissipating the energy of flow by offering resistance to flow and may stabilise the flow in a shorter length of the basin, thus affecting economy.
• In general, a stilling basin may be defined, as a structure in which the energy dissipating action is confined. If the phenomenon of hydraulic jump is basically used for dissipating this energy, it may be called a hydraulic jump type of stilling basin.

U.S.B.R Basins:-
They have different basins. And the important of these basins are:-
(i) U.S.B.R. Stilling basin II:-
This is recommended for use on large structures, such as dam spillways, large canal structures etc, when the incoming Froude number (F_1) is more than 4.5.

F_1	Length of the basin (L)
4	$3.6y_2$
6	$4y_2$
8	$4.2y_2$
10 and more	$4.3y_2$

(2) U.S.B.R Stilling basin IV :→

It is used for Froude number varying between 2.5 and 4.5, which generally occures in canal weirs, canal falls, diversion dams, etc. This basin is applicable only to rectangular cross-section.