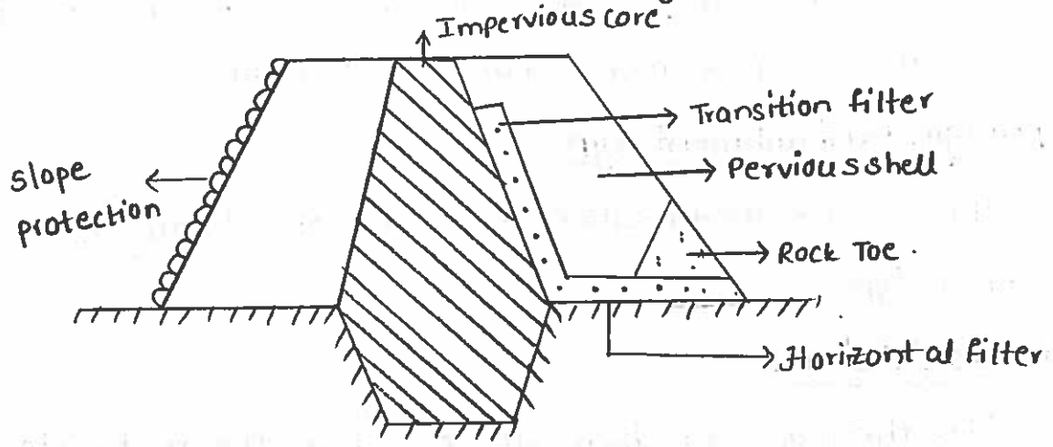
Text book Ref: Santhosh Kumar Garg.

UNIT - 3

Earth dams (or) Earthen dams (or) Embankment dams

Def:

It is the most common type of dams, which is generally built with locally available materials [such as soils & gravels]. They are of trapezoidal shape with lighter structure.



Types

Depending upon the method of construction, earth dams can be divided into two categories:-

i. Rolled fill dam

ii. Hydraulic fill dam.

→ Again Rolled-fill earth dams can be sub-divided into:

a. Homogeneous embankment type.

b. Zoned embankment type.

c. Diaphragm embankment type.

i. Rolled fill dam

→ The embankment is constructed in successive, mechanically

compacted layers.

→ The following are the various types :-

a. Homogeneous Embankment type

Homogeneous embankment type earth dam is the one in which the dam is made up of single kind (or) one material.

b. Zoned embankment type :

Zoned embankment type earth dam is the one in which the dam is made up of more than one material.

C. Diaphragm Embankment type

This is the modification dam over the homogeneous embankment type.

ii. Hydraulic fill dam :

In the case of hydraulic fill dam, the materials are excavated, transported & placed by hydraulic methods.

Advantages / Merits :

→ Earthdam is constructed on any type of foundations.

→ It is constructed with locally available material.

→ It is most commonly used dam.

→ They are in expensive, compared with other dams.

→ The construction of earth dams can be done even with unskilled labour.

Disadvantages / Demerits / Limitations :-

→ The risk of damage by floods is more.

→ The failure can occur without sufficient warning.

→ Heavy maintenance cost is required.

→ These dams can't be used as overflow dams.

Causes of failure of Earth dams :-

On the basis of investigation reports on most of the past failures, it has now been possible to categories the types of failures into three main classes :-

1. Hydraulic failures : 40%.
2. seepage failures : 30%.
3. Structural failures : 30%.

100%.

1. Hydraulic Failures :

→ This type of failure occurs on the earth dam is 40%.

→ Hydraulic failures includes the following:

a. Over topping

b. Wave erosion

c. Toe Erosion

d. Gullying

2. Seepage failures :

→ This type of failures occurs on the earth dam is 30%.

→ seepage failures may be due to :-

a. piping

b. sloughing.

3. Structural failures

→ This type of failures occurs on the earth dam is 30%.

Structural failures may be due to the following reasons:

a. Failure by spreading

b. Failure due to Earth quake

c. Failure due to damage caused by burrowing anomals.

d. Slope protection failures.

e. Damage caused by water soluble materials.

f. upstream slope failure.

g. Downstream slope failure.

Precautions (or) Preventive measures to be taken for avoid such type of failures

Hydraulic failures

→ sufficient free board should be provided.

→ Providing suitable terms can effictively prevent erosion of downstream face.

Seepage Failures

→ sufficient measures should be adopted to control seepage through body of dam & foundation.

→ Compacting the soils thoroughly at the outlet conduits prevents piping through the dam.

→ Controlling of cracks & leakage at the conduits prevents failures due to piping.

Structural Failures

→ The dam should be constructed as an earthquake resistant structure.

→ Downstream slope must be protected from erosion due to wind & rain.

→ Upstream slope should be safe against erosion by waves.

Criteria for safe Design of Earth Dam:

The practical criteria for the design of earth dams may be stated briefly as follows:-

i. The embankment must be safe against overtopping during occurence of the inflow design flood by the provision of sufficient spillway & outlet works capacity.

ii. The dam must have sufficient free board so that it is not overtopping by wave action.

iii. The seepage line should be well within the d/s face so that no sloughing of the slope takes place.

iv. Seepage flow through the embankment, foundation & abutments must be controlled by suitable design.

v. The dam should be earthquake resistance.

vi. The u/s & d/s slopes of dam should be flat.

vii. The u/s slope must be protected against erosion by wave action.

vii. There should be no free passage of water u/s to d/s.

viii. The u/s & d/s slopes of dam should be flat.

x. The d/s slope must be protected against erosion due to wind & rain.

Seepage Analysis

→ The following assumptions must be kept in the mind :-

1. The rolled embankment & the natural soil foundation of the earth dam are in compressible porous media.
2. The seeping water flows under a hydraulic gradient which is due to only to gravity head loss (or) Darcy's law is valid.
3. There is no change in the degree of saturation in the zone of soil.
4. The hydraulic boundary conditions at entry & exit are known.
5. Water is incompressible.

Seepage Control Measures

→ The following devices are used for seepage control through earth dam :-

a. Embankment seepage control :-

i. Toe filter.

ii. Horizontal drainage filter.

iii. Protective filter d/s of the toe.

iv. D/s coarse section (or) embankment zoning.

v. Chimney drain extending upward into embankments.

b. Foundation seepage control

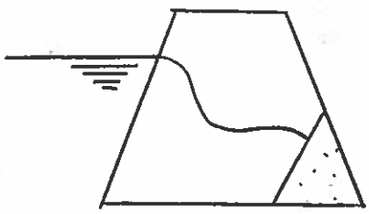
vi. Impervious cutoff.

vii. u/s impervious blanket.

viii. D/s seepage berms.

ix. Drainage trenches

x. Relief wells.



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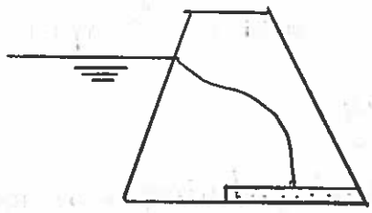

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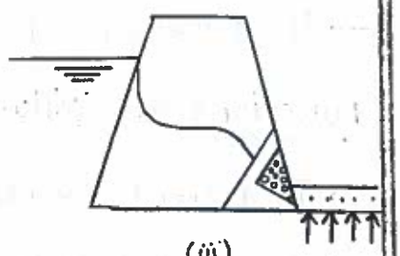

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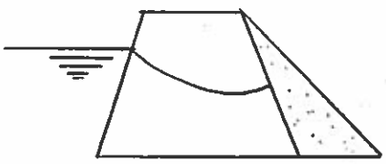

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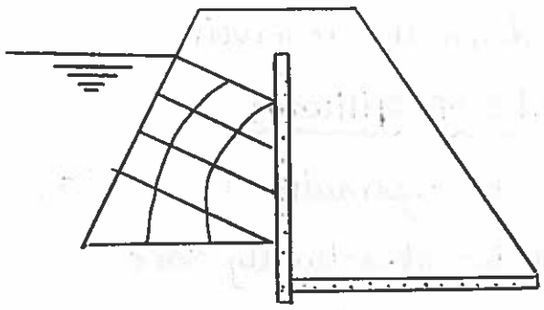

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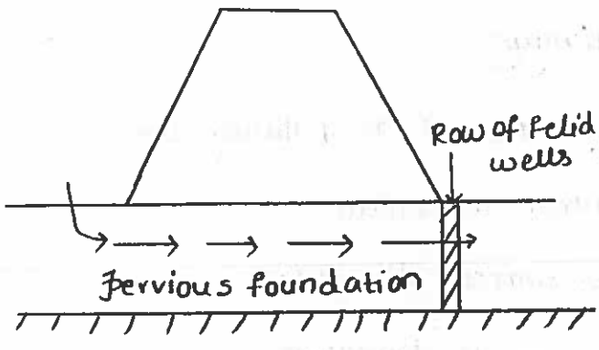


(x)

Spill ways

Def:

Spillway is a structure which is constructed along the dams (or) reservoirs used to provide controlled release of flow from dam in to downstream area.

→ A spillway is also called as "surplussing work"

Functions of spillway

→ To prevent overtopping during a design flood.

→ To prevent failure to close the gates.

→ To drawdown the reservoir.

Requirements of spillways

→ It must be hydraulic

→ It must be structurally safe.

→ The capacity of discharge must be adequate.

Components of spillways

→ The main components of a spillway are:-

a. Control structure.

b. Conveyance structure.

c. Terminal structure.

d. Entrance & exit channels

Factors which affect the spillway capacity

a. Inflow flood hydrograph.

b. Available storage capacity.

c. Capacity of outlet.

d. Gates of spillway.

e. possible damages.

Applications of spillway:

→ It is provided for both dams & reservoir.

→ It is used to control floods.

→ It is used to store water.

Types of spillways

→ Based on their utility, spillways can be of two types:-

i. Main spillway.

ii. Subsidiary (or) Emergency spillway.

→ Based on their most prominent features, the following are main types of spillways:-

a. Free overfall (or) straight drop spillway.

b. Ogee (or) overflow spillway.

c. side channel spillway.

d. Chute (or) open (or) trough spillway.

e. conduit (or) tunnel spillway.

f. Siphon spillway.

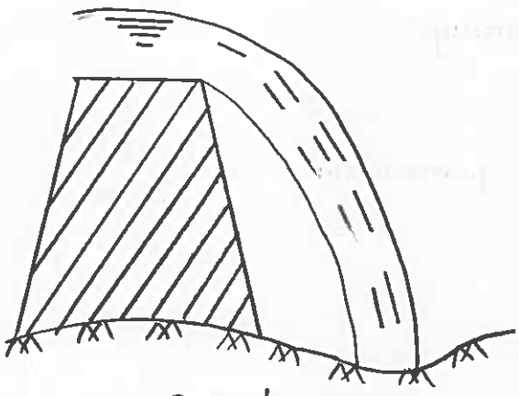
g. Drop inlet (or) shaft (or) morning glory spillway.

a. Straight Drop Spillway:-

→ This is a simplest type of spillway.

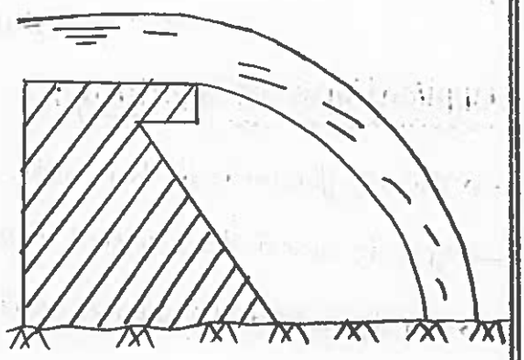
→ It is constructed in the form of a low height weir having down stream face either vertical (or) nearly vertical.

→ This type of spillway is not recommended for high heads.

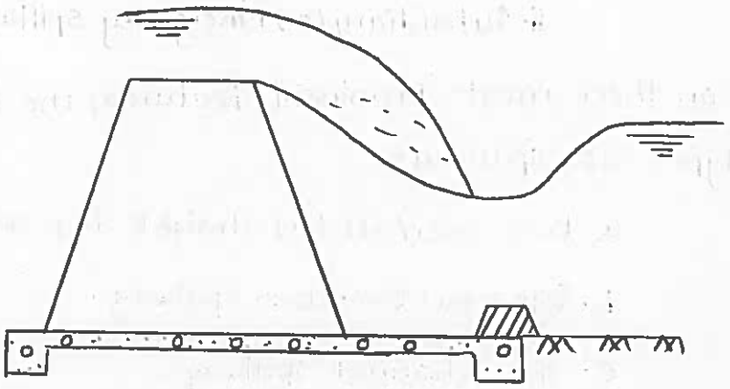


Sound rock

a. Spillway without D/s protection.



b. spillway with over hanging lip.



c. Spillway with D/s protection.

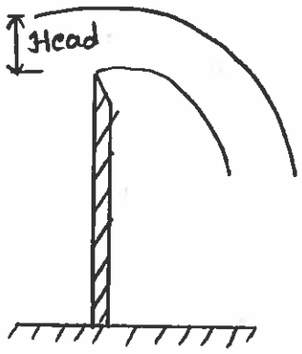
b. Ogee (or) overflow spillway:

→ Ogee spillway is also called as "over flow spillway".

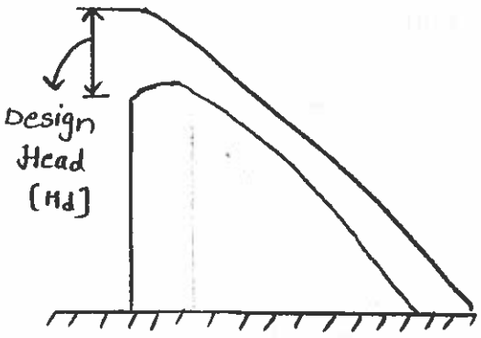
→ This is the most common type of spillway provided on the gravity dams.

→ The profile of the spillway is ogee (or) 's' shaped.

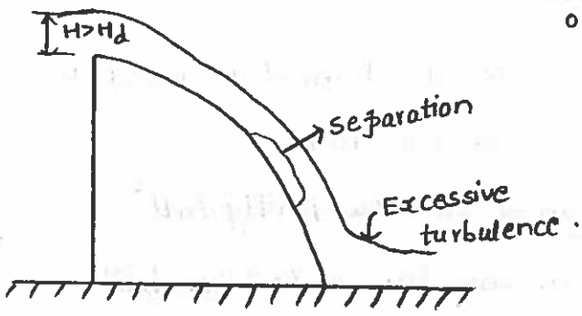
→ Hence, the upper profile of the ogee is made to conform with the lower nappe of a freely falling jet of water.



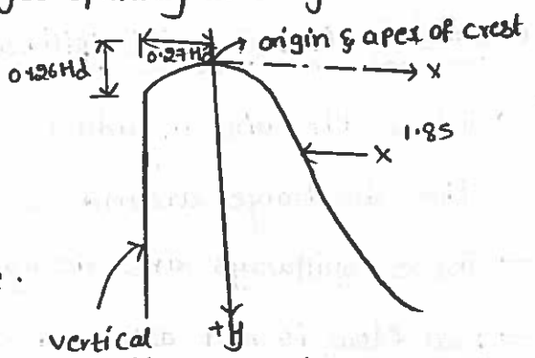
a. Sharp crested weir



b. ogee spillway at design flow



c. ogee spillway with greater flow



d. Elements of nappe-shaped crest profile.

C. side channel spillway:

→ It is the one in which the flow, after passing over a weir (or) agee crest.

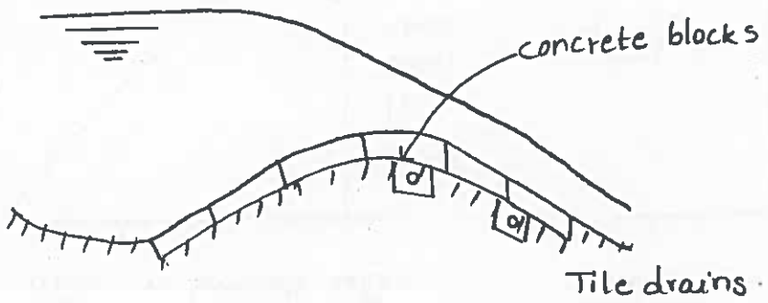
→ Its discharge characteristics is similar to overflow spillway.

→ However, the flow of this spillway may differ from overflow spillway.

→ This type of spillway is also desirable where the spillway discharge is to be connected to narrow discharge channel.

d. Chute (or) Trough spillway:

It is the one which passes the surplus discharge through a steep sloped open channel, called a chute (or) Hough spillway.



e. conduit (or) Tunnel spillway:-

→ It is the one in which a closed channel is used to convey the discharge around (or) under a dam.

→ These spillways are designed to flow partly full.

→ Full flow is not allowed in the tunnel (or) conduit.

f. shaft (or) drop inlet (or) morning glory spillway:-

→ A shaft spillway normally consists of three elements:

i. Overflow control weir

ii. vertical control

iii. closed discharge channel.

g. Siphon spillways:-

→ There are generally two types.

i. Saddle siphon spillway.

ii. volute siphon spillway

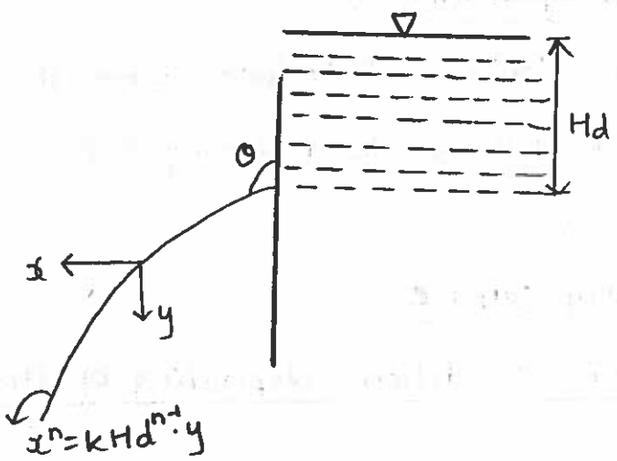
Priming devices of siphon spillway

1. Provision of cup type basin.
2. Provision of tilted outlet
3. Provision of auxiliary (or) baby siphon.
4. Provision of steps.
5. Provision of priming weir.

Design principles of Ogee spillway:-

The most generally recommended profile of an ogee spill-way is the one which offers maximum hydraulic efficiency, structural stability & economy. It must be able to reduce the formulation of objectionable sub-atmospheric pressure at the surface. A desirable ogee profile is designed as follows.

i. Down stream profile of an ogee spillway:



→ The downstream profile of an ogee spillway is represented with khosla's formula:-

$$x^n = kH \cdot d^{n-1} \cdot y$$

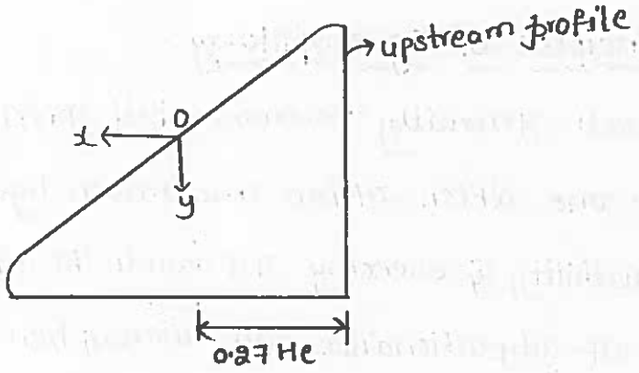
where,

$x, y \rightarrow$ Coordinates of the points.

$H_d \rightarrow$ Design head.

$k, n \rightarrow$ Constants which depends on the inclination of upstream side of spillway.

ii. upstream profile of an ogee spillway:



$$y = \frac{0.724[x+0.27H_e]^{1.85}}{H_e^{0.85}} + 0.126H_e - 0.4315H_e^{0.375}[x+0.27H_e]^{0.625}.$$

iii. Offsets & Risers on upstream

The constructional cost reduces when the offsets & risers are provided on spillways be removing a portion of concrete on u/s section.

iv. pressure over spillway surface

The pressure conditions depending on the design head are given below:-

a. The pressure on crest is positive if the actual head is less than the design head.

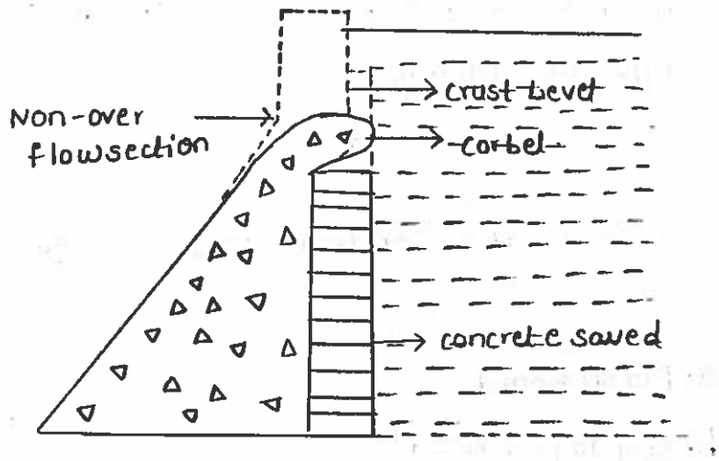
b. The pressure on crest is negative if the actual head is

is more than the design head.

v. Orifice flow:

This flow occurs at the openings of past gate in the gated spillways. If the crest profile is steeper than one, then a sub-atmospheric pressure is originated at crest immediately below the gate.

vi. Corbel



vii. Discharge in an ogee spillway:

$$Q = C_d L_e H_e^{3/2}$$

where,

$Q \rightarrow$ Discharge in cumecs

$C_d \rightarrow$ coefficient of discharge.

$L_e \rightarrow$ Effective Length.

$H_e \rightarrow$ Effective head.

Spill Way Gates (or) Spill way Crest Gates

Def:

Spillway Gates are also called as "Stop Gates" (or) "Spill way Crest gates" are adjustable gates which are used to control water flow in reservoir, river, Streams etc.

→ They also acts as barrier for the storage of additional water.

→ Gates can be provided to all types of spillways, expect Siphon spillway, because the raise in flood level is already small compar-ed to the other types of spillways.

Types

→ The following are some of the common types of gates used for spillways:-

a. Flash boards
b. Stop logs & needles.
c. Radial gates (or) Tainter gates.
d. Drum gates
e. Vertical lift gates
f. Bear trap gates.
g. Rolling gates

a. Flash Boards

→ These are the temporary gates, used only for small spillway of minor importance.

→ They consists of wooden panels supported by pins on the

edges

→ It may be either baced (or) hinged (or) automatic.

→ The flash boards are two types:-

i. Temporary

ii. Permanent

→ These are very simple.

→ These are made up of wood (or) panel.

b. Stop logs & Needles

Stop logs

→ It is made up of wood timber logs.

→ They consist of horizontal timber planks spanning across piers having grooves.

→ These are placed horizontally to spillways.

Needles

→ It consist of wooden planks.

→ These are placed inclined position to spillways.

→ It is made up of wooden logs.

c. Radial gates

→ It is also called as "Tainter gates"

→ It is made up of steel plates.

→ The gates can be lifted by means of ropes & chains.

d. Drum Gates

→ It is normally used for long span.

→ It is hinged at the centre of curvature.

→ It is enclosed on all the three faces & at ends to form a water-tight vessel.

e. vertical lift gates

→ It consists of a frame work of skin plate at the u/s face

→ It is rectangular in shape.

→ There are several types of vertical lift gates

i. sliding gates

ii. Fixed wheel gates.

iii. Stoney gates.

f. Bear Trap Gates

→ It consist of two leaves of either timber (or) steel hinged to the dam.

→ These gates are often used for low navigation dams.

g. Rolling Gates

→ It consists of steel cylinder.

→ The gates is rolled up the inclined rock by means of pull from the hoisting cable operations from the hoist room.

Energy Dissipaters

Def:

The water flowing over the spillways acquires a lot of kinetic energy by the time it reaches near the toe of spillway.

→ To dissipate this huge kinetic energy of water & reduce large scale of scouring the structural arrangement is made is called as "Energy Dissipaters".

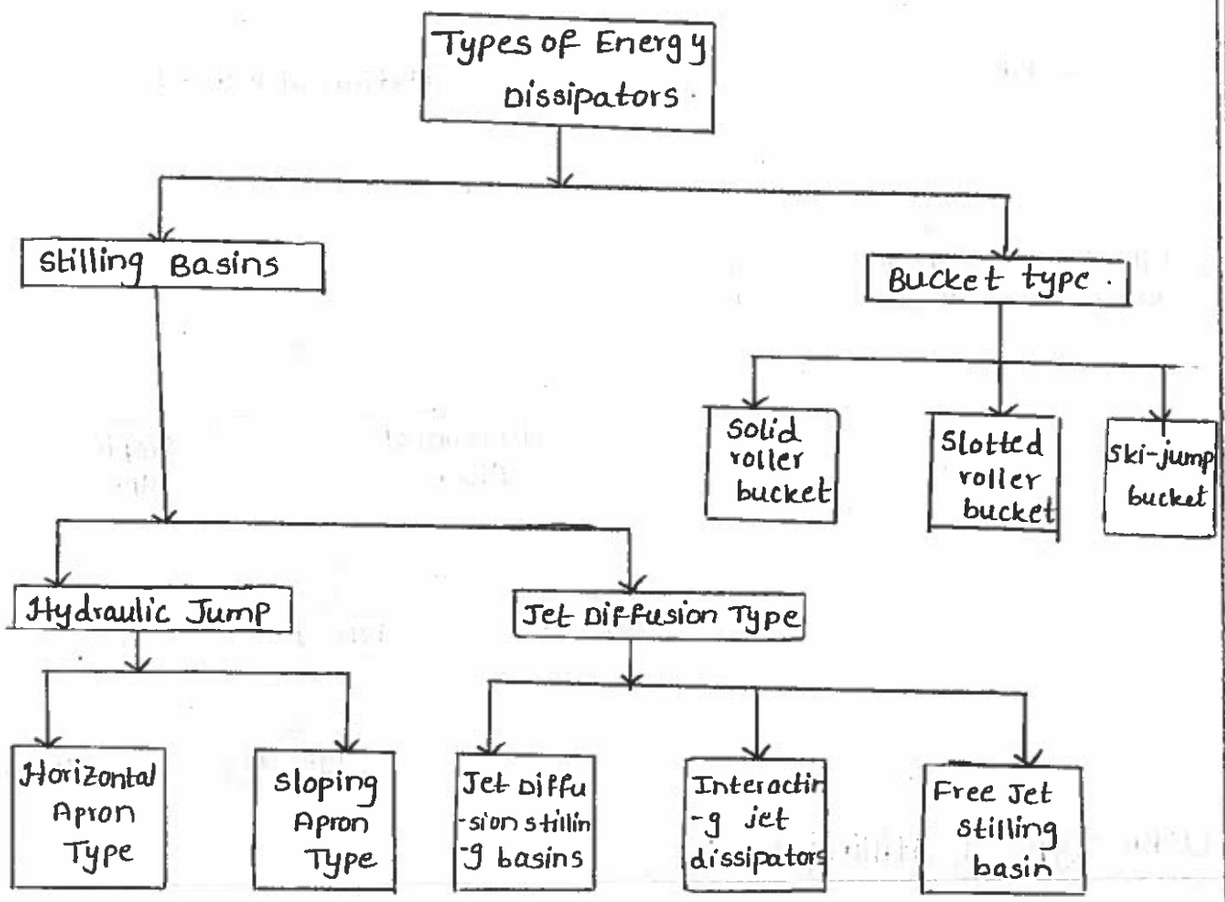
→ Energy dissipator is a device.

Types

→ Types of energy dissipators are of two types:-

a. Stilling Basins.

b. Bucket type.



Stilling Basins

Def:

The device which is used for energy dissipation fully (or)

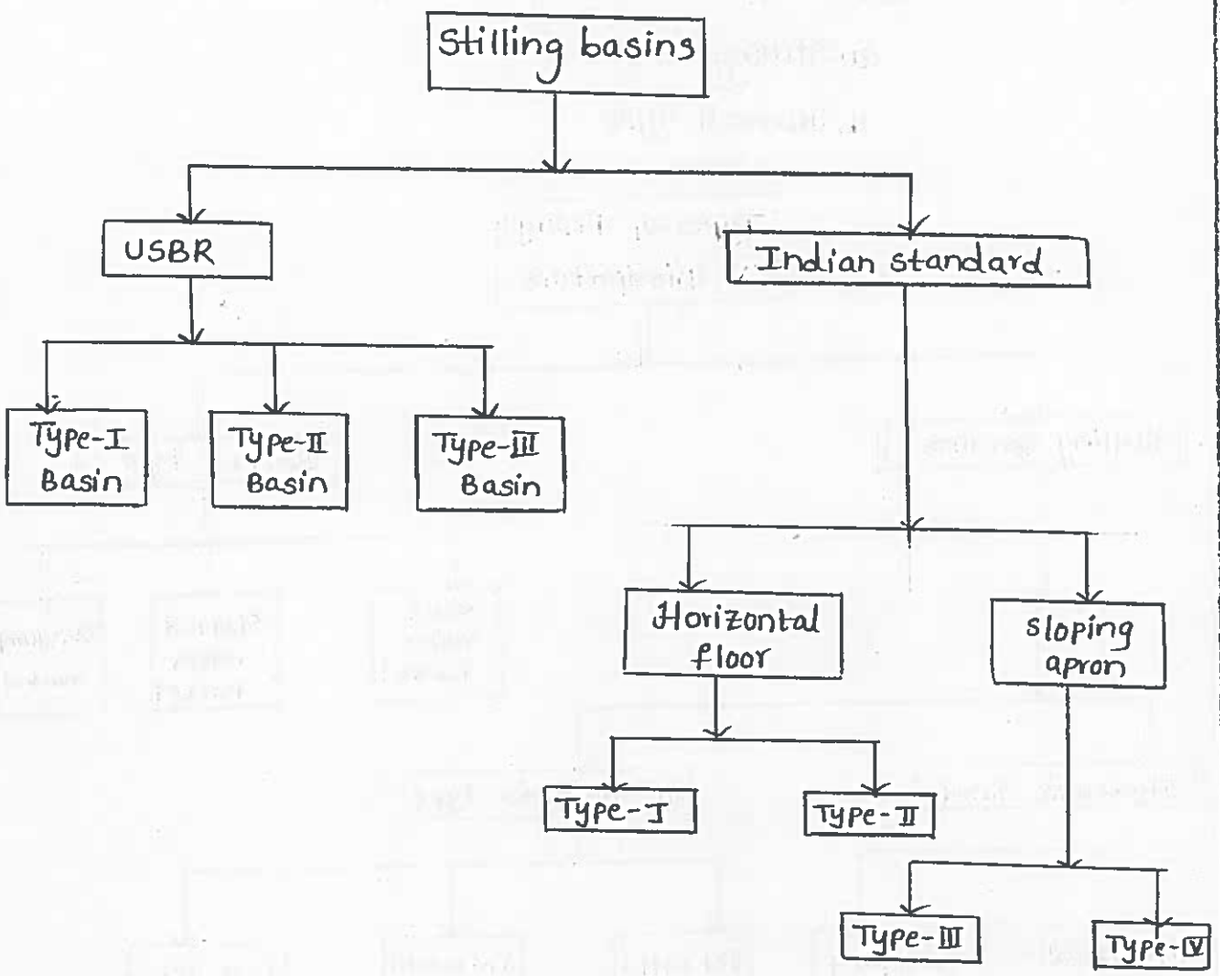
partially is known as "stilling Basins".

Types of stilling basins:

→ The stilling basins are classified as:

i. USBR type stilling basins.

ii. Indian standard basins.



USBR Type-I stilling basin

→ It is suitable for the froude number varies from 2.5 to 4.5

→ It contains of chute blocks.

→ It is most suitable for effective dissipation of energy.

→ The depth of water is about $1.10y_2$

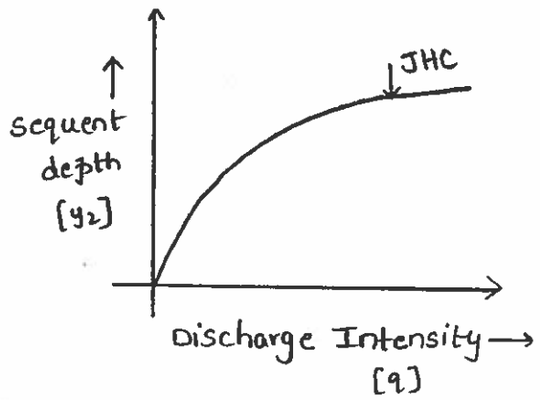
Indian standard Type-I Basins

→ It consists of chute block, basin blocks etc.

→ The depth of water should be less than $1.10y_2$

Jump Height curve [JHC]:

The graph (or) curve plotted between sequent depth [y_2] & discharge intensity [q]



Tail Water Rating Curve [TWRC]:

The graph (or) curve plotted b/w tail water depth [y_2'] & discharge intensity [q]