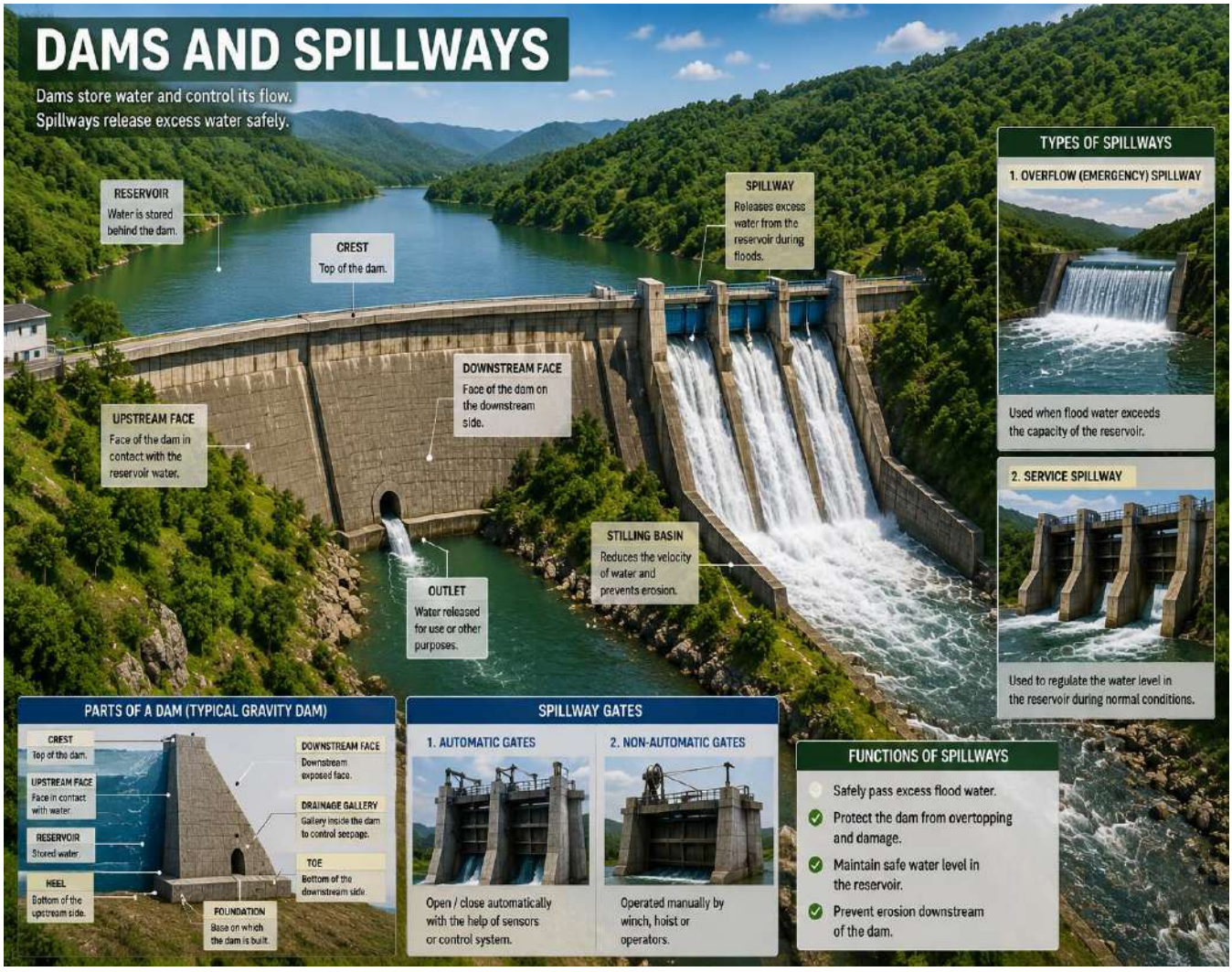
R.C.Patel College Of Engineering & Polytechnic, Shirpur

Department of Civil Engineering

Course Title- Water Resource Engineering **Course Code -** 315314

Programme Name - Civil Engineering **Semester-** Fifth

Unit	Title	COs	Learning hours	R Level	U Level	A Level	Total Marks
III	Dams and Spillways	CO3	11	04	08	06	18



Unit 3: Dams and Spillways

3.1 Dam and its classification based on use materials and hydraulic design.

Dam definitation:

A dam is a structure built across a river or stream to stop or store water. The stored water forms a reservoir.

Functions of dam

1) stores water during rainy season.
2) Supplies water for irrigation.
3) Provides drinking water.
4) Generates hydroelectric power.
5) Controls floods.
6) Supports fisheries and tourism.

Factors affecting the selection of the type of dam:

The factors which affect selection of dams are as follows:

1) Material available
2) Funds available
3) Nature of foundation
4) Space for surplus work. (ie. spillways)
5) Nature of valley.
6) Seepage and uplift under dam.

Classification of Dams

A) Based on Use

1. **storage dam:**
   - stores water for future use
   - used for irrigation, water supply and power generation.

2. Diversion Dam:

- Diverts river water into canals.
- Does not store a large quantity of water.

Ex. Weir.

3. Detention (flood control) Dam

- stores flood water temporarily.
- Releases water slowly to reduce flooding.

4. Debris dam :

- stops stones, mud and other debris from flowing downstream.

B) Based on Material

1. Earthen dam

- Constructed using soil.
- Suitable where soil is easily available.
- Economical.

Advantages →
a) Low cost
b) Flexible structure
c) Good for wide valleys

Disadvantages →
a) Requires regular maintenance
b) Can be damaged by seepage.

2. Rockfill dam

- Made of large rock pieces.
- Impervious layer is provided to stop seepage.

3. Masonry dam

- Built using stone masonry.
- Strong and durable.

4. Concrete dam

- Made of reinforced or plain concrete
- suitable for high dams.

5. Composite dam

- Combination of two or more materials
- Example : Earth + concrete.

c) Based on Hydraulic design

1. Overflow dam
   - Water flows over the top of the dam
2. Non overflow dam
   - Water is not allowed to flow over the crest.
   - Spillway is provided separately.

3.2 Earthen Dams:

- The dams which are constructed of earthen materials such as gravel sand, silt and clay are called as earthen dam.
- It has trapezoidal section with a top width of 3 to 10m and upstream slope of 1V: (2.5 to 4)H downstream slopes of 1V: (2 to 3) H.

Types of Earthen dam

The various types of earthen dam are as follows

1. Zoned type earthen dam
2. Homogeneous type earthen dam
3. Diaphragam type earthen dam

Types of earth dams based on Methods of construction.

1. Rolled fill earth dam.
2. Hydraulic - fill earth dam
3. Semi hydraulic earth dam.

Construction of Earthen dam

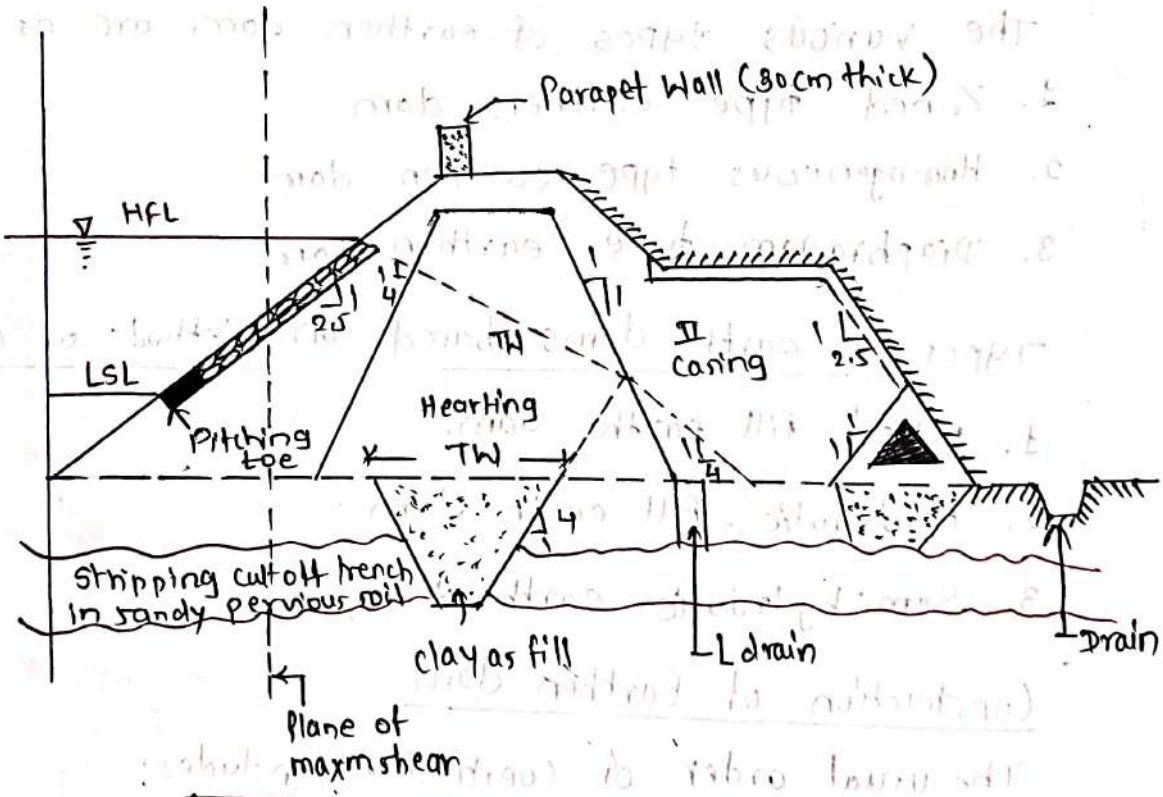
The usual order of construction includes:

1. construction of reference point.

2. Stripping or benching.
3. Excavation of cut off trench.
4. Excavation and filling of seepage drains.
5. Construction of rock toe.
6. Raising of upstream casing and hearting zone.
7. Keying to flanks.
8. Foundation of masonry casing and hearting zone. work like head regulator and spillway.
9. Earthwork in hearting and casing.
10. Pitching on U/S as well as D/S if required.
11. Gorge filling, finishing downstream slope.
12. Construction of drains and berms.

Components parts and their functions.

An earthen dam is a dam made mainly from compacted soil. It is the most common type of dam because soil is easily available.



Component of earthen dam

1) Crest →

The crest is the top horizontal surface of the earthen dam.

Typical dimensions → Width : 6 to 12 m
Freeboard : 1 to 3 above maxm water level.

Functions → a) Provides an inspection road.
b) Prevents overtopping by maintaining freeboard.
c) Allows movement of maintenance vehicles.

2) Hearting → (Impervious core)

Hearting is the central watertight portion of an earthen dam made of clay or other impermeable material.

Typical dimensions → Top width : 3 to 6 m
Bottom width : depends on dam height and design.
Location : Usually at the centre or slightly towards upstreamside.

Functions → a) Prevents seepage through the dam
b) Makes the dam watertight.
c) Reduces piping and internal erosion.
d) Improves the stability of the dam.

Material → a) clay b) Black cotton soil (if suitable)
c) Highly plastic impervious soil.

3) Casing →

- The casing is the outer shell of the earthen dam provided on both sides of the hearting.
- It develop shear resistance against slip and provides stability of dam, it also helps in drainage.

Functions → a) Gives strength to the dam.
b) Protects the hearting.
c) Increases stability.
d) Supports the uptream and downstream slopes.

Typical dimensions →
Thickness depends on dam height.
Usually forms the major portion of the embankment.

Material → a) Gravelly soil
b) sand c) Moorum d) well compacted earth.

4) Cut-off Trench
A cut off trench is an excavation made below the centre of the dam and filled with impervious material.

Typical dimensions:
Depth: 2 to 10 m or up to impervious layer
width: 2 to 8 m

Functions → a) Prevents seepage through the foundation.
b) Reduces uplift pressure.
c) Prevents piping.
d) Increases foundation safety.

Material → a) clay b) concrete.

5) Rock Toe → A rock toe is a layer of large stoner placed at the downstream toe of the dam.

functions → a) supports the downstream slope.
b) Improves drainage
c) Prevents erosion.
d) Reduces seepage pressure.

Typical dimensions → Height → 1 to 3 m
Width → 3 to 8 m

Seepage Fl

6) Pitching → (Stone pitching)

Pitching is a protective layer of stones placed on the upstream slope.

Function → a) Protects against wave action.
b) Prevents erosion of the upstream slope.
c) Increases durability.

Material → Hand packed stones, Riprap.

Typical dimensions → Thickness : 300 - to 600 mm
Stone size : 200 to 500 mm.

7) Turfing →

Turfing means covering the downstream slope with grass.

Functions → a) Prevents soil erosion due to rain.
b) Protects the slope from weathering.
c) Improves appearance.
d) Reduces dust.

Material → Grass, Vegetation.

Typical dimensions →

Grass layer : 100 – 150mm
Entire downstream slope is usually covered.

8) Berms →

A berm is a horizontal bench provided on the slope of the dam.

Functions → a) Reduces slope length.
b) Improves stability.
c) Makes inspection easier.
d) Reduces erosion.

Typical dimensions →

Width : 2 to 6m
Vertical spacing : depends on dam height.

9) Drains →

Drains collect and safety discharge seepage water from the dam.

Types → a) Toe drain
b) Chimney drain
c) Horizontal drain

Functions → a) Removes seepage water.
b) Reduces pore water pressure.
c) Prevents piping
d) Improves stability.

Material → Gravel, coarse sand, crushed stone.

Typical dimensions →

Thickness : 0.6 to 1.5 m
Width : 1 to 3 m

10) Transition filter →

A Transition filter is a graded filter layer placed between the impervious hearting and the casing.

Functions → a) Prevents fine soil from moving into the casing
b) Allows seepage water to pass safely.
c) Prevents piping.
d) Protects the hearting.

Material → a) Fine gravel b) Coarse sand c) Graded filter material

Typical dimensions →

Thickness : 0.5 to 1.5 m

3.3 Methods of construction of earthen dam:

methods are given below:

1) Rolled fill method
2) Hydraulic fill method
3) Semi Hydraulic fill method.

1) Rolled Fill Method:

- In this method, soil is spread in thin layers and each layer is compacted by rollers before placing the next layer.
- It is the most widely used method because it gives a strong and durable dam.

Procedure →
i) clear bushes, trees, and loose soil from the site.
ii) Excavate the cutoff trench.
iii) Bring suitable soil from borrow area.
iv) Spread soil in thin layers (15 to 30 cm thk).
v) Sprinkle water to maintain proper moisture.
vi) Compact each layer using rollers.
vii) Repeat until required height is achieved.
viii) Construct drainage system and protective works.

Advantages →
i) strong and stable structure
ii) Less settlement
iii) High density
iv) Longer life
v) Suitable for large dams.

Disadvantages →
i) Requires heavy machinery
ii) Construction is slower
iii) Cost is higher.

2) Hydraulic Fill method:

Soil is mixed with water to form slurry. The slurry is pumped into the dam area where soil particles settle naturally.

Procedure → i) Excavate soil from the borrow area.
ii) Mix the soil with water to form a slurry.
iii) Transport the slurry through pipelines or channels.
iv) Allow the soil particles to settle.
v) Drain the excess water.
vi) Continue filling until the required height is achieved.

Advantages → i) Suitable for large projects.
ii) Faster transportation of soil over long distances.
iii) Requires less manual handling of soil.
iv) Useful where water is readily available.

Disadvantages → i) Requires a large quantity of water.
ii) Fine particles may be washed away if not controlled.
iii) Lower compaction compared to the rolled fill method.
iv) Not commonly used today.

3) Semi hydraulic fill method

The semi hydraulic fill method is a combination of the Rolled fill method and the Hydraulic fill method. Soil is first transported to the dam site by trucks, dumpers, or conveyors, and then water is used to spread and settle the soil before compaction.

Advantages → i) Requires less water than the hydraulic fill method.
ii) Faster than manual construction.
iii) Suitable where only a limited quantity of water is available.

Disadvantages → i) More expensive than the rolled fill method.
ii) Not suitable where water is very scarce.

Seepage Through Earthen dam

- Seepage is the slow movement of water through the body or foundation of the dam due to water pressure.
- Some seepage is normal, but excessive seepage is dangerous.

A) Seepage Through Embankment:

When water passes through the embankment of the dam.

Causes →
i) Poor compaction
ii) Highly permeable soil.
iii) Cracks in the dam.
iv) Absence of an impervious core.

Effects →
i) Loss of water
ii) Internal erosion
iii) piping
iv) weakening of the dam.

B) Seepage Through Foundation

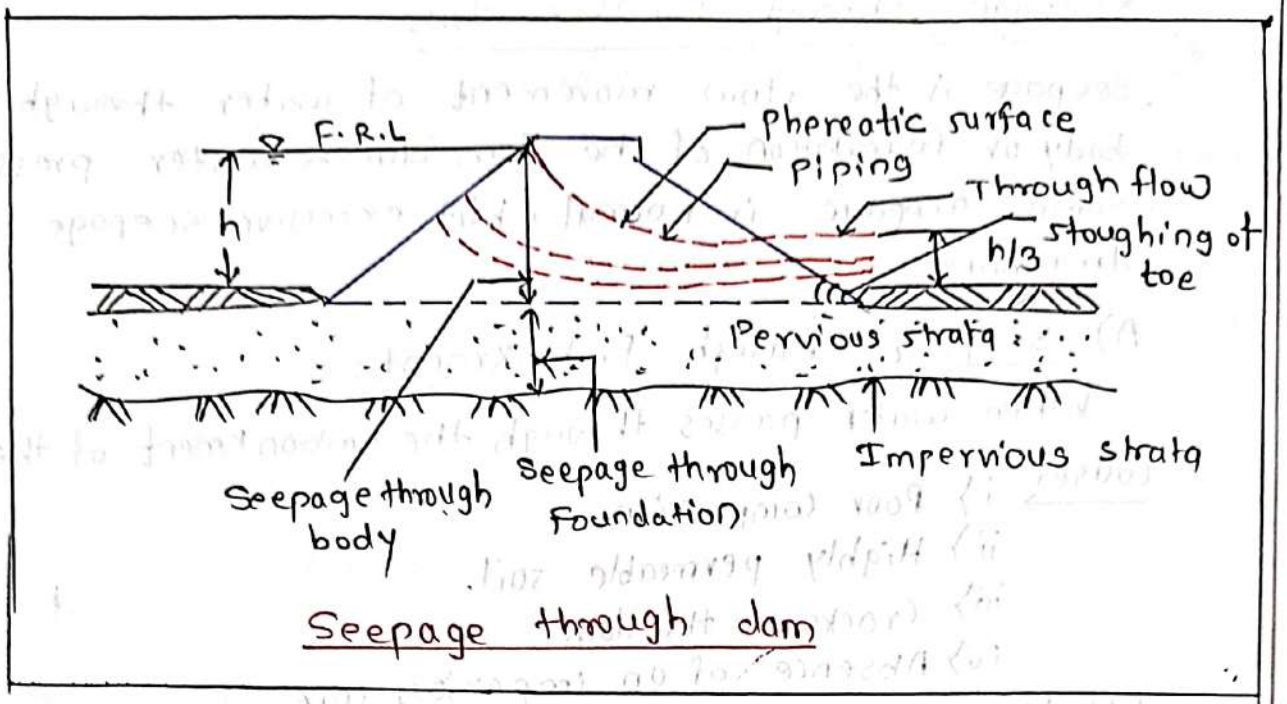
When water flows below the dam through the foundation soil or rock.

Causes →
i) Permeable foundation
ii) cracks & joints in rocks
iii) weak foundation treatment.

Effects →
i) Uplift pressure
ii) Soil erosion
iii) settlement
iv) foundation failure.

Methods used to reduce seepage in earthen dam.

- When seepage takes place through the body of dam it is called horizontal piping and if it is through foundation it is called vertical piping.
- If seepage is controlled properly it does not damage the dam but if it is uncontrolled it may lead to failure.



Seepage through dam

1) Trap efficiency →

It is the percent of total inflow sediment which is retained in reservoir.

$$\text{Trap efficiency } (\eta_t) = \left(\frac{\text{Sediment retained}}{\text{total sediment}}\right) \times 100$$

2) Capacity inflow ratio →

The ratio of the reservoir capacity to the total inflow of water in it is known as capacity inflow ratio.

Control measures for seepage →

1. Cut off Trench: stops seepage through the foundation.
2. Impervious core: Clay core reduces seepage through the embankment.
3. Filters: Prevent soil particles from being washed away.
4. Toe drain: Collects and safely removes seepage water.
5. Grouting: Fills cracks in rock foundations using cement grout.
6. Proper compaction: Reduces air voids and seepage.
7. Upstream Blanket: An impervious soil layer on the upstream side increases the seepage path and reduces leakage.

Types of failure of earthen dam and its preventive measures

The failure of earthen dam as three type are or follows:
1) Hydraulic failure
2) Seepage failure
3) Structural failure

1) Hydraulic failure

These types of failures occur due to following reasons:

i) Erosion of upstream and downstream

This types of failure occurs due to wave action caused by flow of water.
- The erosion occurs at upstream side due to unproper pitching of stone at upstream side of dam.
- The erosion at downstream side may occurs due to heavy falling directly over downstream face.

ii) Overtopping

Water of flow over reservoir the top of the dam.
Such type of failure may occur due to:
a) Insufficient free board.
b) If excess flood water enters into reservoir.
c) If length of spillway is less.

- To Prevent this failure provide sufficient free board, sufficient spillway length and more top width.

iii) Toe erosion

In that toe of dam may get eroded due to current of water which may come from spillway bucket and tailwater.
- To avoid such failure stone pitching should be provided upto a height slightly more than the tail water depth.

iv) Gullying

formation of gullies will also result in failure of dam.
To safe gaurd against external erosion upstream face is properly protected with stone called pitching and downstream face is by turfing and stone laying and by providing berms.

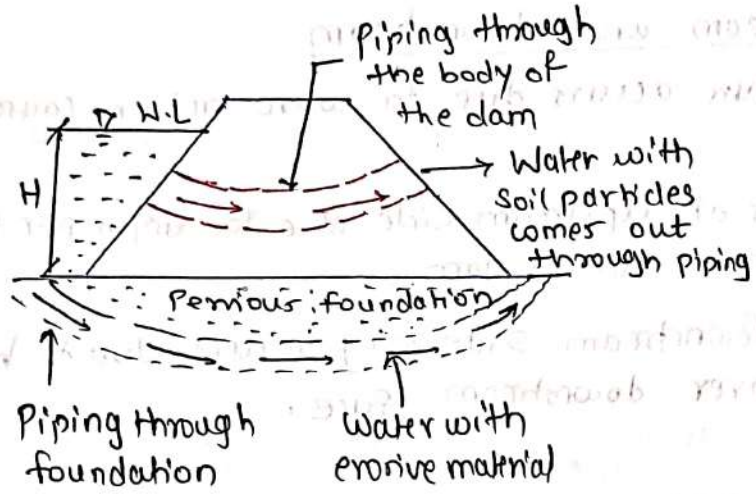
v) Frost erosion

- Low temperature frost may occur which may leads to more seepage during summer.
- For this purpose in such areas additional measures should be adopted.

2) Seepage failure

Seepage failure may occur due to following cause.

i) Piping through dam



- more than 25% failure occurs due to pipe leakage due to presence of sand and gravel.
- These may develop due to faulty construction improper compaction.
- shrinkage cracks, cracks developed due to settlement of foundation.

ii) Piping through foundation

If soil below foundation is pearmeable and if foundation strata consist of cavities then water start seeping through them which may erode the soil causing piping failure.

iii) Sloughing of downstream toe

It is process in which soil mass falls down after saturation, occurs due to downstream toe.

- from this downstream portion of dam becomes saturated. & continuously remains in same state causing piping failure.
- It may occurs due to choking of downstream drains.

3) Structural failure

structural failures in the earth dams are of following types:

i) Slide in embankment

when slope of embankment is too steep for strength of soil then dam may fail due to sliding embankment.

ii) Foundation slides

If the foundation is laid on soft soil then dam will slide. If soft and weak strata exist in foundation.

iii) Failure by spreading

Such type of failure may occur when earth dam is located above stratified deposit that contains layers of silt clay.

iv) Failure due to holes caused by burrowing animals.

The burrowing animals dig holes in dam and through these holes free passage of water may occur, which may leads to piping failure.

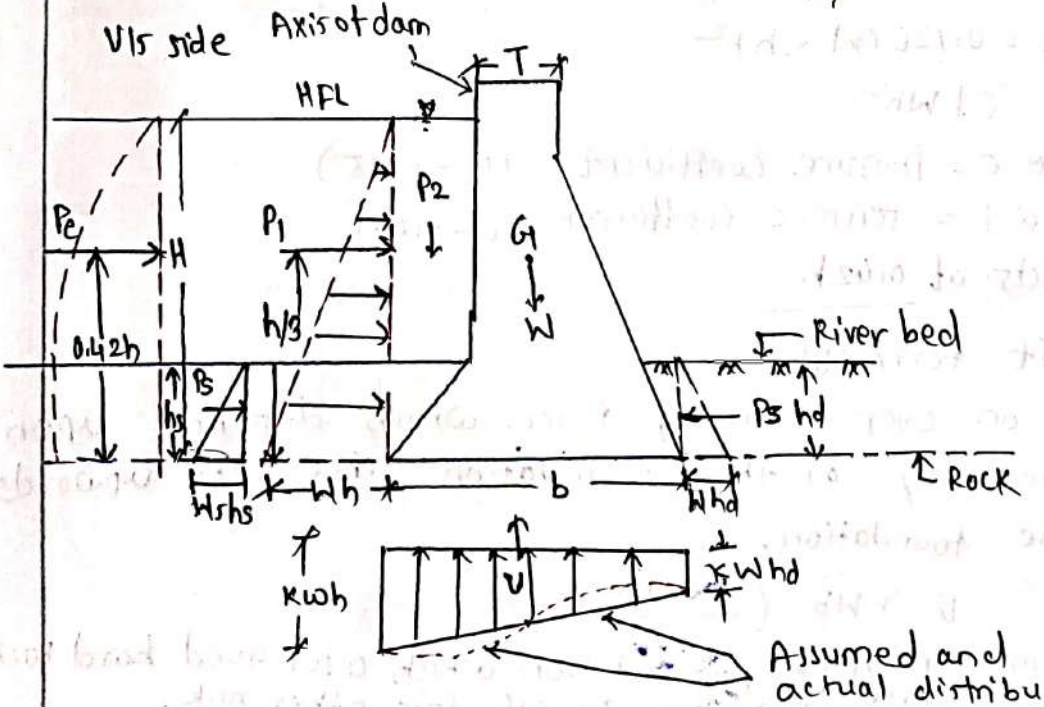
v) failure due to holes caused by leaching of salts.

The salt such as gypsum, iron oxide etc, If present in water, abutment and foundation may occur cavities which leads to excessive settlement of dam, which may leads to failure of dam.

3.4 Gravity Dams.

Gravity dam is a solid structure made up of masonry or concrete and are constructed across river to create reservoir on its upstream side.

Forces Acting on a gravity dam



1) Water pressure.

It is major external force acting on dam.

$P_1 = \frac{Wh^2}{2}$ acting at $\frac{h}{3}$ from the base.

It is also called as overturning force.

2) Weight of wedge water on upstream slope.

Weight of wedge water on upstream slope acting downward toward through CG.

P_2 = Area of c/s of water on slope x W

3) Weight of wedge on downstream slope.

weight of water on downstream wedge acting as CG downwards.

P_3 = Area of triangle x W acts downward

4) Upstream silt pressure.

$$P_s = \frac{W_b h^2 s}{2} \times \frac{1-\sin\phi}{1+\sin\phi}$$

acts in downstream direction horizontally at h/3 from rock where, W_b = weight per m3 of submerged silt.

ϕ = angle of internal friction of silt.

5) Seismic force

It occurs when earthquake is more and these are taken as,

$P_c = 0.726\, cW \alpha_h h^2$

$\simeq 1 Wh^2$

Where c = Pressure coefficient (0 - 0.75)

α_h = seismic coefficient (0 - 0.12)

This acts at 0.42h

6) Uplift force 'U'

It is an over turning force which depends upon Permeability of the foundation. This acts upwards of the foundation.

$$U = kW_b \left(\frac{h+h_d}{2}\right)$$

k = Permeability of the foundation which 0 for good hard rock without crack and 0.2 to 0.6 for other rock.

7) Tail Water pressure.

$P_3 = \frac{Whd^2}{2}$ ... acting $\frac{hd}{3}$ from base

8) Other forces.

a) Ice pressure : When reservoir is likely to freeze ice pressure should be considered and allowed @ 5 kg/cm² on the area.

b) Wave pressure : Wave pressure = $200\, hw^2$ kg/m
where hw = height of wave obtained.

c) Wind pressure : It is minor force depends on wind uniformly.

Theoretical / Elementary Profile

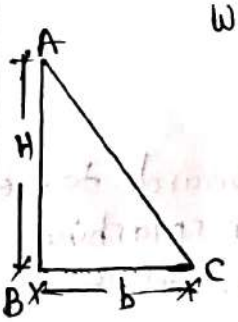
A theoretical profile of solid dam is an imaginary section having the shape of right angled triangle with its base on the rock and apex at HFL and water face vertical and base width is obtained to fulfill stability condition.

1) No tension
2) No sliding

- Considering only important forces:

1) Water thrust 2) Weight of dam 3) Uplift pressure.

Assuming profile in triangle ABC.



Where AB = H and BC = b

G = special gravity of dam masonry.

K = Permeability of rock. (0.14 to 0.16)

Consider 1m length of dam normal to the plane of paper.

Water thrust $P = \frac{WH^2}{2}$ kg — acts H/3 from base.

Weight of dam $W = \frac{GWbH}{2}$ — acts centre of gravity

Uplift pressure $U = \frac{KWHb}{2}$ — acts upward through m

net vertical force $= W - U = \frac{WbH}{2} - (G - K)$

1) No tension →

for no tension resultant must pass through middle third that is at point N on base. since point N is in direction of resultant sum of moment of all forces about N must be zero.

$$P \times \frac{H}{3} - (W-u)\frac{b}{3} = 0$$

$$b = \frac{PH}{W-u} = \frac{WH^2}{2} \times \frac{H^2}{WbH(G-K)}$$

$$b = \frac{H}{\sqrt{G-K}}$$

2) No sliding →

For no sliding and minimum value of safety factor is 1 neglecting shear.

Factor of safety against sliding,

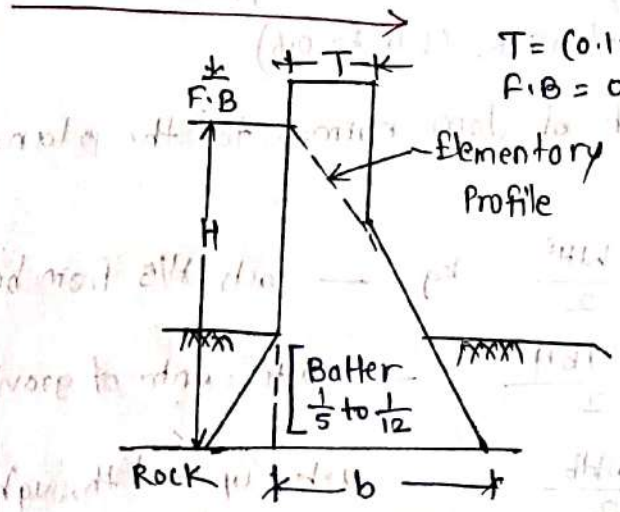
$$P = \frac{\Sigma V - u \mid u + b.g}{\Sigma H}$$

$\Sigma H = \Sigma (V-u)u$, $P = (V-u)u$ and

$$\frac{WH2}{2} = \frac{WbH}{2}(G-K) \quad , \boxed{b = \frac{H}{(G-K)}u}$$

Thus, foundation show abc greater of two values given by equation.

Practical Profile →



$T = (0.10-0.15)H$

$F.B = 0.05H$

Practical profile

1) Free board to prevent water splashing to Provide additional storage

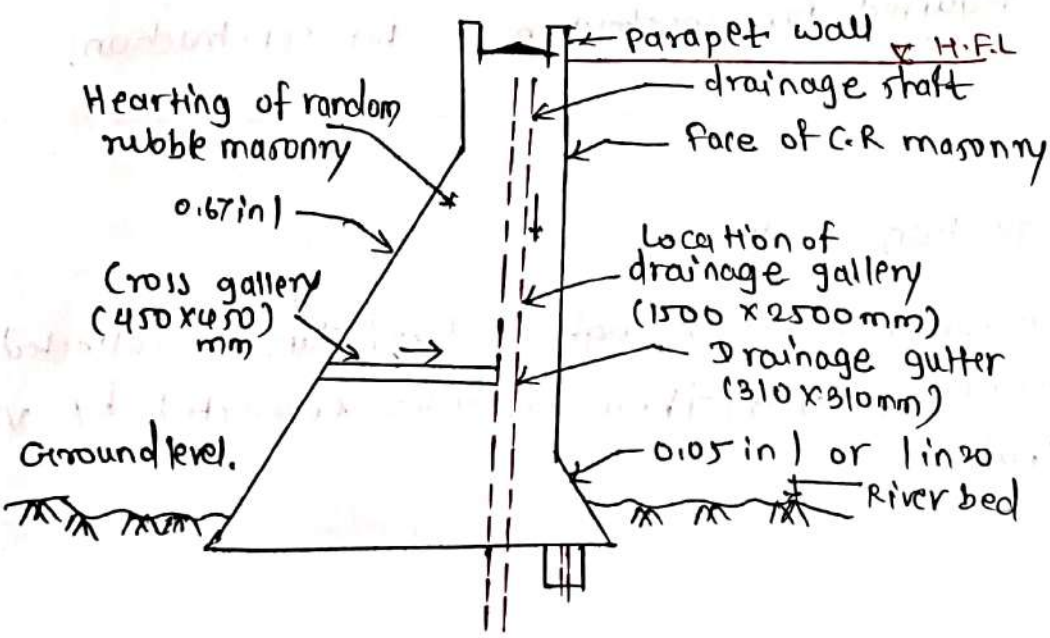
2) Width at top - to accommodate road.

3) Additional upstream width - to balance load due to top width.

Difference between Theoretical and practical profile of gravity dam:

Theoretical Profile	Practical Profile
1) Provision of free board is not provided	1) Provision of free board is Provided.
2) Road way at top is not Possible.	2) Road way at top is possible.
3) for reservoir empty condition it will provide maximum possible stability.	3) For reservoir empty condition tension is developed at toe & hence some masonry is Provided on U/S side.
4) Usually has a triangular cross section with a vertical upstream face.	4) has a trapezoidal cross-section with modifications such a curved facer and wid crest.
5) Used mainly for preliminary design and analysis	5) Used for final design actual Construction.
6) Less safe under real field conditions.	6) safer, more economical and Suitable for long term service.

Drainage Gallery →



- It is provided near to the rock foundation. Its main function is to drain off the water which percolates through the foundation.
- It varies from 1.5 x 2.2m to 1.8 x 2.4m after completing found-ation grouting drainage holes are drilled to collect seepage water and then it is drained off by cross galleries.

Differentiate between Gravity dam and Earthen dam

Earthen dam	Gravity dam
1) These are less durable	1) These are more durable
2) It cannot withstand very high pressure.	2) It can withstand high Pressure.
3) It cannot be 100% water tight.	3) It can be 100% water tight.
4) It cannot be made thinner	4) It can be made thinner.
5) Failure is sudden.	5) Failure if any is not sudden.
6) Locally available soil stone silt clay and sand can be used.	6) Stone, brick and concrete only can be used.
7) Skilled labour is not required for construction	7) Skilled labour is required for construction.

Inspection Gallery →

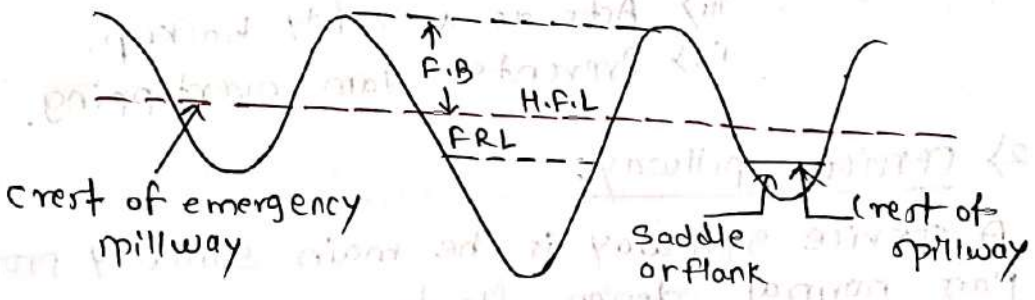
The water seeps through body of dam is collected by various galleries. These are inter connected by vertical shafts.

3.5 Spillways →

A spillway is a hydraulic structure provided at a dam to safely release excess water from the reservoir to the downstream river whenever the water level rises above the full reservoir level (FRL).

Functions of spillway

1) safely passes excess flood water
2) Prevents overtopping of the dam
3) Protects the dam from failure
4) Maintains the reservoir at the desired water level.
5) Controls floods by regulating water release.
6) Reduces danger to downstream structures.



Location of spillway.

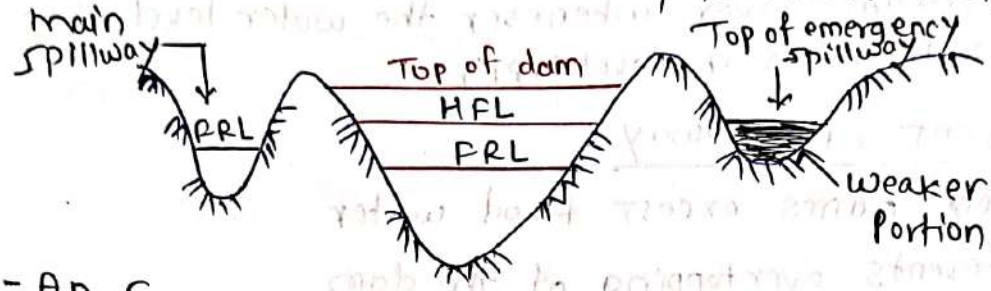
Types of spillways →

Spillways are divided into following types:

1) Emergency spillway
2) Service spillway
   - ogee spillway
   - Bar spillway
   - chute spillway (open channel spillway)
   - side channel spillway
   - shaft spillway (Morning glory spillway)
   - siphon spillway.

1) Emergency spillway:

- It is provided with an earthen dam. In such spillway part of the length of earthen dam is kept weak above FTL/FRL (Full tank/ Reservoir level)



- An Emergency spillway is an additional spillway that operates only during extremely high floods when the service spillway cannot pass all the flood water.

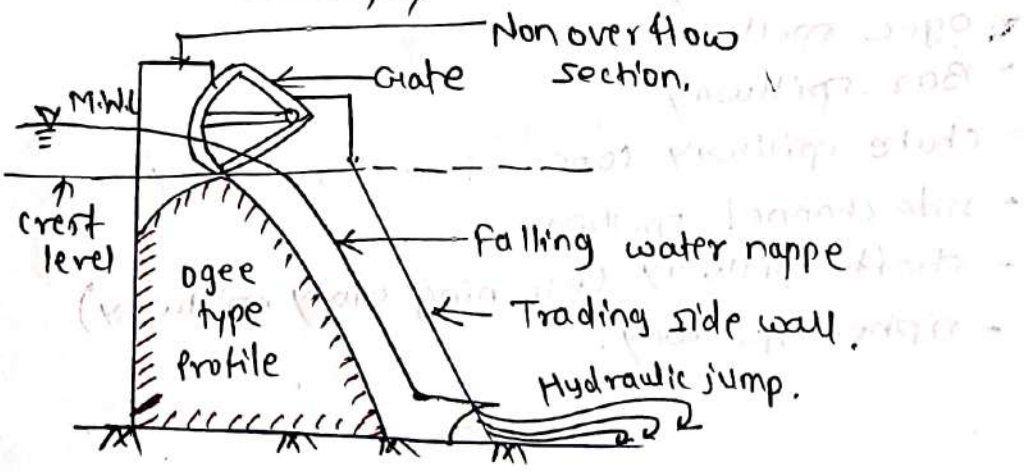
Characteristics →
i) Used only during severe floods.
ii) Normally remains dry.
iii) Acts as a safety backup.
iv) Prevents dam overtopping.

2) Service Spillway:

A service spillway is the main spillway provided to pass normal design floods.

Characteristics →
i) Operates regularly.
ii) Controls reservoir level.
iii) Usually provided with gates.
iv) Designed for expected flood discharge.

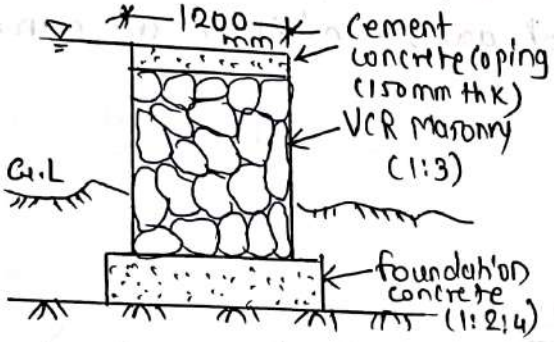
a) Ogee Spillway →



- The crest has an S-shaped (ogee) curve.
- Water flows smoothly over the curved surface.
- Mostly used in concrete gravity dams.
- It has high discharge capacity and good efficiency.

Advantages → i) Smooth flow of water
ii) Less energy loss
iii) Suitable for large dams.

b) Bar spillway



- It consist of rectangular masonry concrete bar with crest width to 1.5 m.
- Low height spillway.
- Rest on hard rock foundation.
- The top of crest is at FRL.

c) Chute Spillway (open channel spillway)

- Water flows through a sloping concrete channel.
- commonly used in earth dams and rockfill dams.

d) Side channel spillway

- Water first enters a side channel and then flows parallel to the dam before reaching the river.
- Used where there is limited space.

e) Shaft spillway

- Water enters through a circular opening like a funnel.
- It then flows downward through a vertical shaft.
- Used in narrow valleys.

f) Siphon spillway

- Works on the siphon principle.
- Starts automatically when the water level rises above a certain height.

Spillway Gates:

Defination → Spillway gates are movable barriers installed on a spillway to control the amount of water released from the reservoir.

Advantages →

i) Economical construction is possible due to reduction in height
ii) Useful storage up to some extent is possible.
iii) Saving in land acquisition.
iv) Reduction in spillway length is possible.

There is different types of gates and there are non-automatic and automatic.

1) Automatic Gates.
2) Nonautomatic Gates.

1) Automatic spillway gates:

Automatic Spillway gates open and close without human operation. They work automatically when the reservoir water level rises or falls.

Types of automatic spillway gates

a) Drum Gate → i) A hollow curved gate that rotates automatically due to water pressure.
ii) opens when the water level rises and closes when it falls.

Uses - Medium and large dams.

b) Flap Gate (Hinged Gate) →
i) Hinged at the bottom.
ii) opens automatically due to excess water pressure.
iii) closes when the water level decreases.

Uses : Small dams and weirs.

c) Fuse Gate →
- A temporary gate placed on the spillway crest.
- During extreme floods, it tilts or collapses automatically to release excess water.
- Usually replaced after operation.

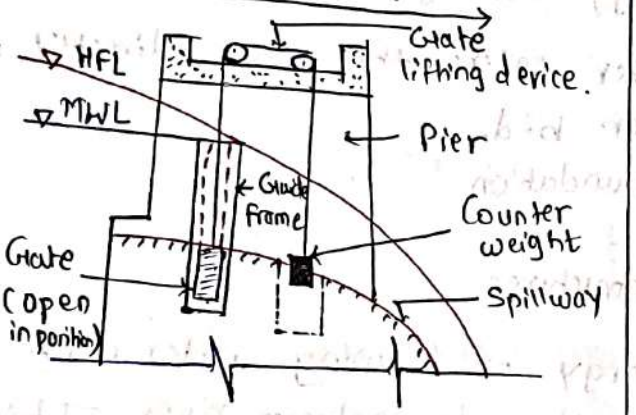
Uses → : Protection against extreme floods.

2) Non automatic Spillway Gates.

Non automatic spillway gates require manual or mechanical operation by operators.

Types of Non automatic gates:

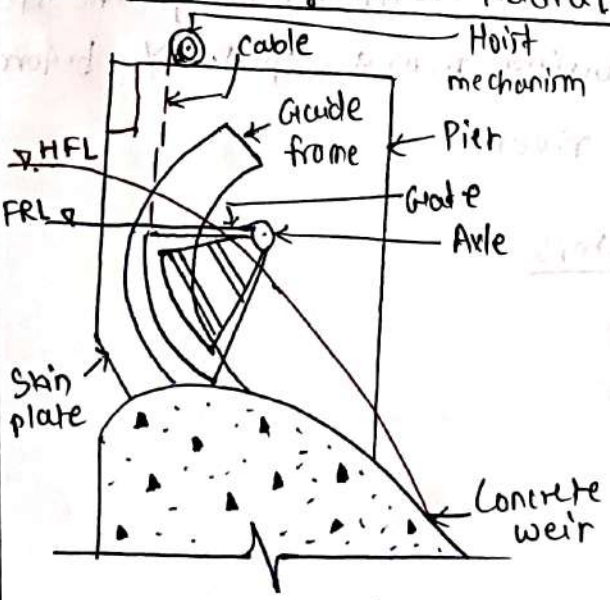
a) Vertical lift gate:



Vertical lift gate.

i) These are made of steel sheets fitted on frames.
ii) Flat gate that moves vertically up and down.
iii) These gates are suspended by iron chains or wire rope within frames and guides with rollers to reduce and lifting force.

b) Taintor gate or Radial gate



Taintor gate

i) It consist of plate of iron mounted on triangular frame of girder and fitted to an axle.
ii) The shape is like segment of circle and properly braced steel framework.
iii) During floods gates are lifted and flood water is allowed to flow towards downstream side from over crest.

c) Roller Gate →

i) Large gate supported on rollers.
ii) Used for wide spillway openings.

d) Stop Log Gate →

i) Made of wooden or steel beams placed one above another.
ii) Mainly used for maintenance work or temporary closure of spillway.

3.6 Energy Dissipators

When water flows over a spillway, it moves with high very high speed. This fast moving water has a large amount of kinetic energy (energy due to motion).

* If this high energy water enters the river directly,
  i) Wash away the river bed.
  ii) Damage the dam foundation.
  iii) Cause soil erosion.
  iv) Endanger nearby structures.

Therefore, the extra energy of flowing water must be reduced before it enters the downstream river. This process is called energy dissipation.

OR

Energy dissipation is the process of reducing the speed and energy of water flowing from a spillway before it enters the downstream river.

Types of energy dissipators

1) Hydraulic Jump type
2) Bucket type.
   i) Flip Bucket
   ii) Roller Bucket.

1) Hydraulic Jump type

A hydraulic jump is a sudden rise in the water level when fast moving water changes into slow moving water.

During this process :- Water speed decreases
- Turbulence is created
- A large amount of energy is lost.

Importance →
- Reduces water velocity
- Prevents erosion
- Protects the downstream side of the dam.

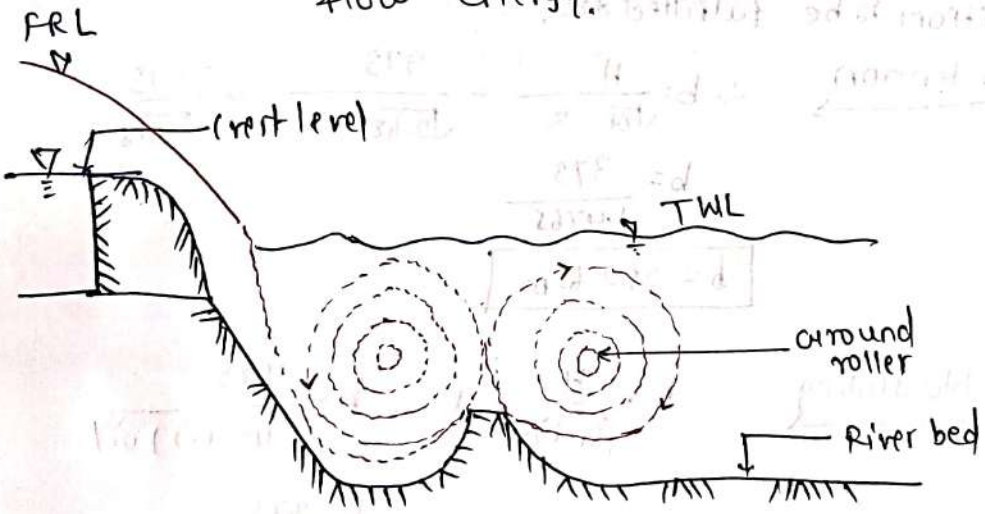
2) Bucket type

i) Flip Bucket → A flip Bucket is a curved structure provided at the end of the spillway.

Working →
- Water is thrown into the air like a fountain.
- It falls into a plunge pool away from the dam.
- Most of the energy is lost during the fall and impact.

ii) Roller Bucket → : A roller bucket is a curved bucket shaped structure at the end of the spillway.

Working →
⇒ water enters the bucket and forms a rotating water current.
- The rotating water absorbs and reduces the flow energy.



Bucket type energy dissipater

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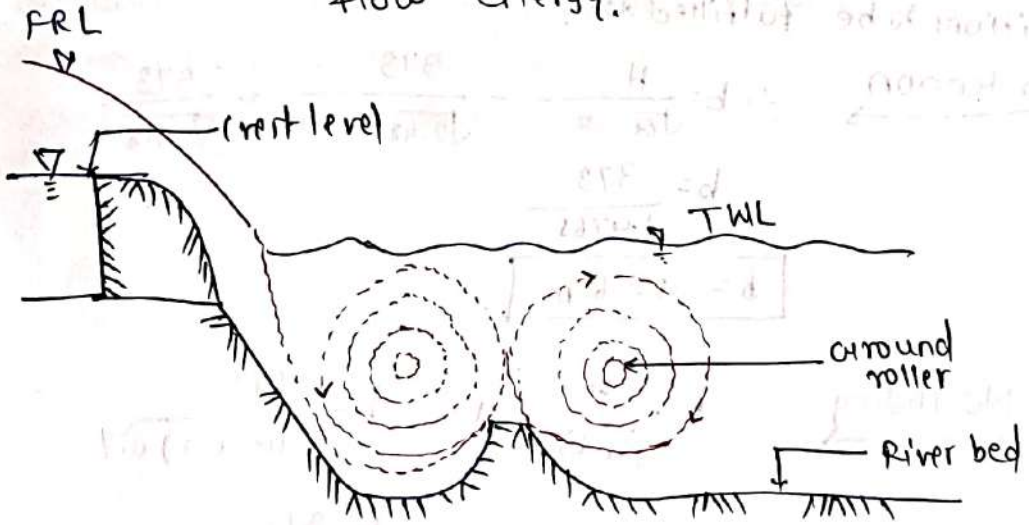

Bucket type energy dissipater

Q1. Find the length of the spillway for a reservoir for MFD of 2000 m³/sec with head of 2.5 m.

→ Solution → $Q = 2000\ m^3/sec$

$H = 2.5\ m$

$C = 1.84$ (Assume Coefficient of discharge)

Using francis formula,

$$Q = CLH^{3/2}$$

$$2000 = 1.84 \times L \times (2.5)^{3/2}$$

$$\therefore \boxed{L = 274.9\ m}$$

W-22,

Q.2. Calculate the base width of the elementary section of gravity dam from the following data.

Unit wt of concrete = 2480 kg/m³

HFL at RL = 373 m.) Coefficient of permeability (K) = 0.3

Coefficient of static friction (u) = 0.70.

Solution → $K = 0.3$, $u = 0.7$

$H = H.F.L$ at $RL = 373\ m$

Unit weight of concrete = 2480 kg/m³

G = specific gravity,

= unit weight of concrete / 1000 kg/m³

$G = 2.48$

Conditions to be fulfilled are:

i) No tension → $\therefore b = \dfrac{H}{\sqrt{G} - K} = \dfrac{373}{\sqrt{2.48} - 0.3} = \dfrac{373}{\sqrt{2.18}}$

$$b = \frac{373}{1.4765}$$

$$\boxed{b = 252.62\ m}$$

ii) No Sliding → $b = \dfrac{H}{(G - k)u}$ $\quad b = \dfrac{373}{(2.48 - 0.3)\,0.7}$

$$b = \frac{373}{1.526}$$

$$\boxed{b = 244.43\ m}$$

∴ The highest among the two base width value is to be selected $b = 252.62\ m$

Shirpur Education Society's
R. C. Patel College of Engineering and Polytechnic, Shirpur

President
Shri. Amarishbhai Patel

Survey No. 41/1, 41/2A,
Opposite to Pharmacy Education Complex,
Near Balaji Nagar, Karwand Road,
Shirpur- 425405 Dist: Dhule (MS)
Telephone: (02563)299299
Email: registrar@rcpcoep.ac.in

ASSIGNMENT QUESTIONS

1. Enlist any two purpose of galleries in gravity dam.
2. Draw a neat sketch of ogee spillway and advantages of spillway in dams.
3. Define silting of reservoir and state any three factors affecting silting of reservoir.
4. Differentiate between Earthen dam and Gravity dam on any four points.
5. Enlist any four functions of spillway.
6. Explain Energy Dissipation.
7. Explain the failures of earthen dams with their preventive measures.
8. Enlist various types of gates in dams, explain Vishweswarya gate with a neat sketch.
9. Explain with sketch the various forces acting on gravity dam.
10. Draw a labelled sketch of earthen dam showing all its component parts and state functions
11. Suggest suitable routine measures to maintain earthen dam, to serve its purposes.
12. Define seepage? Enlist various methods used to reduce seepage in earthen dam.
13. Draw a neat sketch of hydraulic jump type dissipators.
14. Differentiate Between elementary profile and practical profile of Gravity Dam.
15. Describe the concept of Low and High gravity dam.
16. State the components and use of the Bandhara scheme.