Assignment-1

Q.1 What is dam? Why it is constructed?

A dam is hydraulic structure constructed across a river or a natural stream to create a reservoir for impounding water.

The water stored in reservoir is used for various purposes, such as irrigation, municipal and industrial supply, hydropower generation recreation, flood control etc. Due to construction of the dam, water level in the river at its upstream side is very much increased, and a large area may be submerged depending upon the water spread of the reservoir so formed.

Q.2 Give detail classification of dam

⇒ Dams can be classified into different categories as under.

(a) classification according to use
(b) classification according to hydraulic design
(c) classification according to materials
(d) classification according to structural behaviour.

(a) classification according to use :-

(1) Storage dam :- Storage dams are constructed to store water during the rainy season when there is a large flow in the river. The stored water is utilized later during the period when the flow in the river is reduced.

→ Gravity dam
→ Earthen dam
→ Rockfill dam

④ Arch dam

② Diversion dams:-

A diversion dam is constructed for the purpose of diverting water of the river into an off-taking canal. A diversion dam is usually of low height and has a small storage reservoir on its upstream. For example

- weir
- barrage

③ Detention dam

Detention dams are constructed for flood control. A detention dam retards the flow of water in the river on its downstream during floods by storing some flood water. The water retained in the reservoir is released gradually at a controlled rate.

For example

- Debris dam

(b) classification according to hydraulic design

According to hydraulic design dams may be classified as

① Overflow dam
② Non-overflow dam

① Overflow dam

An overflow dam is the one which is designed to carry surplus discharge over its crest. Its crest level is kept lower than the top of the other portion of the dam.

such dams are generally made of concrete or

or masonary. An overflow dam is commonly known as spillway.

(2) NON-OVERFLOW dam

A non-overflow dam is the one in which the top of the dam is kept at a higher elevation than the maximum expected high flood level (MFL). Water is not permitted to overtop the dam.

For example

→ Gravity dam
→ Earthen dam
→ Rockfill dam

(c) Classification according to materials

According to materials dams are classified as

(1) Rigid dams
(2) Non-Rigid dams

(1) Rigid dams:

Rigid dams are those which are constructed of rigid materials such as concrete, masonary, steel, timber, etc. These dams deflect and deform very little when subjected to water pressure and other forces.

For example

→ Concrete gravity dam
→ Solid masonary dam
→ Arch dam
→ Steel dam
→ Timber dam

(2) Non-rigid dams

Non-rigid dams are those which are constructed

of non-rigid materials such as earth and/or rockfill. These are relatively large settlements and deformations in a non-rigid dam.

For example

→ Earth dam

→ Rockfill dam

(d) Classification according to structural behaviour

Based on structural behaviour, dams are classified as

(1) Gravity dam

(2) Arch dam

(3) Buttress dam

(4) Earthen dam

(5) Rockfill dam

Q.3 Explain embankment dam.

The embankment dams are classified as non-rigid type dams. They are built of soil or rockfill or both. These dams usually provide the most economical and most satisfactory solution for sites at which suitable foundation at reasonable depth may not be available for concrete or masonary dam. Conditions favouring the selection of an embankment dam are as follows.

(1) Significant thickness of soil deposits overlying bedrock.

(2) Weak or soft bed rock which would not be able to resist high stresses from a concrete dam.

(3) Abutments of either deep soil deposits or weak rock.

(4) Availability of a suitable site for separate spillway

(5) Availability of sufficient and suitable soils from required excavation or nearby borrow areas.

The embankment dams are broadly classified as
① Earth dams
② Rockfill dams
③ Composite earth and rockfill dams

Q.4 Give advantage and disadvantage of gravity dam, arch dam & buttress dam.

⇒ Advantages of Gravity dams:-
① Gravity dams are relatively more strong and durable than earth dams.
② Gravity dams can be constructed of any height, provided suitable foundations are available to bear the stresses.
③ Gravity dams are well adapted for use as an overflow spillway crest, Earth dams cannot be used as overflow dams.
④ A gravity dam requires the least maintenance.
⑤ Gravity dams are specially suited to such areas where there is likelihood of very heavy downpour.
⑥ The failure of gravity dam, if any is not sudden.
⑦ Scouring sluices can be used in the gravity dams to remove silt deposited in the reservoir.
⑧ A gravity dam is cheaper is long run. The benefit-cost ratio is always higher.

☆ Disadvantages
① Sound rock foundations are required.
② The initial cost of gravity dam is always higher than an earth dam.
③ Mechanised plants for manufacturing and transporting concrete are required.
④ Gravity dams require skilled labour for its construction.

⑤ it is very difficult to allow subsequent rise in the height of a gravity dam.

* Arch dam
→ Advantages
1 Arch dams are particularly adopted to the forces where the length is small in proportion to the height.
2 Because of much less base width, the problems of uplift pressure are minor.
3 For a given height, the section of an arch dam is much lesser than a corresponding gravity dam.
4 Since only a some part of water load is transferred to the foundation by cantilever action, an arch dam can be constructed on moderate foundation.
→ Disadvantages
① it requires skilled labour and sophisticated formwork.
② The speed of construction is usually slow.
③ It requires very strong abutments capable of resisting arch thrusts.

* Buttress Dam
→ Advantages
① A buttress dam is less massive than a gravity dam. It can be constructed on a relatively weak foundation.
② The spacing of buttresses may be adjusted to utilize zones of good foundation.
③ The water load acts normal to the inclined deck. Hence the vertical compound of the water load stabilises the dam against both overturning and sliding. Thus, it possesses a higher factor of safety.
④ The ice pressure is relatively unimportant since the ice tends to slide over inclined u/s deck.

(5) Power houses and water treatment plants can be housed in between buttresses thus saving some cost of construction.

(6) The amount of concrete required is about 1/2 to 1/3 of the concrete required for a gravity dam of the same height.

(7) The uplift pressure acting on a buttress dam is considerably less which leads to economy in concrete and overall stability of the dam.

(8) Access is possible to the back of upstream face and to foundations between buttresses for periodic inspection and for subsequent grouting and draining of pressure relief holes.

* Disadvantages

(1) Skilled labours and more shuttering is required.

(2) Deterioration of upstream surface of relatively thin reinforced concrete deck slab or arch of a buttress dam has more serious effects on the stability of the dam.

(3) Buttress dam is more susceptible to wind damage.

(4) The number of water seals to be provided and maintained for a buttress dam are usually more than that of other dams.

(5) The foundation stresses being higher, either sound rock foundation is necessary or spread footings or continuous footings must be required.

Q.5 Characteristics of concrete dam.

A gravity dam is a solid structure, made of concrete or masonary, constructed across a river with its cross-section approximately triangular in shape, so proportioned that the extraneous force exerted on it are resisted by its own weight.

A gravity dam is generally straight in plan, although sometimes, it may be slightly curved. The gravity dams are usually provided with an overflow spillway in some portion of its length. The dam thus consists of two sections namely the non-overflow section and the overflow section or spillway section.

→ Axis of the dam

In plan the axis of the dam is defined as the horizontal trace of the upstream edge of the top of the dam and it is also called base line of the dam. The axis or base line of dam may be straight or slightly curved.

→ ~~Length of the dam~~

① Concrete dams are not sensitive to overtopping under extreme flood conditions.

② Concrete dams can easily accomodate a spillway within the body of dam.

③ They possesses high ability to withstand seismic disturbances without catastrophic failure.

④ Valves, outlet pipe works and other ancillary works can safely be housed in chambers or galleries within the dam.

⑤ Concrete dams are suitable to the topography of wide or narrow valleys provided with a strong rock foundation available at moderate depth (not more than 5 m).

Q.6 Factors Governing Selection of type of dam.

=> The various factors which affect the choice of the type of dam are.

1. Topography
2. Geology and Foundation Conditions
3. Availability of construction materials
4. Spillway size and location
5. Roadway
6. Length and height of the dam
7. Life of dam
8. Earthquake zone
9. Cost

① Topography

The first choice of type of dam is usually governed by the topography of the site.

A low rolling plains counter suggests an earth dam with a separate spillway. A low narrow V-shaped valley suggest an arch dam. A narrow steam flowing between high rocker banks would suggest a concrete overflow dam.

② Geology and Foundation conditions

All the forces acting on the dam including its weight are transmitted to the foundation. As such the foundation conditions at the dam site need to be thoroughly investigated.

If the foundation consists of sound rock with no fault or fissures, any type of dam can be constructed on it. Poor rock or gravel foundations are suitable for earth dam, rockfill dam or low concrete gravity dam. Silt and fine sand foundations

have the problems of settlement seepage and toe erosion. Hence, such foundations are suitable only for either earth dam or low concrete gravity dam but not rockfill dams or gravity dams or rockfill dams are not suitable on clay foundations.

③ Availability of construction materials

The cost of construction of a particular type of dam depend upon the availability of the construction materials in near by area so that transportation charges are reduced.

If sand, gravel and crushed stone is easily available, a concrete gravity dam may be more suitable. If, however, coarse and fine grained soils are available an earth dam may be suitable.

④ Spillway size and location.

Spillway is a structure provided for a dam to pass surplus water or floods. It is an overflow portion of the dam. The size and type of spillway are mainly decided by the magnitude of the flood to be bypassed and its location depends on the site condition.

If a large spillway capacity is required to be provided, an overflow concrete gravity dam should be preferred. Where small spillway capacity is required and where separate site for spillway location is available an earth dam may be preferred.

⑤ Road way

If a roadway is to be passed over the top of the dam, an earth dam or gravity would be preferred.

⑥ Length and Height of dam

If the length of dam is very long and its height is low, an earth dam would be a better

choice. If the length is small, but height is more, gravity dam is preferred.

(7) Life of dam:-

Concrete or masonary gravity dams have very long life. Earth and rockfill dams have intermediate life. However timber dams are adopted only for temporary storage.

(8) Earthquake zone:-

If a dam is to be constructed in an area that is subjected to earthquake shocks, then the selection of the type of dam should be such that it is able to resist the earthquake shocks without damage.

Normally earth dam and concrete gravity dam is preferred in earthquake prone area.

(9) Cost

The overall cost of construction of dam and the cost of subsequent maintenance would often become the decisive factor in the choice of the type of dam. The cost of construction of dam is affected by the availability and price of construction materials and labour.

The initial cost of concrete gravity dam is high but subsequent maintenance cost is low. While in case of earth dam, initial cost of construction is low but maintenance cost is high.

Q-7 Explain Spillway

Spillways are important auxiliary works of dams, provided to dispose of surplus flood water safely which can not be stored in the reservoir. Spillways are invariably provided for all the dams and often called safety valve for the dam. It is necessary to provide a spillway of sufficient capacity so as to avoid the water from overtopping the dam (especially in case of earthen dam). Overtopping of earth dam may lead to failure of dam resulting in serious damage to property lives, crop field, roads, rails etc. To save damage, spillway is the only device in each dam reservoir protect.

* Location of spillway

A spillway can be located either within the body of the dam or totally away from the main dam as an independent structure. If a deep narrow valley with steep banks, seperated from a flank by a hillock is available, the spillway can be best constructed independently of the dam. Under these circumstances, a concrete or an earthen dam can be constructed across the main valley and spillway can be built independently in to the saddle (flank). A separate spillway is generally preferred for earthen dams. However, a concrete spillway is sometimes built within or at one of the ends of an earthen dam.

* Requirements of a spillway

A spillway should fulfill the following requirements

1. The spillway should have sufficient capacity.
2. The location of spillway should provide safe

disposal of water without toe erosion.

(3) spillway should be hydraulically and structure sufficient.

(4) It should possess hard bonding structure to withstand high scouring velocities created by the drop from the reservoir surface.

(5) Usually spillway should be accompanied by an energy dissipation work on its downstream side.

7 Components parts of a spillway.

The various component parts of spillway are as under.

(1) Control structure

Control structure consists of a weir which may be sharp or narrow crested, ogee shaped or broad crested. It is a major component of a spillway. It regulates and controls the surplus water from the reservoir. It does not allow the discharge of water below the reservoir level and allows only when water surface in the reservoir rises above that level.

(2) Discharge Channel

It is provided to convey the surplus water released through control structure to the stream bed below the dam safely. The discharge channel may be the down stream face of spillway itself, or open channel excavated along the ground surface or closed conduit placed through or under a dam.

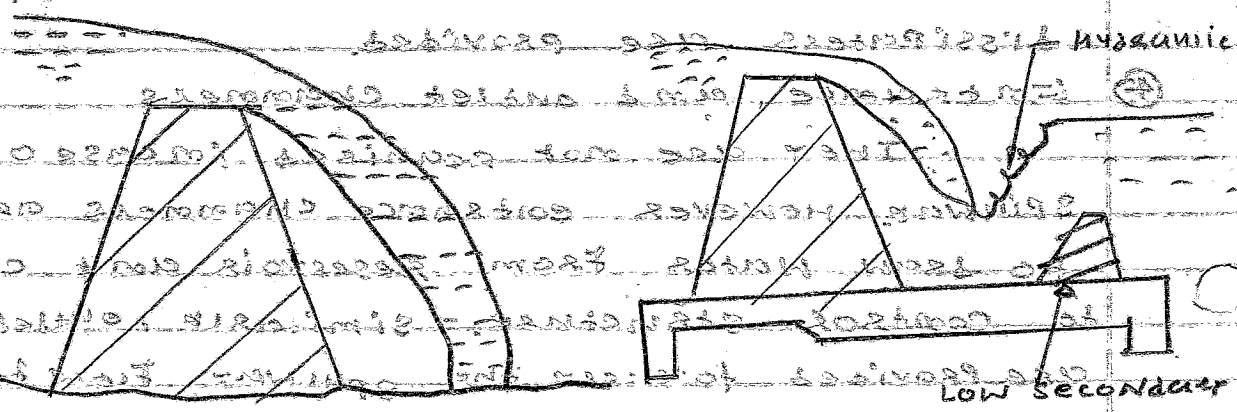
(3) Energy dissipators

They are usually provided on the downstream

side of the spillway. High velocity water coming through spillway may cause serious damage to the toe of dam and to the adjacent structures. This high energy of flow must be dissipated before it flows back to river. For this, energy dissipators are provided.

(4) Entrance and outlet channels

They are not required in case of overflow spillway. However entrance channels are provided to draw water from reservoir and convey it to control structure. Similarly, outlet channels are provided to carry the spillway flow to river channel below the dam.



Straight drop Spillway

Q.8 Give types of spillway detail with figure.

According to the prominent features pertaining to the various components of the spillway such as control structures, discharge channel etc. the spillways may be classified in the following types

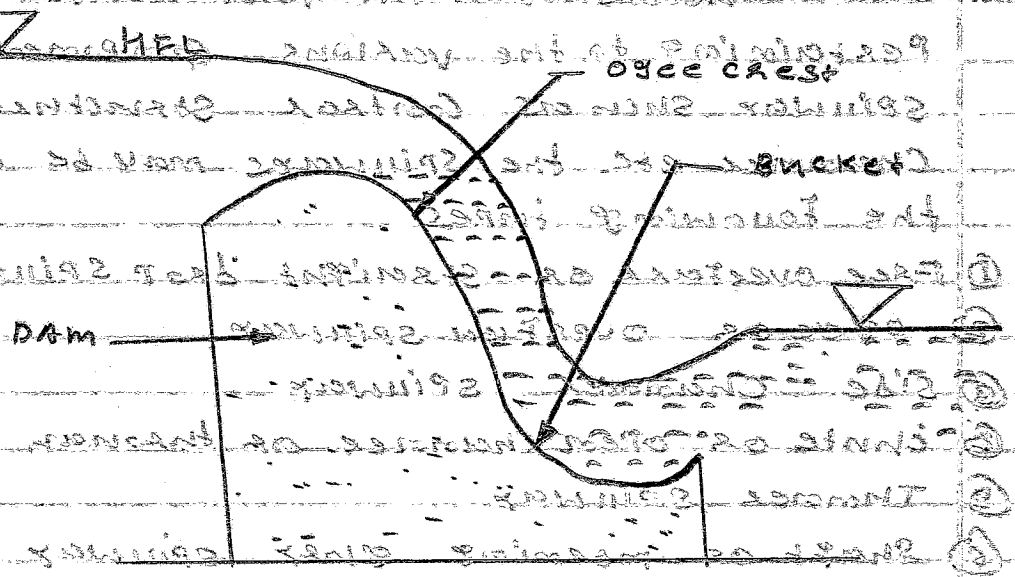
1. Free overfall or straight drop spillway
2. Ogee or overflow spillway
3. Side channel spillway
4. Chute or open channel or trough spillway
5. Tunnel spillway
6. Shaft or morning glory spillway
7. Siphon spillway

1. Free overfall or straight drop spillway

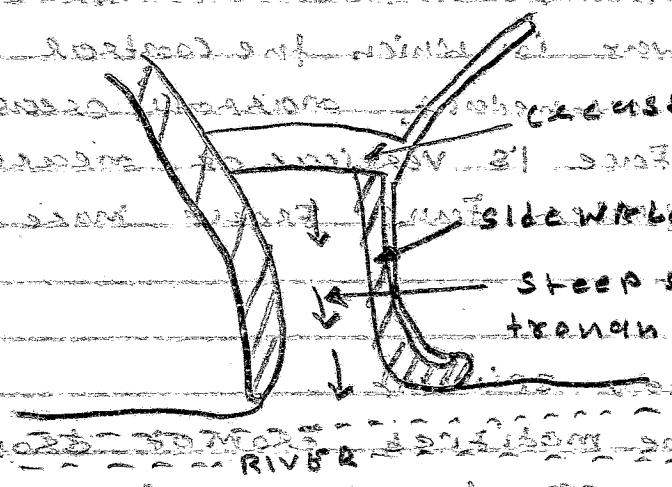
A free overfall or straight drop spillway is type of spillway in which the control structure consists of a low-height, narrow crested weir and the d/s face is vertical or nearly vertical so that the water falls freely more or less vertical.

2. Ogee or overflow spillway

It is the modified from of drop spillway suitable for high gravity dam, arch dam and buttress dam. The overflow water is guided smoothly over the crest and profile of spillway. The overflow water usually does not break the contact with the spillway surface. However the possibility of vacuum due to separation of jet and consequent cavitation cannot be neglected. As the downstream profile forms the shape of the letter "S", this



Ogee Spillway



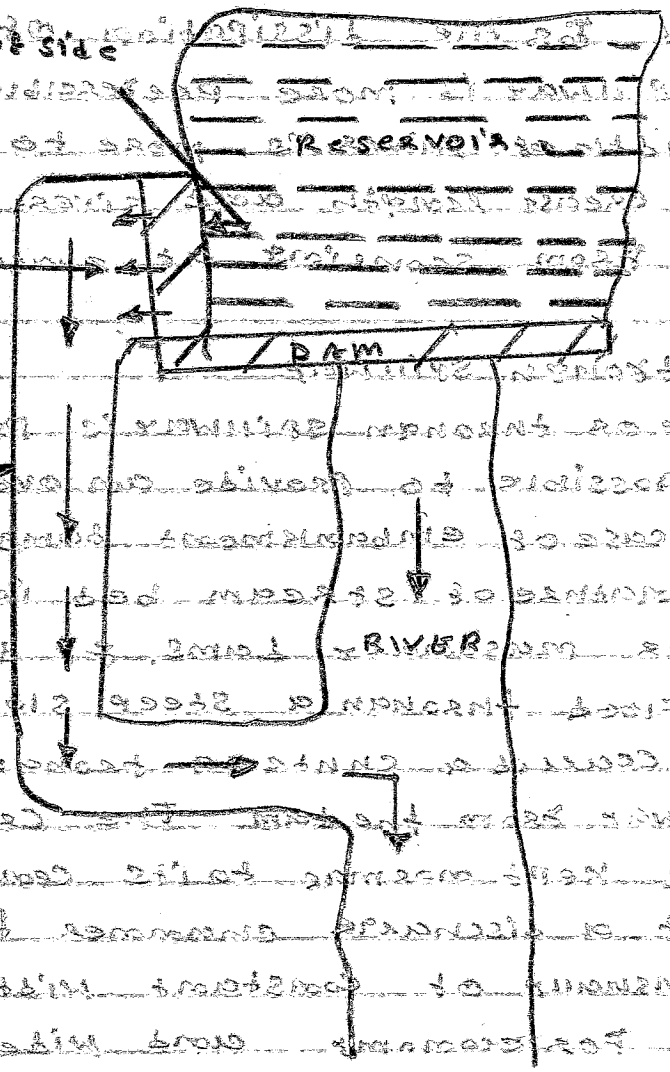
spillway is termed as ogee spillway. A bucket is also provided for the dissipation of energy. This type of spillway is more preferable on valleys where width of river is more to provide sufficient crest length and river bed can be protected from scouring at reasonable cost.

(3) Chute or through spillway

Chute or through spillway is provided when it is not possible to provide an overflow spillway such as in case of embankment dams or due to erodible nature of stream bed in case of concrete or masonary dams. It discharges the surplus flood through a steep sloped open channel called a chute or through placed in saddle away from the dam. The crest or chute spillway is kept normal to its centre line it consists of a discharge channel to the river. The chute is usually of constant width but may be narrowed for economy and widen near the end to reduce the discharge velocity.

(4) Side channel spillway

It is the spillway in which, the flow after passing over a weir or ogee crest, is carried away by a side channel. This channel runs necessarily parallel to the crest. Discharge characteristics of a side channel spillway are similar to those of an ordinary overflow spillway. It is best suited for non-rigid dam like earth or rock fill dams placed in narrow gorge and there is no place or location for



SIDE CHANNEL SPILLWAY

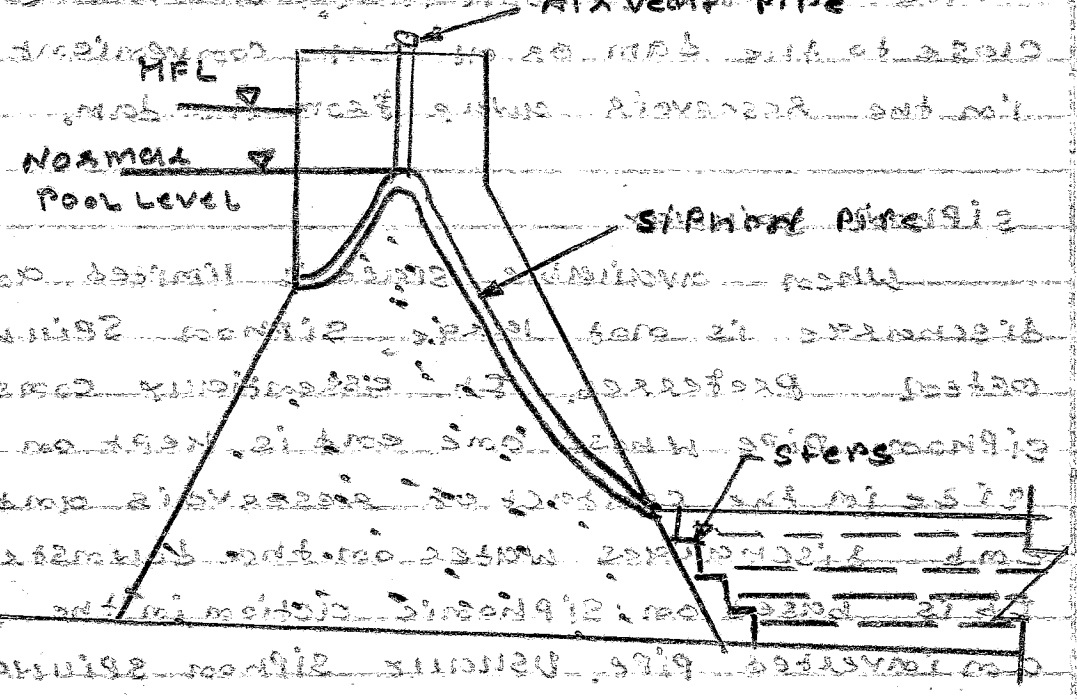
This the spillway in which the flow passing over a weir or exceedance is carried away by a side channel. This channel serves necessarily further to the crest discharge channel. In a side channel spillway the flow turns to flow on dam overflow spillway. It is best suited for narrow dam sites. Again as soon the dams built in mountain have very little space for location for

chute spillway. Sometime, spillway is situated close to the dam or at any convenient place in the reservoir away from the dam.

(5) Siphon spillway

When available space is limited and surplus discharge is not large, siphon spillway is often preferred. It essentially consists of a siphon pipe whose one end is kept on upstream side in the contact of reservoir and other end discharges water on the downstream side. It is based on siphonic action in the shape of an inverted pipe. Usually siphon spillway is provided in concrete gravity dam through its body. Air vent pipe is provided at the top of inverted U-pipe.

When reservoir is full upto normal pool level air enters the siphon through vent pipe and siphonic action can not start. Once the water rises above normal pool level, siphon gets filled with water. Now water starts flowing through siphon by siphonic action. This action will remain continue till reservoir water level falls back to normal pool level.



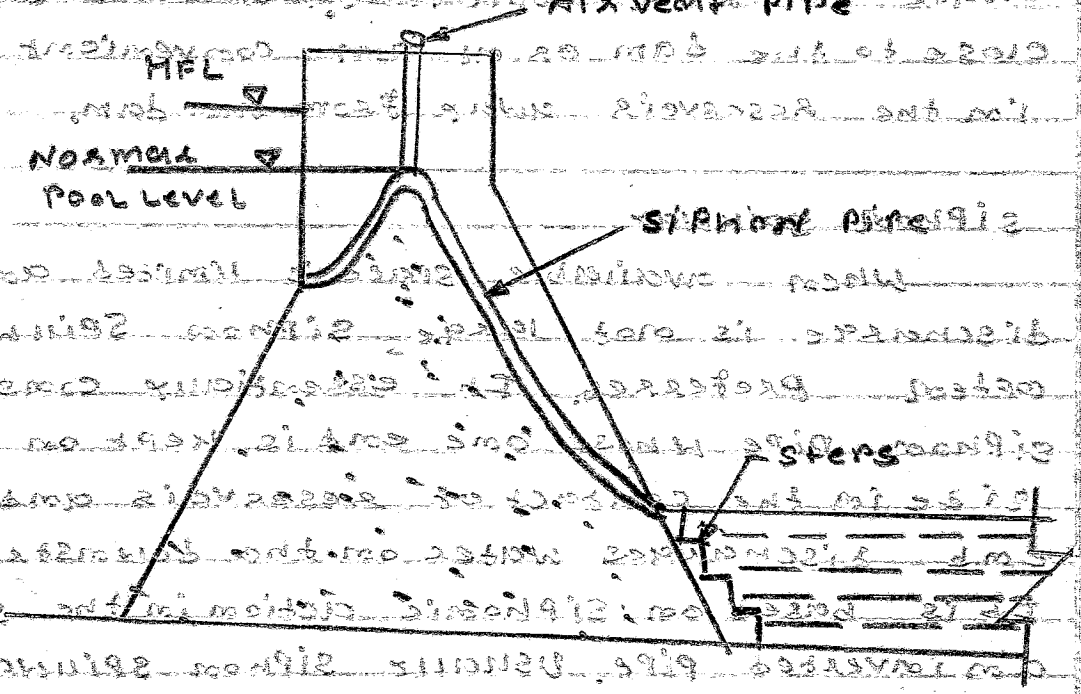
SIPHON SPILLWAY

Q.9 explain energy dissipation below spillway

water flowing over a spillway has high potential energy which gets converted in to kinetic energy as it glides along spillway. This large kinetic energy gives rise to high velocity of flow which may cause large scale scour/erosion at the downstream toe, if proper arrangements are not made to dissipate this high energy. The arrangements provided to dissipate this energy are known as energy dissipators. For general the dissipation can be achived for two ways.

① By developing a hydraulic jump :- For this hydraulic jump is made to form which dissipates the excess energy of falling water.

② By directing the jet of water using a deflector bucket or up so that jet falls away from the structure. This dissipates the energy by impact.



SIPHON SPILLWAY