UNIT-4

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~~Resource Engineering~~

Reservior planning

Investigation :—

The following investigation are required for reserviour planning

① Engineering surveys. 2. Geological Investigation 3. Hydrological Investigation

1. Engineering Surveys :

The area at the dam site is surveyed in detail and contour plan is prepared. From the plan, the following characteristics are prepared

ⓐ Area Elevation curve ⓑ storage Elevation curve

ⓒ Map of the area to indicate the land property to be surveyed.

ⓓ Suitable site selection for the dam.

1. Area Elevation & storage Elevation curves

Figure shows the typical contour plan at the reservior site. The hatched area shows the water spreaded area. The area A_1, A_2, A_3 enclosed by the successive contours can be determined with a planimeter.

The reservior capacity, or the volume of the storage corresponding to a given water level in the reservior may be calculated either by a Trapizoidal formula. or by prismoidal formula. Thus, if V is the storage volume and h is the contour interval, the formula are.

1. $V = \Sigma \frac{h}{2}(A_1 + A_2)$ ..... Trepizoidal formula

2. $= \left\{ \frac{A_1 + A_n}{2} + A_2 + A_3 \ldots\ldots A_{n-1} \right\}$

2. $V = \Sigma \frac{h}{3}(A_1 + A_2 + \sqrt{A_1 A_2})$ .... (cone formula)

3. $V = \frac{h}{3}\left[A_1 + A_n + 4(A_2 + A_4 + \ldots) + 2(A_3 + A_5 + \ldots)\right]$

..... prismoidal formula.

where A_n is the area of the Contour Corresponding to the water surface elevation in the proposed reservior. The volume corresponding to various water surface elevation may be calculated and a curve in below figure.

② Geological Investigation

Geological investigation are required to give detailed information about the following items.

1. water Tightness of reservior basin.
2. Suitability of foundation for the dam
3. Geologically and structural features such as folds faults, fissure etc. of the rocks basin.
4. Type and depth of over burden
5. Location of permeable and Suitable rocks if any
6. Ground water Conditions in the region.
7. Location of quarry sites for material required for the dam Construction and quantities available from them.

The geology of the Catchment area should also be studied since it affects the proportions of runoff percolations

The special requirement for the geology of the reservior site is that there should be no danger of serious leakage when the ground is under pressure from the full head of water in the reservior.

③ Hydrological Investigations :-

The hydrological investigation is a very important aspect of reservior planning. The capacity of the irrigation canals. The capacity of the irrigation canals and or the installed capacity of the power house will depend upon the available supplies from the reservior.

1. Study of runoff pattern at the proposed dam site, to determine the storage capacity corresponding to a given demand.
2. Determination of the hydrograph of the worst flood, to determine the spillway capacity and design.

④ Site selection of site for a Reservior

The final selection of site for a reservior depends upon the following factors.

① The geological condition of the catchment area should be such that percolation losses are minimum and maximum runoff is obtained.

② The reservior site should be such that quantity of leakage through it is a minimum. Reservior site having the presence of highly permeable rocks reduce the water tightness of the reservior. Rocks which are not likely to allow passage of water includes shales and slates, schists, gneisses and crystaline igneous rocks such as granite.

③ Suitable dam site must exist the dam should be founded on sound watertight rock base, and percolation below the dam should be minimum. The cost of the dam is often a controlling factor in selection of a site.

④ The reservior basin should have narrow opening in the valley so that the length of the dam is less.

⑤ The cost of the real estate for the reservior, including road, railroad dwelling relocation etc. must be as less as possible

⑥ The Topography of the reservior site should be such that it has adequate capacity without submerging excessive land and other properties.

⑦ The site should be such that a deep reservior is formed a deep reservior is preferable to a shallow one because of

(i) lowest cost of land submerged per unit of capacity

(ii) less evaporation losses because of reduction in the water spread area and (iii) less likelyhood of weed growth

⑧ The reservior site should be such that it avoids or excludes water from those Tributeries which carries a high percentage of silt in water.

✱ Zones of Storage :-

The following are the various zones in reservior

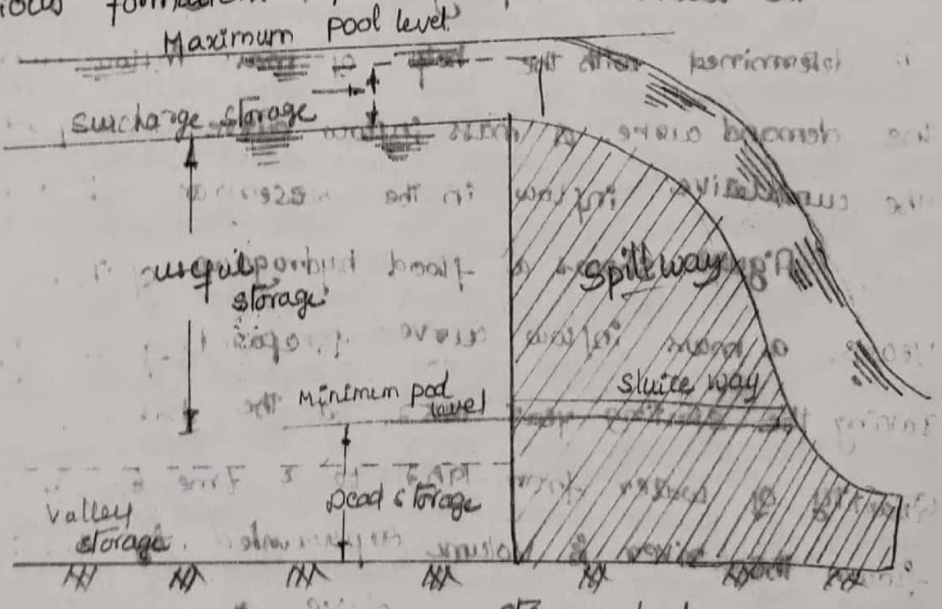
1. useful storage
2. Dead storage
3. valley storage
4. surcharge storage
5. Bank storage

The maximum level to which the water will rise in reservior during ordinary operation condition is called normal pool level. The normal pool level is corresponding to either

(3)

r. spillway crest, or to the top level of spillway gates. The level to which water rises during the design flood is known as the maximum pool level. The lowest elevation to which the water in the reservoir to be drawn under ordinary operating conditions is known as maximum pool level.

The volume of water stored between the normal pool level and maximum pool level is known as the useful storage. The volume of water below the minimum pool level is known as the dead storage. and is not useful under ordinary condition. The volume of water stored between the normal pool level and maximum pool level corresponding to a flood is called surcharge storage. The terms bank storage and valley storage are referred to the volume of water stored in the pervious formations of the river banks and the soil above it.



Zones of storage

* Storage capacity and yeild

yeild:- yeild is the amount of water that can be supplied from the reservior in a specified interval of time. The interval of time chosen for the design varies from the day for small distribution reservior to a year for 6 ge Conservation reservior. For example, if 25000 cubic metres of water is supplied from a reservior in one year, its yeild is 25000 cubic metres/year or 2.5 hectare - metres per year.

* **Safe yeild or firm yeild** :— The maximum Quantity of water that can be guaranteed during a critical dry period is known as the safe yeild or firm yeild.

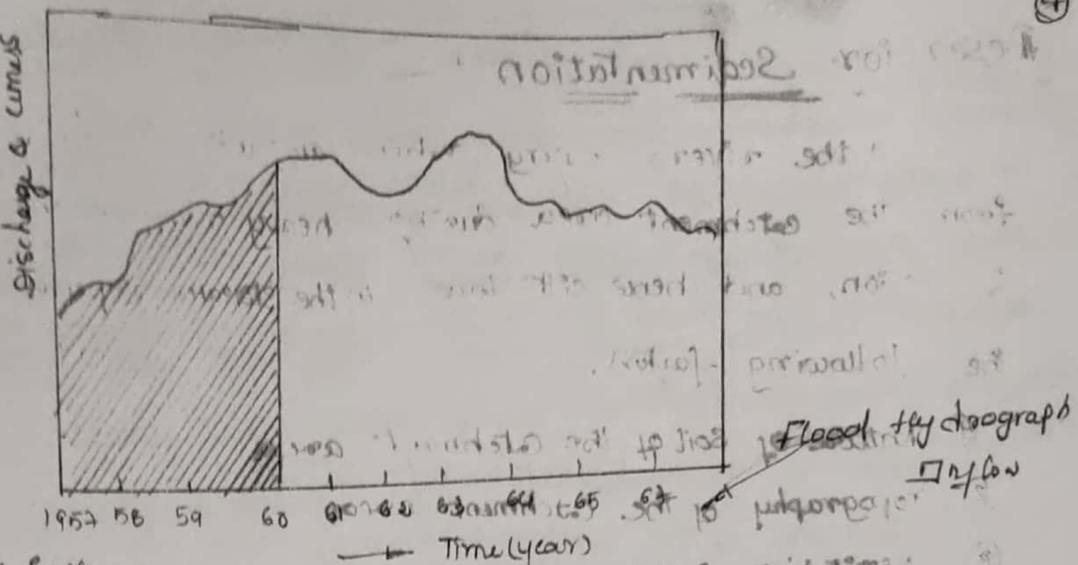
* **Secondary yeild** :— It is the Quantity of water available in excess of safe yeild during periods of high floods.

* **Average yeild** :— The arithmetic Average of the firm and secondary yeild over a long period of Time is called Average yeild.

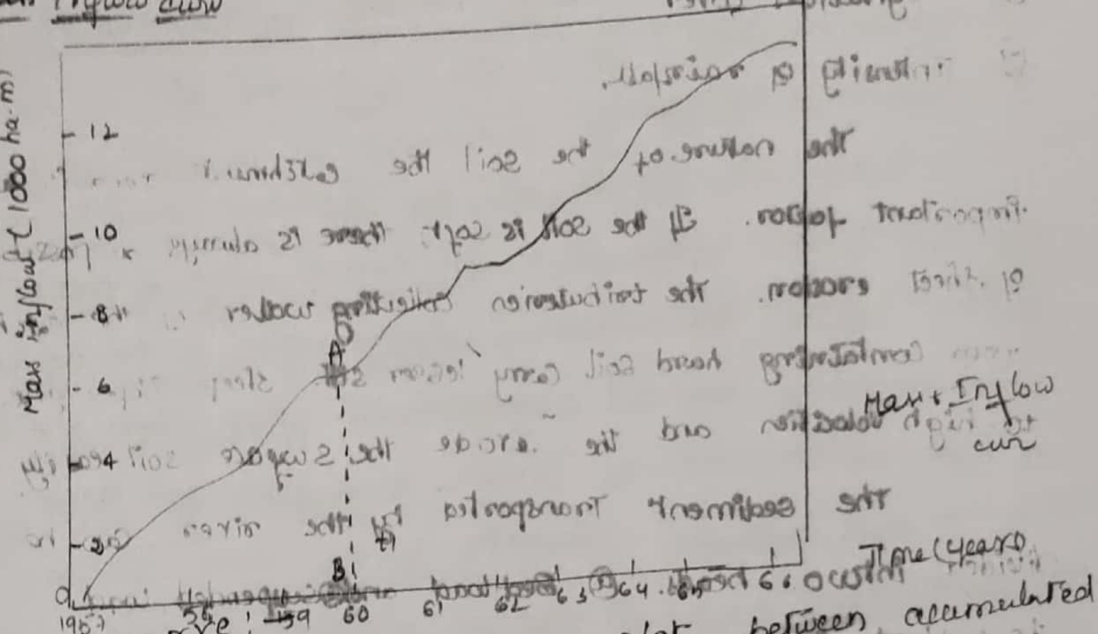
Mass Inflow curve :—

The reservior capacity corresponding to specified yeild is determined with the help of mass inflow curve and the demand curve. A mass inflow curve is a plot between the cumulative inflow in the reservior with time.

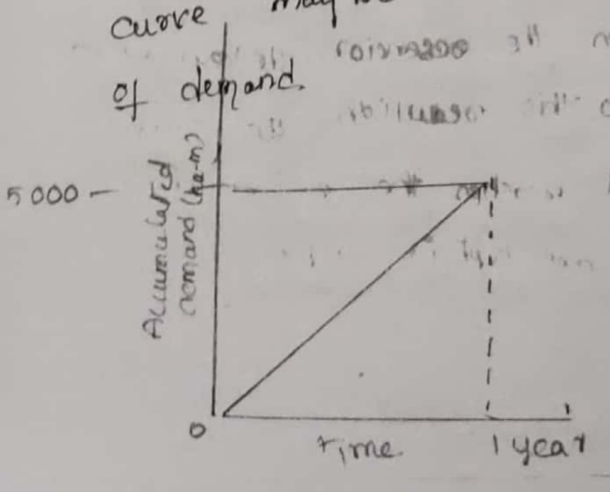
Figure shows a flood hydrograp of inflow for several years. a mass inflow curve prepared from flood hydrogr Taking the starting year 1957 at the base. The Total Quantity of water from 1957 to a time t_1 that has flown the river is volume represented by the hatched area. In the mass inflow curve the corresponding Ordinate at time t_1 will therefore, be Equal to the volume of water indicated by the hatched area. similarly the ordinates of the mass inflow curve corresponding to other can be computed from A fig. and plotted

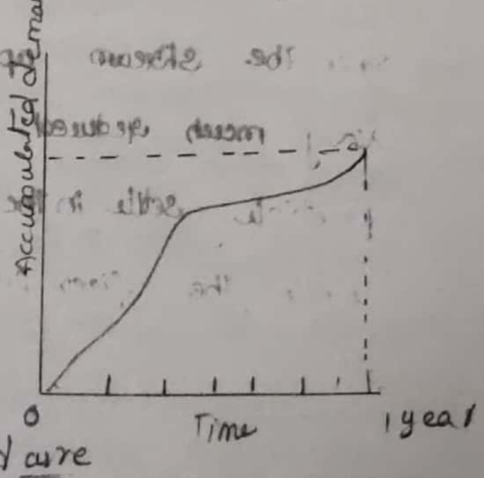


Mass inflow curve



Demand curve: A demand curve is a plot between accumulated demand with time. The demand curve representating a uniform rate of demand is a straight line having the slope equal to the demand rate. A demand curve may be curved also indicating variable rate of demand.





Demand curve

Reservior Sedimentation :—

All the rivers carry certain amount of silt eroded from the catchment area during heavy rains. The extent of erosion, and hence silt load in the stream depends upon the following factors.

1. Nature of soil of the catchment area
2. Topography of the catchment area
3. vegitation cover
4. Intensity of rainfall.

The nature of the soil the catchment area is an important factor. If the soil is soft, there is always a possibility of sheet erosion. The tributeries collecting water of the catchment area containing hard soil carry lesser silt. steep slopes give rise to high velocities and the erode the surface soil easily.

The sediment Transported by the river can be divided in two heads. (a) Bed load and (b) suspended load

The bed load is dragged along the bed of the stream. The suspended load is kept in suspension load is kept in suspension because of the vertical component of the eddies formed due to friction of flowing water against the bed. The bed load is generally much smaller - 10 to 15 % of suspended load.

when the stream approaches the reservior the velocity is very much reduced. Due to this reduction the coarse particle settle in the head reaches the reservior. while the finer particles are kept in suspension

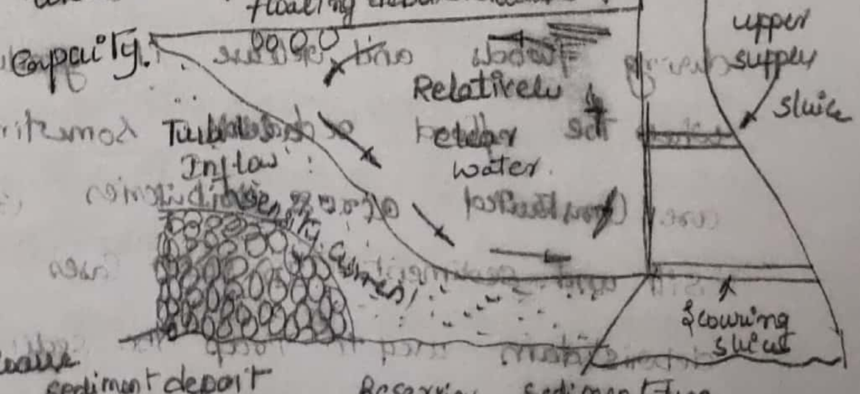
* **Density currents :-** Density current may be defined as gravity flow of fluid under another fluid of approximately equal density. In case of reservior the water stored is usually clean and the inflow during the flood is generally muddy. The two fluids have therefore different densities. The heavy turbid water flows along the channel by gravity as shown. This is known as density current.

* **Measurement of sediment load :-**

The amount of silt or the sediment load carried by the stream is determined by taking the sample of water carrying silt at various depth. The sample are then filtered and the sediment is removed and dried. The sediment load measured in the units of parts per millions parts of water (ppm).

* **Life of Reservior :-**

The ultimate density of a reservior is to be filled with silt deposits. To allow silting, a certain percentage of total storage is usually left unutilised and is called dead storage. However the time passes on more and more silting takes place and the live or effective storage is gradually reduced. The useful life of reservior is terminated when its capacity is reduced to 20% of the designed capacity.



Reservior sedimentation.

Types of Dams :—

A dam is hydraulic structure constructed across a river to store water on its upstream side.

Classification according to use :—

① Storage dam ② Diversion dam ③ Detension dam

① **Storage Dam :**— This is most common type of dam. normally constructed to impound water to its upstream side during the period of excess supply in the river and is used in periods of deficient supply. Behind such a dam a reservior or lake is formed. The storage dam may be constructed for various purposes such as irrigation, water power, irrigation or for water supply for public health purpose or it may be for a multipurpose project.

② **Diversion Dam :**—

The purpose of a Diversion dam is essentially different. while storage dam stores water at its upstream for future use, a diversion dam simply rises water slightly in the river and thus provide head for carrying and diverting water into ditches, canals or other conveyence systems to the place of use.

③ **Detension dam :**—

A detension dam is constructed to store water during floods and release it gradually at safe rate when the flood recedes. Sometimes detension dams are constructed across tributaries carrying large silt and sediment. In such cases it is knows as a debris dam used to trap the sediment and thus to exclude the Sediment to flow to the main reservior formed on the main river to which the Tributary meets.

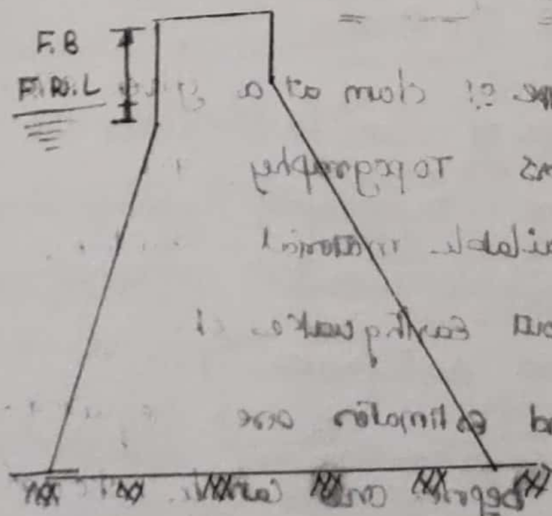
II Classification According to Design

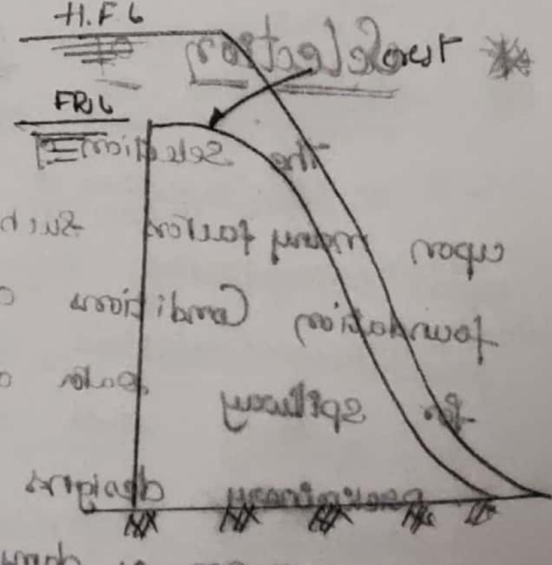
① Non over flow ② overflow:

1. Nonoverflow:— A non overflow dam is one in which the Top of the dam is kept at a higher elevation then the maximum expected high-flood level. water is not permitted to overtop the dam. Hence the non over flow dam may be Constructed of wide variety of material such as earth rockfill masonry concrete.

② overflow dam:—

A overflow dam is the one in which is designed to carry surplus discharge over its crest. Its crest level is kept lower then the Top of the other portion of dam. since water glides over its downstream face it should be made of such material which is not easily eroded by flowing water.





iii. Classification according to material :

According to the most common classification the dams may be classified as

① Rigid dams ② Non rigid dams

① **Rigid dams** : Rigid dams are those which are constructed of rigid material such as masonry, concrete, steel or timber.

Rigid dams may further be classified as

① Solid masonry or concrete dams

② Arched masonry or

3. Concrete Buttress dam

4 Steel Dam ⑤ Timber dam.

② **Non rigid dam** :

Non rigid dams are those which are constructed of non rigid material such as earth and/or rockfill.

The most common type of rigid dams are

① Earthfill dam ② Rockfill dam ③ Combined earth & rockfill dam.

* Selection of Type of Dam :

The selection of type of dam at a given site depends upon many factors such as topography, geological and foundation conditions, available material, suitable site for spillway, data about earthquake etc.

preliminary designs and estimates are required for several types of dams before one can be shown to be the most economical. The choice of a dam may also be guided by many local problems such as availability and labour and equipment.

* Topography ;— The first choice of dam is usually governed by the Topography for the site. A low rolling plains Country suggests an earth dam with a separate spillway A low narrow V-shaped valley suggests an arch dam, provide the Top width of valley is less than one-fourth of height and separate site for spillway is available

& Geology and foundation Condition :—

The next important factor is the geology and foundation Condition. If the foundation Consists of, sound rock with no fault or fissures, any Type of dam Can be Constructed on it. The removal of disintegrated rock Together with the sealing of seams and fractures by grouting will frequently be necessary. poor rock or gravel foundation for earth dam, rockfill dam or low Concrete gravity dam. silt or fine sand foundation have the problems of settlement dam or low Concrete gravity dam but not rockfill dam. Hence earth dams are suitable with foundation Treatment

* Materials of Construction :—

The next important factor is the availability of materials of construction for dam. The cost of construction of a particular Type of dam will depend upon the availability of the materials in the nearby area so that Transportation dam may be suitable. If however carse and fine grained soils are available an earth dam may suitable.

* spillway size and location :—

The safe discharge of flood water through dam is very essential. and for that suitable site for spillway should be available If The area is such that a large spillway capacity is required an overflow Concrete gravity dam should be preferred. where large discharges are to desired during the construction of dam. a Concrete gravity dam is preferred To an Earth dam.

* **Roadway:** If a roadway is to be passed over Top of the dam, an earth dam or gravity dam would be preferred.

* **Length and height of dam:** If the length of the dam is very long and its height is very low an Earth dam would be a better choice.

* **Life of a dam:** Concrete or masonry gravity dam have very long life. Earth and rockfill dams have intermediate life.

Selection of site for a dam:—

1. **Foundations:** suitable site foundation site should be available at the site selected for particular Type of dam. For gravity dam sound rock is essential. For Earth dams any types of foundation is suitable with proper Treatment.

② **Topography** :— The river cross section of at the dam site should have preferably have a narrow gorge to reduce the length of the dam. However the gorge should open out upstream to provide large basin for a reservior

③ **Site for spillway**: — Good site for the location for a separate spillway is essential especially in the case of earthfill or rockfill dam. However, in the case of Gravity dam, spillway maybe located at its middle. The best site for a dam may be considered to be one where a deep gorge and a flank at its sides are separated by hillock higher then the height of the dam

④ **Material** :— Materials required for a particular Type of dam should be available nearby, without requiring much of Transportation. This would very much reduce the cost of Construction.

⑤ **Reservior and Catchment Areas**: —
(i) The side should ensure adequate storage capacity of reservior basin at a minimum cost.
(ii) The cost of land and property submerged in the water spread area should be minimum.
(iii) The reservior site should be such that quantity leakage through its side and the bed is minimum.
(iv) The geological condition of the catchment area should be such that percolation losses are minimum and maximum runoff is obtained.
(v) The reservior site should be such that it avoids or excludes water from those Tributaries which carry a high percentage of silt in water

⑥ Communication :- It would be preferable to select a site which is connected by a road or rail link or can be conviniently connected to the site for transportation of cement, labour machinery food and other equipment.

⑦ Locality :- The surroundings near the site should preferably be healthy and free of mosquitoes etc. as labour and staff colonies have to be constructed near the site.

Gravity Dams

A gravity dam is a structure so proportioned that its own weight resists the forces exerted upon it. This type of dam is the most permenant one requires little maintanance and is most commonly used.

Forces acting on a gravity dam :—

Following are the forces acting on a gravity dam

1. water pressure
2. uplift pressure
3. weight of the dam
4. pressure due to earthquake
5. Ice pressure
6. wave pressure
7. silt pressure
8. wind pressure.

1. Water pressure :—

This is the major external force acting on a dam. when the upstream face of the dam is vertical, the water pressure acts horizontally. The intensity of pressure varies triangularly with a zero intensity at the water surface to a value what any depth h below the surface. when the upstream face is partly vertical and partly inclined.

Scanned by CamScanner

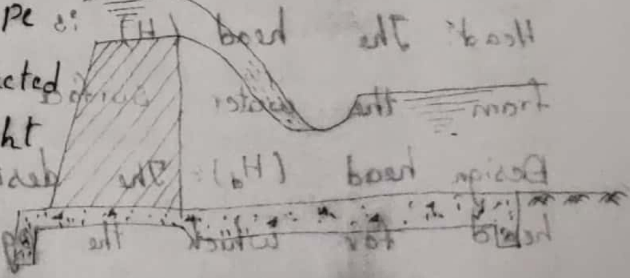
SPILLWAYS

A spillway is the overflow portion of dam, over which surplus discharge flows from the reservoir to the downstream. A spillway is therefore called as surplussing work, designed to carry this flood water not required to be stored in the reservoir, safety to the river lower down. Spillways are invariably provided for all storage and detention dams. Ordinarily, this surplus water is drawn from the top of the pool created by the dam. Spillways are very important structures; many failures of the dam have been caused by improperly designed spillways or by spillways of insufficient capacity. A spillways is thus the safety valve for a dam.

Main types of spillways:-

1. Free overfall or straight drop spill way
2. Side channel spillway
3. chute or open channel or trough spillway
4. Ogee or over flow spillways
5. Conduit or tunnel spillway
6. Drop inlet or shaft or morning glory spillway
7. Siphon spillway.

1. straight drop spillway:-

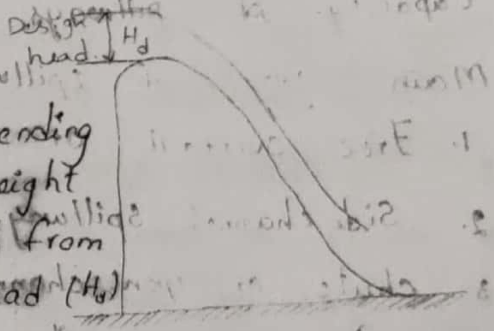


This is the simplest type of spillway which is constructed in the form of a low height weir having d/s face either vertical or nearly vertical. water drops freely from the crest & the underside of the falling nappe is ventilated sufficiently to prevent a pulsating, fluctuating jet. Occasionally, the crest is extended in the form of an overhanging lip to direct the small discharge away from the face of the overfall section.

Ogee or Overflow spillway:-

This is the most common type of spillway provided on gravity dams. The profile of the spillway is ogee or S shaped. The overflowing water is guided smoothly over the crest profile of the spillway so that the overflow water doesnot break contact with the spillway surface. If it is not assumed, a vacuum may form at the point of separation & cavitation may occur. In addition to cavitation, vibration from the alternate making and breaking the contact b/w the water & face of the dam result in serious structural damage.

High overflow spillway:-



Overflow or ogee spillways are classified as high & low depending on whether the ratio of the height (P) of spillway crest measured from the river bed to the design head (H_d) is greater than, & equal to or less than 1.33 respectively. In case of high overflow spillways, the velocity of approach head (H_a) which is generally of the order of 0.04 H or less may be considered negligible.

Head: The head (H) is the distance measured vertically from the water surface to the crest axis.

Design head (H_d): The design head is that value of head for which the ogee profile is designed.

Head due to velocity of approach (H_a): It is the velocity head given by $H_a = V_a^2/2g$, where V_a = velocity of approach.

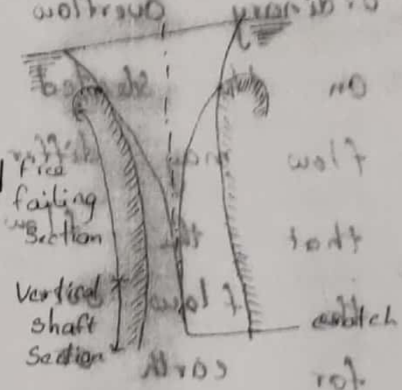
Total energy head (H_e): It is equal to the actual head plus the head due velocity of approach. Thus

$$H_e = H + H_a$$

Conduit or tunnel spillway:-

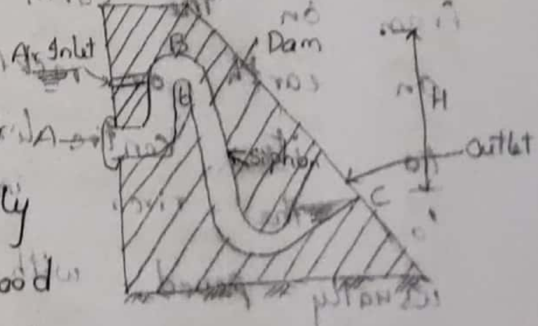
Conduit spill way or tunnel spillway is the one in which a closed channel is used to convey the discharge around or under a dam. The closed channel may be in the form of a vertical or inclined shaft a horizontal tunnel through earth dam or a conduit constructed with open cut and backfilled with earth materials.

Shaft spillway:-



Shaft spillway, drop inlet spillway or morning glory spillway is the one which has horizontally positioned lip through which water enters and then drops through a vertical or sloping shaft and then to a horizontal conduit which convey the water past the dam. A shaft spillway can often be used where there is inadequate space for other types of spillways. It is generally not desirable to use a spillway over or through an earth dam. Thus on an earth dam location, if there is no enough space or if the topography prevents the use of a chute or side channel the best alternative would be to use shaft spillway.

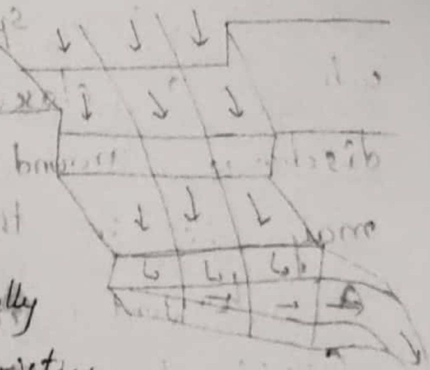
Saddle siphon spillway:-



The fig shows two types of saddle syphons, the former being more common. It especially consists of reinforced concrete hood constructed over an overflow section

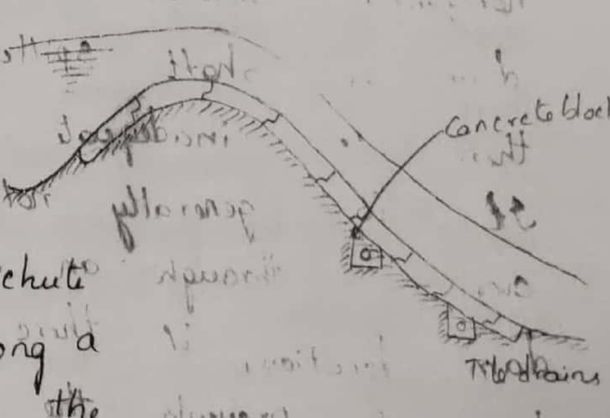
If $H = H_d$, $H_{ed} = H_d + H_a$

Side channel spillway:



A side channel spillway is the one in which the flow, after passing over a weir or ogee crest, is carried away by channel running essentially parallel to the crest. Discharge characteristics of a side chamel spillway are similar to those of an ordinary overflow spillway and are dependent on the dependent on the selected profile of the weir crest. However, this flow may differ from that of overflow spillway in that the flow in the trough may partly submerge the flow over the crest. Side channel spillway is suitable for earth or rockfill dams in narrow canyons and for other situations where direct over flow is not permissible.

Chute or through spillway:-



A chute spillway is the one which passes the surplus discharge through a steep sloped open channel, called a chute or trough, placed either along or isolated from the main dam. Generally, this type of spillway is provided on earth or rockfill dam, and is isolated from the earth or rockfill dam. Its crest is kept normal to its centre line. It consist of a discharge channel to the river in an excavated trench which is usually paved with concrete in whole or in part.

a gravity dam. The inlet or mouth of the main hood is kept submerged in water so that floating debris etc., do not enter the siphon. A small deprimer hood is kept above the main hood and both these hoods are connected through air vent.