unit-I

EARTH DAM ⇒

EARTH Dam is hydrulic structure which is Constructed to accoss of river to store water on the upstream side. it is generally built with locally available ~~material~~ Earthen material.

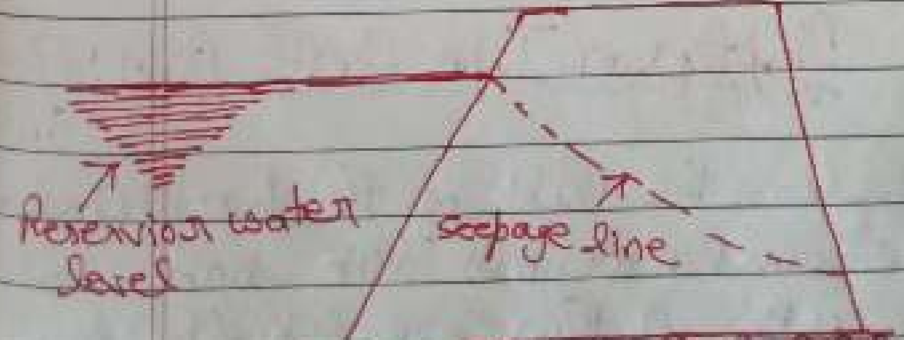
Type of Section of EARTH DAM :⇒

EARTH Dam may be Classifed into Three main Categories.

(I) Homogeneous type Earth Dam
(II) Zoned type Earth DAM
(III) Diaphgram type Earth DAM

① Homogenous Earth DAM :⇒

Expecting the Slope A purley homogenous type Earth dam is Composed ~~with~~ of single kind of material. these dam are wholly built of imperviou or semi- impervious soils.



Purly Homogenious Earth DAM

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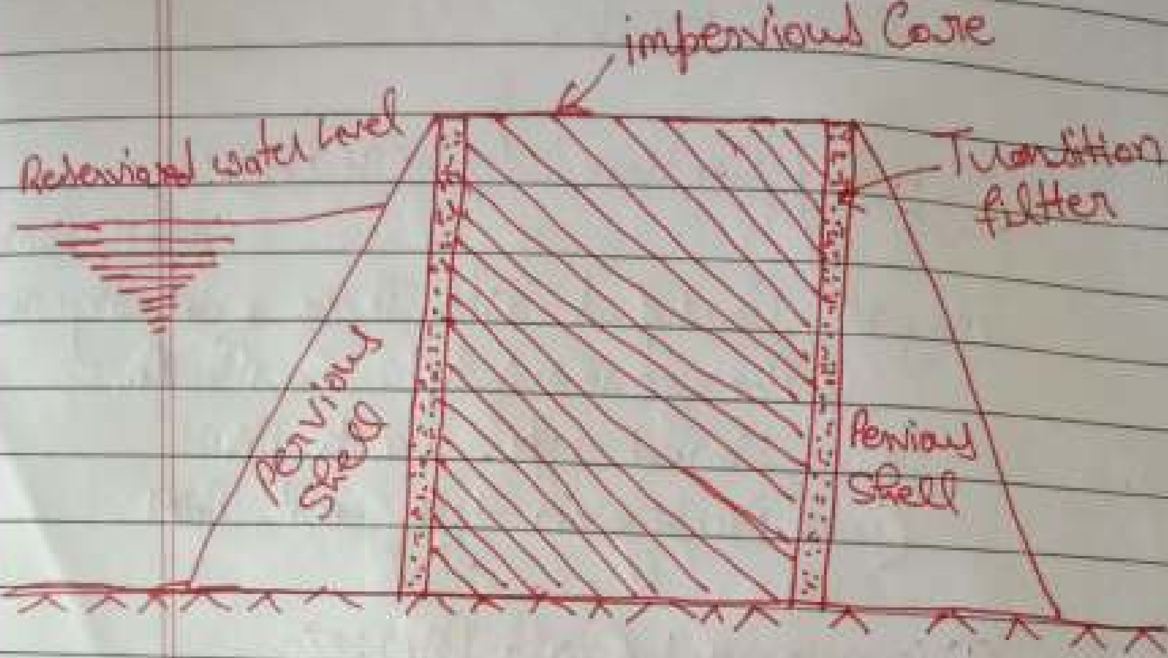
(2) Zoned Type EARTH DAM ⇒

A Zone type earth dam is Compased of more than one Kind of Material. This is the most Common type of Soilbed filled Dam.

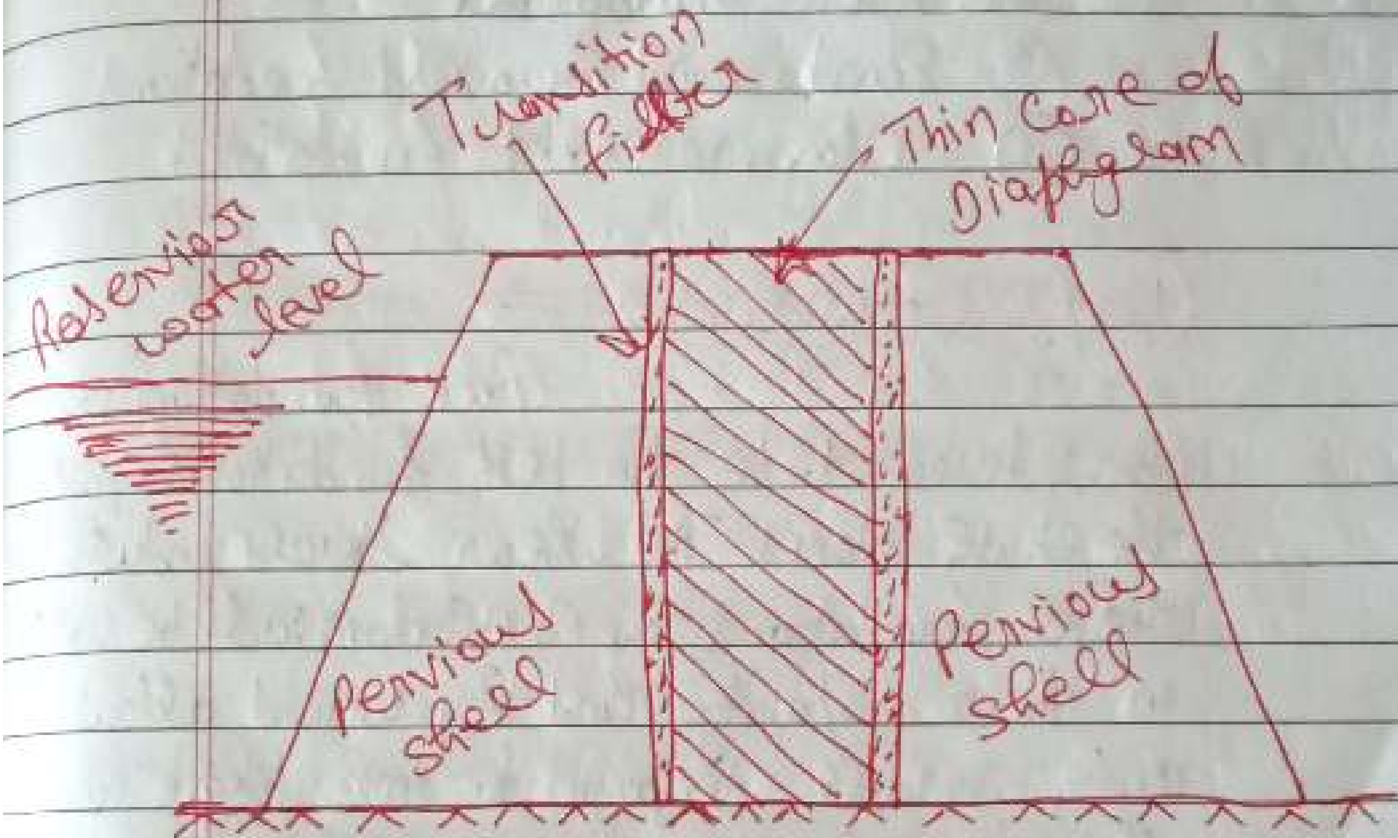


Zone Type of Earth DAM with Centre vertical Core

In this ~~type~~ of Dam, A central vertical Core of impervious material is protected two zone of pervious materials.

(3) Diaphgram Type Earth Dam :⇒

In a Diaphgram, the Bulk of the dam is Constructed of pervious materials like sand, gravels or rocks. A thin Core, usually known as diaphgram of impermiable materials is provided to check seepage. These dam are also known as thin core dams.



Thin Core Diaphgram Dam

A Diaphgram type Earth Dam is usually Consturcted whare, there is ample supply of pervious material and limited supply of suitable soil is aveilable.

Various Type of foundation of Earth Dam :⇒

The different Type of foundations Can be adopted for Earth dams:-

1. Rock foundations
2. Sands and Gravels foundations
3. Clay materials foundations

(1) Rock foundations :⇒

Rock foundation are Considered to be the best foundations for the Earth dams. The shear Stress induced in these foundations by Earth dam will be with in their Capacity and they would allow only small seepage to take place under the dam. In some Cases, grouting may be required if there is some permiable strea present in the foundation rock. If it is not ~~grouted~~ grouted. it would result in erosive seepage and excessive loss of water.

(2) Sands and Gravels foundations :⇒

Sands and gravels foundations also gives no trouble from the point of view of Stability. These soils are highly permio which permit the excess water to be drained out, which is present in to voids of to soil and hence these soils Consolidated very rapidly. since increase in the shear strength of a soil depends upon the route of Consolidations of that soil.

The shear strength of these soil increase simaltansouly with Construction of the dam. Hence the shear stress induced in these soils by the load of the dam are mostly with in two increa shear strength of these soil.

The main problem with sand and gravel foundation is that they are highly pervious and seepage descharge them is undersibly high. However, By using verious method of seepage contro the quantity of seepage can be reduced to a Considerable extent

(3) Clay Material foundations :⇒

Clay foundations requires attentions, since they are most susceptible to shear failure. The clay have lower rate of Consolidation. When a dam is Constructed on a Clay foundations, due to the lower rate of Consolidation. The shear strength of the soil increase at a slow rate. Hence the shear stress induced in the soil by the load of the dam may exceed the shear strength of the soil which may result in the failure of the dam.

So, it is neccesary to ensure that the foundations shear stress are less than the shear strength of the soil, for this, a flat slop is provided to the dam.

Causes of failure of Earth Dam ⇒

Earth Dam are less Rigid and more suceptible to failure, Earthen dam may fail like other Engg. structure due to improve design, faulty Construction like of maintenence. There are mainly three type of failure generally accured in the Earth dam.

1. Hydrulic failure
2. seepage failure
3. structural failure

(1) Hydrulic failure :⇒

About 40% of Earth dam failure have been occured due to these causes.

The failure under this category, may occures due to the following reasons.

(a) By over Topping ⇒

The water may overtop the dam if the design flood is under estimated or if the spillway is of insufficient capacity or the spillway gates are not properly operated. Therefore sufficent freeboard should be provided as an additional safety measure.

(B) Erosion of upstream face ⇒

The waves developed near the top water surface due to the wind try to cut the soil from the upstream face. To avoid this stone pitching done on the upstream face of the dam.

(C) Cracking due to frost Action ⇒

frost in the uper section of the dam may cause heaving and cracking of the soil. An additional freeboard allowances upto maximum 1.5m should be provided to dam in the areas of low temperatures.

(2) Seepage failure ⇒

Controlled seepage or limited seepage is invertible in the dam and ordinary it does not produce any harm. But if it is uncontrolled or concentrated through the drain body or foundation. It will causes a serious damage more than 1/3rd of the Earth dam have failure because of this reasons.

(a) Piping Through foundations ⇒

When highly permeable materials like causes sand and gravels are presented in the foundation of the dam. Water may start seeping at a huge rate through them. This concentrated flow at a high rate may erode the soil. Due to this the dam may sink down and causing its failure.

(B) Piping through the Dam Body ⇒

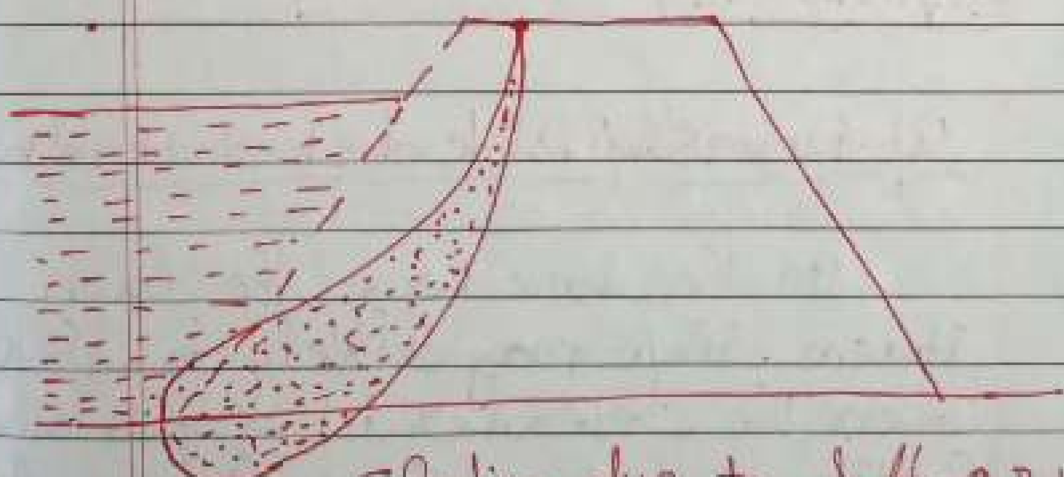
When the concentrated flow channels developed in the body of the dam, soil may be removed in the same as in the foundation piping, leading to the foundation of hollows in the dam body. These flow channels may be developed due to faculty construction / insufficent compaction. All these causes may be removed by better construction and better maintenance of the dam embankments by steep failure causing slides.

(3) Structural failure :=>

(a) foundation side slide =>

when the foundation of the earth dam are made of soft soil. Such as fine silt, soft clay etc. The earth dam may slide over the foundations.

In this type of failure the top of the embankment get cracked and sub-sides, the lower slop moves outward forming large mud waves near the heal.

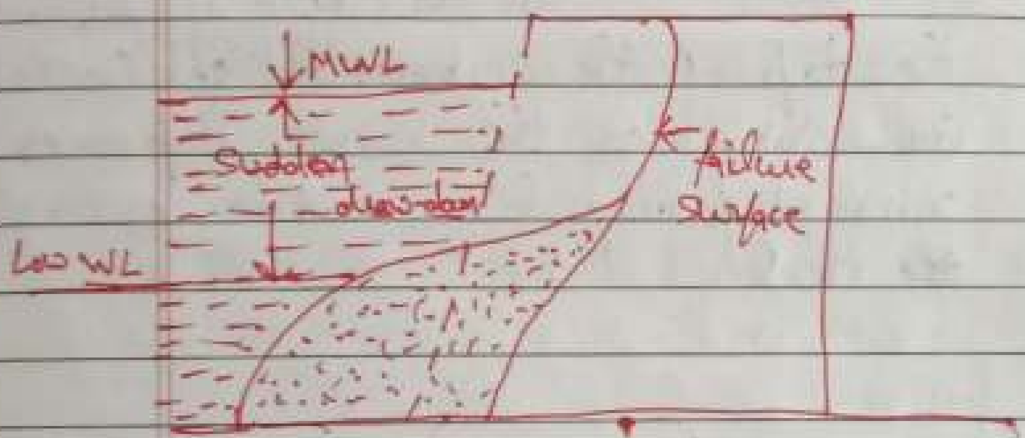


Sliding due to soft or week foundations

(b) Slide in the Embankments ⇒

When the Embankment slopes are too steep for the strength of soil they may slide causing Dam failure.

The most critical condition of the slide of the upstream slope is the sudden-draw-down of the reservoir.



Upstream Slope slide due to sudden draw-do[wn]

In the same way, the down stream slope may likely to slide when the reservoir is of full and continous seepage construction or after construction during the process of consolidation.

Criteria for the Safe Design of Earth Dam ⇒

① A fill of sufficiently low permeability of may be developed out of the available materials. Borrow pits should as close to the dam site as possible, so as to reduce the loads.

② Sufficent spillway and outlet capacities should be provided so as to avoid the possibilites of overtopping during design flood.

③ Sufficent freeboard must be provided for wind setup wave action, frost action and Earthquake motions.

④ The seepage line should be remain wall with in the clean shown face of the draw so that, no sloying of the face occurs.

⑤ There is a little beref in the seepage through a flood Control dam if the stability of the foundations and Enbankment is not improved.

⑥ There should be no possibility of free flow of water from the upstream to the downstream face.

⑦ The upstream face should be properly protected against wave action and for downstream face against the rain.

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(8) The upstream and downstream slopes should be stable under most critical condition of loading.

(9) The u/s and d/s slope should be flat enough, as to provide sufficent bases at the foundation level such that the maximum shear stress developed remains well below the corresponding maxi shear strength of the soil.

Control of Seepage through the Embankment of the Earth Dam ⇒

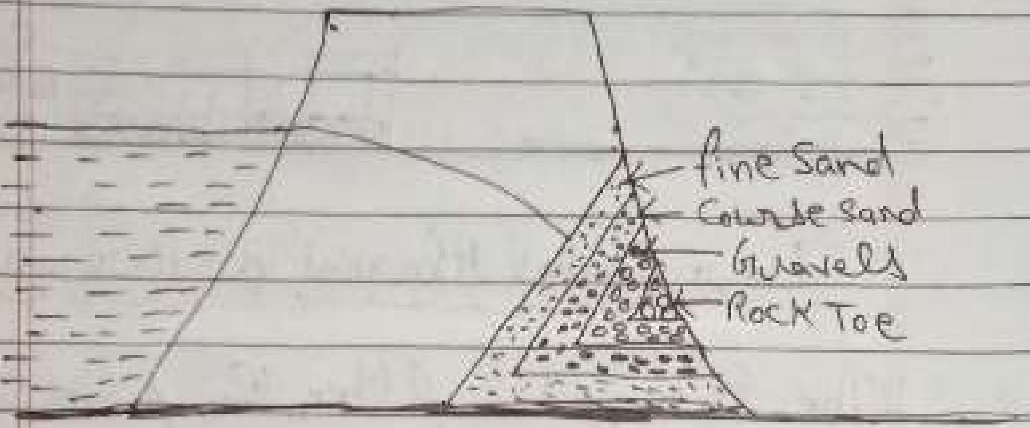
In order to control the seepage through the embankment, drainage filter, or drain, generally provided. The provision of such filter reduce the pore pressure in the downstream portion of the dam and increase the stability of the dam.

The various kind of drain which are commonly used are described below: ⇒

(1) Rock Toe or Toe filter ⇒

The rock Toe consist of stones of size

usually from 15 to 20 cm. A Toe filter is provided as a tradition zone

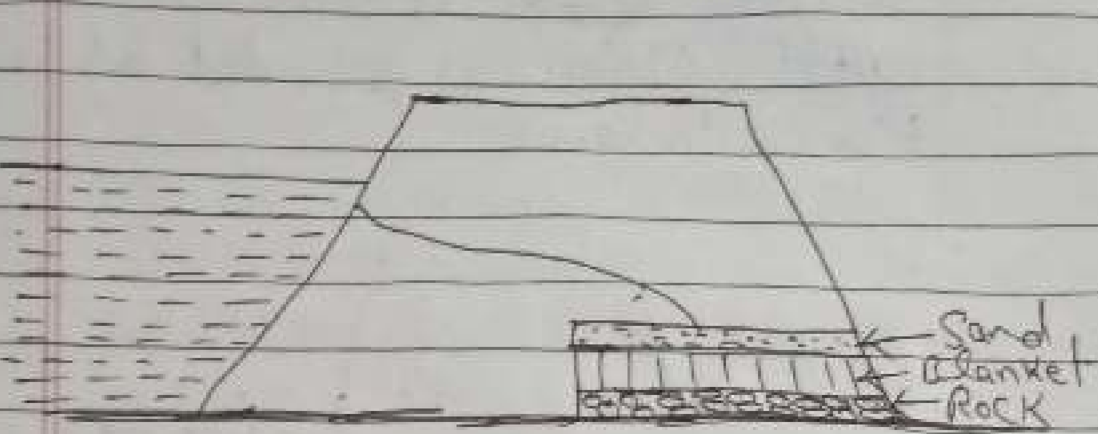


Toe filter

between the homogenous, Embankment fill and Rock Toe. The filter Consists of the three layes of fine Sand, Course Sand and gravel as per the filter Criteria requirement. The height of the toe filter generally kept b/w 25 to 35 % of reservior of head.

(2) Horizontal Blanket or Horizontal filter ⇒

The horizontal filter may extends from 25 to 100% distance from the down stream toe to the Centre line of dam.



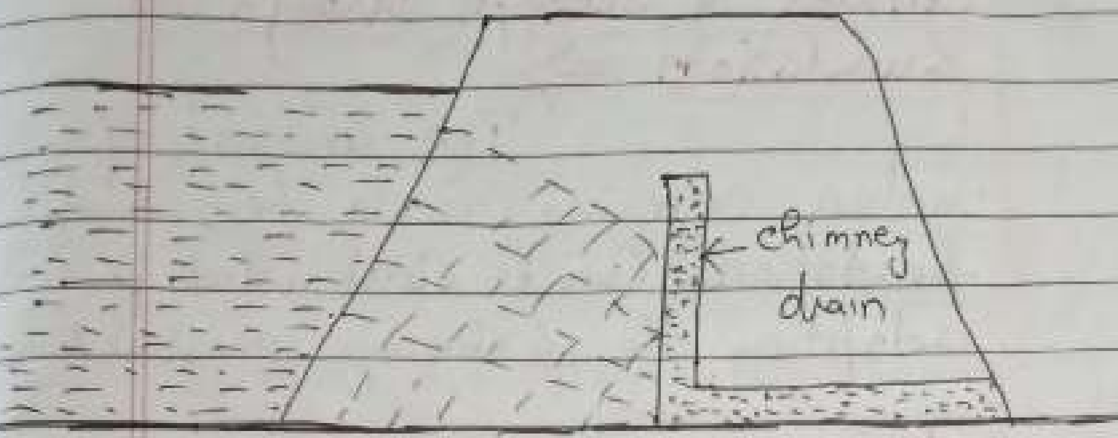
Horizontal Blanket or Horizontal filter

The horizontal filter the following Purpose

it keeps the seepage line with in the Embankment.
It also provide drainage for found.
It accelerate Consolidation.

(3) Chimney drain ⇒

The Horizontal filter not helps in bringing the seepage line in the body of dam But also provided drainage to the foundation and if in the the rapid Consolidation, but the Horizontal filter tries to make the soil more pervious and started.



Chimney drain

When large scale stratification occurs the Horizontal filter is in insufficient. In such cases A vertical filter is placed with Horizontal filter so as the intercept the seeping water effectively. Such arrangement is termed as chimney drain.

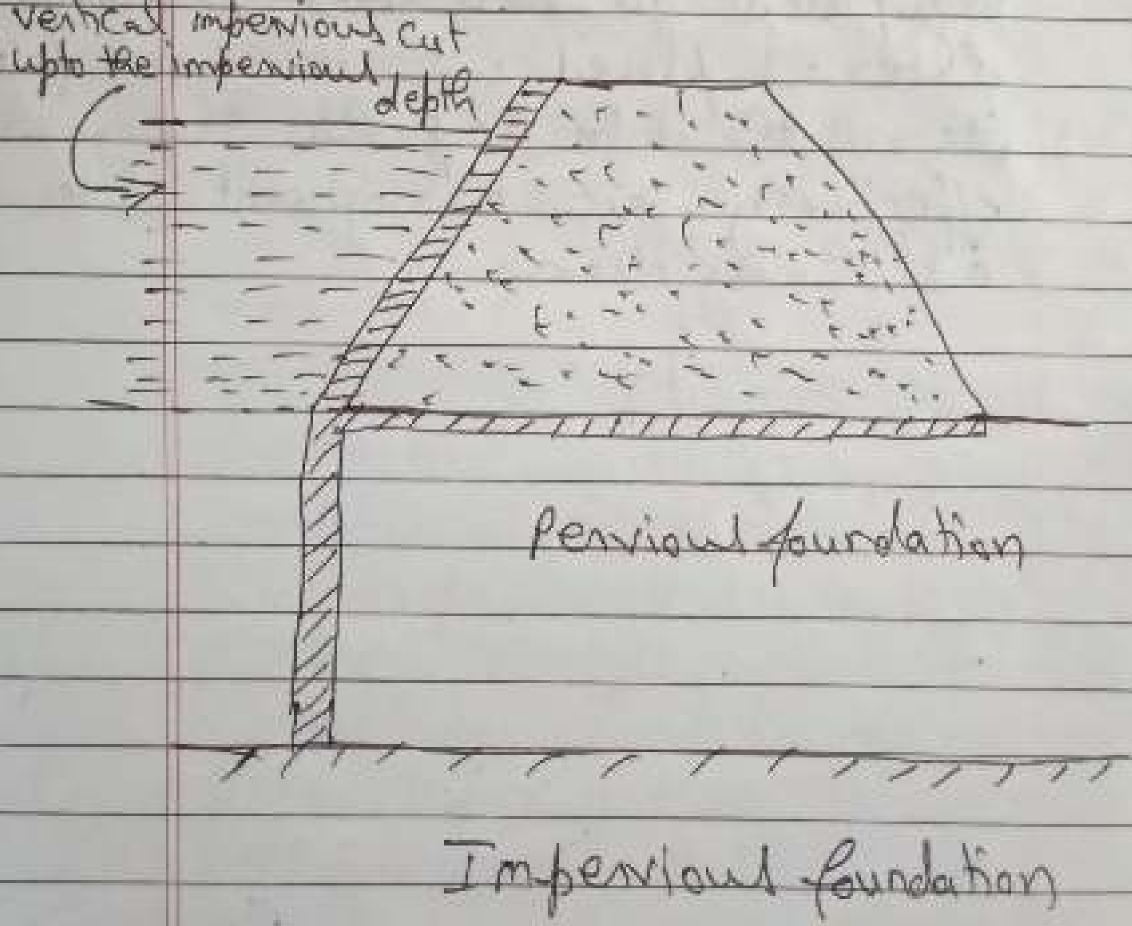
P.T.O

Control of seepage through the foundation ⇒

The amount of water entering in the pervious foundations can be controlled by adopting the following measures.

(1) Impervious Cut offs ⇒

Vertical impervious cut offs made of concrete sheet pile may be provided at the upstream end of the earth dam.

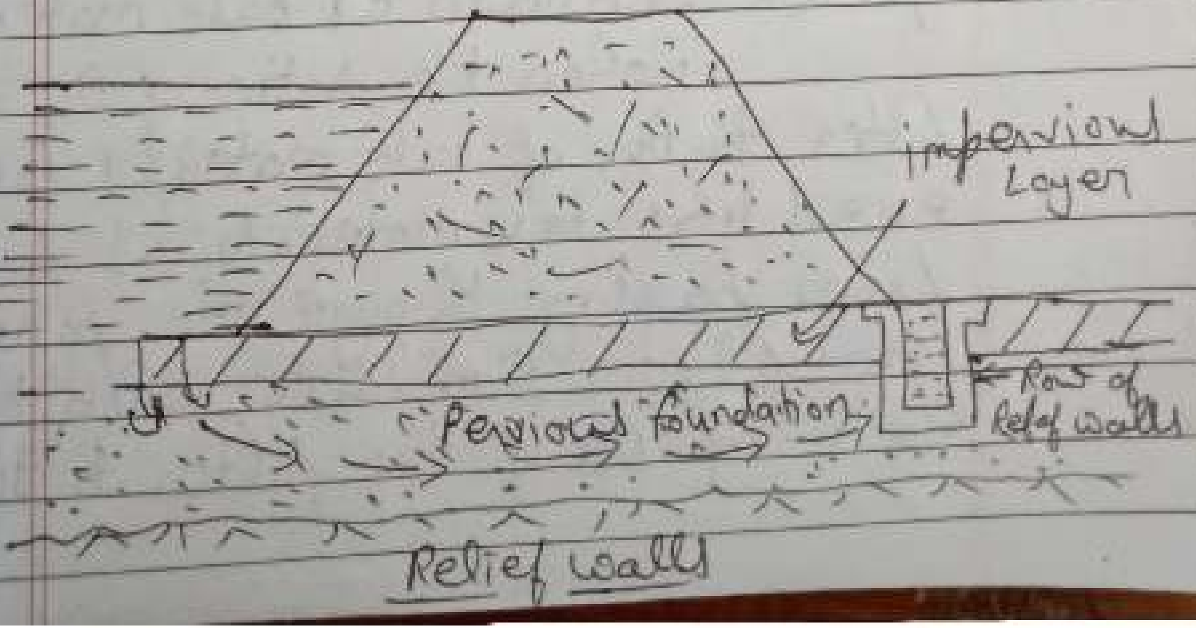


These cutoff generally extened upto the entire depth of impervious fundation so as to effective Contrul of Seeping water.

when the depth of Pervious fundation streedes is very large as portical cutoff is provided such a cut off reduce the dischage by a smaller ammount so that 50% depth reduces the dischage 25% and 90% depth reduces the dischage 65%.

② Relief wall and drain trenches ⇒

when large scale seepage takes place through the pervious foundations. There is a possibility that the water may up near toe of the dam. Such a possibility can be contrulled by ~~select~~ relif wall as drain trenches.



Design of filters ⇒

The drainage filter must be designed in such a way that neither the embankment or the foundations materials can penetrate and the filter. The Permeability or size of filter materials should also be sufficent to carry the anticipted flow with an ample margin of safety. A approch to the design of filter has been provided by Terzaghi. According to Terzaghi, the following filter criteria should be satisfied.

$$\frac{D_{15} \text{ of filter}}{D_{85} \text{ of Base materials}} < 4 \text{ to } 5 < \frac{D_{15} \text{ of filter}}{D_{15} \text{ of Base materials}}$$

The Embankment soil or the foundations soil surrounding the filter is known as base materials.

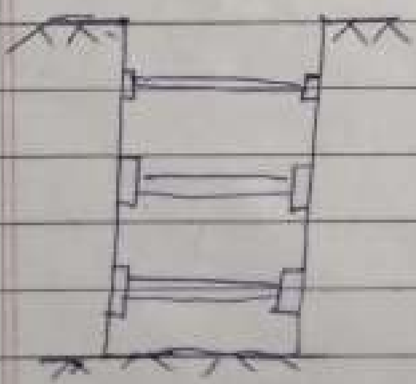
when the ratio of D_{15} of filter to D_{85} of base materials does not exceed 4 to 5 base materials is prevented from passing through the pore of the filter. Similarly, when the ratio of D_{15} of the filter to the

Braced Cut

Unit - 2

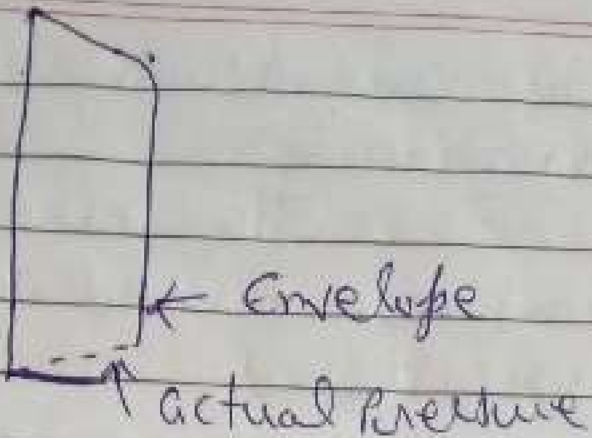
Braced cuts depth of unsuparted vertical cuts ⇒

Braced cuts → Deep excavations with vertical sides require lateral support to prevent cave in of the Sarth and to protect the adjacent areas against ground subsitance and lateral movement of subsoil. When excavations are shallow and ample space is availble the sides of excavtion can be sloped of a safe angle to ensure stability at a safe angle to ensure stability moreover it becomes uneconomical to provide safe slope because of large quantity of the earth involved excavations which are laterally supports are called braced cut.



(1) Braced cut

(2) Deformation condition



(c) Pressure
envelope

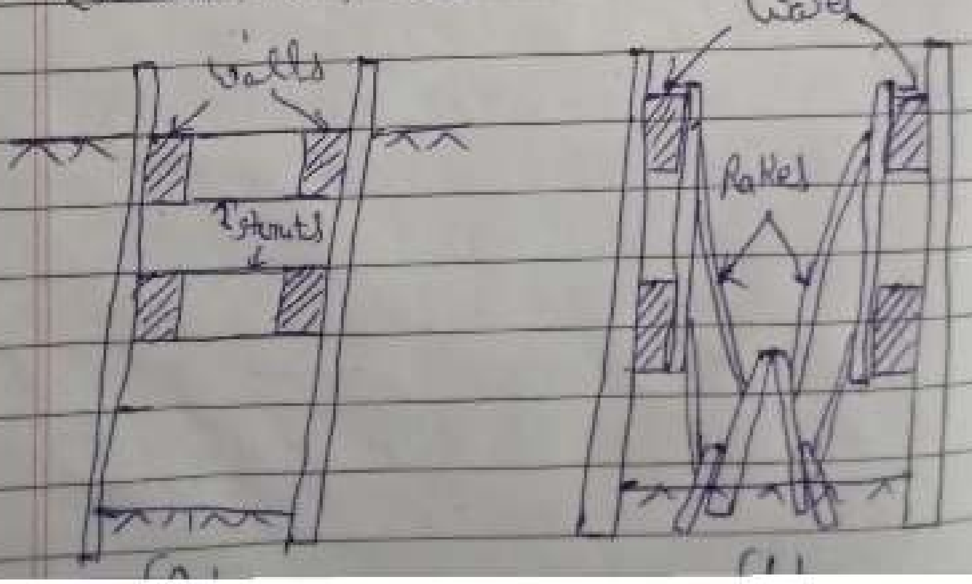
The vertical side of excavations are supported by a Sheeting and bracing System. It Consists of a relatively flexible Sheeting placed against the excavation walls.
Bracing is provided as the excavation proceeds and the face of the Sheeting become exposed.

Sheeting and bracing for deep excavation =>

They are following systems for braced cuts are commonly used

(1) vertical Timber sheeting =>

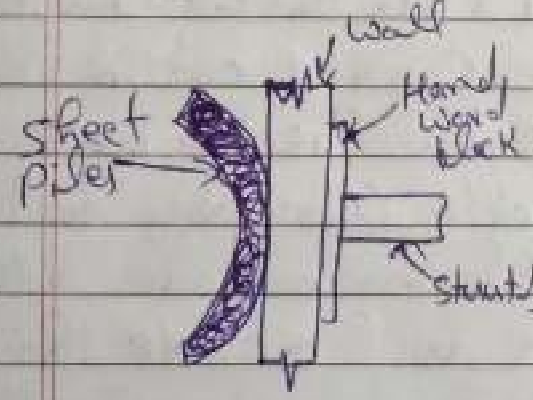
In this method vertical timber sheeting consisting of planks about 8 to 10cm thick driven around the boundry of the proposed excavation to some depth the base of the excavation. The soil between the sheeting is then excavated. The soil b/w the sheeting is then excavated. The sheeting is hold in place by a system of wales and struts. The wales are harozontal beams runing paralled to the excavation wall.



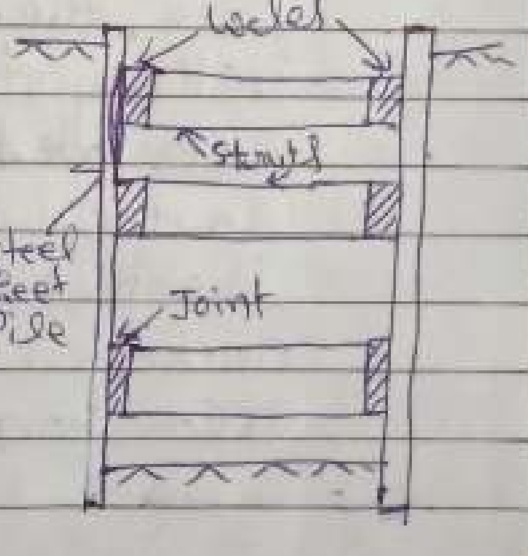
The wales are supported by horizontal struts extend from side to side of the excavation. However if the excavations are relatively wide it become economical to support the wales by inclined struts known as rakers.

(2) Steel Sheet Piles =)

In this method, the steel sheet pile are driven along the side of the proposed excavation. As the soil is excavated from the enclosure, wals and struts are placed as. The walls are made of steel. The struts may be steel or wood.



(b) Plan of detail of Joint



(a)

The Process of is continued till the excavation is complete. It is recommended that the sheet pile

Should be driven several metres below the bottom of excavation to prevent local heaves.

③ Soldier Beam ⇒

Soldier ~~pile~~ beam are H piles which are driven at a spacing of 1.5 to 2.5 m around the ~~boundary~~ boundary of the proposed excavation.

④ Tie Backs ⇒

In this method no bracing in the form of struts or inclined rakers provided. There fore, there is no to the Construction activity to be carried out inside the excavated area. The tie back is a rod or a cable connecting to the sheeting or laging on one side and anchored into soil outside the excavation area.

~~Mome~~ Movement associated with Sheeting and bracing =>

The cross lot of internal bracing transfer the lateral earth b/w opposing wall through compressive struts rakers resting on a foundation mat as rock often anther internal bracing.

- Pre-logging ensure a rigid contact b/w interacting member and is accomplished by inserting a hydraulic jack at each side of an individual pipe strut b/w the wall beam and a special jacking plate welded to the strut.

- Some earlier project the struts were not preloded and as a result when the excavation progressed deper the soil and the wall moment are large.

- Cross lot making ~~sure~~ sense in narrow excavations (60ft to 120ft) when the tie back installation is not feasible. The strut can bend excessively under their own weight if the excavation spacing is too large.

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- Deep excavation with vertical sides require lateral supports to prevent cave in of the earth and to protect the adjacent areas against ground subsidance and lateral movement of the sub soil. The side of excavation can be sloped at a safe angle to ensure stability.

- Excavation which are lateral supports are braced cut. The vertical side of excavtion are sported by a sheeting and bracing system.

- A gravity Retaing wall is a ~~permanent~~ per moment structure used when an excavation is permant. But wehe excavation is temporery i.e excavation for building or subway.

- There are various method by which a braced cut can be expected to att failure. Before carrying out a braced excavation the stability.

- The vertical sides of excavation are supported by a sheeting and bracing system. It consists of a relatively flexible sheeting placed against excavation wall.

Mode of failure of braced cut pressure distribution =>

- we are starting that is your braced excavation mean. where it is required first thing a once. we are saying that the applications of soil mechanics, topic is your braced excavation and where it is required particularly for underground construction in built-up area. generally what happened. it has been excavated with side slope. If i draw this is the ground surface then how this excavation has been done by going through the side slope.

If this is my ground surface from side slope by doing inside by side slope. So that it will be stable you can cut inside. So that construction can be done below the ground.

2nd Part

Coffer DAM =>

The ward Coffer means a chest or trunk. A Coffer dam a tempparary structure built to enclose area for excavation of foundation Coffers dams are used when the size of excavation is very large and sheeting and bracing system become difficult difficult or uneconomical Coffer dam generally required for foundation of structure such as a bridge pier docks, locks and dam which are built in open water. These are always used for laying foundation on open land where there is a high ground water table

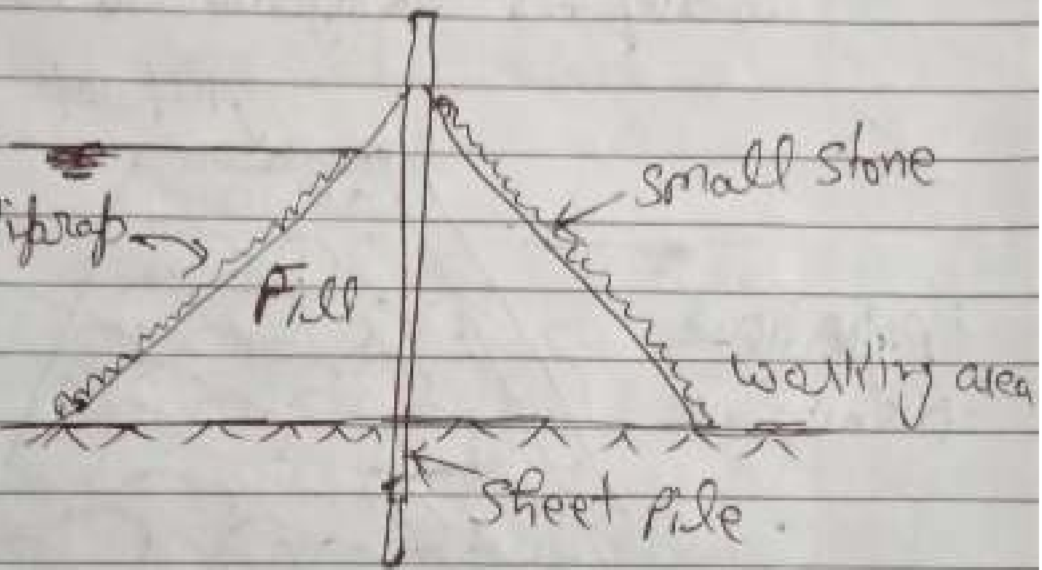
Type of Coffer dam =>

1. Earth Coffer dam
2. Rockfill Coffer dam
3. Single sheet pile Coffer dam
4. Double - sheet pile coffer dam
5. Braced Coffer dam
6. Cellular Coffer dam

Earth Coffer dam ⇒

There are the Simplest type of Coffer dam well adopted to depth of water upto 3m. Earth embankment are Constructed arround the area ~~devided~~ diverted.

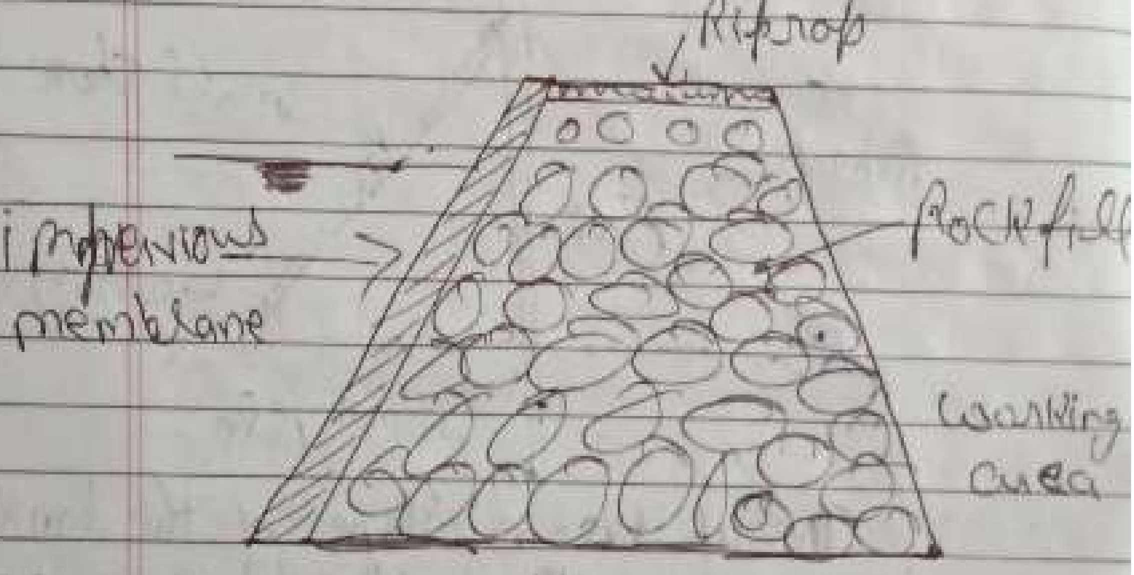
The earth Coffer dams are built of local soils, preferably fine sand. There usually have a clay core of a vertically driven sheet pilling in the middle.



The upstream slope of the bank is Covered with a riprap as a succesfu Coffer dam need not to be Completely water tight. The water call Collected is pumped out of the excavation. The embank-ment should be provided with a minimum free board of 1m to prevent overtoping by waves Sand-bags Coffer dam used in an emargency.

(2) Rockfill Coffer DAM =>

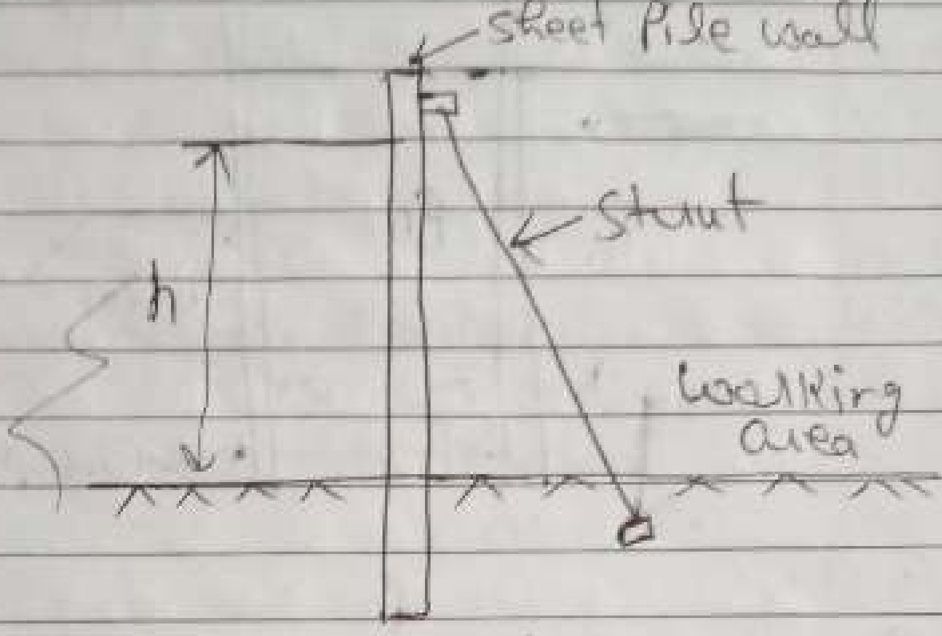
Rockfill Coffer dams made of rockfill are sometimes used to enclose the site to be dewatered. These are permeable and are usually provided with an impervious membrane of soil to reduce seepage. The crest and upper parts of the impervious membrane are provided with rip-rap to provide protection against wave action. The slope of rock fill Coffer dam Can be made as steep as horizontal to 1.5 vertical.



(3) Single Sheet Pile Cofferdam =>

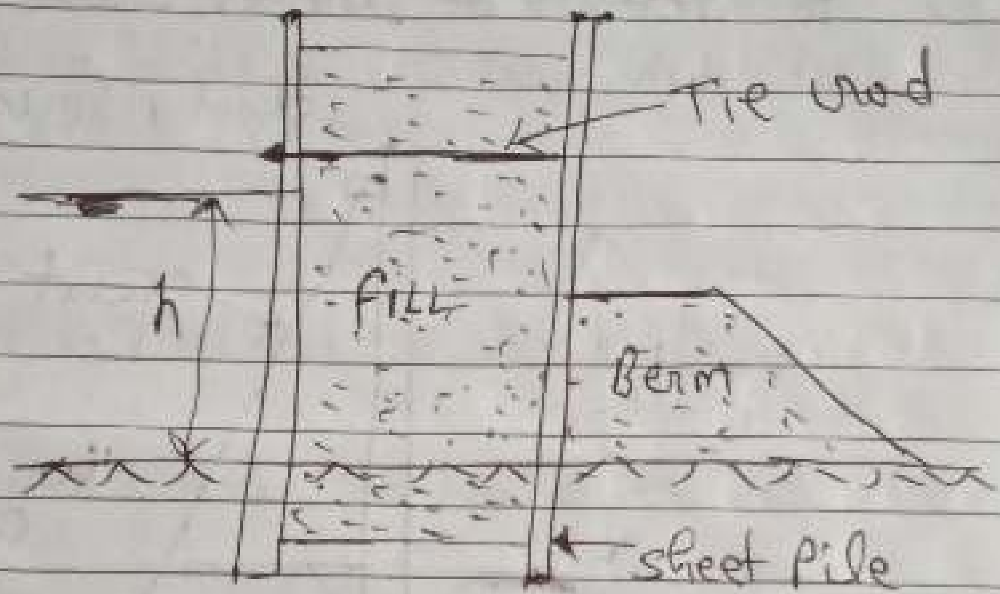
Single Sheet pile Coffer dam are generally used to enclose small foundation site in water of bridge at a relatively Shallow depth. In this type of

Coffer dam - There is a single row of cantilever sheet piles single sheet piles coffer dams are provided with earth fill on one or both sides to increase the lateral stability.



(4) Double-wall sheet Pilling Coffer dam ⇒

Double wall sheet pile coffer dam consists of two straight, parallel vertical wall of sheet piles tied to each other and the space b/w walls filled with soil as shown in the width b/w the pallel pile is impirially set as (h/2 + 1.50m). Where h is hieght of water double wall sheet pile coffer dam. Higher than 9.5m should be strutted sometime an inside beem is provided to keep the phreatic line within the beam. These coffer dam are suitable upto a hight of 10m.



(5) Braced Coffer dam ⟹

A braced coffer dam is formed by driving two rows of vertical sheeting and bracing with wales and struts. Braced coffer dams are used to isolate a working area surrounded by water. The braced coffer dam are susceptible to flood damage.

Design, lateral stability and design data ⇒

The objective of a dynamic lateral stability analysis to calculate the lateral displacement of a pipline subjected to hydronamic load from a given combination of waves and current during a design sea state.

The resisting force from the soil consist normaly of two parts a pure friction term and passive resistance term depending on the pipe's depth of penetration into the soil.

The dynamic simulation should be performed for a complete sea states if no information is available on the duration of sea states a sea state of three hourse is recomended.

on bottom stability is a highly non-linear phenomenon with a large of stick / slip respones. This is particularly important to keep in mind for large values of current to wave.

The application of different phase shift b/w the harmonic wave Components give rise to different time series realistates with varying maximum wave height. when the standard deviation in the resulting displacement has stabilised the mean value plus one standards diviation should be used as design value.

A Compressive ~~axial~~ axial force, due to internal pressure and temp. will tend to increase the lateral displacement and should be accunted.

A very heavy pipe will result the hydrodynic load from the largest wave in the design sea.

⇒ Design Data, Stability analysis, interlock stress

Design Data ⇒

A Cofferdam is a Structure that retains water and Soil that allow the enclosed area to be pumped out and excavation dry coffer dam are Commonly used for Construction of bridge and other support Structure built within water Cofferdam wall are usualy formed Sheet pile that are supported by water and and internal braces, and cross braces. Cofferdams are typically dismantled after permant works are Completed.

Cofferdam Construction Sequence ⇒

- Drive temprary support pile template.
- Temporarily erect bracing frame on the support for the template.
- Install Steel Sheet piles starting at all four Corner and meeting at the center of each side.
- Drive Sheet Piles to grade.
- Block b/w bracing frame and sheets and provide ties for Sheet piles at the top necessary.

Stability analysis ⇒

The pipes are intended to be placed be checked for possible sinking. Sinking should be considered with maximum content density as water filled and floation should be consided with minimum content density are filled.

If the specific weight of the pipe is less than that of the soil, no further analysis is required to documents the safety aganest ~~floati~~ sinking.

If the specific gravity of the pipe is less than that of the soil the shear strength of the soil should be documented as being sufficent to prevent floatation. The specific weight of the pipe should not be less than of the soil if burial is required.

interlock Stress =>

The design of circular type Cellulardams is formulated as a nonlinear optimization model that takes explicit account of revelent economic and technologic aspects. The object is minimization of total expected Cost. The sheet pile on the river side and interlock stress at the joint

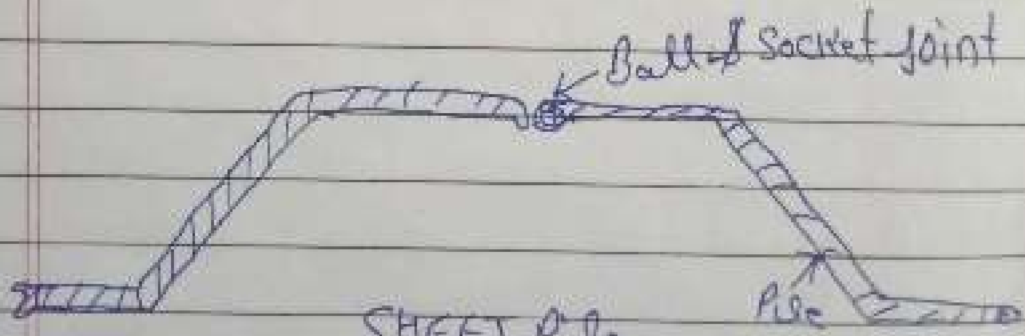
A solution archived with geomtric programing techniques, yields optimal cell size and design hieght The geomtric progamming approach provides important design insights by yielding the proportions of the total Cast to be assigned to the Cast Component fill materials, sheet pilling and flooding in an optimal design.

Unit ⇔ 3

Cantilever Sheet Pile ⇒ Purpose of Cantilever sheet

Sheet Pile ⇒

Sheet pile are generally made of steel or timber. However sometimes reinforced cement conc. sheet piles are allowed. The use of timber piles is generally limited to temporary structure in which the depth of driving does not exceed 3m for permanent structure and for depth of driving greater than 3m sheet pile are most suitable. Sheet pile are relatively water tight and can be extructed if required. However the cost of steel sheet pile is generally more than that of timber piles. Reinforced cement conc. pile are generally used when these are to be jetted into fine sand or driven in a very soft soil.

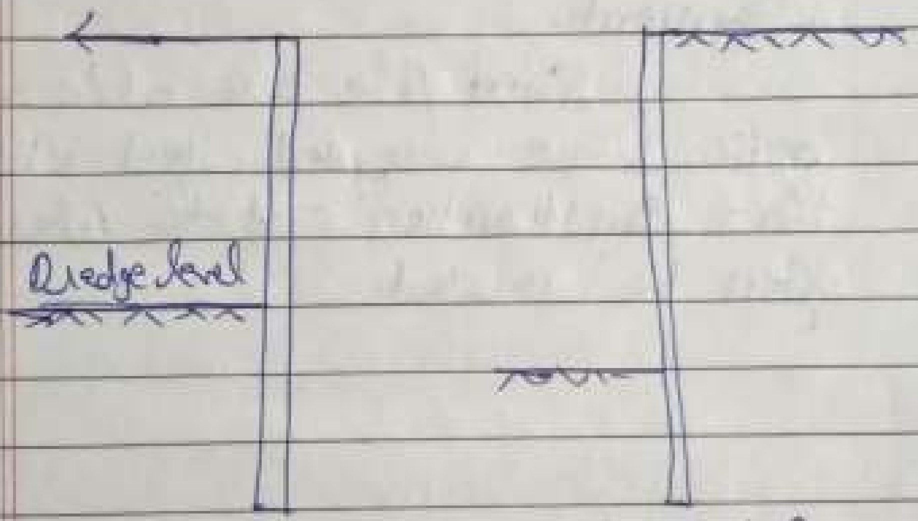


SHEET Pile

Types of Cantilever sheet Pile =>

1. **Free Cantilever sheet Piles =>**

It is a sheet pile subjected to a Concentrated horizontal load at its top dredge level. The free Cantilever sheet pile derives its stability entirely from the lateral passive resistance of the soil below the dredge level into which it driven.



(a) Free Cantilever sheet Pile

(b) Cantilever sheet Pile

2. **Cantilever sheet Pile =>**

A Cantilever sheet pile retains backfill at a higher level on one side. The stability is entirely from the lateral passive resistance of the soil into which the sheet pile is driven like that of a free Cantilever sheet pile.

Purpose of Sheet Pile ⇒

Sheet pile is an earth retention and excavation supports technique that retains soil using sheet section with interlock edges sheet piles are installed in sequence to design depth along the planned excavation parimeter or seawall alignment.

Sheet pile are also a sustainable optic since recycled steel is used in their Construction and the piles Can often be reused.

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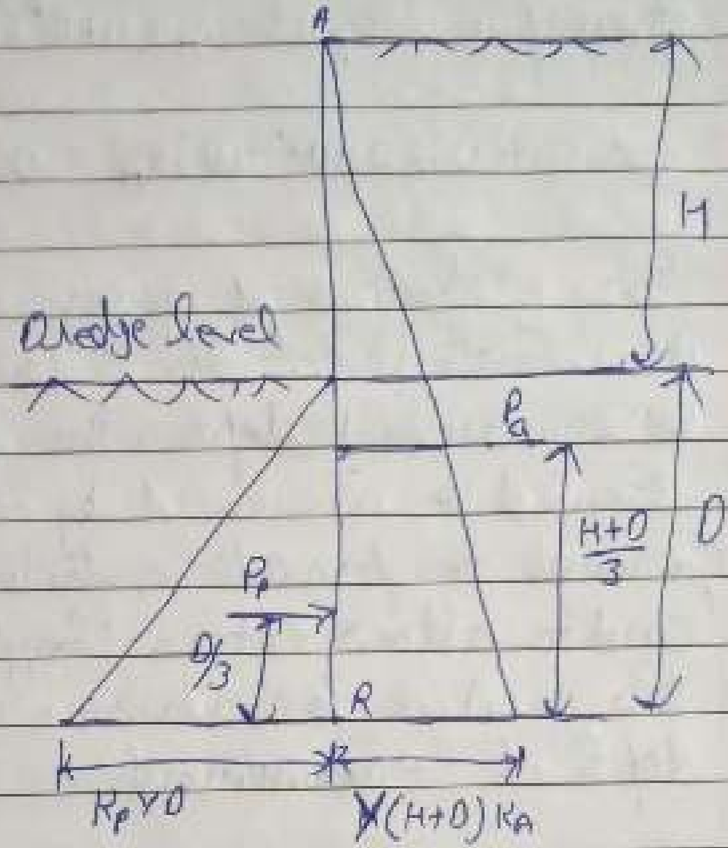
~~# Depth of Embankment is granular soil =)~~

Simplified Procedure Cantilever Sheet Pile =)



Simplified Procedure =)

The solution of the fourth equation is quite laborious and the problem can be simplified by assuming the passive pressure P_p as a concentrated force R acting at the foot of the pile.

For equilibrium the moment of the active pressure on the right and passive pressure on the left about the point of rotation R must balance.

$$\frac{1}{3} P_p D - \frac{P_a}{3}(H+D) = 0$$

Now $P_p = \frac{1}{2} K_p \gamma D^2$ and $P_a = \frac{1}{2} K_A \gamma (H+D)^2$

There fore $K_p D^3 - K_A (H+D)^3 = 0$

or $K D^3 - 3HD(H+D)K_A = 0$

The solution of given a value for D which is at least a guide to be required depth. The depth calculated should be increased by at least 20 percent to provide a factor of safety and to allow extera length to develop the passive pressure. An approximate depth of embankment.

⇒ Penetuating clay and limiting height of wall ⇒

The purpose of this is the present the study on the effect of wall penetration depth on sheet pile wall behavior. The conventional method used in the structural desigen of sheet pile wall are based on the limit equilibrium approach and they do not consider wall deformations. The effect of wall penetration depth for varying soil conditions and wall heights on both cantilever and anchored sheet pile wall behavior has been investigated by conducting a parametric study.

The finite element method was used to perform numerical modeling and to evalute the structural response and behavior of the wall.

Anchored bulk heads method of design =)

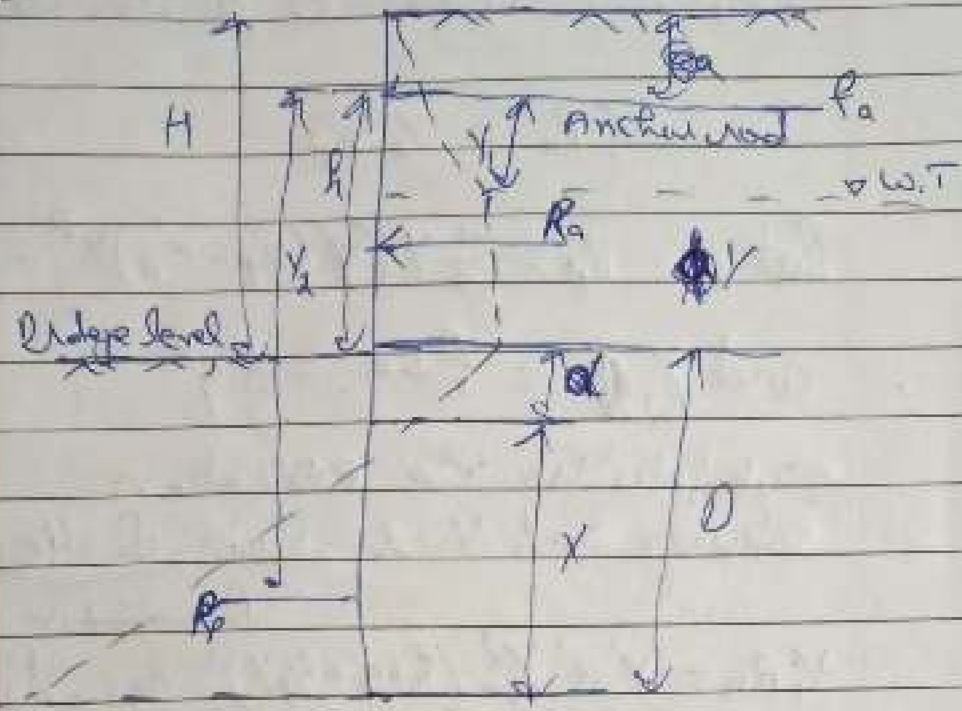
An anchored bulkhead is the one which is held above its driven depth by one or more tie rods and anchor at or near its top. The design of anchored bulkhead consists of the determination:-

(i) length of embankment
(ii) magnitude of the tensile force in the anchor or rod.
(iii) Design of the section of sheet

Design of the anchored bulkhead by free earth supports is based on the following assumptions:-

- The sheet pile is perfectly rigid as compared to the surrounding soil
- The sheet pile is free to rotate at anchor rod level with failure occurs by a rotation about the anchor rod
- The active and passive soil pressure acting on the sheet pile may be computed by the Rankine theory and their distribution is Hydrostatic.

A bulkhead is a sheet pile retaining wall of water front backed up by ground.



Let P_a = tensile force in the anchor rod

K_a and K_p = Co-efficients of active and passive pressure base on ϕ

$$K' = K_p - K_a$$

a = Depth of point of zero pressure below the dredge line

If P_a' = Active pressure intensity at the dredge line we have

$$a\gamma'(K_p' - K_a') = P_a'$$

$$a = \frac{P_a'}{\gamma'(K_p - K_a')} = \frac{P_a'}{\gamma' K'}$$

Let R_a = Resultant active earth pressure acting at y_1 below the anchor rod level

R_a = Resultant Passive earth pressure acting at Y_2 below the anchor rod level.

Applying $\Sigma M = 0$ at the rod level we get

$$Y_1 R_a = Y_2 R_p$$

But $R_p = \frac{1}{2} Y (\gamma' (K'_p - K'_A) Y^2) - \frac{1}{2} Y^2 \gamma' K'$

and $Y_2 = h + a = \frac{2}{3} Y$

Substituting the equation

~~Solving this Y is obtained Hence~~

~~D = Y + a~~

$Y_1 R_a = \gamma' K' \frac{Y^2}{2} (h + a + \frac{2}{3} Y))$ Regarding the te

$$Y^3 \left(\frac{\gamma' K'}{3}\right) + Y^2 \left(\frac{\gamma' K'}{2}\right)(h + a) - R_a Y_1 =$$

Solving this Y is obtained Hence

$$D = Y + a$$

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