GOVERNMENT POLYTECHNIC FOR GIRLS

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TOPIC: COFFERDAM

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COFFERDAMS

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INTRODUCTION

- A cofferdam is a temporary structure that retains water and soil that allows the enclosed area to be pumped out and excavated dry.
- Cofferdams are commonly used for construction of bridge piers and other support structures built within water.
- Cofferdams walls are usually formed from sheet piles that are supported by wales and internal braces and cross braces.

- Cofferdams are typically dismantled after permanent works are completed .

- Since cofferdams are usually constructed within water, the sheet piles are installed using pre-constructed templates that permit the correct positioning of each sheet pile from a barge.

REQUIREMENTS OF A COFFERDAM

I. The cofferdam should be reasonably watertight.

II. It should be generally constructed at site of work

III. The design and layout of a cofferdam should be such that the total cost of construction maintenance and pumping is minimum.

IV. It should be stable against bursting, overturning and sliding, under the flood and waves.

V. The water to be excluded by a coffer dam may be either ground water or water lying above ground level. It may be deep or shallow and still or running.

VI. The materials used in the construction of a coffer dam are earth, timber, steel and concrete.

VII. It should be so planned as to facilitate any dismantling and reuse of materials.

NECESSITY OF COFFERDAMS

The coffer dams are required in the following situations:

I. When it is required to construct a structure in the river bed.

II. When structure is to be constructed on a sea shore.

III. When it is required to construct a structure one a bank of the lake or inside the lake.

IV. When deep excavations are carried out in a coarse grained soil.

V. When excavation is carried out below ground water table.

VI. During deep excavations, when sides of the trenches are likely to collapse.

VII. When public/government property is situated close to the excavation.

VIII. When there are chances of seepage of water in the trenches from the surrounding area.

USES OF COFFERDAMS:

Following are the uses of cofferdams:

i. To facilitate pile driving operations.

ii. To place grillage and raft foundations.

iii. To construct foundation of piers and abutment of bridges, dams, docks etc.

iv. To enclose a space for the removal of sunken vessels.

V. To provide a working platform for the foundation of buildings when water is met with.

VI. To provide space for carrying out the foundation work without disturbing or damaging the adjoining structures such as buildings, sewers, pipelines etc.

SELECTION OF TYPE OF COFFERDAMS

The selection of a type of cofferdam depends upon the following factors:

I. The area to be protected by a cofferdam, i.e. a small area or a large area.

II. The depth of water to be dealt with, i.e. shallow depth or deep depth.

III. The possibility of overtopping by floods tides etc.

IV. The nature of bed on which the cofferdam is to rest, i.e., a pervious layer or an impervious layer.

V. Velocity of flowing water.

VI. The possibility of scour due to reduction of waterway caused by the construction of cofferdam.

VII. The availability of construction materials in the vicinity of site of work.

VIII. Transportation facilities available.

TYPES OF COFFERDAMS:

- The following are the most common types of cofferdams

1.Earth fill cofferdam

2.Rock fill cofferdam

3.Rocked filled crib cofferdam

4.Singled walled cofferdam

5.Double walled cofferdam

6.Cellular cofferdam

7.Concrete cofferdam

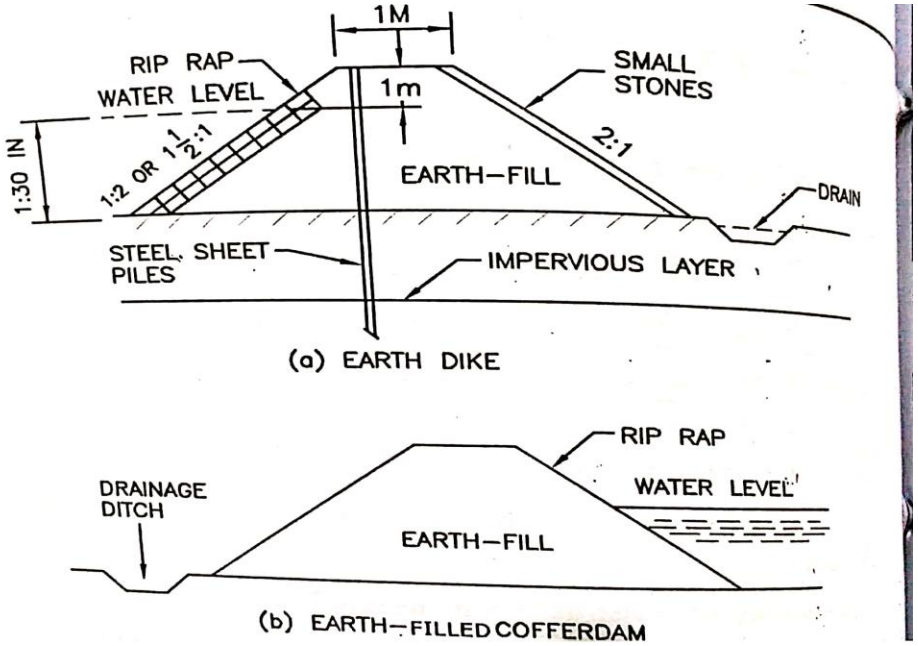
8.Suspended cofferdam

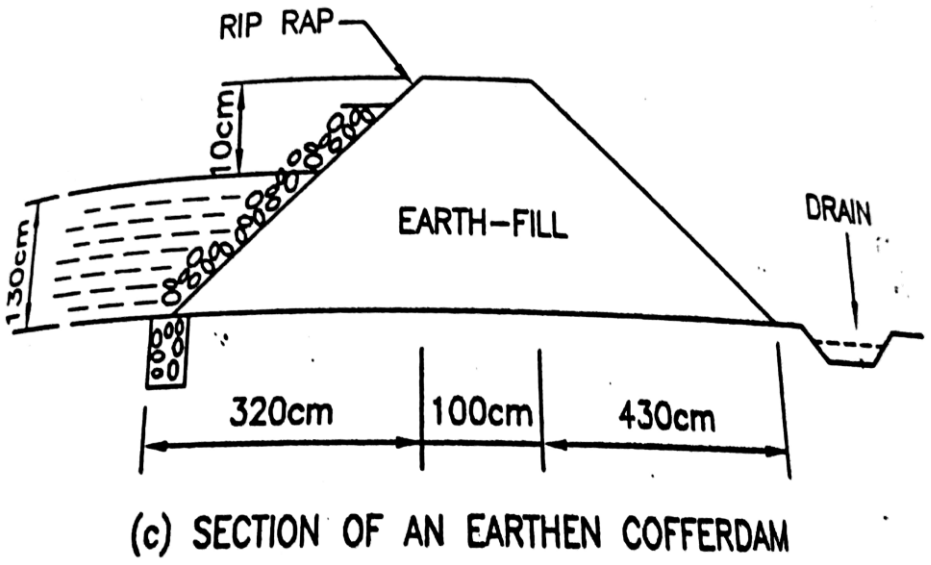
1. EARTHFILL COFFERDAM:

- These are the simplest type of cofferdams well-adapted to depths of water up to 3 m.
- Earth embankments are constructed around the area to be dewatered.
- The earth coffer dams are built of local soils, preferably fine sand.
- These usually have a clay core or a vertically driven sheet piling in the middle.
- The upstream slope of the bank is covered with a rip rap.

- A successful coffer dam need not be completely watertight.
- For reason of economy, it is not possible to make it watertight and hence some seepage of water into the excavation is usually tolerated.
- The water collected is pumped out of the excavation.
- The embankment should be provided with a minimum free board of 1 m to prevent overtopping by waves.
- Sand-bag coffer dams are used in an emergency.

- The top width of the bank should not be less than 1m,and side slopes may vary from 1:1 ½ to 1:2.
- The earth embankment should be built from a mixture of clay and sand or clay and gravel. if the estimated quantity of clay is not easily obtainable ,the bank may be constructed with a central clay wall slopes of sand on either side.
- In order to prevent the embankment from scouring due to the action of water, side slopes of the bank on water side should be pitched with rubble boulders.
- When the construction of earth fill cofferdam is over, the water from inside is pumped out so as to leave a dry surface inside and the construction work of foundation is started.

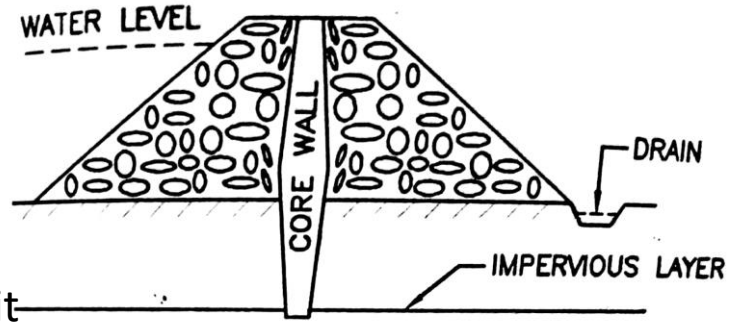




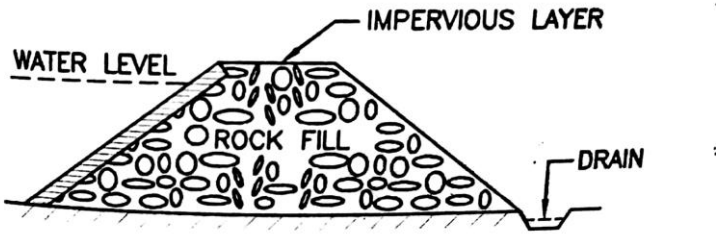
ROCKFILL COFFERDAM:

- Rock-fill cofferdams are better than that of earthen dams.
- These dams are preferred when the rock is available easily at the construction site.
- These dams are very pervious, to prevent water from seeping an impervious membrane of soil is provided in the dam.
- The height of the dam is can be up to 3m. The slope can be maintained at 1:1.5 to 1:1.25.
- The slope on the water side is pitched so as to protect dam from wave action.

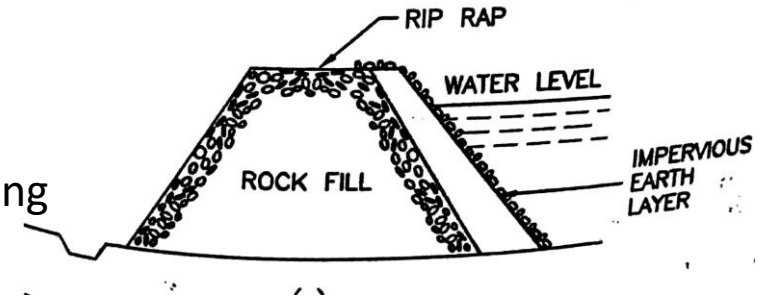
- If the depth of water to be retained by the embankment of cofferdam is of order of 1.8 to 3m, stone or rubble used for the embankment.
- This construction is adopted only if the stone is easy available in the nearby areas.
- An impervious layer of earth is laid on the outer face of the cofferdam, which makes it impervious.
- The particles of earth are carried in the voids of rocks and a faily water tight structure is gradually formed.
- For better construction, the core walls or steel sheet piles extending up to the impervious layer may be provided.
- The core wall may be of clay or concrete.
- A rock fill cofferdam, if properly constructed, can withstand the overtopping of water without any serious danger.



(a) ROCK DIKE WITH CORE WALL

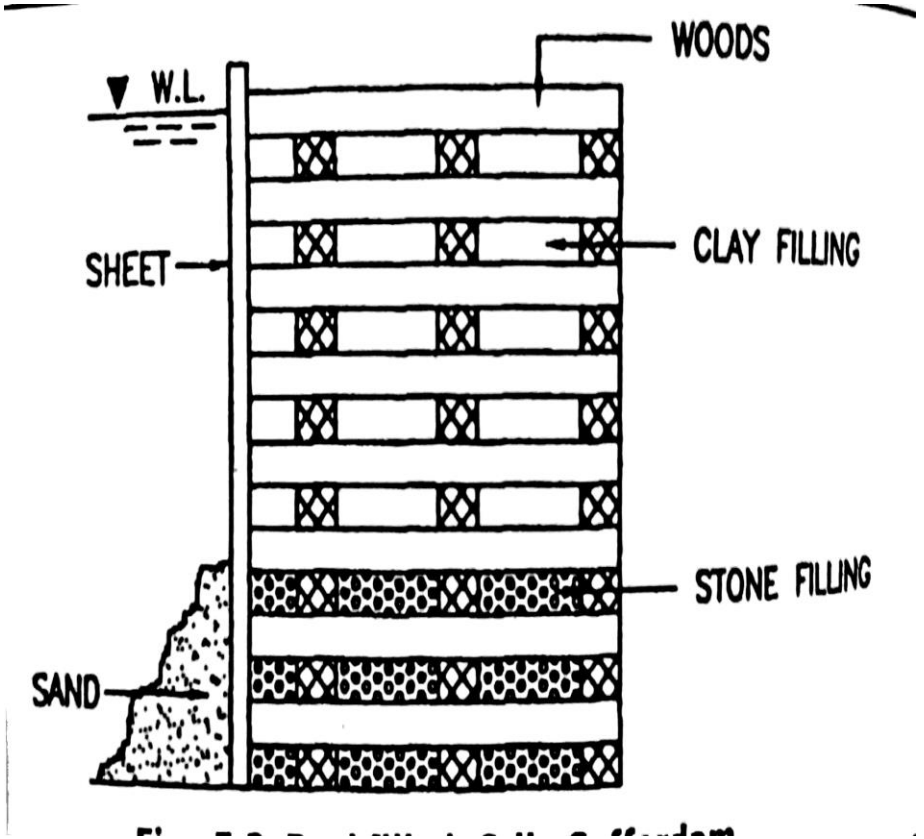


(b) ROCK DIKE



ROCK FILLED CRIB COFFERDAM:

- A rock filled crib cofferdam is comprised of timber cribs.
- a crib is a framework of wooden horizontal and cross beams laid in alternate course.
- The cribs are open at the bottom and are filled with rock or gravel or earth.
- This gives stability to the crib against overturning or sliding.



C0NSTRUCTION PROCEDURE:

- Following procedure is adopted in the construction of a rock-filled crib cofferdam:

I. The dimensions of each crib unit are decided . The length and breadth of each crib depends upon the depth of water and the current of flow. The crib is made as long as can be conveniently handled and as required for the structural stability.

II. The bottom courses of the crib are started on land. The crib is built on land up to such height that when it is placed in water, some of its portion will project above water level.

III. The crib is then taken on the site of work. It is floated and placed in position.

IV. The pockets of the crib are filled with rock,earth or gravel.

V. The sheet piles are then provided on the water side of the cribs and also in the space between the adjacent cribs.

VI. Suitable earth filling is provided on the water side as shown in fig.

VII. The pumping is started and work of foundation is carried out. while dismantling the cofferdam, the filling is removed by some suitable equipment and the cribs are dislocated by the diver

FOLLOWING POINTS ARE WORTH NOTING IN THE CONSTRUCTION OF ROCK-FILLED CRIB COFFERDAMS:

i. The bottom of the crib should be shaped to suit the profile of the bed of stream so that the crib may settle and attach with ground.
ii. The stability of crib against overturning and sliding with full water pressure on one side should be checked.
iii. If the current of water is very swift, the crib are to be properly anchored. For this purpose, the cables connecting the crib with some fixed object on the shore or with another rock-filled crib may be employed.

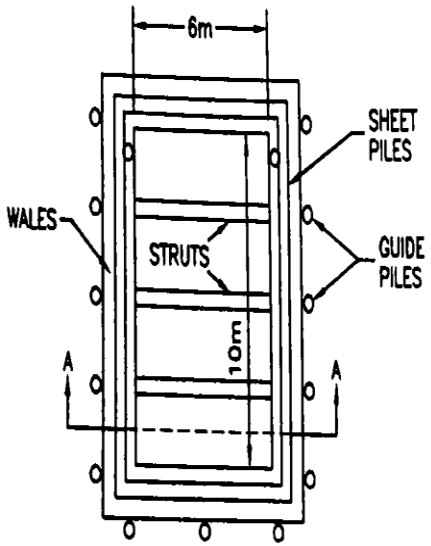
iv. The crib may be constructed with double rows when the depth of water is high and the velocity of water is more. The space between the rows is then to be filled up by an impervious .

v. If the depth of water is shallow, the cribs can be built on site of work.

vi. It is desirable to remove the loose material lying over the bed of stream and to prepare the floor to receive the crib.

SINGLE WALLED COFFERDAM:

- This type of cofferdam is used in places where the area to be enclosed is very small and the depth of water is more , say 4.5 to 6.0m.
- Timber piles known as guide piles are first driven deep into the firm ground below the river bed.
- Depending upon the velocity of flow of water, the center to center spacing of the piles may vary between 1.8m to 4m.
- longitudinal runners called wales are then bolted to the guide piles at suitable distance apart sheet piles of steel or wooden are then driven into the river bed along the wales and are secured to the wales by bolts.
- The sheets on the two faces are braced by struts.
- Half filled bags of sand are stacked on the inside and outside faces of the sheet to increase the stability of cofferdam.
- After the cofferdam is constructed , the water in the enclosed area is pumped out the construction work is taken up.



PLAN OF SINGLE WALL COFFERDAM

DOUBLE WALLED COFFERDAM:

- Double wall cofferdam are provided to enclose a large area.
- Its construction is essentially the same as that of a single-wall cofferdam, except that in place of one wall, a pair of wall with a gap in between is used all along the boundary of the space to be enclosed.
- This types of cofferdam can be used in depth of water up to 12m.

The double wall coffer dams can be divided into two categories:

A. Ohio river type wood sheeting cofferdam.

B. Wood or steel sheeting cofferdam with wales and tie rods.

a. Ohio river type wood sheeting cofferdam:

- This type of cofferdam was frequently used on the river ohio in USA, and hence it derive its name as ohio river type cofferdam.
- It is cheap and can be built rapidly. It is suitable for hard bed where there is no problem of erosion.
- It can even be used on soft ground, if properly protected against corrosion .
- it is not suitable for deep water and for flow of water with swift currents.

CONSTRUCTION PROCEDURE:

I. A skeleton framework is prepared. The horizontal pieces known as wales are fixed at a vertical distance of about 1.50m. The section of wales above water level is 200mm × 200mm.

II. The framework is then assembled on a barge.

III. At the wale joints, double vertical planks are provided and the tie rods are threaded through planks.

IV. The cross braces with light section are fixed.

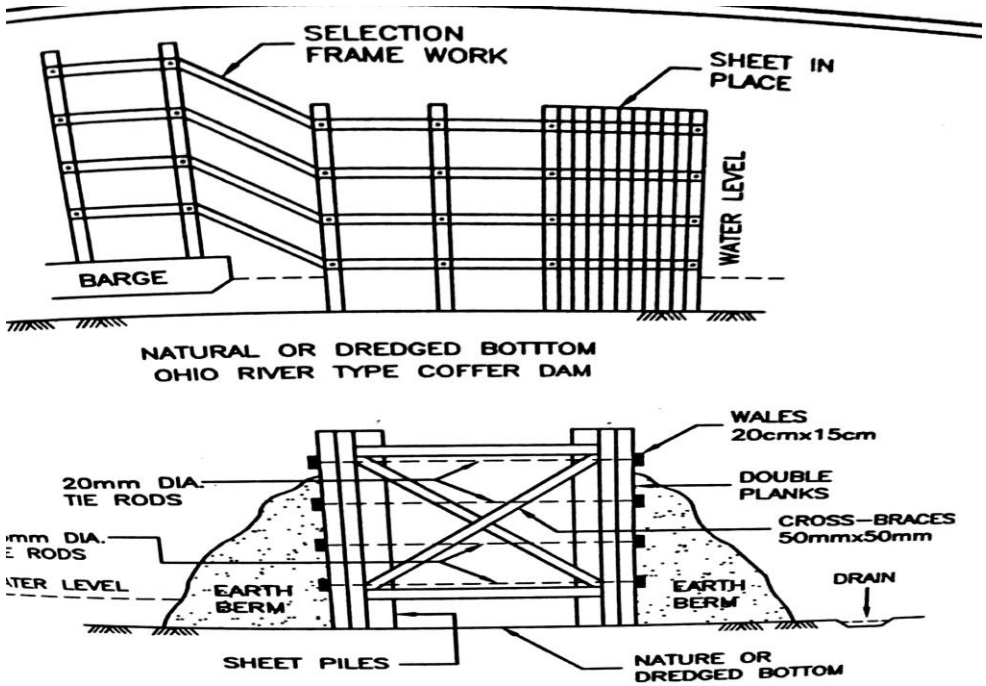
V. To permit the rotation of joint, the tie rods are not fully tightened.

VI. A derrick boat picks up the skeleton framework and while it is in suspension, the barge is slipped from under as shown in fig. The framework is thus lowered into the river. In this position, the wales connecting the section still on the large are in the diagonal position.

VII. After several sections are thus placed in the river, a separate gang of workers operate from a second barge and fixes sheet piles and nails them with the wales above water level.

VIII. The berms of suitable material are then provided on the inside and outside of the cofferdam by means of a dredger.

- When the purpose of cofferdam is over, it is removed by a reverse process.



Wood or steel sheeting cofferdam with wales and tie rods:

- This type of cofferdam is useful when depth of water is about 6 meters to 10 meters. For small and ordinary type of cofferdam , the wooden sheet piles are employed. But when cofferdams are large or where it is not possible to drive guide piles due to more depth of water, the steel sheet piles with suitable bracing are used for the construction of this type of cofferdam.
- The section of a typical wood sheeting cofferdam 3.50m wide with wales and tie rods.it essentially consists of the following parts.

1. Horizontal wales and caps
2. Vertical sheet piles
3. Vertical guide piles
4. Puddle filling
5. Tie rods which are required to connected each pair of guide piles so as to prevent the spreading of the wales of cofferdam due to filing.
6. Struts, near and parallel to the tie rods, to hold the two wales of cofferdam at a fixed distance apart.

CONSTRUCTION OF WOOD OR STEEL SHEETING COFFERDAM:

- Following procedure is adopted in the construction of this type of cofferdam.

I. The guide piles are first driven. They are usually placed at a distance of about 2 meters to 3 meters and are driven deeper than sheet piles so as to be safe when acting as a free cantilever above the river bed.

II. The wales running horizontally are fixed between the guide piles.

III. The sheet piles are then driven along the inside edge of wales to a fairly impervious strata.

IV. The soft material from the bottom of the cofferdam is dredged out.

V. The space between the sheet piles is filled with puddle which may consist of an intimate mixture of sand or clay and gravel. The filing is to be done in thin layers and it should be well consolidated when it is in a damp state.

VI. A berm of clay may be provided on the outside of the cofferdam as an additional safeguard against leakage.

VII. The width of cofferdam should be decided by keeping in view the structural stability, degree of water tightness desired, space required for placing machinery, etc. following rule of thumb is worth nothing in this connection.

- For $H < 3m, w = H$
- And for $H > 3m$, $w = 3 + 1/3 (H-3)$
- Were w= width of cofferdam in meters

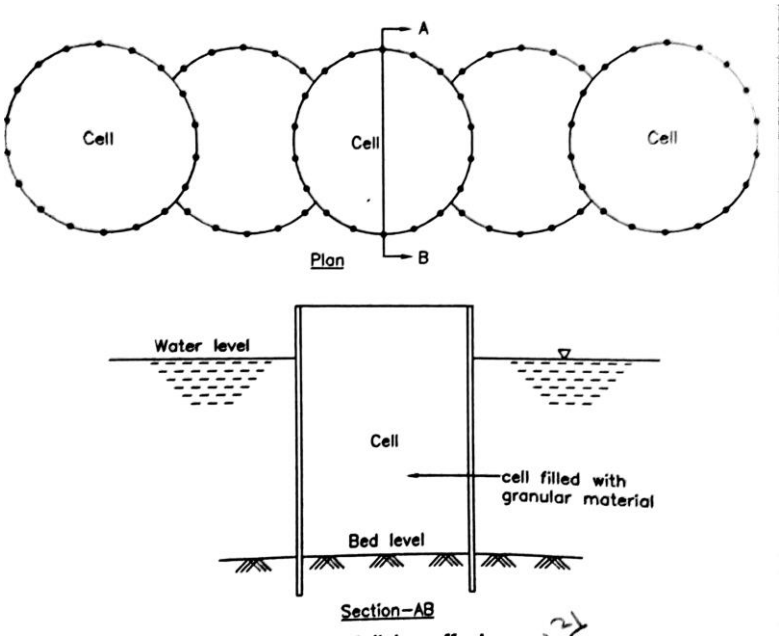
  H=height of water above river bed in meters.

CELLULAR COFFERDAM:

- The cellular cofferdam is made of steel sheet piles. It is mostly used for de-watering large areas in place where the depth of water may be of the order of 18 to 21m.

They are two types:

1. Circular type of cellular cofferdam
2. Diaphragm type cellular cofferdam



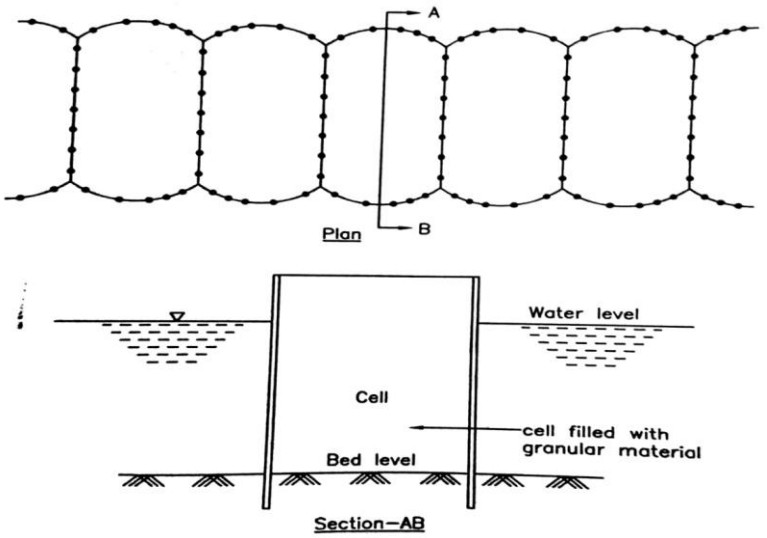
- In case of diaphragm cellular cofferdam, series of arcs are connected to straight cross walls. The radius of arcs is generally made equal to the distance between the cross walls. With this arrangement, the tension in the arch and cross walls remains equal. After the cell is driven to the required depth, they are filled with earth, sand or gravel. It is necessary to fill adjacent cells at approximately the same rate.

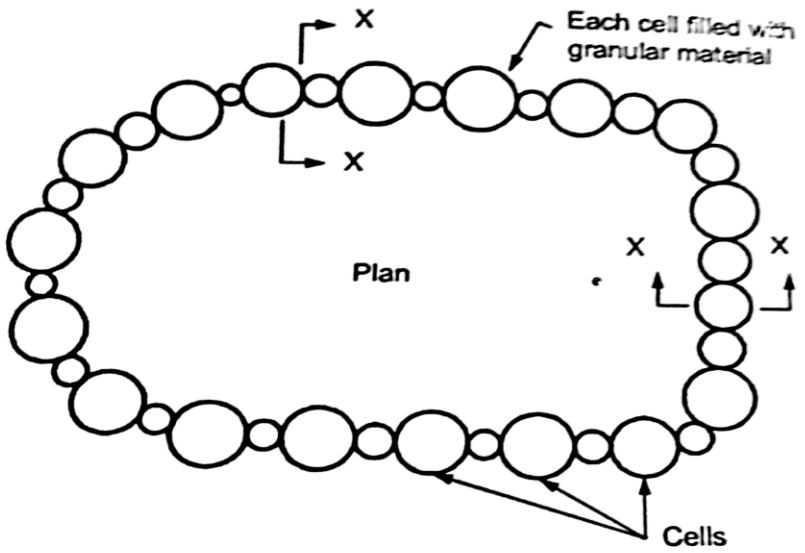
- In case of circular cellular cofferdam, series of complete circles are connected by short arcs as shown in fig.

- The radius of the arc is generally 250cm and it makes an angle of 30˚ to 45˚at the point of contact with the circular cell.

ADVANTAGES OF CIRCULAR CELLULAR COFFERDAMS:

- Each cell may be filled up independently of other cells without any danger of distortion of cells. Hence, the construction work for cell may be started simultaneously from several points. The arcs are installed after the completion of cells.
- Each circular cell is a self-supporting unit.
- For the construction of cellular cofferdam with circular cells , less quantity of sheet per running length of cofferdam is required as compared to that of the cellular cofferdam with diaphragm cell.





FOLLOWING POINTS SHOULD BE NOTED IN CONNECTION WITH THE CELLULAR COFFERDAM:

I. This type of cofferdam has got the advantage that little false work is required in its construction. Only top and bottom templates are required to drive the piles in proper position.
II. Each cell when complete forms a working platform for the adjacent cell.
III. The materials which are suitable as filling materials for this type of cofferdam are crushed stone, broken bricks, gravel and sand. The clay and other materials which require consolidation before they can offer resistance to external pressure should not be used as the filling materials.
IV. The cellular cofferdams can also be used on an irregular river bed. The lengths of steel sheet piles will have to be adjusted according to the profile of the river bed.

V. The driving of steel sheet piles should be smooth. otherwise, it will break the interlocking joint and the cell may fail.

VI. If there is any danger of overturning of cell due to earth pressure, the inside and outside berms should be provided.

VII. It should be remembered that if one sheet or interlocking joint fails, the whole cell fails with serious consequences. Hence, this type of cofferdam is unsuitable for grounds containing boulders or such obstructions.

VIII. It is found that the cellular cofferdams are relatively hard to pull. It is very difficult to remove the first sheet pile. It is therefore necessary to provide sufficient grease in the interlocks of the sheet piles before they are placed in position.

CONCRETE COFFERDAMS:

- These are actually small concrete dams and they have been used economically on many jobs. The framework usually consists of pre-cast R.C.C. piles and sheets. The pre-cast R.C.C. sheet piles are provided with suitable edges and they are driven in a similar manner to steel sheet piles. The design of different units should be properly made. The main disadvantage of a concrete cofferdam is that it is costly. But when it is to be incorporated as part of a permanent structure, it proves to be economical.

- These cofferdams also prove to be useful under the following conditions:

1. The head room limitations prevent the driving of steel sheet piles.
2. It is necessary to avoid vibration from the process of pile driving.
3. The ground through which the piles are to be driven contain boulders which would split steel sheet piles or cause them to come out of interlocks.

SUSPENDED COFFERDAMS OR MOVABLE COFFERDAMS:

- Sometimes, a cofferdam is designed in such a way that a single unit of it is used several times. The cofferdam as such is lifted, floated and placed in another position as soon as its purpose is served. Such cofferdams are also known as the movable cofferdams.

- They are suitable under the following circumstances:

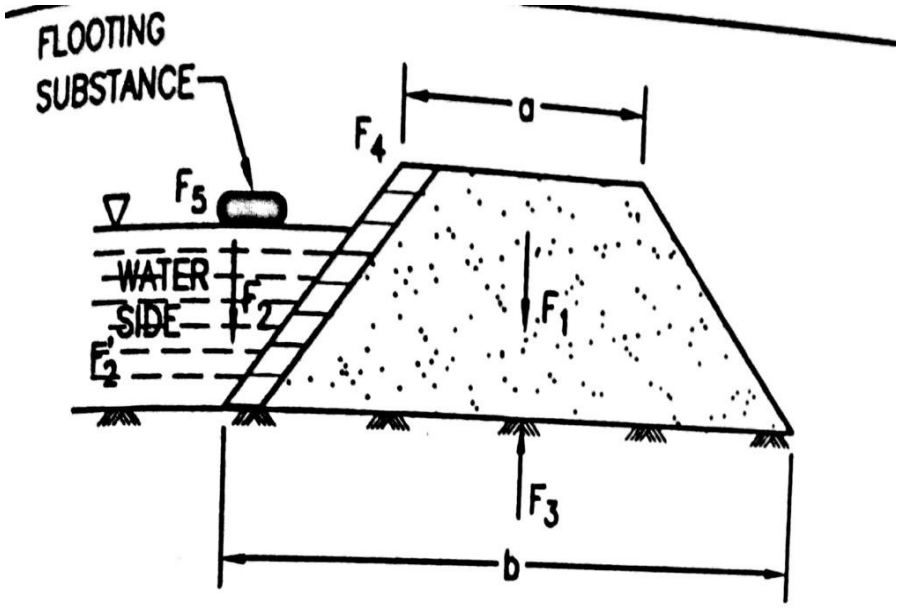
1. The construction work is of such type that a number of identical cofferdams is required. Hence, if a single unit of cofferdam is used several times in such a case, it may result into economy.
2. A cap is to be provided on the top of piles or caisson below low water and the depth of river bed is more. In such a case, the movable cofferdam will be found very much suitable.

- The suspended cofferdam may take up any form, it consists of a hollow steel cylinder which can be used to prepare a temporary enclosed space for the construction work. In another form, it may consist of a watertight timber box which may be floated and fixed with the piles or caissons by divers.

DESIGN FEATURES OF COFFERDAMS:

The design of a cofferdam depends upon the following factors:

- Hydrostatic head of water.
- Dimensions of the area to be covered by the cofferdam.
- Velocity of flow to be excluded.
- Subsoil conditions.
- Fluctuation of outside water level.
- Possibility of erosion.
- Floating logs.
- Presence of ice etc.



F_1: SELF WEIGHT

F_2: WATER WEIGHT

F_2' : THURSY DUE TO WATER

F_3: UP LIFT PRESSURE ($F_3 = F_1 + F_2$)

F_4: EROSION OF COFFER DAM SURFACE

F_5: IMPACT FORCE DUE TO FLOATING SUBSTANCE

Various forces acting on cofferdams:

- Self weight of cofferdam
- Water pressure
- Earth pressure from outside soil
- Uplift pressure
- Scouring action
- Ice pressure

- As it is sometimes not possible to determine accurately the forces acting on cofferdam, the worst conditions should be assumed in the design to prevent its failure sometimes, purely theoretically designed cofferdam may fail for factors unaccounted in its design. Thus, it is necessary to combine experience and practical knowledge along with the theoretical aspect in the design of a cofferdam.
- The width and depth of cofferdam are determined as below:

For $H<3$ m, $W=H$

For $H>3$ m, $W=3+1/3\ (H-3)$

Where,

W= width of cofferdam (m)

H= height of water above river bed (m)

LEAKAGE PREVENTION IN COFFERDAMS:

- The water enters the cofferdam in two ways:

1. By leakage through the sheet piling.
2. By flow from base.

The following measure may be employed to prevent leakage in cofferdams:

I. The materials such as clay, sand, ashes etc. may be damped all around the cofferdam to reduce the quantity of entering water.

II. If the entry of water is through the cracks or fissures of the rock, it can be stopped by or fissures of the rock, it can be stopped by pumping cement grout through 100mm diameter pipes.

III. The leakage in case of a single wall cofferdam may be prevented by placing V-shaped wooden trough outside each joint and filling it with puddle.

IV. The leakage in case of a double wall cofferdam occurs due to insufficient compaction of fill.

This may be prevented in the following ways:

- Driving piles through the filling.
- Driving holes and filling these holes with the material which swells quickly when wet and it also acts as a filter.
- Forcing clay cylinders through pipes into the filling to increase the density of filling.

V. In a simple method, a box filled with a mixture of sawdust and ashes is held near the joints of leakage. The water while flowing through the joints to the inside of the cofferdam takes with it the sawdust or ash. This leads to the sealing of the joints and consequently, the leakage is reduced.

VI. The interlocks of steel sheet piles may be provided with sufficient quantity of grease before driving. The fine material carried by the water will stick to the grease and it will make the joint effective in preventing the leakage of water.

VII. If the leakage is of serious nature it can be reduced by providing tarpaulin which is canvas coated with tar.

ECONOMIC HEIGHT OF COFFERDAM:

- The maximum height of cofferdam for which its total cost is minimum, is known as the most economic height of cofferdam.
- When a cofferdam is constructed in a river, it is necessary to determine the height that will be most satisfactory. Usually, the height of cofferdam is determined based on height of the average normal flood during every year.

- The cost of damage caused by the flood higher than the decided height of cofferdam is estimated. Under this condition, it is cheaper to assume the risk of loss due to flood damage than to build a dam enough to eliminate the danger of over topping.
- Therefore, cofferdams are constructed to exclude normal flood water and provision is made to bare the damage caused by higher floods. If the cost of increasing the height of cofferdam is less than the cost of damage caused by higher floods, than it is advisable to increase the height of dam.

- Courtesy Dr.R.P.Rethliya Sir


THANK YOU