UNIT 3- SUB STRUCTURE CONSTRUCTION

2 MARKS

1. what is micro piling (April/May2017)

Micropiles are small diameter drilled and grouted friction **piles**. Each **pile** includes steel elements that are bonded into the bearing soil or rock – usually with cement grout. The bearing stratum is logged during installation drilling to assure that bearing capacity is adequate.

2. Define shoring (Apr/May2017, Nov/Dec2011,Apr/May2015,Nov/Dec2016)

The temporary support provided to an unsafe structure or to a structure undergoing alteration is called a shore and the method of construction is called shoring. When a wall shows signs of building out due to bad workmanship. When a wall cracks due to unequal settlement of foundation and the cracked wall needs repairs. When openings are to be made or enlarged in the wall.

3. Why caissons are used (Apr/May2018)

The uses of caissons are:

- To reach the hard bearing structure for transferring the load, coming on support for bridge piers and building columns.
- To serve as an impervious core wall of earth dams. When placed adjacent to each other. To provide an access to a deep shaft or a tunnel.

4. What is shoring in construction and its components (Nov/Dec 2018, Apr/May2018,Nov/Dec 2016)

Shoring is the construction of a temporary structure to support temporarily an unsafe structure.

When a wall cracks due to unequal settlement of foundation and the cracked wall needs repair. So, shoring is provided in foundation.

- Rakers or inclined member.
- Wall plate.
- Needles.
- Cleats.
- Bracing.
- Sole plate.

5. List the various methods of tunneling through soft ground. (Apr/May2019)

The various methods of tunneling through the soft ground are:

Fore paling method
Needle beam method
Five piece set method
Linear plates method

Other methods

Casting methods
Square sets and logging method
Horse cups method

6. **Write any two functions of sheet pile? (Apr/May2019)**

- To protect river banks.
- To retain the sides of foundation trenches.
- To resist flow of underground or loose soil or of both.
- To resist bending abrasion or other stresses which may arise in use.

7. Define caisson. What are the types (Nov/dec 2015)

a caisson is defined as a structure which is sunk through ground or water. They exclude water and semi fluid material during the process of excavations of foundations and which subsequently becomes an integral part of the substructure

Types: box, well, pneumatic

8. **What is sheet pile? (Nov/dec 2015)**

- The uses of sheet pile are:
- To protect river banks.

- To retain the sides of foundation trenches.
- To resist flow of underground or loose soil or of both.
- To resist bending abrasion or other stresses which may arise in use.

The types of sheet piles are: Concrete sheet pile Steel sheet pile Timber sheet pile

9. What is an under reamed pile? (Nov/Dec 2016)

Under reamed piles are bored cast-in-situ concrete **piles** having one or more number of bulbs formed by enlarging the **pile** stem. These **piles**are best suited in soils where considerable ground movements occur due to seasonal variations, filled up grounds or in soft soil strata.

10. **State the various methods of dewatering. (Nov/Dec 2018, Nov/Dec2013,Nov/Dec2015)**

- Ditches
- Well point system Shallow well system Deep wall system
- Vacuum method (forced flow method) Electro osmosis method

11. What is grouting (April/May 2019)

Grouting is basically a process of injecting a pumpable material into a structure to change its physical properties. Different types of grouting based on material used are cement grouting , chemical grouting and bituminous grouting. Sometimes resins are also used as grout material.

Sixteen mark

1. **Explain in detail about underwater construction methods (April/May 2017)**

Underwater construction is a method on how to place the concrete underwater. During the construction of bridges, dams or any structure where the foundation is most

likely to lie underwater, the underwater construction is opted. Construction in water poses many difficulties especially in the places where the depth is considerable. During underwater construction, the main objective is to create dry and water free environment for working so that the stability of the structure is balanced.

Underwater Construction techniques:

- Caissons
- Cofferdams

Caissons

A caisson is retaining water tight structure used to work for the construction of a concrete dam, on the foundation of

a bridge pier or for the repair of ships. They are sunk through water during the process of excavation of foundations to exclude water which eventually becomes an essential part of the substructure.

Types of Caissons

- Box caissons
- Open caissons
- Suction caissons
- Pneumatic caissons

Box Caissons

Box caissons are the prefabricated concrete boxes of various shapes with water tight floor and walls, which are set down on the prepared bases. Once they are in place, they are filled with concrete to become a part of the permanent structure.

Open Caissons

Open caissons are box type structure similar to box caissons except that they don't have a bottom face and mainly consists of vertical walls. These caissons are sunk by self-weight, concrete, water ballast placed on top, by hydraulic jacks depending on site.

Suction caissons

Suction caissons are defined as an upturned bucket that is embedded in the marine sediment. The embedment is achieved either by pushing or by creating negative pressure. This type is usually used in offshore construction.

Pneumatic caissons

Pneumatic caissons are the ones which are closed on top and open at the bottom .The compressed air is used to exclude water from the caissons chamber. The construction of this type of caisson is similar to the others expect that, the working chamber and the shaft are made air tight.

Cofferdams

Cofferdams are temporary watertight enclosure pumped dry below the water line to execute the building operation to be performed on dry surface.

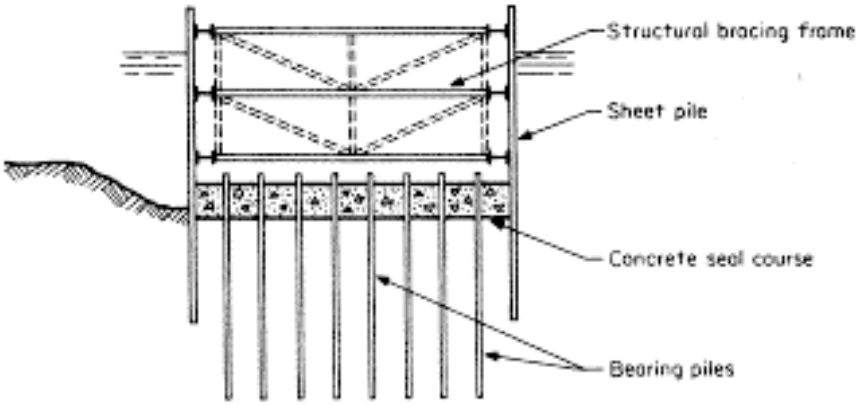
Types of cofferdams

- Earthen cofferdam
- Rock-fill cofferdam
- Cellular cofferdam
- Single walled cofferdam
- Doubled cofferdam
- Crib cofferdam

Components of cofferdams

- Sheet piling
- Bracing frame
- Concrete seal

The typical cofferdam consists of sheet piles set around a bracing frame and are driven in the soil sufficiently to cut off the flow of soil and to develop lateral and vertical support and in some cases to cut the flow of water.



Comparison of Caissons and Cofferdams

Caissons and cofferdams are selected depending on site conditions. Caissons are permanent structure used for small area where the water height is more than 12m whereas Cofferdams are temporary structures which are used for large area with water height up to 12m.

Underwater Concreting

This is a process where the prepared concrete is poured below the water surface using suitable methods.

Placement methods:

Tremie method – A Tremie is a water tight pipe which is supported on a working platform above water level.

Pump method – It's a method where the concrete is pumped directly into its final position including both horizontal and vertical delivery of concrete.

Toggle bags – Toggle bags are ideal for small amount of concrete placement .They are filled with wet concrete and is squeezed out by a diver.

Bagwork – In this method, bags are filled with rich mix concrete, which are made of open weave material. They are either diver- handled bags or placed using a crane. This method is used for temporary works or short term solutions.

2. **Explain in detail about the tunneling techniques. (April/May 2019, April/May 2017,Nov/Dec2016)**

TUNNELING

Process of making tunnels in order to reduce distance of travel or traffic congestion for highway and railway is called tunneling

Tunneling is important for the following purpose

- Time saving and reduction in fuel
- Avoid unwanted traffic congestion o Maintain a proper speed
- Avoid tiredness of travel o Avoid unwanted accidents

- To avoid deforestation and death of animal while crossing
- To avoid land slide in hilly region
- To avoid the long route around the mountain
- To reduce the length of highway and railway and it may be economical
- To have flatter gradient that is essential to maintain the speed of the vehicle

Tunneling types depending upon the shapes

- Poly centric
- Horse shoe

Size of the tunnel

It depends upon the number of track and the width and length of the mountain

Alignment of tunneling

- Identify the shortest route
- Height of mountain should be less
- Mark the points on the mountain
- Transfer the tunnel inside the mountain by making of required depth
- Checking the tunnel cross section whether equal every where

Methods of tunneling

- Shaft tunneling
- Pilot tunneling

Shaft tunnels

Vertical passages are created along the line o the tunnel then the tunnels can be excavated by the passage of having distance half of the distance between adjacent passage openings are available to take the excavated material ,shafts can also be used to pump out the water

Pilot tunneling

If the height of the mountain is more then we can exercise this method of tunneling but uf he horizontal length is more, shaft tunneling is done

Various types of tunneling technique

Tunneling techniques are

1. Drill jumbo
2. Loading and firing
3. Drilling

Drill Jumbo

Drill jumbos used in tunnels are also known as tunnel jumbos. A drill jumbo is a portable carriage having one more carriage having one or more working platforms equipped with columns, bars or booms to support and guide the drills, enabling the drills to perform drilling operation at any desired pattern. These platforms have arrangement for the supporting the compressed air pipes, water pipes. The booms are operated by hydraulic fluid or air and supports the drifters, and are equipped with control enabling the operator to spot a drill in any desired position conforming to the drilling pattern. The platforms are constructed as per the size of tunnel and can be raised or lowered so as to allow mockers or hauling equipment to pass under the jumbo several drill can be operated from each platform for speedy excavation

The jumbos either on rails on pneumatic tyres depending upon the type of work. The jumbo can be equipped with electricity feeding cables, pneumatic concrete placers etc. Mobile jumbos of modern design with four wheel drive and centrally articulated steering speeds production and reduces tunneling costs

Loading and firing

Drilling pattern when followed produces most economical and efficient breakage of rock for a given tunnel, and is determined by conducting tests using different patterns. Explosive selected for working in tunnels should have low fumes characteristics. Ammonium nitrate explosives are therefore preferred over dynamics due to less toxic fumes

Drilling

For driving a tunnel number of holes are drilled as per drilling pattern in size and depth as decided depending upon the size of the tunnel and its formation Drifters are generally used for drilling in the tunnels where in water is used to remove the cuttings from the holes instead of compressed air to reduced the amount of dust in the air. Holes are drilled slightly deeper than the advance per round to taken care of loss in depth during blasting. Depth advanced due to drilling and blasting operation is called as one round

3.a. Explain the term jacking (APRIL/MAY 2018,2019)

- Box jacking
- Pipe jacking

Types of structures under jacking

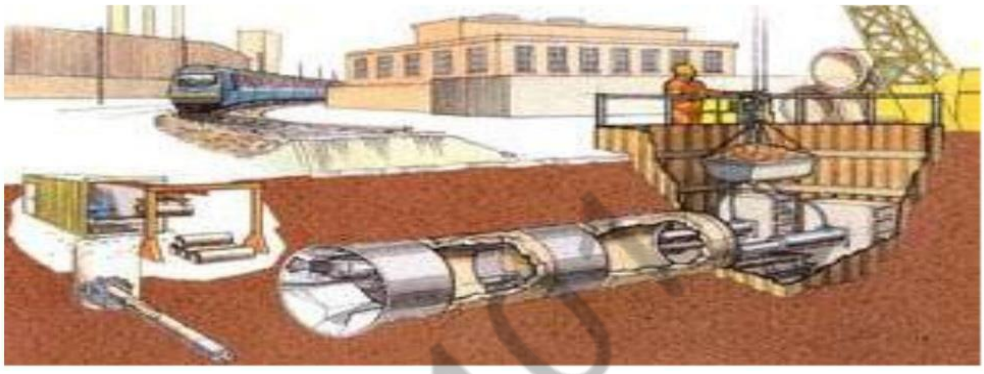
- Box jacking
- Arch jacking
- Pipe jacking

OPERATONS

- The box shaped tunnel structures are pre- fabricated units which are pushed into soil by hydraulic jack
- Soil is excavated at the advancing face by manual means or by excavators
- To avoid settlements of over laying roads or rail track soil is excavated after it enters the cutting heads
- Excavation ahead of the cutting is avoided the cutting head is moved forward in small increments to avoid any having of the road or rail track
- In addition to that, without stabilizing the soil, the box technique would cause the super structure to settle the threatening structure failure so the ground ahead of tunnel boxes needed to be frozen

PIPE JACKING

In tunnels of damages above 2m men and machines worked the tunnel phase exacting and providing soil support to the excavator soil by erecting the lining. The tunnel diameter becomes small it becomes difficult for workers to carry out soil excavation of in erect the tunnel lining system with in the tunnel shield



For diameter in the range of 0.5m to 1.5m it is more efficient to excavate the soil by drilling systems controlled from a shaft or a pit to push the tunnel lining segment from the shaft or pit these techniques are often referred to us pipe jacking or micro tunneling techniques and equipment.

Pipe jacking refers to a technique in which a man in a sitting or crouch position, user's epic and shovels to excavate tunnel face and the pipe is jacked forward from a shaft using hydraulic jacking system

Horizontal auguring refers to a similar technique in which the man is replaced by a horizontal continuous flight helical auger

INSTALATION

The pipe sections are moved forward by hydraulic jacking and the miniature TBM derive its reaction from these section.

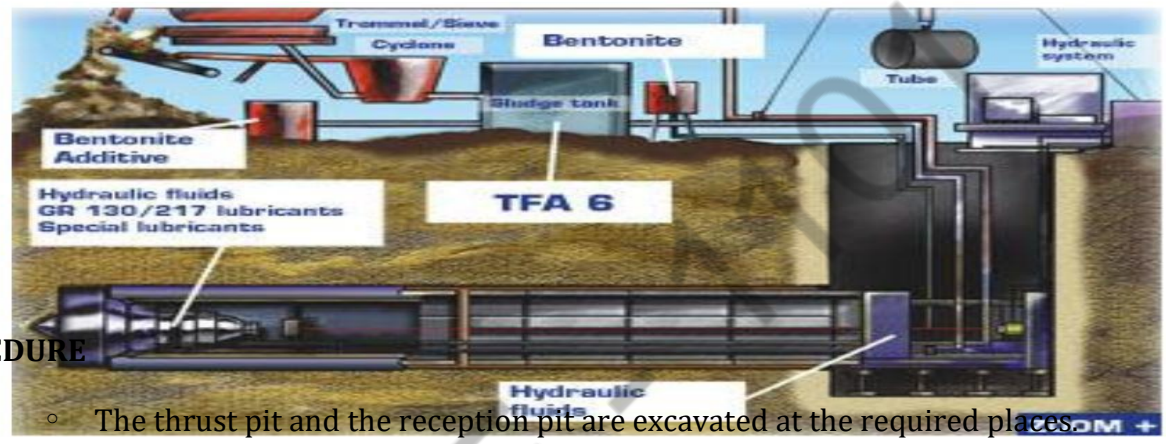
Pipe segments of length 1 to 3 diameters 0.5 to 2m can be jacked into the soil using reaction

from the concrete wall erected at the prior of jacking pit.

ABOUT THE TECHNIQUE

- ✓ It is generally referred as "Micro tunneling"
- ✓ Pipes are pushed through the ground behind the shield using powerful jacks.
- ✓ Simultaneously excavation takes place within the shield.
- ✓ This process is continued until the pipeline is completed.

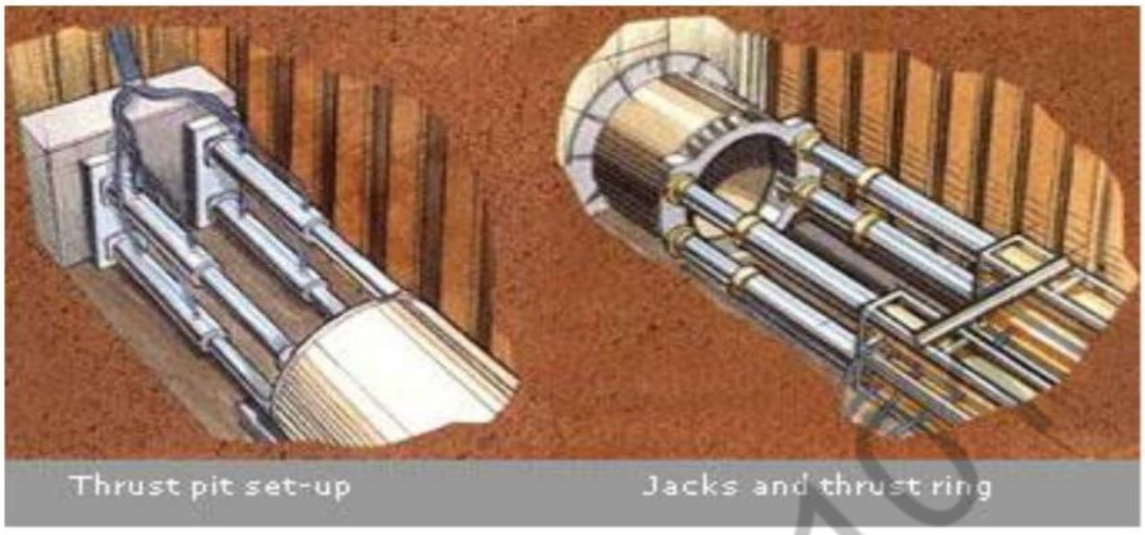
- ✓ The method provides a flexible, structural, watertight, finished pipeline as the tunnel is excavated.
- ✓ No theoretical limit to the length of individual pipelines.
- ✓ Pipes range from 150mm to 3000mm diameter can be installed in straight line or in curvature.
- ✓ Thrust wall is provided for the reaction of the jacks.
- ✓ In case of poor soil, the thrust wall may punch inside the soil.
- ✓ Then piles or ground anchoring methods can be used



PROCEDURE

- ◦ The thrust pit and the reception pit are excavated at the required places.
- ◦ Then the thrust wall is set up in the thrust pit according to the requirement.
- ◦ In case of mechanized excavations, a very large pit is required.
- ◦ But in case of manual excavation, a small pit is enough.
- ◦ Thrust ring is provided to ensure the even distribution of stress along the circumference of the pipe.
- ◦ The number of jacks vary upon the frictional resistance of the soil, strength of pipes etc.,
- ◦ The size of the reception pit is to be big enough to receive the jacking shield.
- ◦ To maintain the accuracy of alignment a steer able shield is used during the pipe jacking.
- ◦ In case of small and short distance excavations, ordinary survey method is sufficient.
- ◦ But in case of long excavations, remote sensing and other techniques can be used.

THRUST SETUP



ADVANTAGES

- It avoids the excavation of trenches. So it is also called as "Trench less Technique".
- There won't be any leak problems in the future.
- Timely finish of projects.

DISADVANTAGES

- Very costly method.
- Skilled personnel is required

METHODS OF BOX JACKING

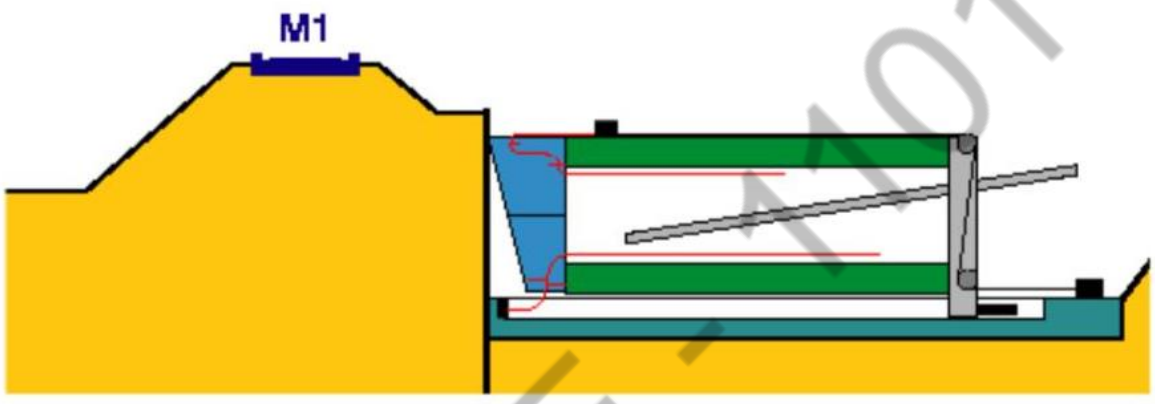
Box Jacking

- Non –intrusive method beneath existing surface infrastructure
- Frequently used where an existing road or rail tracks is an embankment and space exists for the structure to be cast at the side
- Enables traffic flows to be maintained disruption

Procedure

- It involves the advancement of a site-cast rectangular or other shaped box using high capacity hydraulic jacks.
- An open ended reinforced concrete box is cast on a jacking base.

- A purpose designed tunneling shield is provided at its leading end and thrust jacks are provided at its rear end reacting against a jacking slab
- The box is then jacked carefully through the ground
- Excavation and jacking take place in small increments of advance.
- Measure are taken to ensure stability of the tunnel face and to prevent the ground from being dragged forward by the advancing box
- When the box has reached its final position the shield and jacking equipment are removed.



R.C.C box jacking

- Is adopted where it is not possible to constructed in situ R.C.C boxes
- These boxes are used for canal siphon, road under bridge and culvert for conveying water/service pipes
- The R.C.C box is cast over the thrust bed which is provided with –pockets both in longitudinal and traverse jacks
- The box is provided with a shield in front in front called “Front shield” Which pierces through the soil by cutting

Throustboring method

- Is a process of simultaneously jacking pipe through the earth while removing the soil inside the encasement by means of a rotating auger.

- In unstable soil conditions, the end of the auger is kept retracted back inside the encasement so as not to cause voids.

- In stable conditions, the auger can be successfully extended beyond the end of the encasement

4.Explain the types of hammers in pile driving: (APRIL/MAY 2018)

Variety of hammers available to perform some of the acion

- Drop hammer
- Single acting hammer
- Double acting hammer
- Diesel hammer and
- Vibrating hammer

Drop hammer

- ✓ The hammer is lifted by a winch and dropped down
- ✓ The hammer is connected to the rope by a hook
- ✓ When it is lifted up after reaching a particular height it is dropped down
- ✓

Single acting hammer

Hammer is lifted by stream and dropped then it will fell down in the top of the pile by gravitational force

Double acting hammer

It is the same as that of single acting but here both the lifting and dropping is done by steam engine

Diesel hammer

The process of lifting and dropping is done by diesel engine

Vibrators

If the soil condition is loose ,then using some vibrators the pile is inserted

5.Explain sheet piles and its functions (APRIL/MAY 2018)

SHEET PILES

- It is the type of pile that is made of concrete, steel or wood
- The thickness of the pile is very less when compared to the length and width of the pile
- To prevent the entry water in construction the sheet piles are used, this is also used to separate the vertical member of the building
- The piles are inserted by some machine the depth of the piles can be increased by proper joints in successive installment
- Provided when large area is to be excavated for a depth grater than 10m
- Used when the soil is soft or loose
  - Provided when the width of the trench is large
  - It is also provided when the subsoil water is present

Functions

- To enclose the site or part to prevent escape of loose soil
- To retain the sides of trenches or excavation
- To construct retaining wall in the marine structures
- To prevent seepage below the dams or hydraulic structures to construct coastal defense work

Concrete sheet piles

Reinforced precast unit having the width of 50 to 60 cm and thickness 2to 6cm and the depth can be increased by further installment

Timber sheet piles

It is used only for temporary works ,the width of the pile varies from 225to 280 cm the thickness shall not be less than 50mm

6. **What is well pointing (APRIL/MAY 2018)**

DEWATERING WELL POINTS

When construction operation have to be excited below the ground water table level. Dewatering of soil can be done by the following methods:

- ✓ Collecting water in sumps and pumping it out.
- ✓ Installing well points small or deep wells and pumping out ground water
- ✓ Using special technique in fine grained soils such as vaccum dewatering and electro-osmosis

WELL POINTS

- To pump out the ground water small sized wells called well points are used for a more dry working area the two methods used most often for lowering water table below the excavation level are the well point method and the deep well method.

WELL POINT METHOD:

- This is economical and useful for lowering the water table by 15m or less.
- In case of well point method or deep well method it is based on the fact that removal of water by continuous pumping from a well causes the water table level to become depressed and result in the formation of draw down.
- When a series of wells are placed close to each other, the overall effect is lowering of the water table level.
- Well points, being smaller, are easy to install.
- Well points, can lower the water table by only 6.7m because the pump, is located at the ground surface and connected to group of well points through a pipe, cannot lift water from greater depth
- Beyond 7m, multistage well points are used.

7. Explain various types of sheet pile (April/May 2019 Nov/Dec 2016)

Sheet piles are structural sections that can be interconnected to form a continuous sheet pile wall. Sheet piles rely on their structural stiffness to resist lateral forces due to earth,

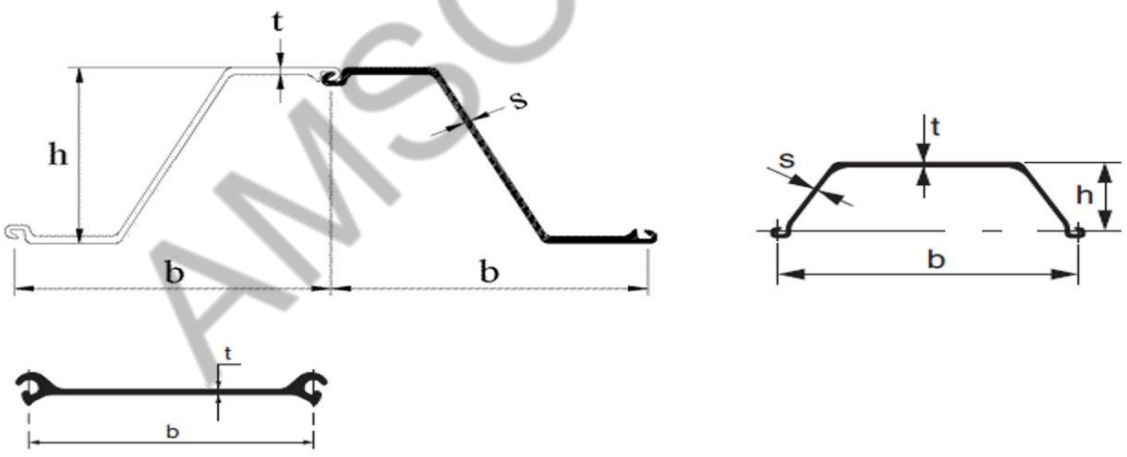
water, or other loads. While different types of sheet piles are available, steel sheet piles are the most common in modern construction. The following paragraphs describe the main types of sheet piles with their relative advantages and disadvantages over other types of sheet piles.

Steel Sheet Piles

Steel sheet piles are the most common types of sheet piles used. Modern steel sheet piles comes in many shapes such as Z sheet piles, U sheet piles, or straight piles. The sheet piles are interconnected with a male to female joint. There are many different types of sheet pile connections each with their own advantages or limitations. At corners, special junction joints are utilized to connect one sheet pile wall line to the next. The main advantages of steel sheet piles over other sheet pile types are:

- Wide range of product availability
- Increased strength
- Durability when corrosion is not an issue
- Can be utilized in heavy civil construction

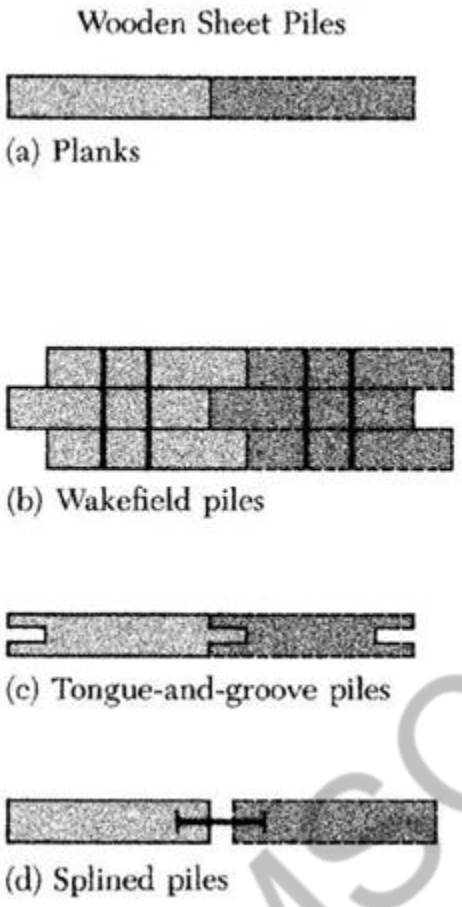
The main drawback of steel sheet piles versus other sheet pile types is that corrosion protection is required in highly corrosive environments. Also, with the exception of precast concrete sheet piles, steel sheet piles are more expensive.



Timber Sheet Piles

Timber sheet piles typically consist of timber planks that are interconnected with a tongue and groove joint. Different types of timber sheet piles include simple planks, Wakefield timber sheet piles (when many planks are nailed or glued together to form a single timber sheet pile section), tongue and groove timber sheet piles, or splined timber sheets. Timber

sheet piles are seldomly used in modern heavy civil construction. Their most common application today is in relatively shallow excavations for utilities when groundwater is not present. Timber sheet piles could potentially be used in long-term or marine environments when the timbers are properly treated. However, their durability would be questionable.



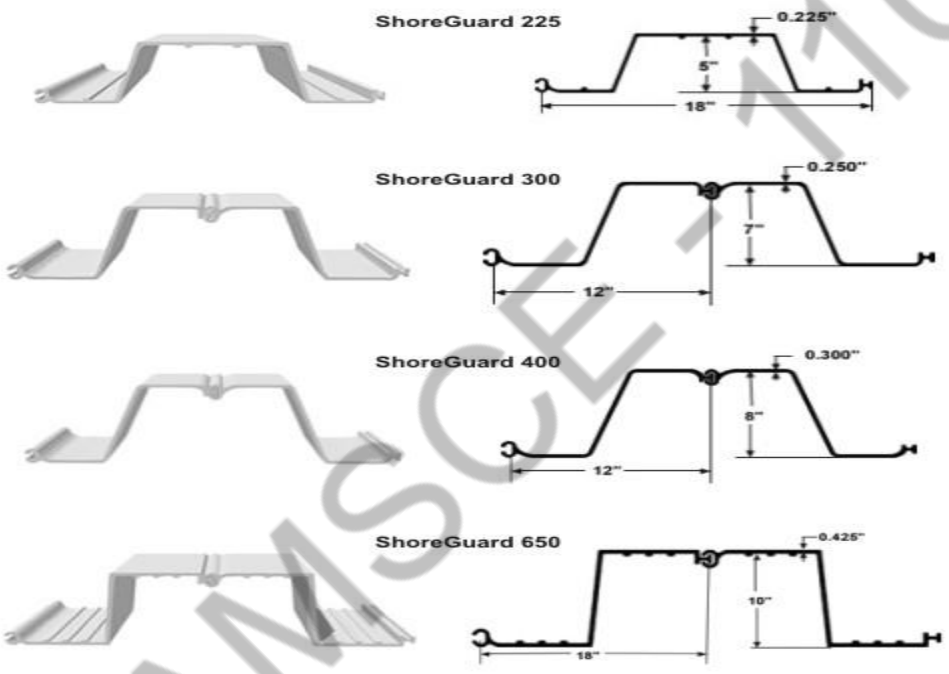
Vinyl Sheet Piles and polymeric sheet piles

Vinyl sheet piles are quite similar to steel sheet piles but are fabricated from synthetic materials. They are ideal for small environmental barriers or sea-front projects where there is a small exposed height. Vinyl sheet piles are commonly used as erosion protection barriers. Depending on the type of synthetic sheet pile material that is used, vinyl sheet piles can perform differently under long term exposure to sunlight or chemicals. Vinyl sheet piles have smaller yield strengths and are less stiff when compared to steel sheet piles. An engineer specifying vinyl sheet piles should consult with the individual manufacturer regarding any restrictions or applicability of using a specific product.

Aluminum Sheet Piles

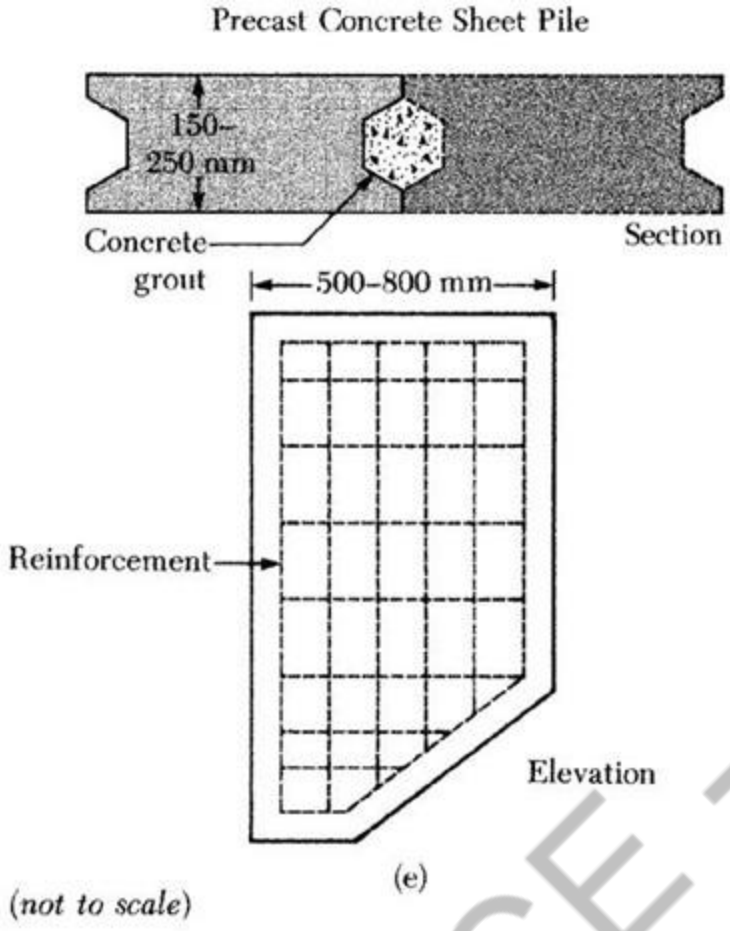
Aluminum sheet piles work similarly to steel sheet piles in provide resistance. Aluminum strengths can vary from 8ksi to 45 ksi, and some aluminum materials exhibit considerably different tensile yield and maximum yield strengths. Aluminum has a modulus of elasticity of 10000 ksi, approximately 30% of the value of steel. As a result, aluminum is considerably more flexible than comparable steel sheet pile sections. Aluminum sheet piles on the other hand are lighter than steel and offer improved corrosion resistance in marine environments. For this reason, aluminum sheet piles might be ideal in some marine applications.

Aluminum sheet piles may corrode in acidic soils or if placed directly against marine treated lumber due to the fact that the lumber has a high concentration of copper, chrome and salt. This problem may be solved simply by placing a membrane between the lumber and the aluminum.



Precast Concrete Sheet Piles

Precast concrete sheet piles are constructed by casting reinforced concrete panel sheets with tongue and groove or fillable joint at the sheet pile ends. Precast concrete sheet piles are relatively uncommon and might be used when steel sheet piles are not available or under very special conditions. They can offer substantial stiffness and strength capacity but require extensive labor to fabricate, care to transport and handle. Because of their increased thickness and tip area, precast concrete sheet piles can be very hard if not impossible to drive. Precast concrete piles might also experience tension cracks during driving as driving tension stresses travel through the section.



8. Describe the procedure involved in under water construction of diaphragm walls and basement. (April/May 2019, May/June2012,Nov/Dec2014,Nov/Dec2015)

DIAPHRAGM WALL

Diaphragm wall are structure elements, which are constructed underground to prevent the seepage into the excavated area

Various methods adopted to construct a diaphragm wall

Slurry trench technique

1. Soil mixing method
2. RC continuous diaphragm wall

3. Precast diaphragm wall
4. Glass diaphragm walls

Slurry trench technique

- The technique involves excavating a narrow trench that is kept full of an engineered fluid or slurry
- The slurry exerts hydraulic pressure against the trench walls and acts as shoring to prevent collapse
- Slurry trench excavations can be performed in all types of soil even below ground water table

Soil mixing method

- This is the method used to make continuous walls by churning up piled soil using an auger, pouring in cement milk and marking soil mortar columns in the ground using the soil as aggregate
- This is an in situ mixing and churning method
- In the method after completing excavation of the groove wall using an excavator, soil cement is produced by mixing and churning excavated soil
- The excavated soil is classified and graded with cement milk after being put through a tremie
- Then the soil cement is poured into the groove wall, after which the steel material is built as the core material

RC continuous diaphragm wall

- This method of building a very long continuous diaphragm wall
- Excavate a given groove between the surface and underground using a stabilizing liquid
- Insert a given steel bar pour in concrete, thereby building a reinforced concrete wall underground.

Precast diaphragm wall

- With this method, a continuous trench or longer panels are excavated under self-hardening cement- bentonite (CB) slurry.
- The precast concrete wall sections are lifted and positioned by a crane

- The CB slurry sets to form the final composite wall
- The trench is excavated under bentonite slurry, which is then displaced with CB slurry.

Glass diaphragm walls

- For contained enclosure, a diaphragm wall system consisting of special glass panels with a sealing made out of glass are used.
- The panels are 50cm wide and upto 15cm long

Common uses of diaphragm wall walls

- To provide structural support for the construction
- To provide retaining wall
- To provide deep diaphragms

Applications of diaphragm wall

- As permanent and temporary foundation wall foundation walls for deep foundation for deep basements
- In earth retention schemes for highway and tunnel projects
- As permanent walls for deep shafts for tunnel access
- As permanent cut - off walls through the core of earth dams
- In congested areas for retention systems and permanent foundation walls
- Deep groundwater barriers through and under dams

8. Explain the process and various methods of dewatering (Nov/Dec 2017, Nov/Dec 2015, Nov/Dec 2016)

Dewatering of excavations is required at construction sites generally for foundation works. Various methods for dewatering of excavations are described in this article.

Firm and sound working conditions are indispensable when construction of buildings, powerhouse, dams, and other structures has to be executed. These structures not only require a dry base for their foundations but also good water-table stability in the girth.

Dewatering of any excavated area is done in order to keep the excavation bottom dry, to prevent the leakage of water or sand and to avoid upheaval failure. Dewatering could turn out to be a herculean task if one doesn't adopt the right method.

The different methods available for dewatering of excavations at constructions sites are not necessarily interchangeable as each one has a narrow range of applications, therefore, adopting the right method of dewatering for a particular ground condition is always a critical and a difficult decision to make.

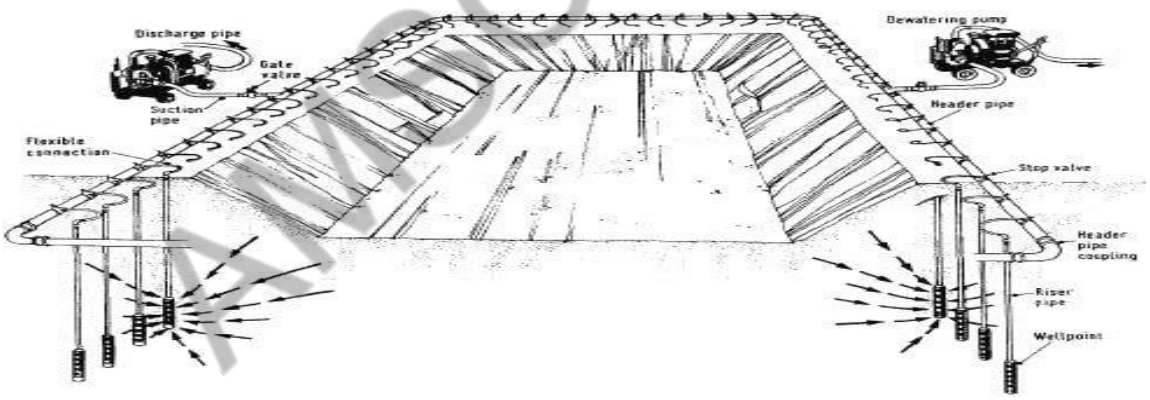
A minor amount of water can always be pumped out by creating a sump but when other factors like continuous seepage, excessive smudge come into play one has to resort to a bit of sophistication

Methods of Dewatering Excavations at Construction Site

There are four important dewatering methods one should be aware of:

- Well point method of dewatering,
- Eductor wells,
- Open sump pumping and
- Deep WellPoint method

Well point Method of Dewatering Excavations



1) A series of wells of required depth are created in the vicinity of the excavated area from where the water has to be pumped out. The wells are arranged either in a line or a rectangular form where the wellpoints are created at a distance of at least 2m from each other.

2) Riser pipes or dewatering pipes are then installed into those closely spaced wells which on the surface are connected to a flexible swing pipe which is ultimately appended to a

common header pipe that is responsible for discharging the water away from the site. The purpose of using a flexible swing pipe is just to provide a clear view of what is being pumped and the purpose of header pipe is to create suction as well as discharge the water off the working area.

3) One end of the header pipe is connected to a vacuum pump which draws water through notches in the wellpoint. The water then travels from the wellpoints through the flexible swing pipe into the header pipe to the pump. It is then discharged away from the site or to other processes to remove unwanted properties such as contaminants.

4) The drawdown using this method is restricted to around five to six meters below the wellpoint pump level. If a deeper drawdown is required, multiple stages of wellpoints must be used.

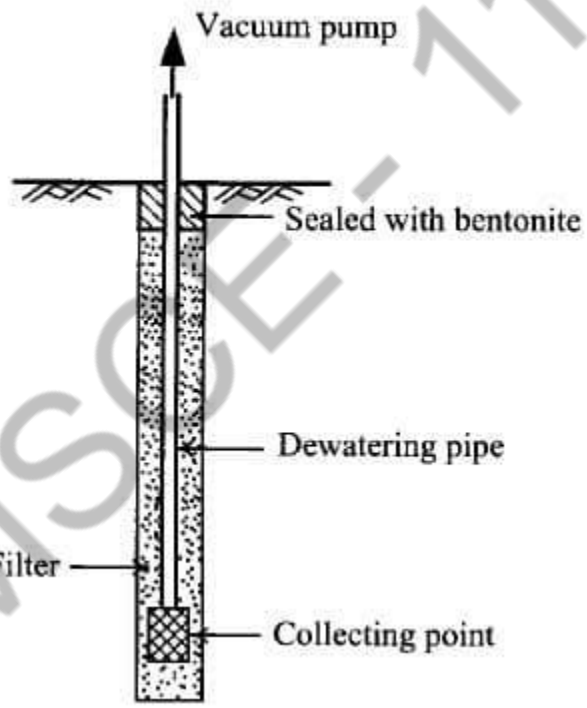


Fig: Details of Wellpoint Method for Excavation Dewatering

Eductor Wells Method of Dewatering Excavations

The method is very similar to the wellpoint method of dewatering; the only difference lies in the usage of high-pressure water in the riser units instead of vacuum to draw out water from the wellpoints. The method uses the venturi principle which is the reduction in fluid

pressure that results when a high-pressure fluid flows through a constricted section of a pipe

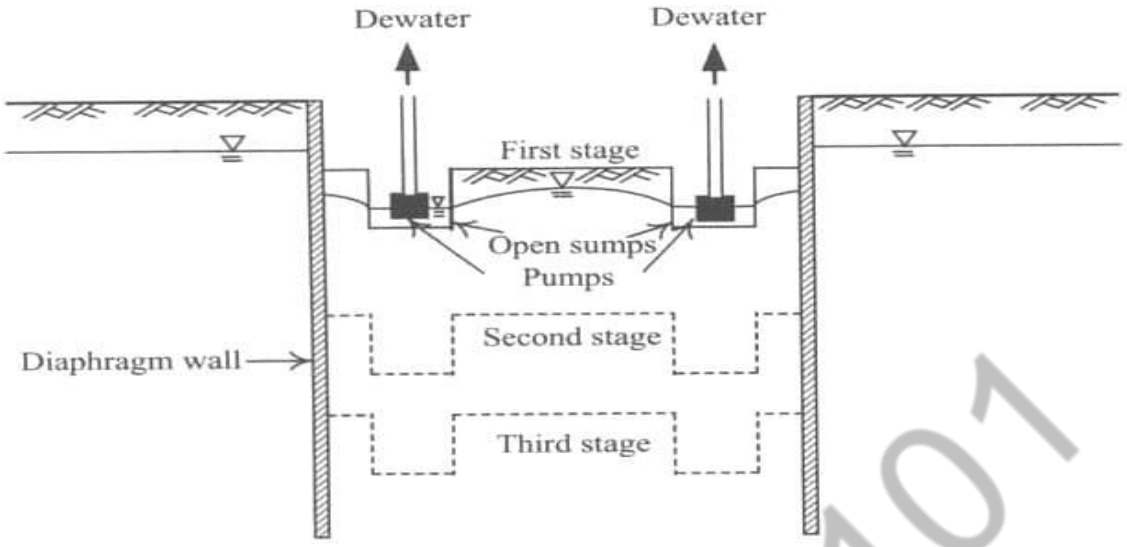
.

A high-pressure supply main feeds water through a venturi-tube just above the well-screen, creating a reduction in pressure which draws water through the riser pipe. The high pressure main feeds off the return water. The biggest advantage of using the eductor system is, the water table can be lowered from depths of 10-45 m if multiple pumps are operated from a single pump station. This method therefore becomes economically competitive at depth in soils of low permeability.

Open Sump Pumping Method of Dewatering Excavations

This is the most common and economical method of dewatering as gravity is the main playing force. Sump is created in the excavated area into which the surrounding water converges and accumulates facilitating easy discharge of water through robust solid

handling pumps.



Its application is however confined to the areas where soil is either gravelly or sandy. Since the bottom of the sump is situated at a level lower than that of the excavation bottom, it will abridge the seepage way along which groundwater from outside seeps into the excavation zone and as a result the exit gradient of the sump bottom will be larger than that on the excavation surface.

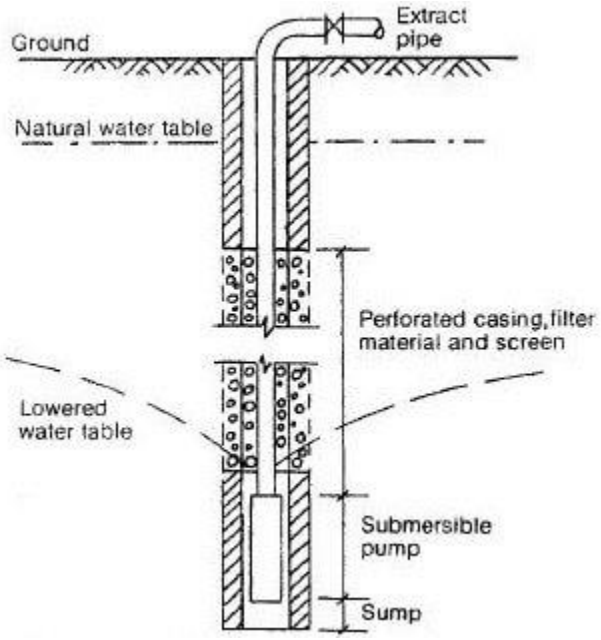
If the excavation area is large, several sumps may be placed along the longer side or simply use a long narrow sump which is called a ditch.

Deep Well Method of Dewatering Excavations

Just like the wellpoint method, wells are drilled around the excavated area, but the diameter of wells, in this case, varies between 150-200mm. By creating deep wells around the vicinity, the groundwater is made to fall into them under the influence of gravity.

As a result, the groundwater level in the surroundings would decline. According to the type and arrangement of pumps, the depths of the wells could reach up to 30m. This method is

generally adopted when a heavy amount of water from the ground has to be drawn out.



Casings of diameter fitting to wells are installed in order to retain the wells. Additionally, well screens and filters (between sidewalls and casing) are used which serve as a filtering device therefore not letting the unwanted sediments enter into the well. The water thus accumulated is pumped out using a submersible pump or a centrifugal pump.

It is prudent to assess ground-permeability conditions beforehand since the whole process of accumulation and pumping takes quite a bit of time. This may cause settlement in the nearby areas and hence a different technique might need to be adopted

8. Describe with neat sketch about the technique of pile driving (Nov/Dec 2017, Apr/May2015,Nov/Dec2013,May/June2013)

Pile Installation Methods (Techniques)

- A variety of methods and special equipment have been used for the installation of piles.
- Installation practices include consideration and utilization of appropriate field methods for storing, handling, and accurately driving each pile to the desired final position within established tolerances.

- The designer should be aware that certain equipment and methods for pile installation have been known to reduce axial and lateral resistance or damage the pile in certain situations.
- Piles made from (Wood, steel and concrete) are driven, drilled or jacked into the ground and connected to pile caps.
- In order to avoid damages to the piles, during design, installation methods and installation equipment should be carefully selected.
- The installation process and method of installations are equally important factors as of the design process of pile foundations. There are two main types of pile installation methods:

Pile driving methods (displacement piles)

Boring methods (non-displacement piles)

A) Pile driving methods (displacement piles)

Methods of pile driving can be categorized as follows:

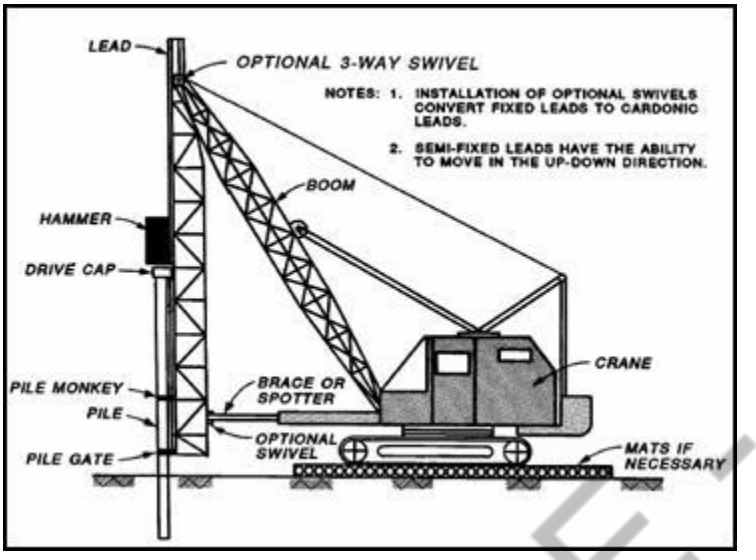
1. **Dropping weight (Impact hammers)**
2. **Vibration (vibratory hammers)**
3. **Jacking**
4. **Jetting**
5. **Explosion**

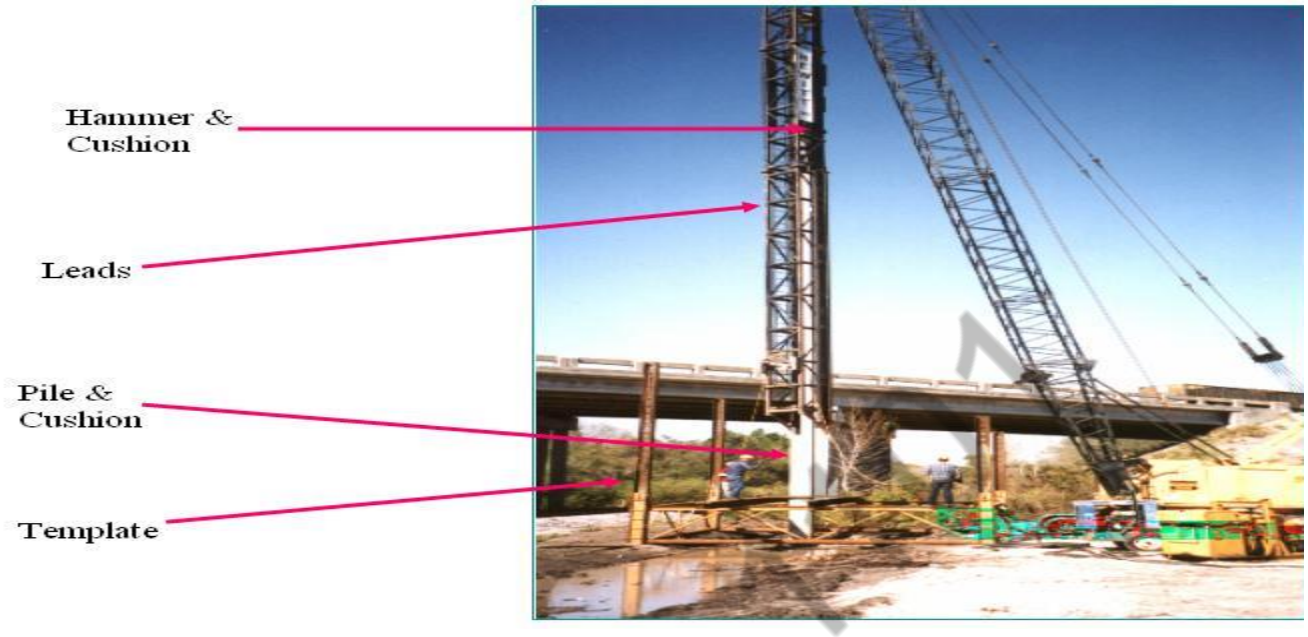
- Hammers can generally be divided into two groups, impact and vibratory. Impact hammers may be lifted manually or automatically by steam, air or diesel, and may also be single or double-acting.

- These hammers are sized by the maximum "rated energy" (foot-pounds) theoretically contained as kinetic energy in the ram just before impact. This rated energy is not necessarily absorbed by the pile.

- Vibratory hammers are electrically or hydraulically powered, usually have a variable operating frequency range (vibrations per minute), and are generally rated by "eccentric moment" (inch-pounds) and "driving force" (tons) for a specified frequency.

1. Pile driving by dropping weight





Pile Driving Equipment

Drop hammers

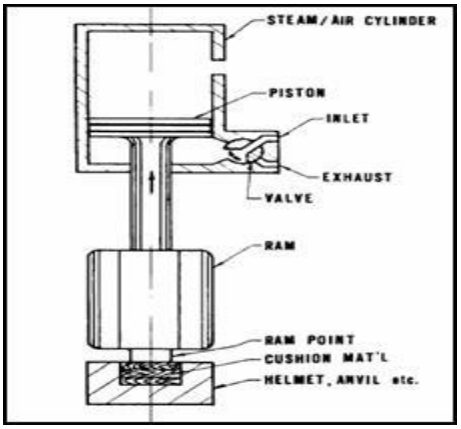
The drop hammer is the simplest and oldest type of impact hammer. A hammer with approximately the weight of the pile is raised a suitable height in a guide and released to strike the pile head. This is a simple form of hammer used in conjunction with light frames and test piling, where it may be uneconomical to bring a steam boiler or compressor on to a site to drive very limited number of piles.

There are two main types of drop hammers:

- Single-acting steam or compressed-air hammers
- Double-acting pile hammers

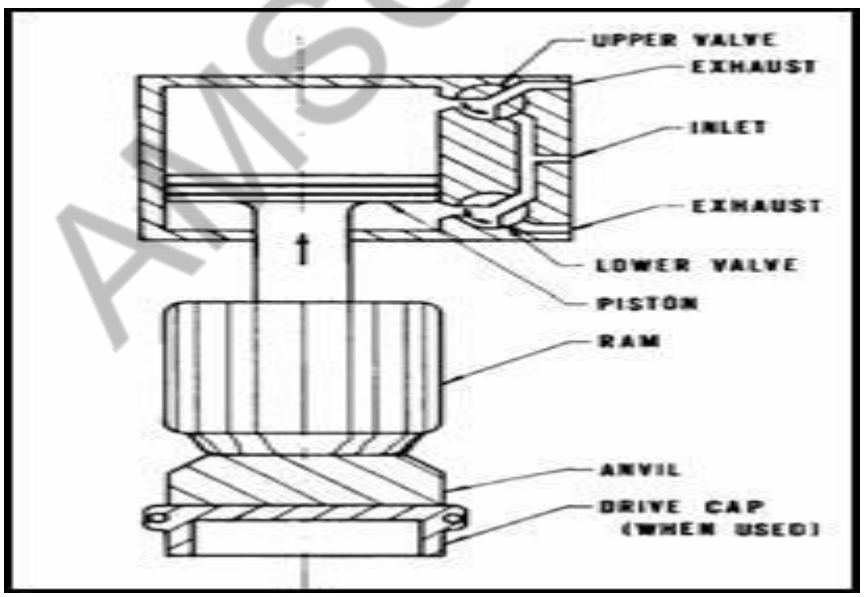
Single-acting hammer

- This hammer type utilizes pressure from steam or compressed air to raise the ram, then automatically releases the pressure allowing the ram to fall freely and strike the drive cap (pile helmet).



Double-acting hammer

- The steam or compressed air is also utilized to supply additional energy to the ram on the downward part of the stroke. The combination of pressure on the down stroke and a short stroke distance results in an operating rate generally ranging from 90 to 150 blows per minute.

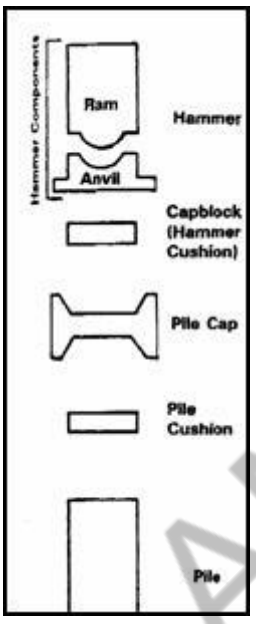


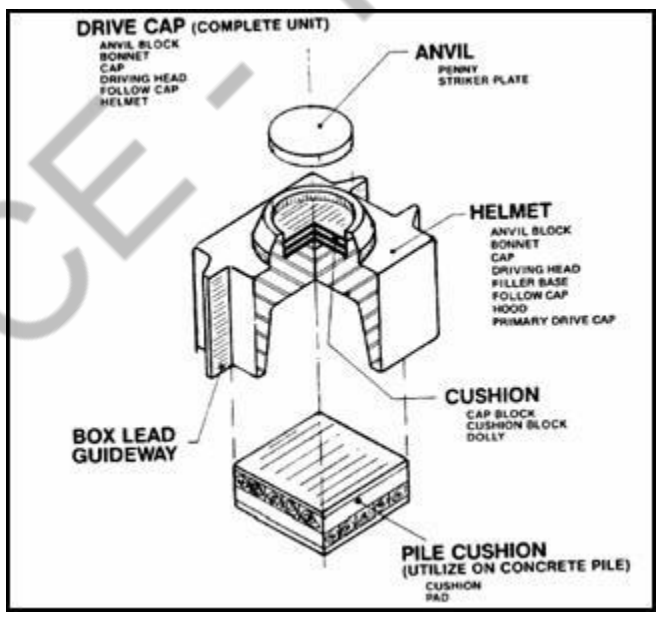
- Double-acting hammers are used mainly for sheet pile driving.

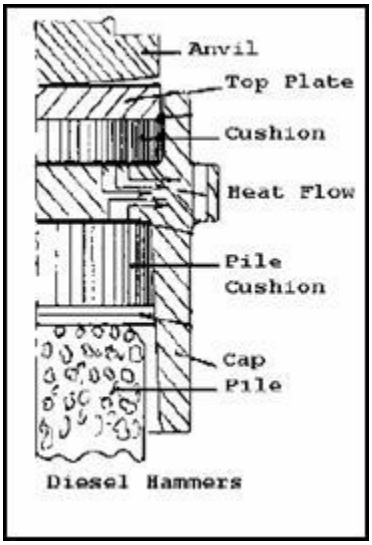
Diesel hammers

Also classified as single and double-acting, in operation, the diesel hammer employs a ram which is raised by explosion at the base of a cylinder. Alternatively, in the case of double-acting diesel hammer, a vacuum is created in a separate annular chamber as the ram moves upward, and assists in the return of the ram, almost doubling the output of the hammer over the single-acting type. In favorable ground conditions, the diesel hammer provide an efficient pile driving capacity, but they are not effective for all types of ground.

1. Pile driving by dropping weight







2. Pile driving by vibrating

- Vibratory hammers are usually electrically powered or hydraulically powered and consists of contra-rotating eccentric masses within a housing attaching to the pile head. The amplitude of the vibration is sufficient to break down the skin friction on the sides of the pile. Vibratory methods are best suited to sandy or gravelly soil.

- Vibratory hammers are available in high, medium, and low frequency ranges.

- It is important that a rigid connection be maintained between the hammer and the pile, usually by means of a mechanical clamp, and a back-up system may be required to prevent release of the clamp in the event of a power failure

3. Pile driving by jacking

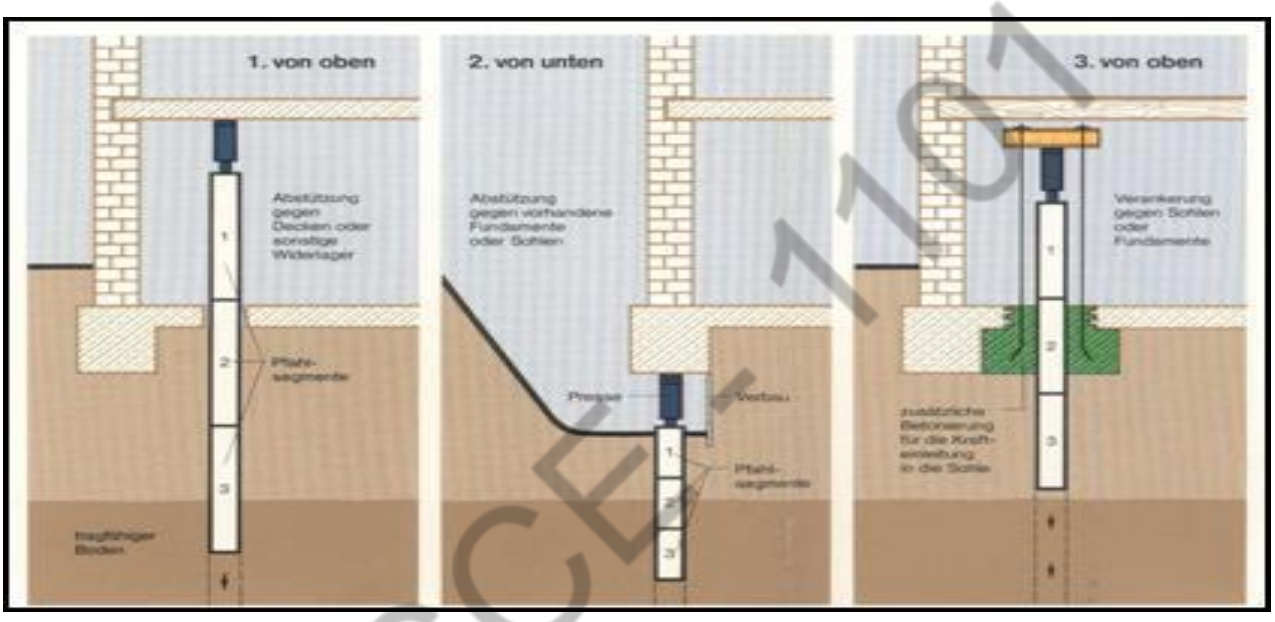
Jacked pile:

Pile driven into the ground by applying force between the top of the pile and a stable object above. Pile driven into the ground by applying force between the top of the pile and a stable object above.

Jacking:

1. A means of imposing a static driving force on a pile by using jacks. Used extensively to install piles in underpinning of structures. (A jacked pile).

2. The means of precisely transferring load from another source (either dead weight or a reaction platform) in the performance of a pile load test.



Micro piles

- Installation equipment for micro piles usually consists of self-contained drill units, similar to those used for tieback anchor installation.
- Micro piles are manufactured with a coupling sleeve and are either hot dip galvanised or left untreated.
- A pile shoe is fitted when the piles are installed.
- The piles are installed using special machines equipped with a light hydraulic or pneumatic ram.

9. Explain the Construction of sheet pile wall (Nov/Dec 2018)

Sheet Pile Wall Construction

Sheet pile walls are retaining walls constructed to retain earth, water or any other filling materials. These walls are thinner in section compared to masonry walls. Sheet pile walls are generally used for following:

- Water front structures, i.e. in building wharfs, quays and piers.
- Building diversion dams, such as cofferdams
- River bank protection
- Retaining the sides of cuts made in earth

Sheet pile walls can be of timber, reinforced concrete or steel.

Steel sheet piles are most commonly used. Steel sheet piles possess several advantages over other piles. They are:

- Steel sheet piles are resistant to high driving stresses
- They are lighter in section
- They can be used several times
- They can be used either below or above water and have long life span
- Suitable joints can be provided to have a continuous wall
- The pile length can be increased either by welding or bolting

Reinforced concrete sheet piles are precast concrete members, usually with a tongue and groove joints. Typical section of the RCC sheet pile is shown in figure below. These piles are relatively heavy and bulky. They displace large volumes of solid during driving. This large volume displacement of soil tends to increase the driving resistance. Due to this reason, suitable reinforcement is provided considering large driving stresses.

Sheet piles are often connected together in pairs and installed using one of three methods:

- **Vibration:** this is the most common method. The first sheet pile of the wall is installed into the ground. A vibratory hammer with clamp is attached to the top of the second sheet pile, which is then interlocked with the first sheet pile, and the sheet pile is vibrated into the ground.
- **Pressing:** sheet piles can also be pressed into the ground when noise hindrance and vibration would otherwise cause problems. This, however, takes longer and is expensive. The sheet piles are pressed into the ground by a hydraulic machine.
- **Excavation:** sheet piles can also be excavated into the soil. A long trench is excavated which is then filled with cement bentonite (a thin concrete slurry) to prevent the walls from collapsing. The sheet piles are then installed in the trench and the cement bentonite is allowed to set

Steel sheet piling is the most common because of several **advantages** over other materials:

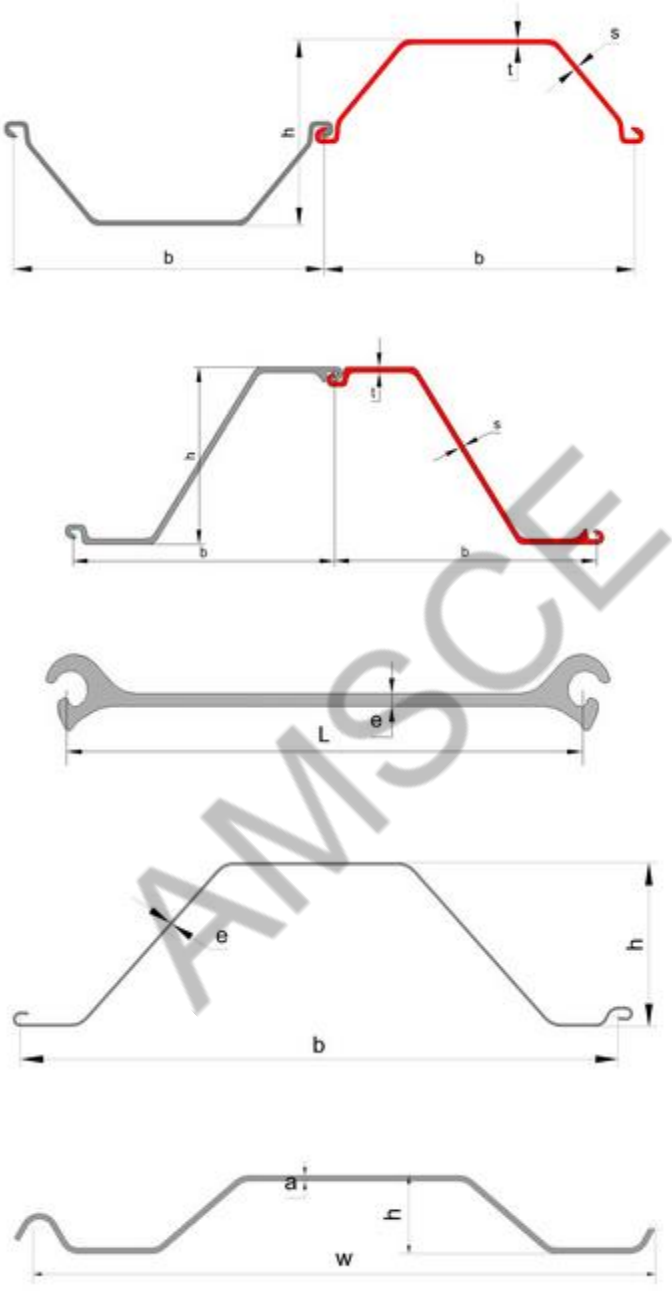
- Provides high resistance to driving stresses.
- Light weight
- Can be reused on several projects.
- Long service life above or below water with modest protection.
- Easy to adapt the pile length by either welding or bolting
- Joints are less apt to deform during driving.

Sheet pile wall **disadvantages** are:

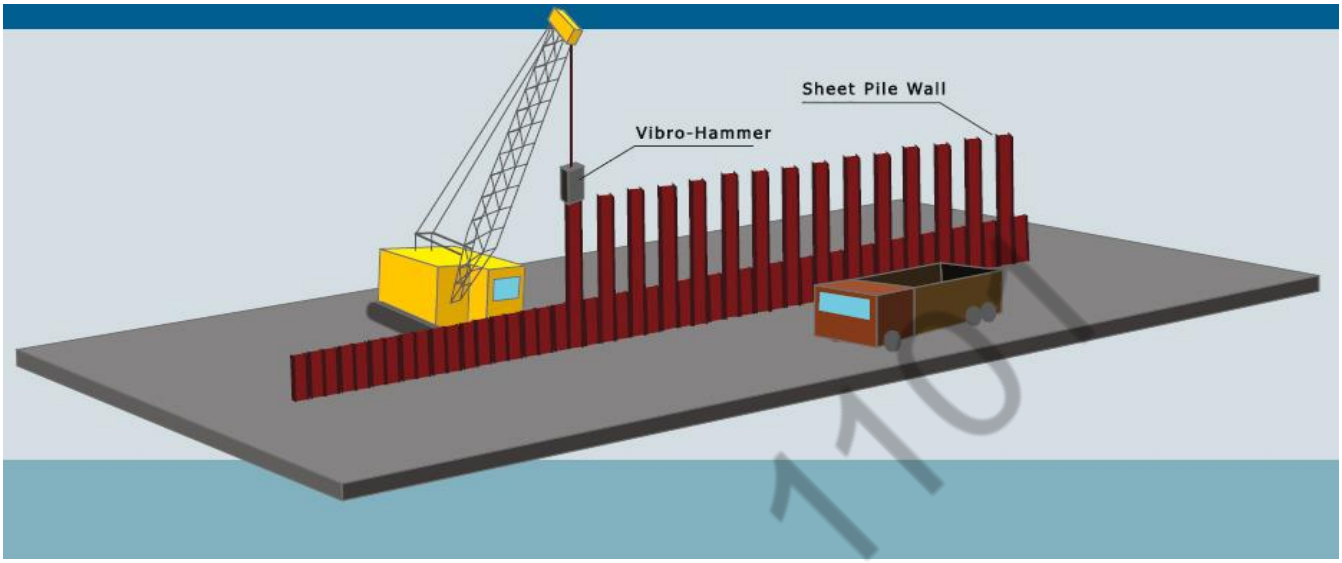
- Sections can rarely be used as part of the permanent structure.
- Installation of sheet piles is difficult in soils with boulders or cobbles. In such cases, the desired wall depths may not be reached.

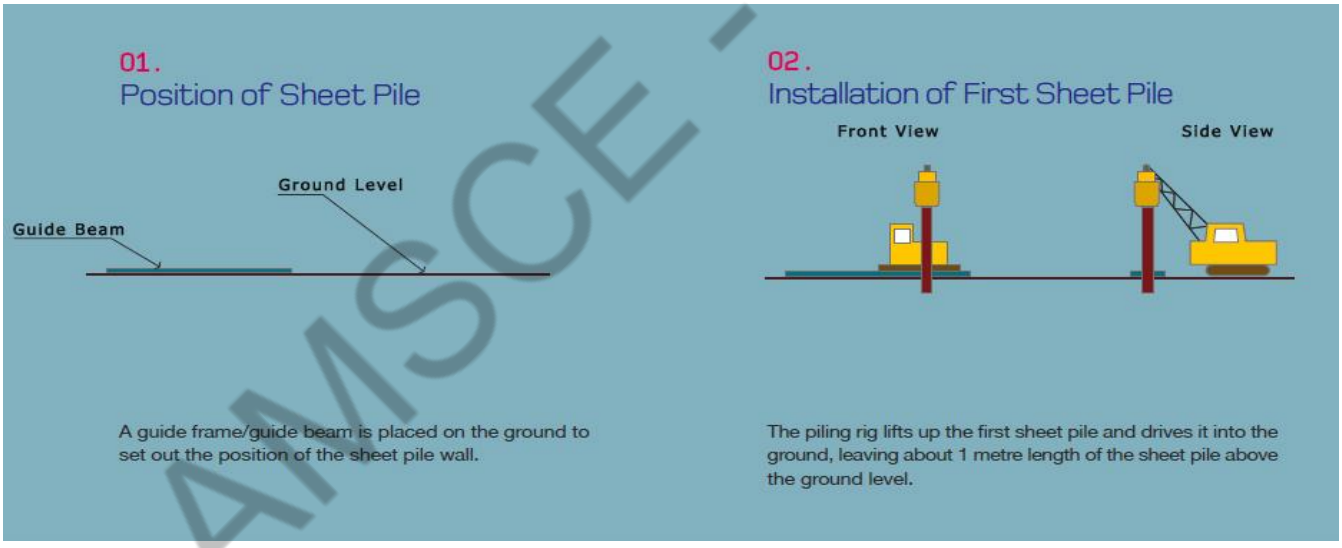
- Excavation shapes are dictated by the sheet pile section and interlocking elements.
- Sheet pile driving may cause neighborhood distrurbace
- Settlements in adjacent properties may take place due to installation vibrations

Some Shapes of Sheet Pile



Construction of Sheet Pile wall

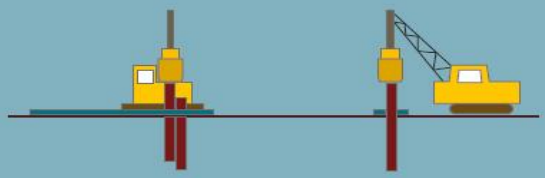




03.

Installation of Second Sheet Pile

Front View Side View

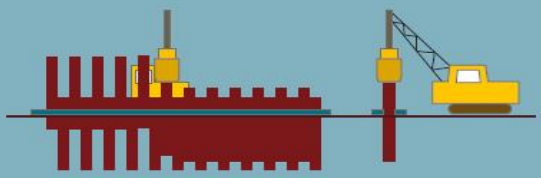


The piling rig drives the second sheet pile into the ground and the second sheet pile interlocks with the first sheet pile.

04.

Repetition of Process

Front View Side View

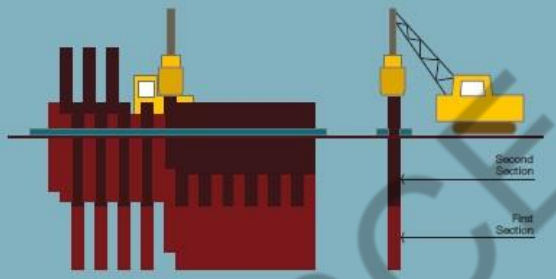


Process 2 and 3 repeats till the installation of sheet piles is completed within the length of the guide frame/ guide beam.

05.

Extension of Sheet Pile

Front View Side View



If the first set of sheet piles installed are not long enough to reach the required depth in the ground, extension of sheet piles is required. This is done by welding the ends of a second sheet pile length to the one driven in earlier and driving the combined length into the ground.

10. Explain the construction of well foundation for a bridge (Nov/Dec 2018)

Construction of well foundation consists of the following stages:

1. Laying the Cutting Edge

2. Alignment Control

3. Construction of Well Curb

4. Construction of Well Steining

5. Well Sinking.

Stage1. Laying the Cutting Edge:

Well foundations are constructed in stages by sinking under self-weight as well as dredging the soil inside the dredge hole and on the sides outside. The first step in the construction of a well foundation is to lay the cutting edge and well curb. If the river bed is dry, the cutting edge is placed in position after removing the top loose layer of sand.

Otherwise, a temporary structure, known as a sand island, is constructed using cofferdams for the purpose of excluding water, and soil is sufficiently constructed using continuous sheet piles all around the well foundation and filling the space with sand, which serves as a working platform for the work force and equipment. If the water is deeper than about 5 m, the cutting edge and the well curb are fabricated on the shore and towed to the sand island for installation.

Stage 2. Alignment Control:

The centerline of the wells should coincide with the centerline of the abutments and piers and of the bridge. Masonry pillars are constructed on the centerline of the bridge to serve as station points for checking the alignment of the abutments and piers.

Stage 3. Construction of Well Curb:

The well curb is assembled on wooden blocks or sand bags placed at suitable intervals so that it does not sink, while assembling the curb. Concreting is done after placing the reinforcement. M15 or richer grade concrete is used for the well curb. The well curb is then allowed to set for a week before sinking is started. The well curb is allowed to sink alone before raising the steining above it.

Stage 4. Construction of Well Steining:

The grip length of the well is very small at the beginning of the sinking operation and the chances for tilting are more. The steining should not be raised too high in the initial stages of well sinking, which would otherwise lead to increasing the tilting further. Hence, the well curb is first allowed to sink alone and the steining is then raised in small heights of 1.5 m at a time, allowing minimum 24 h before adding the next height of steining.

The steining can be raised in installments of about 3 m, once the well has sunk to a sufficient depth to get a min-imum grip length of 6 m. The steining masonry should be constructed perfectly vertical to ensure vertical sinking of the Well. Straight edges of about 2 m length should be used for this purpose along the outer periphery of the steining at suitable intervals. When the steining is raised by this height, the straight edges are removed and fixed at a higher level and the entire height of the steining should be raised using this procedure.

Stage 5. Well Sinking:

The soil in the dredge hole is excavated to facilitate sinking of the well. A large-size spade, known as jham, is used for excavation under water. Jham consists of a sector-shaped steel pan with edges connected by a rope and wooden bullies. When Jham is used, excavation is done manually and hence well sinking is slow. Alternatively, automatic grabs or dredgers can be used for excavation operated by a winch and crane. Bell's dredger is commonly used for sandy soils.

As the sinking proceeds, more depth of the well foundation will be below the scour level, increasing the frictional resistance between the steining surface and the surrounding soil. The steining is loaded with kentledge through a suitable platform and with sand bags piled on it to aid well sinking, overcoming this frictional resistance. The platform for the kentledge is constructed in such a way that it does not obstruct the dredging process. Air and water jets are also used in addition to the kentledge to further overcome the frictional resistance. These jets consist of G.I. pipes of 2.5-5 cm diameter with a nozzle at one end.

Well sinking may stop and tilting may also occur when the cutting edge encounters an obstruction below it. The obstruction can be removed by dewatering the well using pulsometer pumps and blowing of sand into it. The dewatering process should be continuously watched and should be suspended if there is a tendency for tilt-ing of the well.

Dewatering also should not be used unless the well has sunk to a sufficient length of a minimum of 9 m.

11**. Explain in detail about various types of cofferdams (April/May 2019) (Nov/Dec 2017)**

There are various types of cofferdams used for construction of structures in water. Construction details of these cofferdams are provided in this article.

The basic needs of human being are food, air, water, shelter and transport. To fulfill the basic needs of shelter and transport every inch of the earth land is being used for the construction of roads, building or other structures.

Nowadays even structure on water are being constructed. But the construction in water is a very tedious job. As the structure is hard to build in water as concrete doesn't set in water. Many methods are being used to overcome this problem. One the methods used for this purpose are Cofferdams.

Cofferdam can be defined as the temporary structure that is built to keep the water away from the execution site, so that the structure can be built on the dry surface.

The cofferdams should have walls that exclude water from building site. For this the walls must be water proof and the height of the wall must be more than the maximum water level. These types of cofferdams are preferred where the area of building site is large and the dry soil bed is at reasonable depth

Types of Cofferdams and Their Construction Details

Coffer dams can be classified into many types depending upon the depth, soil conditions, and fluctuations in the water level and type of material used.

Types of Cofferdams

Considering the material used in their construction, **cofferdams** may be divided into the following categories.

- Earthen cofferdam
- Rockfill cofferdam

- Single-walled cofferdam
- Double-walled cofferdam
- Braced cofferdam
- Cellular cofferdam (Circular or diaphragm type)

Earthen Cofferdam

Earthen cofferdams are constructed at the place where the height of the water is less say 3m and the current velocity is low. These dams are built using the local available material such as clay, fine sand or even soil.

The height of the dam is kept 1m more than that of max water level. Freeboard of the dam or the top of the dam is kept 1m so that the water doesn't enter the other side even when waves arise.

The slope is usually given but 1:1 or 1:2. The slope of the water side is pitched with rubble stones so the water action doesn't score the embankment. Even sheet piles are driven in the center of the dam to resist water seepage. After the construction of earthen cofferdam, the water from the other site is pumped out and construction is executed.

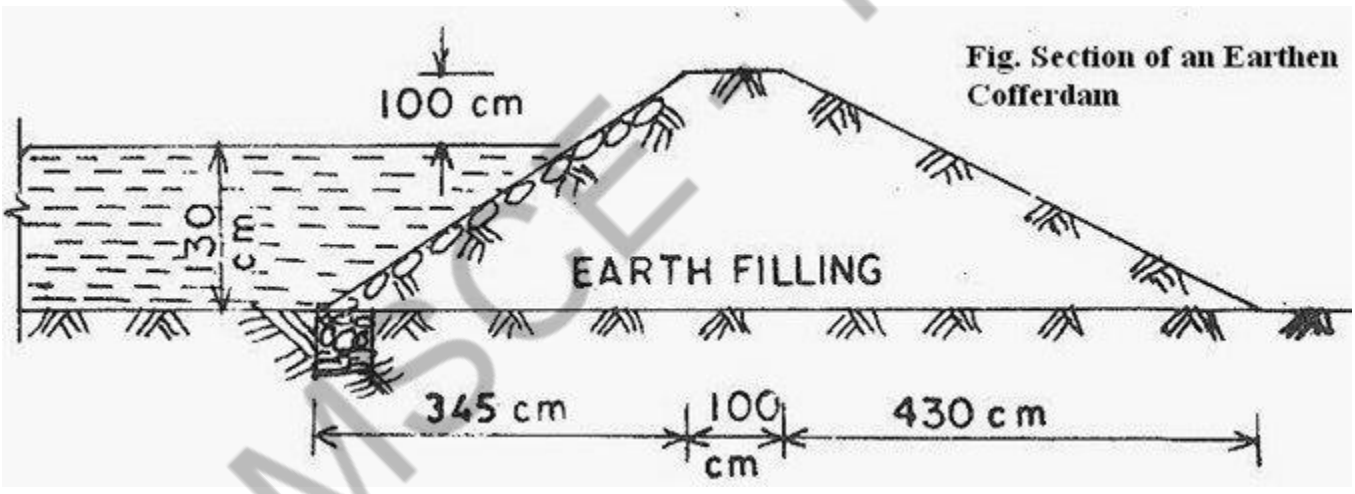


Fig: Cross-Section of an Earthen Cofferdam

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 1:125. The slope on the water side is pitched so as to protect dam from wave action.

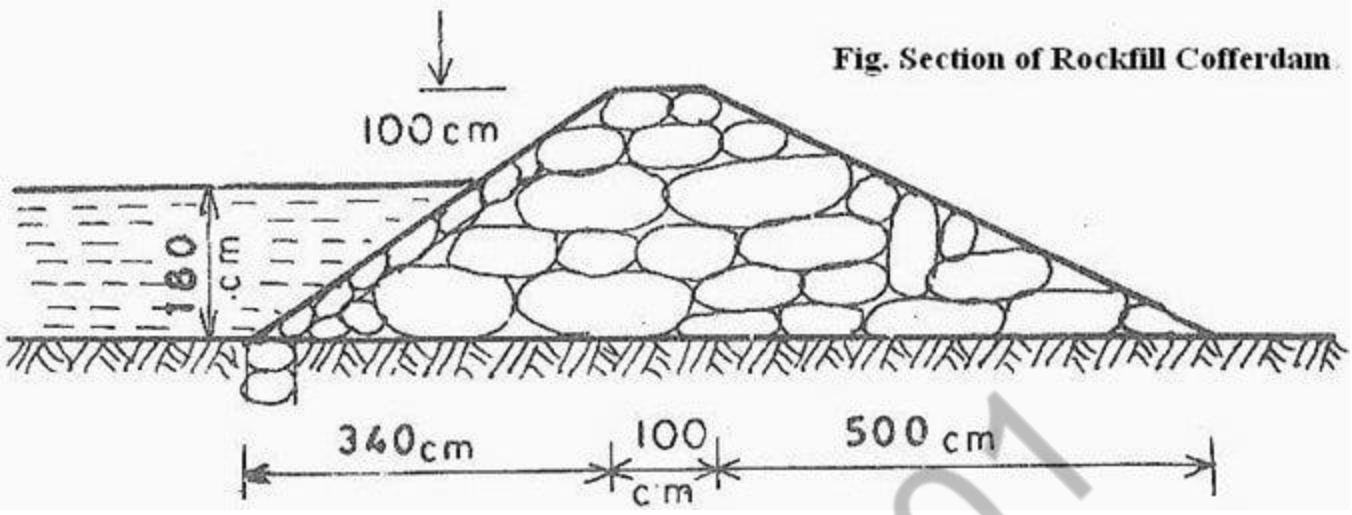


Fig: Cross-Section of Rockfill Cofferdam

Single-Walled Cofferdam

This type of cofferdam is preferred when the depth of the water is more than 6m and area of construction is less. Usually this is used in construction of bridges.

Wooden or timber sheets are driven into the river bed on the perimeter of the area of construction. On the inside steel or iron sheets are driven into the river bed. This inside sheets are placed at equal distance with the help of wales which are bolted to both sheets for either sides.

To improve the stability of this types of dam, half-filled bags of sand are placed on the both side of the walls. The water from the inside is pumped out and the construction process is undertaken.

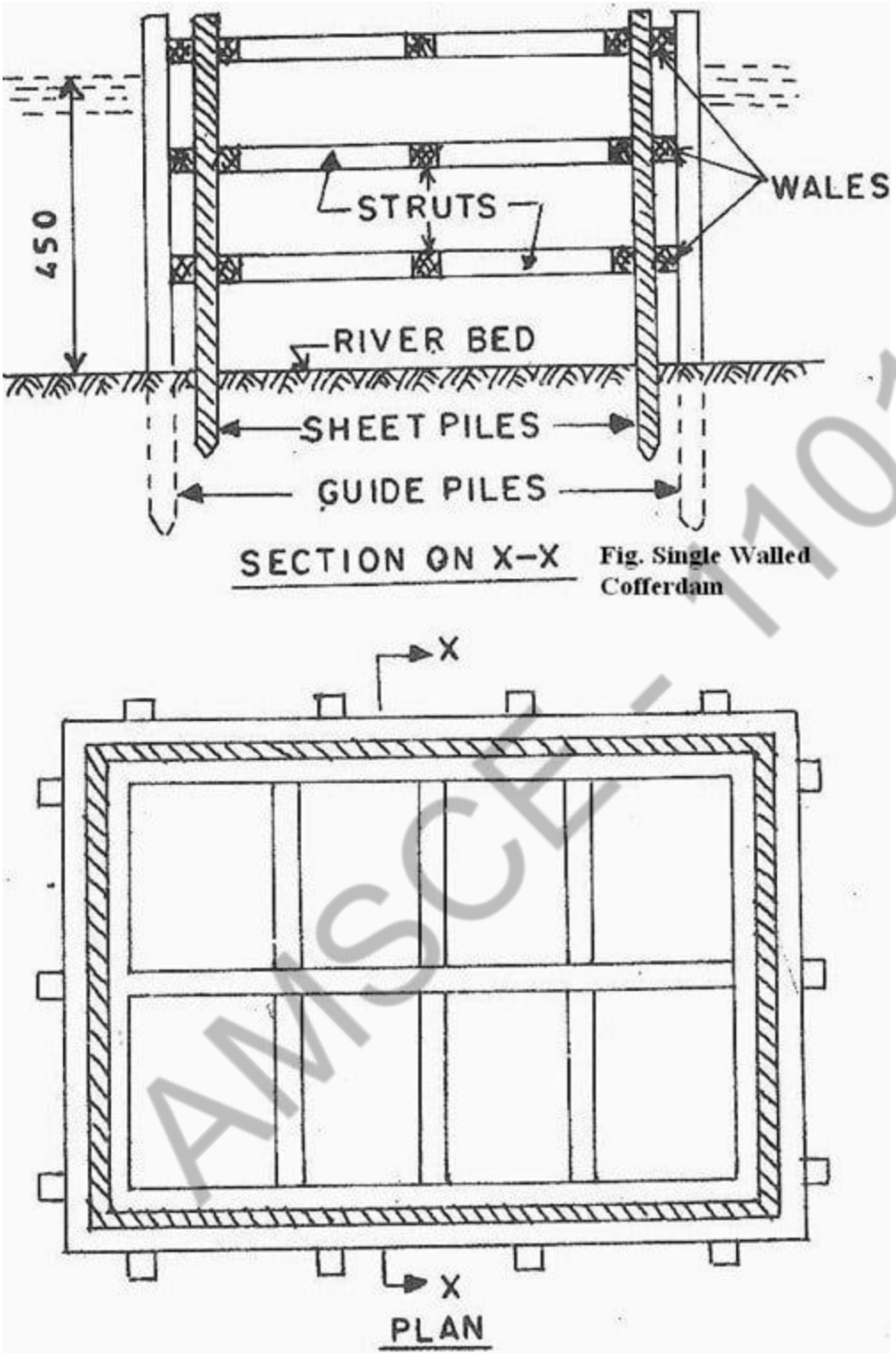


Fig: Construction Details of Single Walled Cofferdam

Double-Walled Cofferdam

Double-walled types of cofferdams are used when the area of construction site is large and depth of water is high. In this place use of single walled cofferdam becomes uneconomical as the supports are to be increased. So double walled cofferdam is used.

The difference in one wall and double wall dam is that her it has two walls instead of walls for extra stability. This type of dams can hold water up to 12m high.

Two piles are driven inside the water bed with a space in between and attached each other with wales with bolted connection. As the water depth increases the space between the walls increases.

The space between the walls are filled with soil. To prevent the leakage from the ground below, the sheet piles are driven to a good depth in the bed.

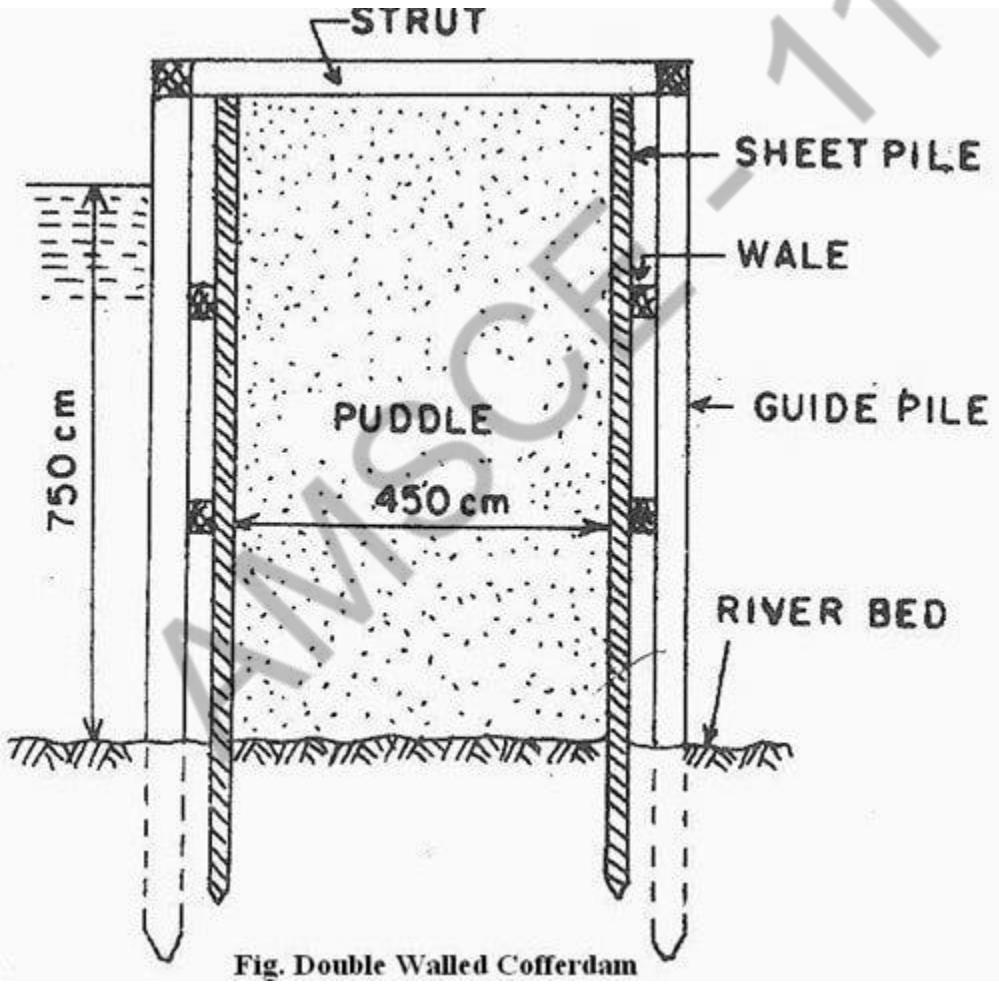


Fig: Construction Details of Single Walled Cofferdam

Braced Cofferdam

When it's difficult to drive piles inside the bed in the water, then this type of cofferdam is used. In braced cofferdam two piles are driven into the bed and they are laterally supported with the help of wooden cribs installed in alternate courses to form pockets.

The empty pockets here are filled with stone and earth. The framework of the cofferdam (made from, logs of wood) is prepared on ground and then floated to the site where the cofferdam is to be constructed.

The layers of sand and the other loose material overlying the impervious hard bed is dredged out. Crib is then sunk to the position, the bottom of each crib is given a shape to fit in the variation in the surface of bedrock. After the pit is dewatered, the structure is concreted. When concreting has been completed above the water level, the cofferdam is removed.

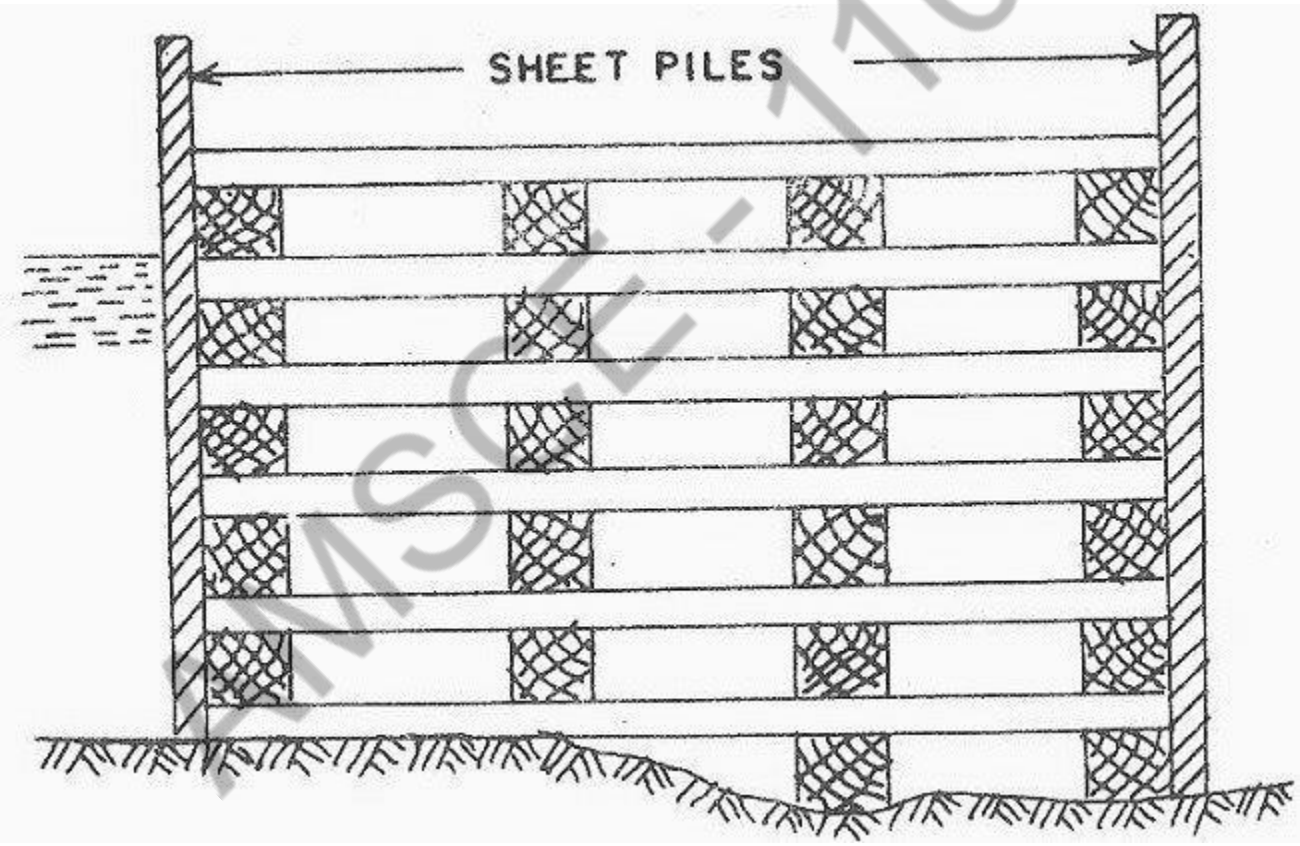


Fig: Braced Cofferdam Construction Details

Cellular Cofferdam

When the water layer is more than 20m, common types of cofferdams are uneconomical to use. In this situations cellular cofferdams are used. This type of dam is used in construction of dams, locks, weirs etc.

Cellular cofferdam is made by driving straight web steel sheet piles, arranged to form a series of interconnected cells. The cells are constructed in various shapes and styles to suit the requirements of site.

Finally, the cells are filled with clay, sand or gravel to make them stable against the various forces to which they are likely to be subjected to.

The two common shapes of the cellular cofferdam are,

(i) Circular type cellular cofferdam.
(ii) Diaphragm type cellular cofferdam.

(i) Circular Type Cellular Cofferdam

This type of cellular cofferdam consists of circular arcs on the inner and outer sides which are connected by straight diaphragm walls. The connection between the curved parts and the diaphragms are made by means of a specially fabricated Y-element.

The cofferdam is thus made from interconnected steel sheet piles. The empty spaces are filled with non pervious materials like clay or sand. Due to the filling material the self weight of the membrane increases and leakage is reduced.

One advantage of the diaphragm type is that the effective length of the cofferdam may be increased easily by lengthening the diaphragm. Hence in case, from design consideration it is necessary to have effective width of the cofferdam more than 21 meter, diaphragm type of cofferdam must be used.

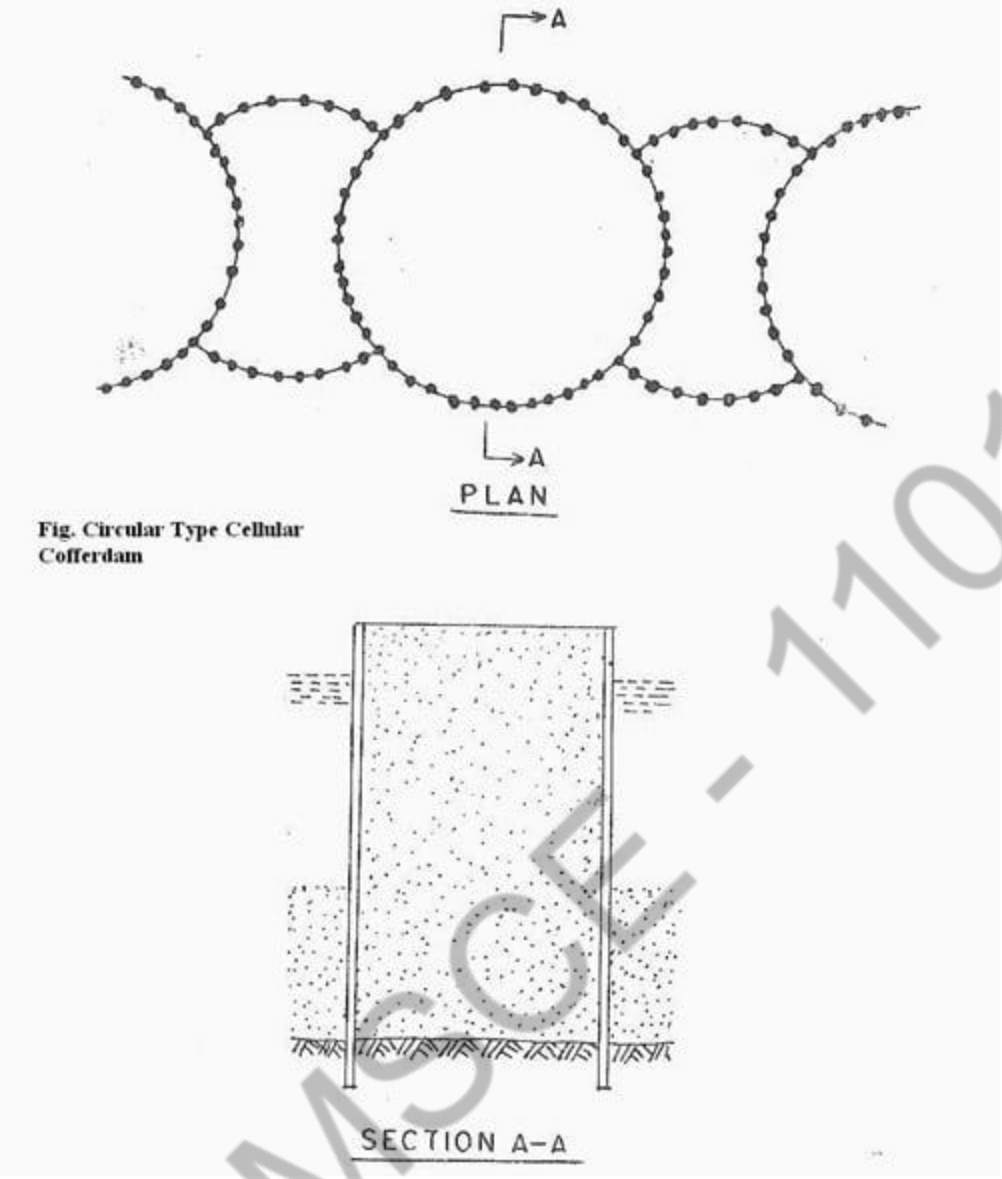


Fig. Circular Type Cellular Cofferdam

Fig: Plan and Section Details of Circular Type Cellular Cofferdam

(ii) Diaphragm Type Cellular Cofferdam

It consists of a set of large diameter main circular cells interconnected by arcs of smaller cells. The walls of the connecting cells are perpendicular to the walls of the main circular cells of large diameter.

The segmental arcs are joined by special T-piles to the main cells. The circular type cellular cofferdams are self-sustaining, and therefore independent of the adjacent circular cells. Each cell can be filled independently.

The stability of such cells is much greater as compared with that of the diaphragm type. However, the circular cells are more expensive than the diaphragm type, as these require more sheet piles and greater skill in setting and driving the piles.

Because the diameter of circular cells is limited by interlock tension, their ability to resist lateral pressure due to high heads is limited.

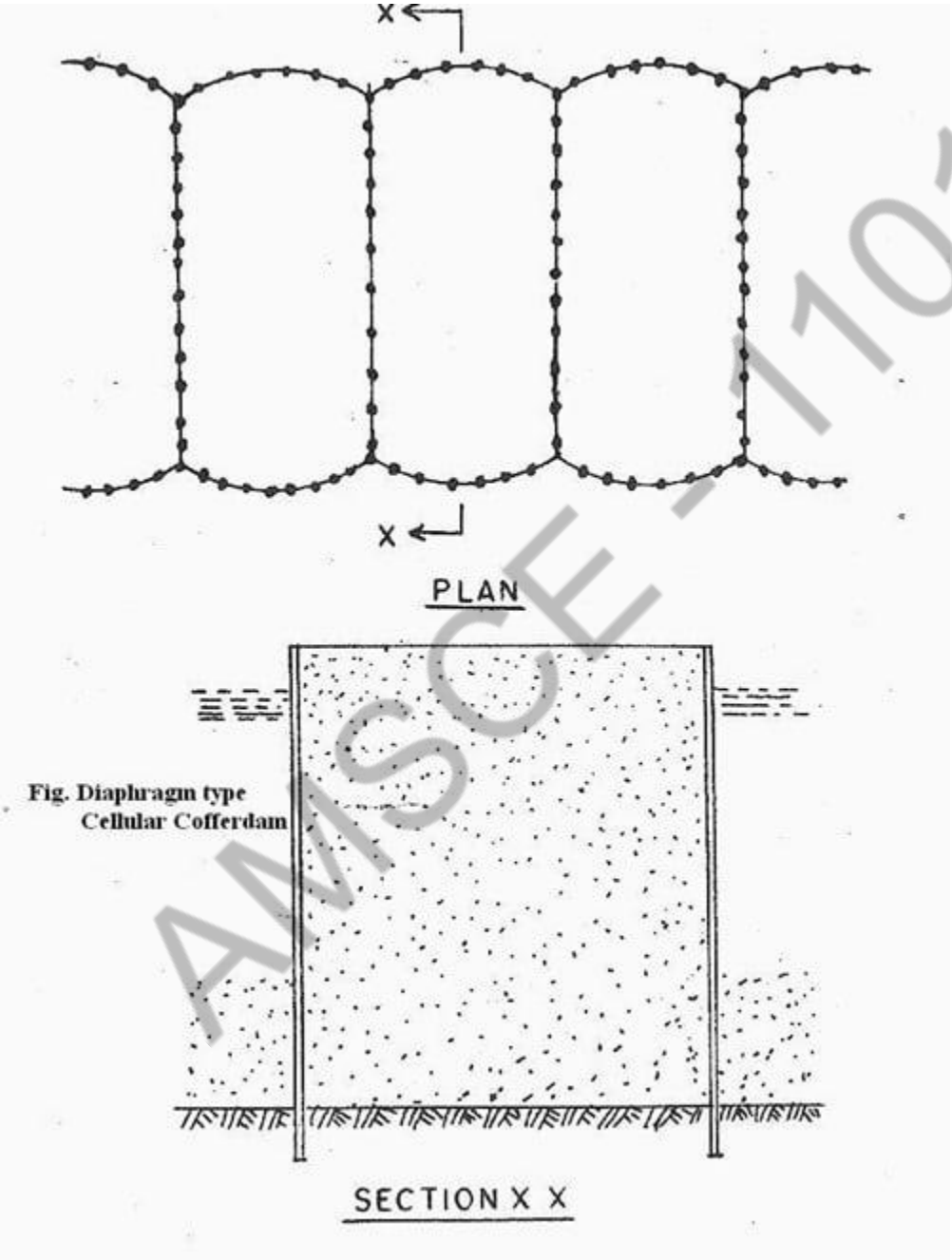


Fig. Diaphragm type
Cellular Cofferdam

Fig: Plan and Section Details of Diaphragm type Cellular Cofferdam

12. **In which situation pile foundation is adopted? Explain various types of pile foundation(April/May 2019) (Nov/Dec 2017)**

Pile foundation, a kind of deep foundation, is actually a slender column or long cylinder made of materials such as concrete or steel which are used to support the structure and transfer the load at desired depth either by end bearing or skin friction.

Pile foundations are deep foundations. They are formed by long, slender, columnar elements typically made from steel or reinforced concrete, or sometimes timber. A foundation is described as 'piled' when its depth is more than three times its breadth.

Pile foundations are usually used for large structures and in situations where the soil at shallow depth is not suitable to resist excessive settlement, resist uplift, etc.

When to Use Pile Foundation

Following are the situations when using a pile foundation system can be

- When the groundwater table is high.
- Heavy and un-uniform loads from superstructure are imposed.
- Other types of foundations are costlier or not feasible.
- When the soil at shallow depth is compressible.

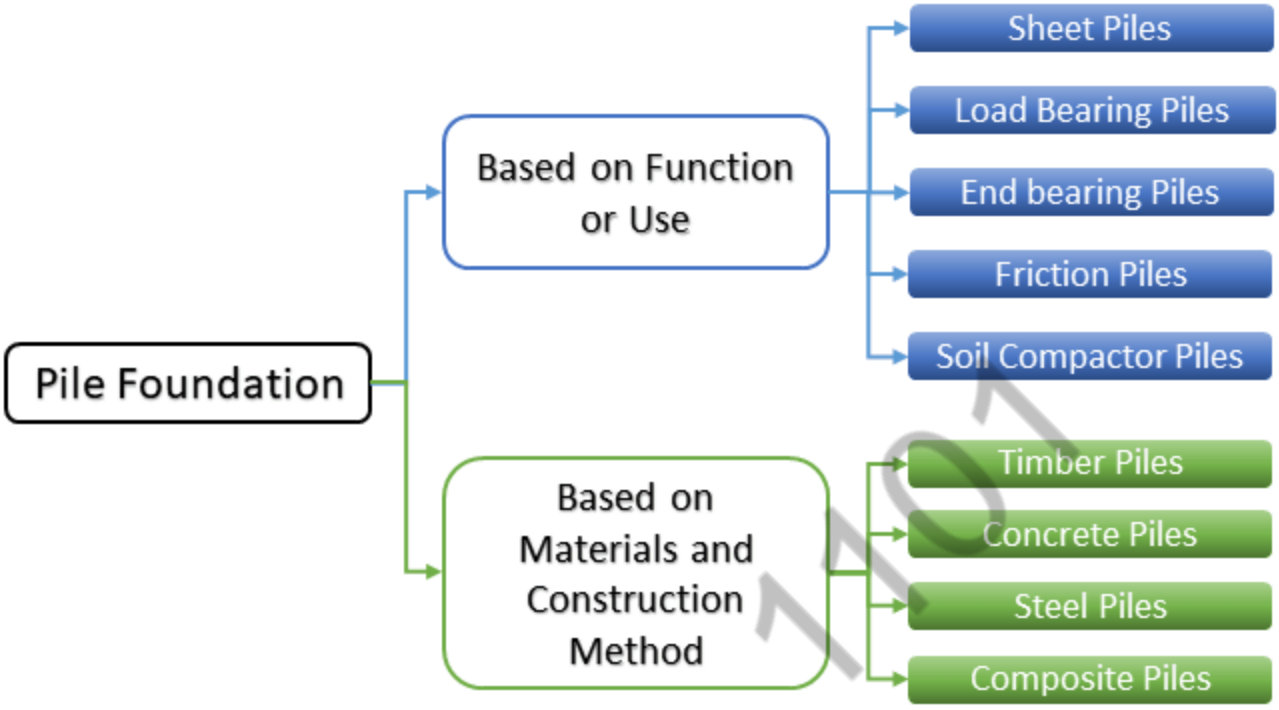
- When there is the possibility of scouring, due to its location near the river bed or seashore, etc.
- When there is a canal or deep drainage systems near the structure.
- When soil excavation is not possible up to the desired depth due to poor soil condition.
- When it becomes impossible to keep the foundation trenches dry by pumping or by any other measure due to heavy inflow of seepage.

Types of Pile Foundation

Pile foundations can be classified based on function, materials and installation process, etc. Followings are the types of pile foundation used in construction:

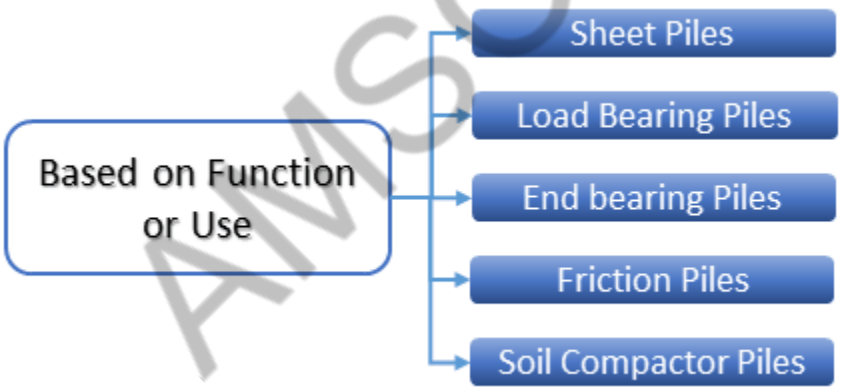
A. Based on Function or Use
    1. Sheet Piles
    2. Load Bearing Piles
    3. End bearing Piles
    4. Friction Piles
    5. Soil Compactor Piles
B. Based on Materials and Construction Method
    1. Timber Piles
    2. Concrete Piles
    3. Steel Piles
    4. Composite Piles

The following diagram is representing pile foundation types discussed above.



These piles are briefly discussed below.

Classification of Pile Foundation Based on Function or Use



Sheet Piles

This type of pile is mostly used to provide lateral support. Usually, they resist lateral pressure from loose soil, the flow of water, etc. They are usually used for cofferdams, trench sheeting, shore protection, etc. They are not used for providing vertical support to the structure. They are usually used to serve the following purpose-

- Construction of retaining walls.
- Protection from river bank erosion.
- Retain the loose soil around foundation trenches.
- For isolation of foundation from adjacent soils.
- For confinement of soil and thus increase the bearing capacity of the soil.

Load Bearing Piles

This type of pile foundation is mainly used to transfer the vertical loads from the structure to the soil. These foundations transmit loads through the soil with poor supporting property onto a layer which is capable of bearing the load. Depending on the mechanism of load transfer from pile to the soil, load-bearing piles can be further classified as flowed.

End Bearing Piles

In this type of pile, the loads pass through the lower tip of the pile. The bottom end of the pile rests on a strong layer of soil or rock. Usually, the pile rests at a transition layer of a weak and strong slayer. As a result, the pile acts as a column and safely transfers the load to the strong layer.

The total capacity of end bearing pile can be calculated by multiplying the area of the tip of the pile and the bearing capacity of at that particular depth of soil at which the pile rests. Considering a reasonable factor of safety, the diameter of the pile is calculated.

Friction Pile

Friction pile transfers the load from the structure to the soil by the frictional force between the surface of the pile and the soil surrounding the pile such as stiff clay, sandy soil, etc. Friction can be developed for the entire length of the pile or a definite length of the pile, depending on the strata of the soil. In friction pile, generally, the entire surface of the pile works to transfer the loads from the structure to the soil.

The surface area of the pile multiplied by the safe friction force developed per unit area determines the capacity of the pile.

While designing skin friction pile, the skin friction to be developed at a pile surface should be sincerely evaluated and a reasonable factor of safety should be considered. Besides this one can increase the pile diameter, depth, number of piles and make pile surface rough to increase the capacity of friction pile.

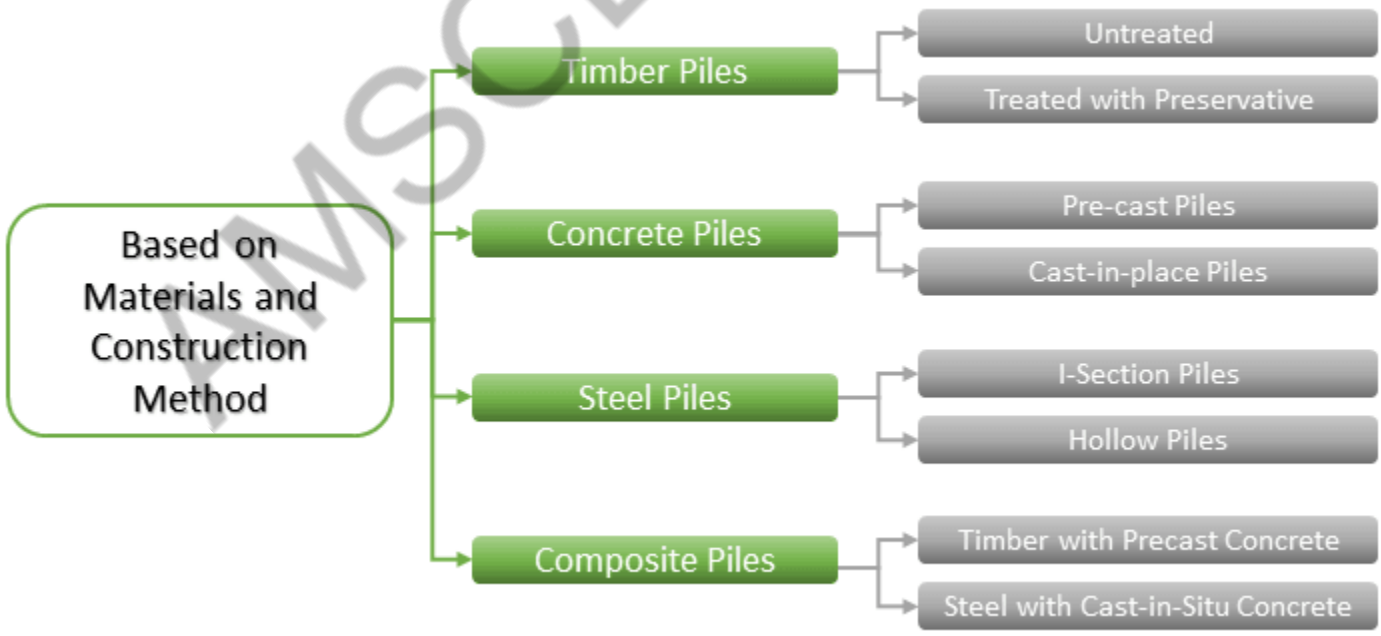
Soil Compactor Piles

Sometimes piles are driven at placed closed intervals to increase the bearing capacity of soil by compacting

Classification of Piles Based on Materials and Construction Method

Primarily piles can be classified into two parts. Displacement piles and Non-displacement or Replacement piles. Piles which causes the soil to be displaced vertically and radially as they are driven to the ground is known as Displacement piles. In case of Replacement piles, the ground is bored and the soil is removed and then the resulting hole is either filled with concrete or a pre-cast concrete pile is inserted. On the basis of materials of pile construction and their installation process load-bearing piles can be classified as follows:

1. Timber Piles
    i. Untreated
    ii. Treated with Preservative
2. Concrete Piles
    i. Pre-cast Piles
    ii. Cast-in-place Piles
3. Steel Piles
    i. I-Section Piles
    ii. Hollow Piles
4. Composite Piles



Timber Piles

Timber piles are placed under the water level. They last for approximately about 30 years. They can be rectangular or circular in shape. Their diameter or size can vary from 12 to 16 inches. The length of the pile is usually 20 times of the top width.

They are usually designed for 15 to 20 tons. Additional strength can be obtained by bolting fish plates to the side of the piles.

Advantages of Timber Piles-

- Timber piles of regular size are available.
- Economical.
- Easy to install.
- Low possibility of damage.
- Timber piles can be cut off at any desired length after they are installed.
- If necessary, timber piles can be easily pulled out.

Disadvantages of Timber Piles-

- Piles of longer lengths are not always available.
- It is difficult to obtain straight piles if the length is short.
- It is difficult to drive the pile if the soil strata are very hard.
- Spicing of timber pile is difficult.
- Timber or wooden piles are not suitable to be used as end-bearing piles.
- For durability of timber piles, special measures have to be taken. For example- wooden piles are often treated with preservative.

Concrete Piles

Pre-cast Concrete Pile

The precast concrete pile is cast in pile bed in the horizontal form if they are rectangular in shape. Usually, circular piles are cast in vertical forms. Precast piles are usually reinforced with steel to prevent breakage during its mobilization from casting bed to the location of the foundation. After the piles are cast, curing has to be performed as per specification. Generally curing period for pre-cast piles is 21 to 28 days.

Advantages of Pre-cast Piles

- Provides high resistance to chemical and biological cracks.
- They are usually of high strength.
- To facilitate driving, a pipe may be installed along the center of the pile.
- If the piles are cast and ready to be driven before the installation phase is due, it can increase the pace of work.
- The confinement of the reinforcement can be ensured.
- Quality of the pile can be controlled.

- If any fault is identified, it can be replaced before driving.
- Pre-cast piles can be driven under the water.
- The piles can be loaded immediately after it is driven up to the required length.

Disadvantages of Pre-cast Piles

- Once the length of the pile is decided, it is difficult to increase or decrease the length of the pile afterward.
- They are difficult to mobilize.
- Needs heavy and expensive equipment to drive.
- As they are not available for readymade purchase, it can cause a delay in the project.
- There is a possibility of breakage or damage during handling and driving od piles.

Cast-in-Palace Concrete Piles

This type of pile is constructed by boring of soil up to the desired depth and then, depositing freshly mixed concrete in that place and letting it cure there. This type of pile is constructed either by driving a metallic shell to the ground and filling it with concrete and leave the shell with the concrete or the shell is pulled out while concrete is poured.

Advantages of Cast-in-Place Concrete Piles

- The shells are light weighted, so they are easy to handle.
- Length of piles can be varied easily.
- The shells may be assembled at sight.
- No excess enforcement is required only to prevent damage from handling.
- No possibility of breaking during installation.
- Additional piles can be provided easily if required.

Disadvantages of Cast-in-Place Concrete Piles

- Installation requires careful supervision and quality control.
- Needs sufficient place on site for storage of the materials used for construction.
- It is difficult to construct cast in situ piles where the underground water flow is heavy.
- Bottom of the pile may not be symmetrical.
- If the pile is un-reinforced and uncased, the pile can fail in tension if there acts and uplifting force.

Steel Piles

Steel piles may be of I-section or hollow pipe. They are filled with concrete. The size may vary from 10 inches to 24 inches in diameter and thickness is usually ¾ inches. Because of the small sectional area, the piles are easy to drive. They are mostly used as end-bearing piles.

Advantages of Steel Piles

- They are easy to install.
- They can reach a greater depth comparing to any other type of pile.

- Can penetrate through the hard layer of soil due to the less cross-sectional area.
- It is easy to splice steel piles
- Can carry heavy loads.

Disadvantage of Steel Piles

- Prone to corrosion.
- Has a possibility of deviating while driving.
- Comparatively expensive.