UNIT III

SUB STRUCTURE CONSTRUCTION

BOX JACKING

EXPLANATION

™ •It is the process in which a pre-cast R.C.C box or a rigid box is pushed into the soil with the help of hydraulic jacks

™ •It is non-intrusive method beneath the existing surface.

™ •It is more often used when a subway or a aqueduct or a underground structure is to be constructed.

™ •It enables the traffic flow without disruption.

R.C.C BOX JACKING

™ •First the box section is designed and cast at the site or can be transported to the site according to the requirement.

™ •The foundation boxes are jacked into the ground designed to carry the dead and the live loads.

™ •Then the high capacity jacks are placed at the back and it pushes the box into the ground.

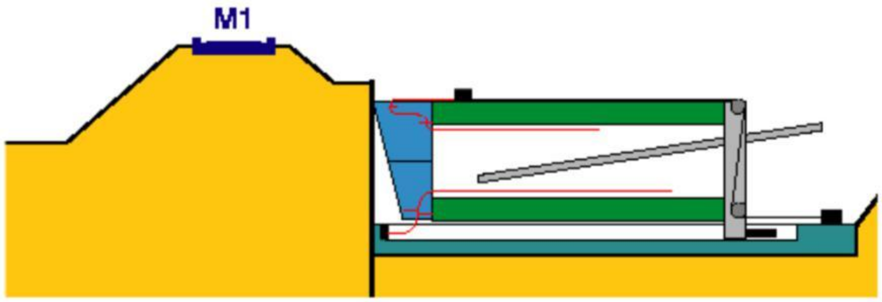
™ •A purpose designed tunneling shield is provided in the front end.

™ •Then the box is jacked carefully through the earth.

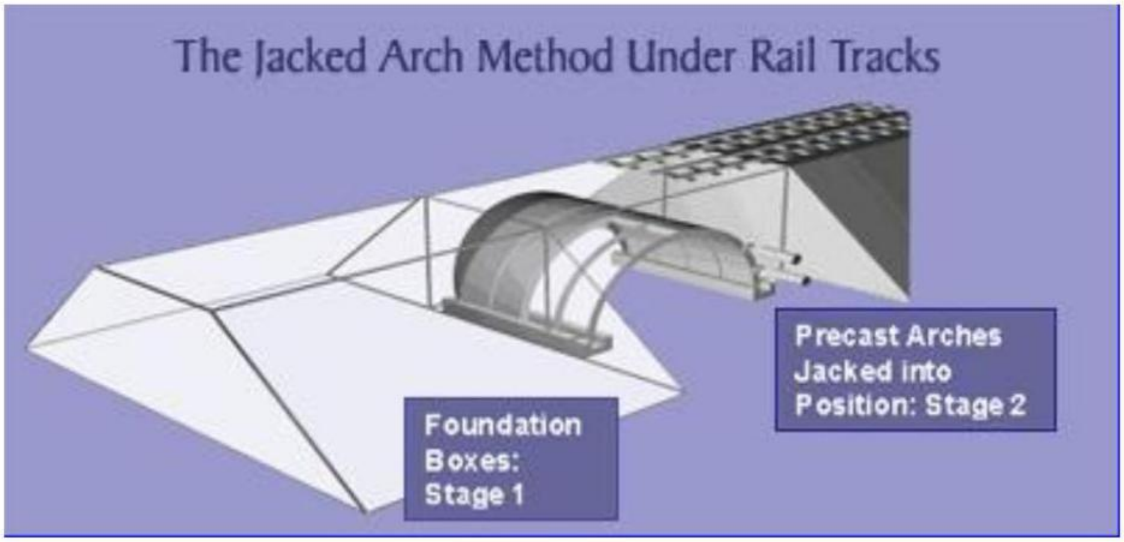
™ •Excavation and jacking are done in small increments in advance.

™ •Measures should be taken to prevent the soil being dragged towards the box.

R.C.C BOX JACKING



ARCHED JACKING



THRUST BORING METHOD

- ™ •It is a process of simultaneously jacking the pipe through the earth while removing the earth inside the box by means of a rotating auger.
- ™ •Unstable conditions- the end of auger is kept retracted inside the encasement so as not to cause voids.
- ™ •Stable conditions- the auger can be successfully extended beyond the encasement.
- ™ •This can be successfully used in any kind of soil conditions.

PROBLEMS ENCOUNTERED IN JACKING

- ™ •Settlement of the above ground.
- ™ •Seepage of ground water.
- ™ •Caving in of soil etc.

FREEZING OF GROUND

- ™ •This method is used when we encounter the problem of ground water seepage and settlement of ground.
- ™ •In this method a brine solution is continuously passed through the pipes fixed in the soil.
- ™ •The temperature of the brine would be -30°c.

™ •So when this brine solution is circulated through these pipes it freezes the ground and the ground behaves like an ice block.

™ •The spacing of the freezing pipes will vary according to the type of soil, its permeability and other factors.

™ •Generally it is kept at a spacing of 1.2 m

PROBLEMS IN FREEZING

™ •The main problem in the freezing method is the UPHEAVING of the above ground.

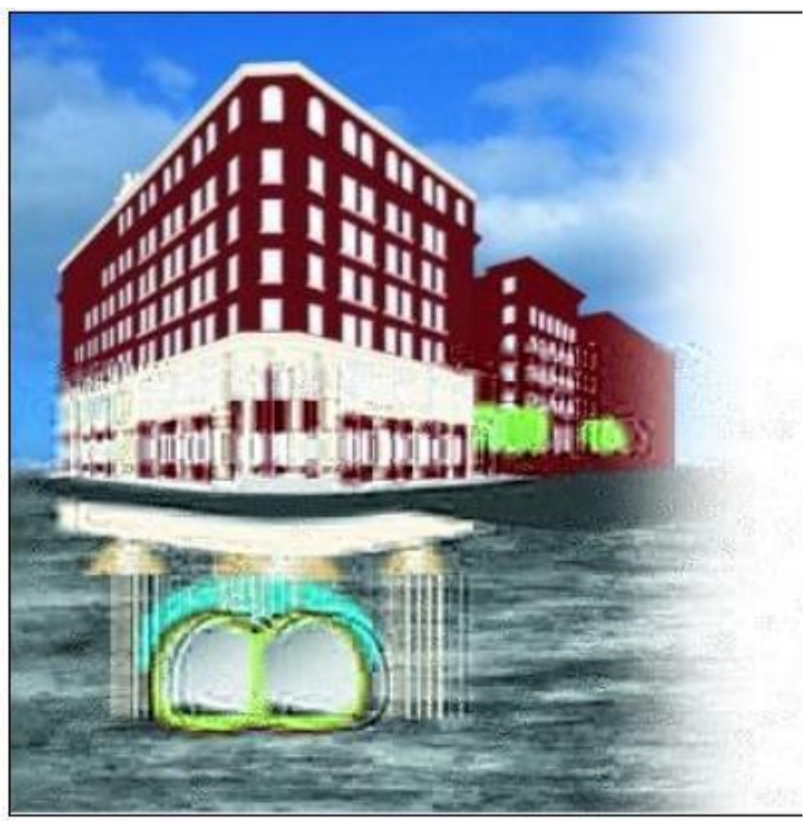
™ •To avoid the upheavement problem we should be careful in the ground freezing process and the temperature of the brine solution.

CASE STUDY - SOUTHERN BOSTON PIERS TRANSIT WAY

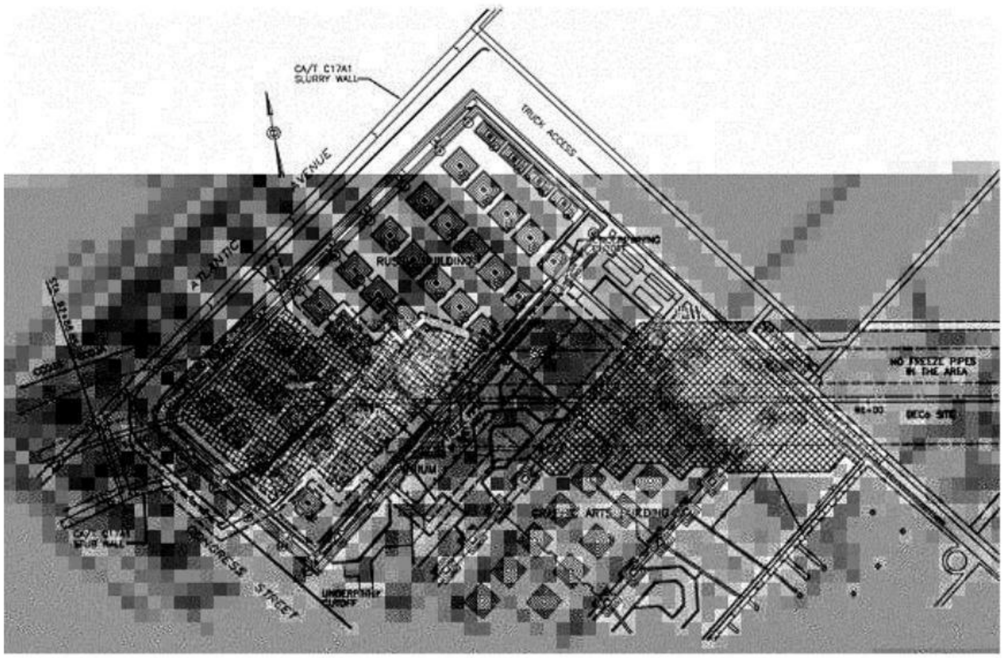
™ •The carriageway has to go beneath – a Russian building,100 year old

™ •2m thick soil was frozen.

™ •Under pinning was also done using mini piles.



PLAN OF THE RUSSIAN BUILDING



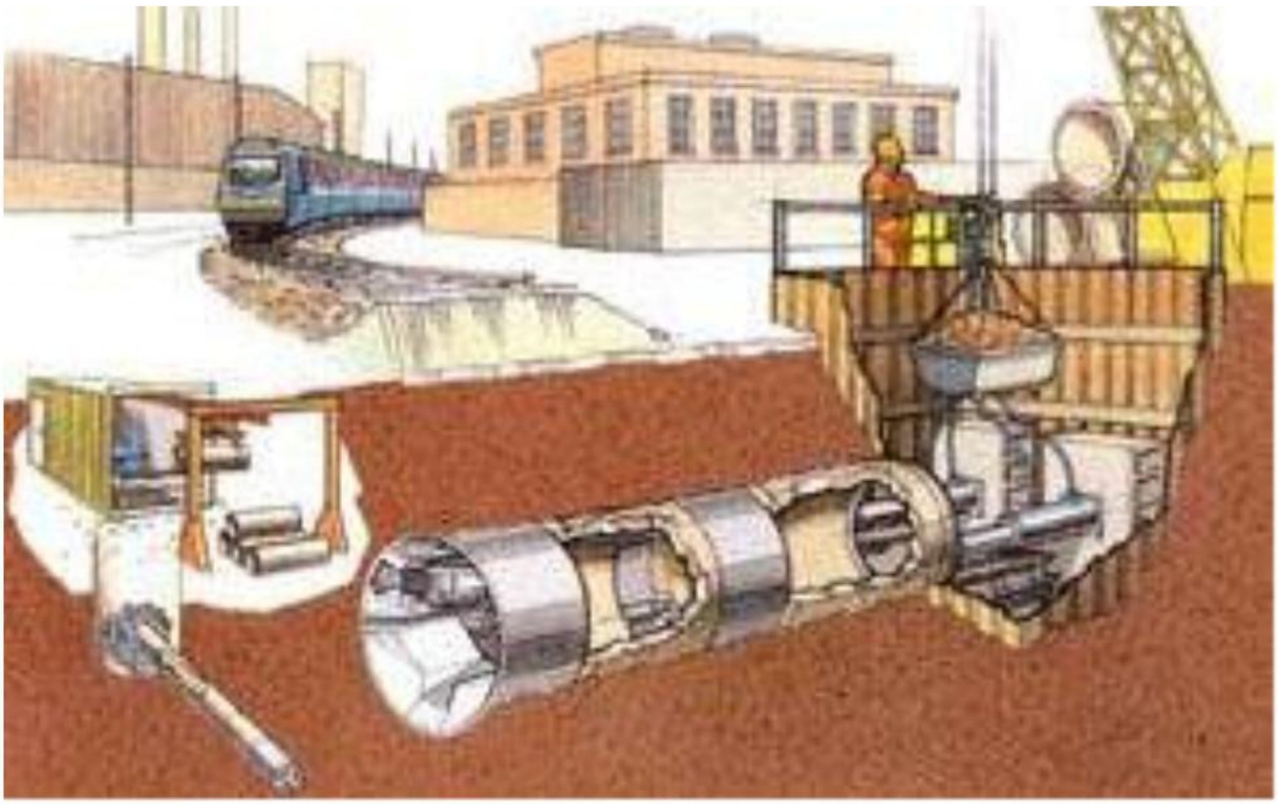
ADVANTAGES

- ™ •Timely completion of project.
- ™ •No disruption of traffic.
- ™ •No need to divert the traffic.

DISADVANTAGES

- ™ •Cost of project increases.
- ™ •Skilled personnel required.
- ™ •Safety precautions to be done properly.

PIPE JACKING



ABOUT THE TECHNIQUE

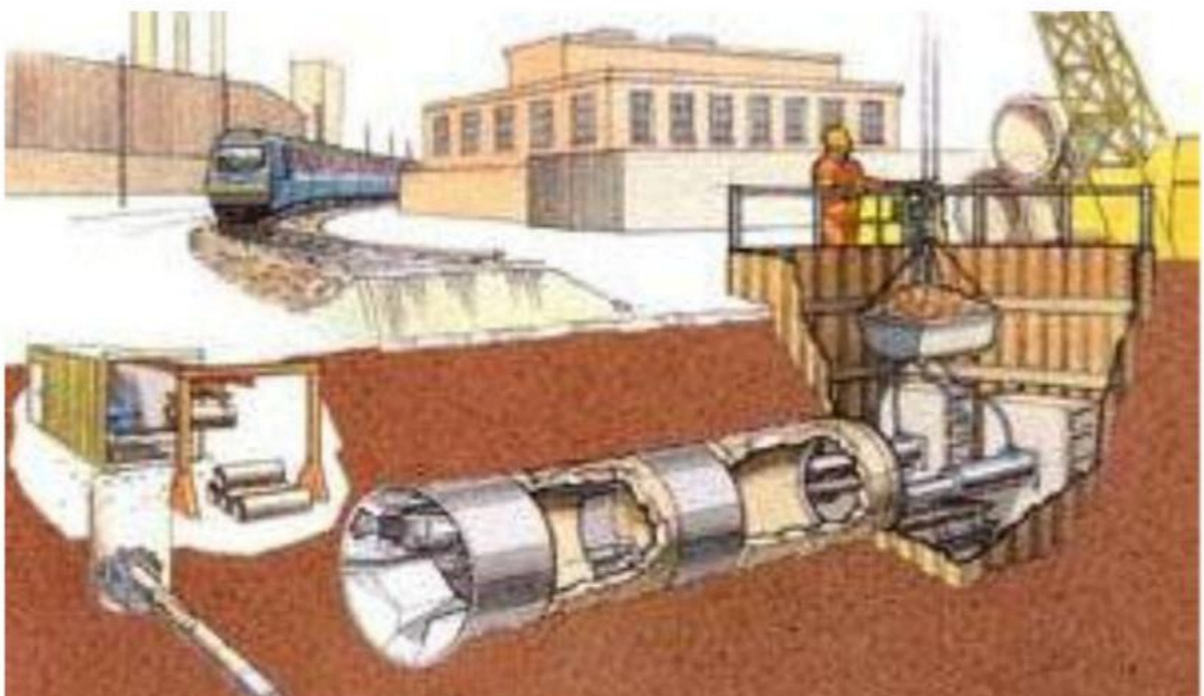
- ™ •It is generally referred as “Micro tunneling”
- ™ •Pipes are pushed through the ground behind the shield using powerful jacks.
- ™ •Simultaneously excavation takes place within the shield.
- ™ •This process is continued until the pipeline is completed.
- ™ •The method provides a flexible, structural, 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.

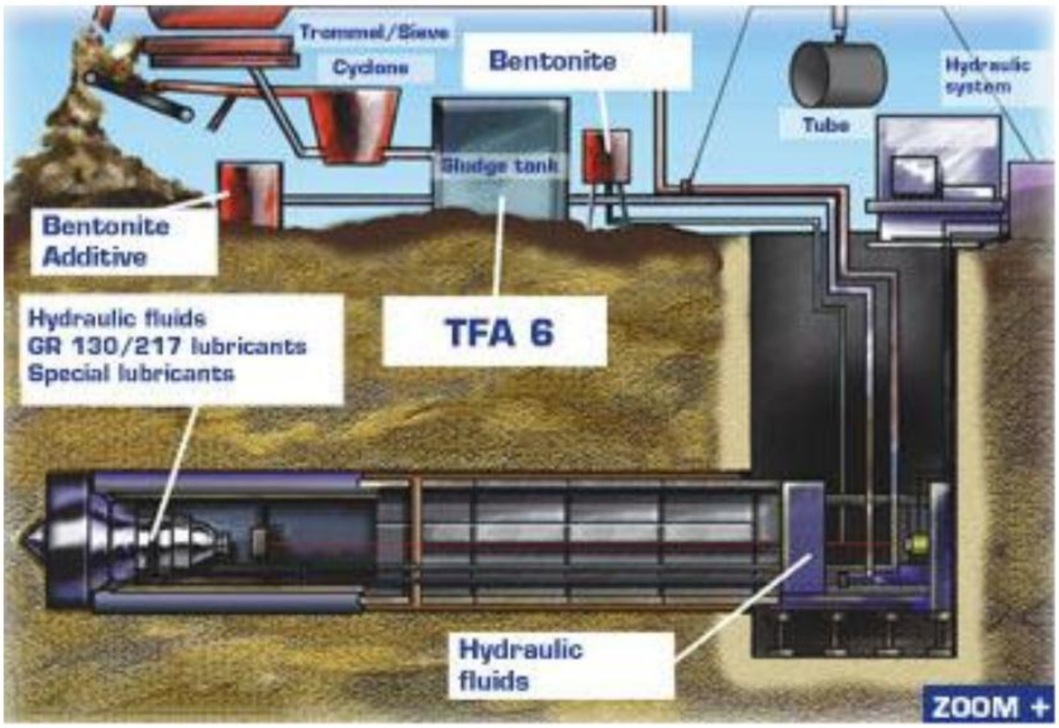
™ •The number of jacks vary upon the frictional resistance of the soil, strength of pipes etc.,
™ •The size of the reception pit is to be big enough to receive the jacking shield.
™ •To maintain the accuracy of alignment a steer able shield is used during the pipe jacking.
™ •In case of small and short distance excavations, ordinary survey method is sufficient.
™ •But in case of long excavations, remote sensing and other techniques can be used.

GENERAL ARRANGEMENTS

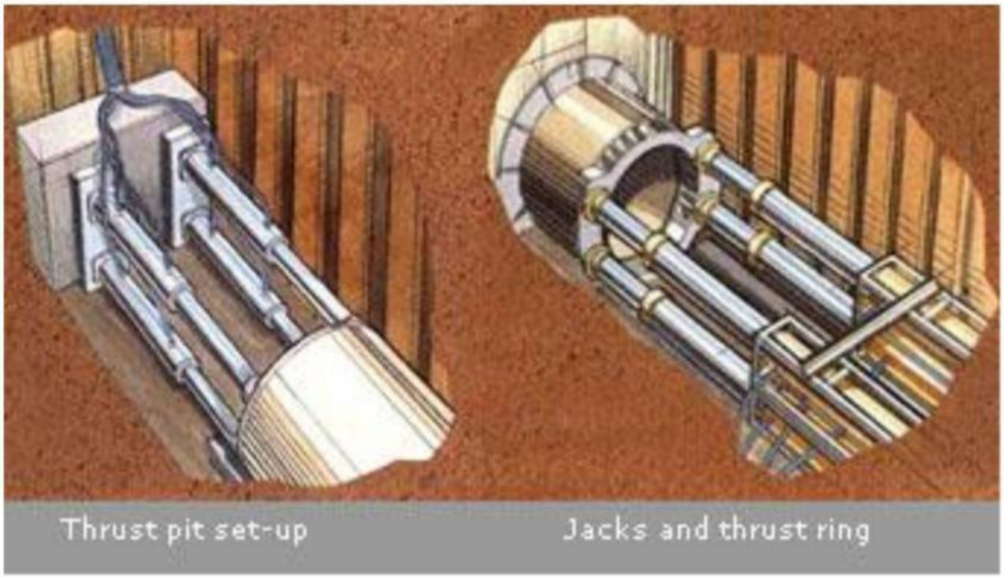


General arrangements of pipe jacking and microtunelling systems

PIPE JACKING SETUP

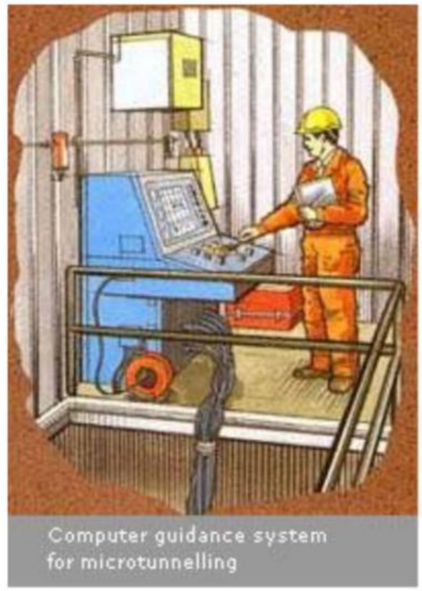


THRUST SETUP



COMPUTER GUIDANCE SYSTEM

- •The computer system enables us to control the work remotely.



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.

™

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 under ground 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

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.

TUNNEL BORING MACHINE

Tunnel boring machine (TBM) as mole recent developments in the tunnel driving technique. The function of TBM is to loosen the earth or break the rock continuously in the entire section of the tunnel, in to cuttings and convey to the rear of the machine, where it can be loaded into muck cars or dumpers or on to conveyor belts for the transportation to the ultimate disposal site.

Working principle and construction features of TBM

These machines perform the boring operation through rotation of the front head against the rock face. The mole has circular cutter head in the front provided with fixed cutters of desired shape. The cutter head while rotating is pressed against the rock to cut or pulverize it. The cuttings while failing down is collected in the buckets provided around the cutter head periphery. These buckets discharge the muck into a hopper to feed it into the belt conveyor leading to the rear of the machine. This conveyor then discharges the muck either into the mine car or to another belt conveyor leading to the portal of the tunnel. The muck of cuttings can also be disposed off by using the slurry pipelines after mixing the fine muck into water to form slurry.

For driving through full- face on full-face TRMs number of cutter heads is mounted on a drum. The drum when rotates in one direction, the individually driven cutter heads having projected Tungsten carbide tipped tools can be rotated in another direction and the drum advances into the tunnel face, by providing a thrust with the help of hydraulic systems. The tips of the tools when worn out can be easily replaced. The tips are kept cooled by spraying a mixture of water and compressed air into the cutting area. This also suppress the dust formed during cutting.

Advantages of tunnel boring machines

- There is very less danger of fall outs in machine bored tunnels, since adjacent or surrounding rocks are undistributed as no blasting is done.
- Mucking is also safe and convenient, since muck is conveyed from the face to the rear of the machine and is loaded automatically by means to the rear of the machine and is loaded automatically by means of belt conveyors.
- Higher speed of excavation.
- Reduction in the tunnel supports requirement.
- Less manpower requirement.

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.

Types of well point systems

1. Pumping from open sumps
2. Pumping from well points

   Well point systems are installed in two ways:

   a) Line system
   b) Ring system
3. Pumping from bored wells

Types of piles

(a) Driven piles – Timber, recast concrete,Prestressed concrete , steel H-section, Box and tube

(b) Driven and cast-in place piles

(c) Bored piles

(d) Composite piles

Use of H-piles

H-Piles are used in construction of bridges where they can be driven through existing construction in small spaces

They are used useful for driving close to existing structures since they cause little displacement of soil. It can be withstand large lateral forces.

They require less space for shipping and storing than wood, pipe or precast concrete piles.

They do not require special slings or special care in handling.

DEEP EXCAVATIONS

Problems normally developed during deep excavations

™ To prevent the collapsing of sides of the trenches

™ To prevent water oozing or coming out from the sides and bottom of the trenches

The remedial measures to avoid the problems deep excavation

™ Providing shoring for the trenches

™ Dewatering of the trenches

Line system

This system is employed when excavation area is long. The header is laid out along the sides of the excavation, and the pumping is continuously in progress in one length as further points are jetted ahead of the pumped down section and pulled up from the completed and back filled lengths and repeated till entire length is completed. For narrow excavation, like trenches, header is laid only on one laid, while for wide excavations, the header are required to be placed on both sides of the area.

Ring system

When excavation is done in area of appreciable width, line system is inadequate. The ring system is used in such condition and the header main surrounds the excavations completely. This system is used for rectangular excavations such as for piers or basements.

CAISSON

Caisson has come to mean a box like structure, round or rectangular, which is suck from the surface of either land or water to some desired depth. Caissons are of three types:

(a) Box caisson

(b) open caisson

(c) Pneumatic caissons

Box caisson

A box caisson is open at top and closed at the bottom and is made of timber, reinforced concrete or steel. This caisson is built on land, then launched and floated to pier site where is suck in position. Such a type of caisson is used where bearing stratum is available at shallow depth, and where loads are not very heavy.

SHEET PILES

Sheet piles are thin piles, made of plates of concrete, timber or steel, driven into the ground for either separating members or for stopping seepage of water. They are not meant for carrying any vertical load. They are driven into ground with help of suitable pile driving equipment, and their height is increased while driving, by means of addition of successive instalments of sheets.

Functions of sheet piles

1. To enclose a site or part thereof to prevent the escape of loose subsoil, such as sand, and to safeguard against settlement.
2. To retain the sides of the trenches and general excavation.
3. To protect river banks.
4. To protect the foundations from scouring actions of nearby river, stream etc. To construct costal defence works

COFFERDAM

Types of cofferdam

1. Cantilever sheet pile cofferdam
2. Braced cofferdam
3. Embankment protected cofferdam
4. Double wall cofferdam
5. Cellular cofferdam

Grout anchors used in constructions

In most cases, however anchorages may be embedded below ground level, with backstays connecting them to adjacent towers, or they may constitute the end abutments of the end spans.

In addition to stability sliding, the anchorage structure must also be checked for stability against tilting and overturning.

Methods o f ground water control

Following methods of ground water control are adopted

1. Pumping from open sumps
2. pumping from well points
3. Pumping from bored wells

(1) Pumping from open sumps

This method is most commonly used where area is large enough for allowing excavation to be cut back to stable slopes and where there are no important structures close to the excavation to effect their stability by settlement resulting from erosion due to water flowing towards the sump. This method is also applicable for rock excavations.

This method costs comparatively low for installation and maintenance.In this method one or more sumps are made below the general level of the excavation.In order to keep the excavator area clear of standing water, a small grip or ditch is cut around the bottom of the excavation failing towards the sump.

For grater depths of excavation the pump is used or submersible deepwell pump suspended by chains and progressively lowered down.Pumps suitable for operating from open sumps are:

- Pneumatic sump pumps
- Self priming centrifugal pumps
- Monopump sinking pumps

Pumping is simple and less expansive, but has serious limitations. When fine sand or cohesion less soil lie below the water, this type of pumping removes the fine material from the surrounding soil and results in settlement of adjacent structures. To product it sumps lined with gravel filter are sometimes used.

(2) Pumping from wellpoints

This system comprises the installation of a number of filter wells generally 1m long, around the excavation. These filter wells are conducted by vertical riser pipes to a large dia header main at ground level which is under vacuum from a pumping unit. The water flows to the filter well by gravity and then drawn by the vacuum upto the header main and discharged through the pump. This system has the advantage that the water is filleted as it removed from the ground and carries almost no soil with it once steady discharge conditions are attained. This system has the limitation of limited suction lift. Therefore for deeper excavations the well points are installed in two or more stages.

The filter wells or well points are usually 1m long and 60 to 75mm diameter gauge screen surrounding a central riser pipe. The capacity of a single we;; point with 50mm raiser is about 10 lit/min. Spacing between two well points depends on the permeability of the soil and on the time available to effect the drawdown. In fine coarse sand or sandy gravels a spacing of 0.75 to 1m is required, while in silty sands of low permeability a 1.5m spacing is sufficient .In permeable course gravels spacing should be as low as only 0.3m.A normal set of wellpoint system comprises 50 to 60 points to a single 150 or 200mm pump with a separate 100mm jetting pump.

(3) Pumping from bored wells

Pumping from wells, for draw-down depth of than the meters can be under taken by surface pumps with their suction pipes installed in bored wells. When dewatering is required to be undertaken from a considerable depth,electrity driven submersible pumps are installed in deep bore holes with rising main to the surface. Since heavy boring equipment is used, installation of wells can be done in all ground conditions including boulders and rocks. Due to higher costs of installation, this method is adopted where construction period is long and other methods of dewatering are not possible.Installation of bore well consists of sinking of a casting having a dia of about 20-30 cm larger than the inner well casting. The dia of inner well casting depends on the size of submersible pump. This inner well casing is inserted after complete sinking of borehole screen over the length where dewatering of the soil is required and it terminates in a 3-5 m length of unperforted pipe to act as a sump to collect any fine material which may be drawn through the filter mesh. Screen having slots are preferable to holes, since there is less risk of blockage from round stones.

Component parts of pipe jacking

Pipe jacking is specialist tunneling method for installing underground pipelines by assembling the pipes at the foot of an access shaft and pushing them through the ground with the minimum of surface disruption

Component parts of jacking systems

The pump unit has two distinct hydraulic systems

- A high pressure systems supplies oil for the main jacking cylinders and till intermediate jacking stations
- A low pressure system supplies oil, via hydraulic lines, for the boring head and conveyor. An auxiliary power pack may be easily installed to double the low pressure hydraulic flow. This may be necessary for larger and more powerful boring heads

Thrust yoke

The yoke is the frame that the main cylinders push against to advance the boring head and pipe. The ring provides a 360 degree surface against the pipe to minimize point pressure and reduce the chance of breakage.

Skid base

The skid base is the foundation of the pump unit and yoke. It also acts as a guide for launching the boring head and pipe into the ground.

Power packs

- Power packs with high and low pressure systems typically are matched with the multiple cylinder system.
- When tunneling, a lower pressure power pack may be selected to supply oil for the tunnel boring machine (TBM)
- Power required depend on the size and features of the boring head
- A mobile electric power pack may be positioned in the boring head/ TBM

Intermediate jacking stations

- Installing intermediate jacking stations is a simple economical way of adding and distributing thrust for pipe jacking

- The size and joint of the pipe, cost, length of push and versatility are important considerations that configure intermediate stations

Most popular design is effective with a variety of pipe sizes and design. Each design consists of ram segments. Each segment has 5 rams. All stations are supplied oil by one set of lines from the power pack and operated from one point in the jacking shaft.

Methods of providing shoring for the trenches

Methods for providing shoring for the trenches

1. Stay bracing
2. Box sheeting
3. Vertical sheeting
4. Runners
5. Sheet piling

(1) Stay bracing

- Carried out in moderately firm ground
- It is adopted when the depth does not exceed 2m
- The vertical sheets are placed opposite each other against the sides of the trench
- The vertical sheets are held in position by one or two rows of struts
- The sheets are placed at an interval of 3 to 4m and they extend to full depth of the excavation
- The normal sizes of
  - Polling boreds 200*40&200*50mm
  - Struts 100*100mm (For trench width upto 2m)
  - Structs 200*200 (For trench width more 2m)

2. Box sheeting

- Carried out in loose soil
- It is used when depth of excavation does not exceed 4m
- A box like structure is formed by providing sheeting,walls,structs and bracing

- In this arrangement, the vertical sheets are placed nearer and touching each other
- The sheets are kept in position by longitudinal rows of Wales, usually two and then,structs are provided across the wales

3. Vertcal sheeting

- Carried out in soft ground
- Adopted when the depth is about 10m
- This is similar to box sheeting except that the work is carried out in stages and at each stage, an offset is provided
- For each stage,vertical sheets,wales,structs and braces are provided as usual
- The offset is provided at a depth of 3 to 4m and it various from 30 to 60cm per stages
- Suitable for laying sewers or water pipes at considerable depths

4. Runners

- Carried out in extremely loose and soft ground which requires immediate support as the excavation progresses
- The runners which are long thick wooden sheets or planks are used in this arrangement
- One end of runner is made up of iron shoe
- These are driven by hammering about 30cm
- The wales and struts are provided as usual

5.Sheet piling

- 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

Large reservoir construction with membranes and earth system

- The main problem in reservoirs is the loss of water due to seepage
- So even if the capacity of the reservoir is large much water by lost due to it

- It can be made impermeable by construction of impervious membranes on the embankment
- The impervious membrane can be placed on
  1. The upstream face of the dam
  2. Core inside the embankment
- Most of the major earth dams constructed before 1925 were provided
- with central concrete core walls or concrete slabs on the upstream face
- The impervious advantages for the impervious membrane placement in
- the upstream side or core of the embankment

Concrete slab

- Concrete slab can be used successfully up to a height of 150ft
- The performance of concrete slab will directly on the quality of concrete
- Even trough the earth earth embankment is not required to act as a water barrier, it should be well compacted in order to minimize post-construction settlement of the upstream slope
- When single reinforced slab is adopted,some leakage will occur due to the hairline cracks so drains should be provided.

Steel plates

- Steel plate can be used where reinforced concrete is used
- The life is approximately the same as that of concrete
- It can be directly placed on the soil containing appreciable percentage of silt or clay
- It is expansive but it has two advantages
- It is watertight
- It is more flexible and can adapt to differential settlement in a better manner

Asphaltic concrete

- They are less costly than concrete or steel
- They are more flexible than reinforced concrete and can adapt to differential

settlement better

- They can be constructed quickly
- Under certain circumstances the leaks development are self-sealine
- The portion above the reservoir level are easy to repair than either concrete or steel

Advantages of upstream membrane

- When the membrane is on the upstream side optimum stability condition are produced ,so the volume of embankment can be reduced
- Since the upstream slab is exposed ,damage can be inspected and repaired easily
- The upstream membrane can be built after the embankment is completed
- Foundation grouting can be carried out while the dam is being built
- The membrane can serve a secondary function as wave protection

Internal impervious membrane

- Concrete is used mostly for internal membrane steel is used rarely
- Since it is not exposed for investigation very little reliable performance is available
- It is less influenced by embankment settlement and less likely to crack as a result

Advantages of internal membranes

- The area of the membrane is smaller than that of an upstream facing, so less material is required
- The surrounding embankment protects the internal membrane
- The core can be made almost watertight even if cracking develops, by placing thin layer of clay upstream
- A vertical extension of the core membrane below the base of the dam can be used through soil deposits in the foundation
- The length of the grout curtain in is shorter.

Well sinking operation procedures

1. Laying the well curb

If the river bed is dry, laying of well curb presents no difficulty. In such a case, excavation upto half a meter above subsoil water level is carried out and the well curb is laid. If, however, there is water in the river, suitable cofferdams are constructed around the site of the well and is lands are made. The sizes of the island should be such to allow free working space necessary to operate tools and plane for movement of labour etc.When the island is made, the center point of the well is accurately marked and the cutting edge is placed in a level plane. It is desirable to insert wooden sleepers below the cutting edge at regular intervals so as to distribute the load and avoid setting of the cutting edge unevenly during concrete.

2. Masonry in well steining

The well steining should be built in initial short height of about 2m only. It is absolutely essential that the well steining is built in one straight line from the bottom to top. To ensure this steining must be built with straight edges preferably of angle iron. The lower portions of the straight edges must be kept butted with the masonry of the lower stage throughout the building of the fresh masonry. In no case should a plumb bob be used to built more than 5m at a time. The well masonry is fully cured for at least 48 hours before starting the loading or sinking operations.

3. Sinking operations

A well is ready to be set in after having cast the curb and having built first short stage of masonry over it. The well is suck by excavating material from inside under the curb. In the initial stage of sinking, the well is unsuitable and progress can be very rapid with only little material being excavated out. Great care should therefore be exercised during this stage, to see the well sinks to true position. To sink the well straight it should never be allowed to go out of plumb.

Excavation and scooping out of the soil inside the well can be done by sending down workers inside the well till such a stage that the depth of water inside becomes about 1m.As the well sinks deeper, the skin friction on the sides progressively increases. To overcome the increased skin friction and the loss in weight of the well due to buoyancy, additional loading known as kentedge is applied on the well.

Pumping out the water from inside the well is effective in sinking of well under certain conditions. Pumping should be discouraged in the initial stage. Unless the well has gone deep enough or has passed through a ring of clayey strata so that chances of tilts and shifts are minimized during this process. Complete dewatering should not be allowed when the well has been sunk to about 10m depth.

4. Tilts and shifts

The primary aim in well sinking is to sink them straight and at the correct position. Suitable precautions should be taken to avoid tilts and shifts. The precautions to avoid tilts and shifts are as follows

1. The outer surface of the well curb and steinings should be as regular and smooth as possible.
2. The radius of the curb should be kept 2 to 4 cm larger than outside of well steining
3. The cutting edge of the curb should be of uniform thickness and sharpness since the sharper edge has a grater tendency of sinking than a blunt edge.
4. As soon as tilt exceeds 1 in 200, the sinking should be supervised with special care and rectifying measures should be immediately taken.

5.Completion of well

When the well bottom has reached the desired strata, further sinking of the well stopped .A concrete seal is provided at the bottom. The bottom plug is made bowl shaped so as to have inverted arch action. As generally under watering concerting as to done, no reinforcement can be provided. Under watering concreting is done the help of tremie.However if it is possible to dewater the well successfully, the concrete can be placed dry also.

After having plugged the well at its bottom, the interior space of the well is filled either with water or sand. It may even we kept empty. The well is capped at its top, with help of reinforced concrete slab. If however sand has been filled inside, top plug of lean concrete is interposed between the wall cap and sand filling as shown in fig.