NARAYANI INSTITUTE OF ENGINEERING & TECHNOLOGY
ARAHAT, ANGUL

4th Semester, Mining Engineering

Theory – I

Sub: - Underground Coal Mining

Chapter – Shaft Sinking

Definition

- **Shaft:** A vertical or inclined opening from surface for the conveyance of men, materials, hoisting ore, pumping water and providing ventilation.
- **Sinking:** The work in excavating a shaft.

SHAFT SINKING

SHAFT SINKING

It may be described as an excavation of vertical or inclined opening from surface for conveyance of men, materials, ventilation, pumping water, in addition to hoisting ore and waste rock. It is also called Shaft Construction or Shaft Mining.

AIM OF THE PROJECT

- To study conventional and advanced techniques of shaft sinking.
- To increase the production and productivity in method of working adopted to win the ore or mineral deposit by selecting appropriate and suitable available technologies for shaft sinking in Indian mines.

OBJECTIVE OF PROJECT

- Increasing the safety during sinking.
- The conditions inside the mine is needed to be improved
- The safe transport of the waste/ material/men.
- Increasing the production, efficiency and productivity of underground mine.
- To improve the ventilation arrangement of a mine.
- For this we require the construction of a new, sufficiently dimensioned shaft.

PURPOSE OF SHAFT SINKING: - **Shaft sinking is used for many purposes.**

- To transport men and materials to and from underground Workings.
- For hoisting ore and waste from underground.
- To serve as intake and return airways for the mine (ventilation shaft).
- To access an ore body
- These shafts are used in applications such as hydro electric projects, water supply, waste water shafts and tunnel projects.
- Drilled shaft machine is used in such process, where it consists of special type of units that are used in both stable and unstable soils.
- Storage of nuclear waste

- Temporary storage and treatment of sewage

Determine shape and size of shaft

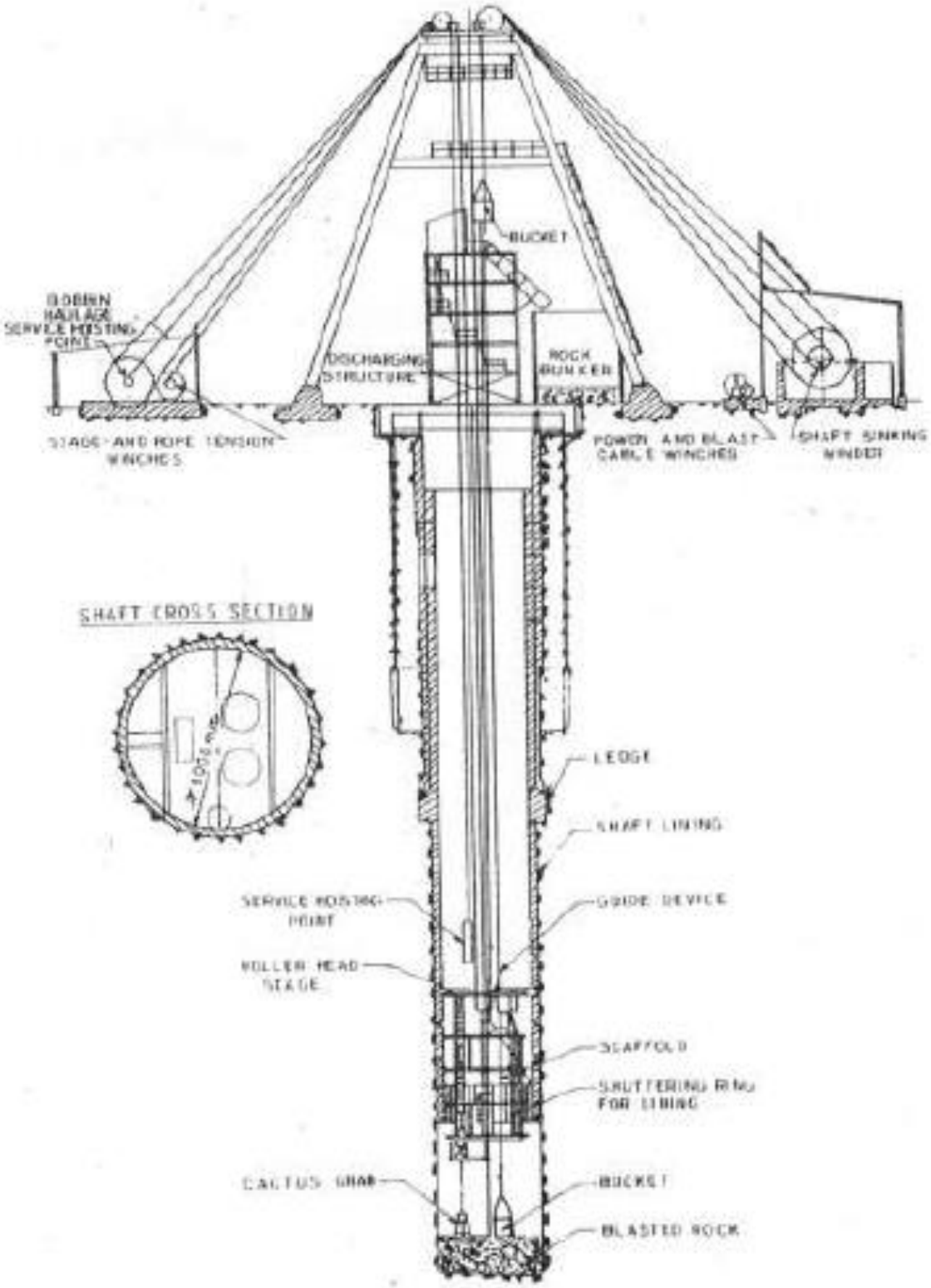
- Shafts are circular in shape and rectangular shafts are rare in this country, the exceptional cases being some of the shafts in metal mines.
- A circular shaft is best able to resist heavy side pressure for a given cross-section, offers the least rubbing surface to ventilating air current.
- It is easy to sink and line with bricks or concrete.
- The finished diameter of a shaft varies from 4.2 m to 6.7 m.

A rectangular shaft sunk in recent years is the main shaft at Mochia Magra Mines, Zawar, Rajasthan (Hindustan Zinc Limited). It is of 5.2 m x 3.8 m in cross-section, vertical, 321 m deep from the shaft collar with 30 cm thick concrete lining.

- Shaft sinking is costly operation. The mining companies pay to the shaft sinking contractors amounts varying from Rs. 50,000/- to Rs. 75,000/- per meter of overall depth of the shaft sunk and this amount includes sinking, lining with concrete, head gear, winding engine, compressors and all the machinery required for sinking and lining up to the final depth.
- The high cost involved demands much care in selecting the shaft site. It is, therefore, a standard practice to bore a pilot hole at the proposed shaft site to have a core of the rocks. Such hole need not be at the shaft centre, but may be within 50 m radius of the shaft centre and often only one hole would serve for twin shafts.
- The hole gives an idea of the rocks to encounter during sinking and provides data essential for :
    1. Confirmation of shaft site.
    2. Selection of water control methods.
    3. Estimation of sinking time and costs.
    4. Design of shaft and permanent lining.
- The present practice prefers holes with cores of 100 mm diameter. Such large diameter cores and holes are preferred for reasons of deviation control, good core recovery, and satisfactory laboratory strength & permeability tests.

Surface arrangement and equipment required during shaft sinking.

1. Steam boilers or diesel engines for winding engine, pumps etc. unless electronic power is available.
2. Winding engines and winder fitted with locked coil ropes.
3. Steel headgear of temporary in nature.
4. Double drum winches' for walling scaffold.
5. Air compressors for jack hammer drill.
6. Generator with diesel or steam engine for lighting purposes.
7. Fan nearly 300m^3 per minute capacity.
8. Folding doors to cover the shaft top.
9. Signaling arrangements from pit bottom to pit top and from pit top to winding engine.
10. For disposal of debris, chutes, buckets and tipping & with trampling etc.
11. Shaft center of arrangement.
12. Workshop inclining smithy shop, mortar mill and other usual machines.
13. Lamp room, first aid room, magazine, store office etc.



(GENERAL ARRANGEMENT OF SINKING SHAFT)

Location of the Shaft:-

Selection of a production shaft location is governed by many factors. The most important factors are:

- Suitability for transport link with the Thermal Power Plant (TPP);
- Shaft location in relation to mining advance and the associated change of the haulage distance;
- Working conditions (methane-producing capacity), hydro geological and geotechnical conditions at the potential shaft location;
- Convenient location relative to the mine infrastructure objects;
- Construction costs.

The preliminary analysis results decide the locations of the production shaft.

The best position for the main opening should be then determined from a consideration of:-

- The topography.
- The position of the mill site or point of loading ore for shipment.
- The feasibility of constructing a surface plant consisting of hoist house, shops, change house and other buildings near the opening.
- The "center of gravity" of the known ore both in plan and vertically.
- It should be so situated relative to the ore bodies that it will not be disturbed by ground movement caused by ore extraction and with a view to low maintenance cost as the main opening is usually a permanent one that will be utilized throughout the life of the mine.
- It should be located centrally with regards to the ore bodies so that underground transportation may be as economical as possible.

The centre of the shaft is marked by concrete pillars, each having a plate with centre line scribed on it. These pillars are required always as reference marks when sinking. They should, therefore, be so placed as not to be damaged by sinking operations or covered by debris.

The strata through which a shaft has to be sunk may be divided into three groups.

i) Sub –soil or alluvium
ii) Hard rock below the alluvium and above the mineral bed (generally consisting of sand stone, shale, thin coal seams, etc. in coal mining areas)
iii) The coal seam or the mineral bed.

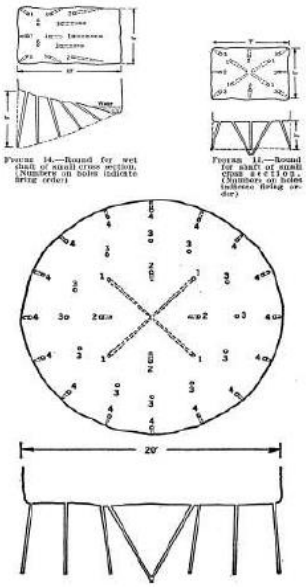
The perimeter of excavation at the surface is marked by pegs. The radius of such excavation is equal to finished radius of shaft + thickness of brick or concrete lining + a clearance of 230 to 300 mm.

CONVENTIONAL METHOD OF SHAFTSINKING

1. Drilling
2. Blasting
3. Mucking and Hoisting
4. Support or shaft lining

5. Auxiliary operations:
    a) Shaft centering
    b) Dewatering
    c) Ventilation
    d) Lighting or illumination

Excavation method



Drilling & blasting:

- A shaft is constructed by drilling holes and filling them with explosives.
- Using this method, drilling and blasting can sink around 5-10 meters in one blast.
- This is very labour-intensive, unsafe and has high running costs.
- The most viable alternative for shafts up to 100m in length.

Mucking:

- The operation of loading broken rock by hand or machine, usually in shafts or tunnels.
- Note: **Muck**, any useless material produced in mining.
- Mucking out cuttings from the bottom of the shaft.
- Usually this would require some skip-hoisting, bucket hoisting or clam-shell-grab equipment

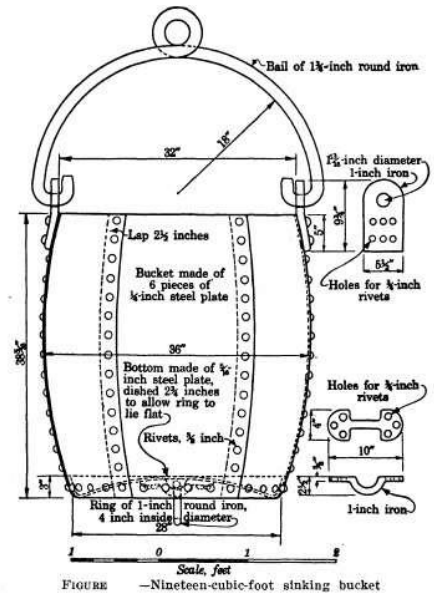
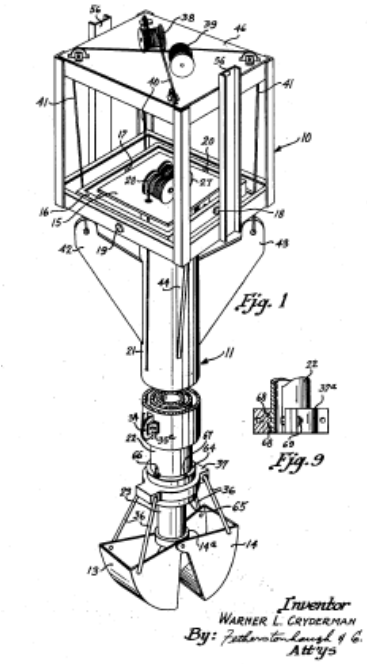


FIGURE —Nineteen-cubic-foot sinking bucket

Fig – Operation of Mucking

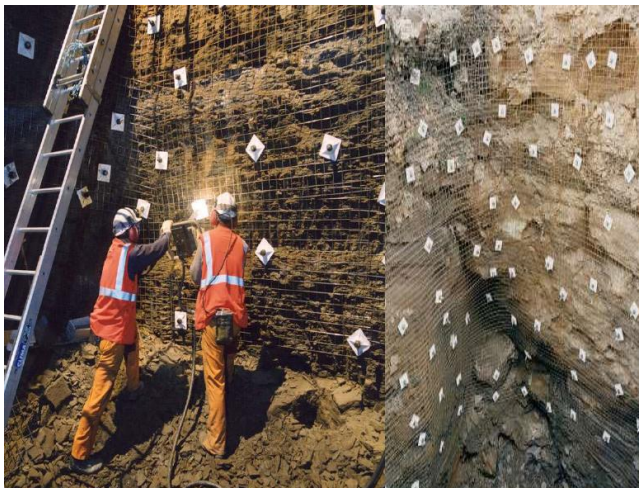


CRYDERMAN MUCKER

CACTUS GRAB

Wall supporting methods

Rock bolting and meshing



- A wire mesh is fastened to the walls with evenly spaced rock bolts.
- Rock bolting is a commonly used, cheap method.
- The rock-bolts increase normal stresses on joints so that shear failure along joints becomes more difficult.
- Often rock bolts and mesh are used as a basis for shotcreting.
- Water in-flow during shotcreting severely reduces the quality of shotcrete.

LINING

- Basically there are two types of lining:-
  I. Temporary, and
  II. Permanent.
- The make of water and strength of the strata through which the sinking operation is to be carried out govern the choice.
- In some situations temporary support is not required, where as in others, it becomes essential to protect the crew and equipment from any side falls.

TEMPORARY LINING

- It is necessary to support the sides of the excavation to prevent their collapse.
- A heavy wooden frame or a frame of steel girder is built across the shaft from which the first ring (top most) of the temporary lining is suspended.
- Alternatively the temporary lining may be suspended from strong iron spikes embedded on the surface round the periphery of the shaft.
- The temporary lining consists of skeleton rings called curb, hanger, and planks of Sal wood and tightening wedges.
- The skeleton rings are of mild steel, made in segments of 3m in length and shaped to the circumference of the shaft.
- The segments of 100 mm X 25 mm in section are joined together by fish plates or lap joints and each one is numbered

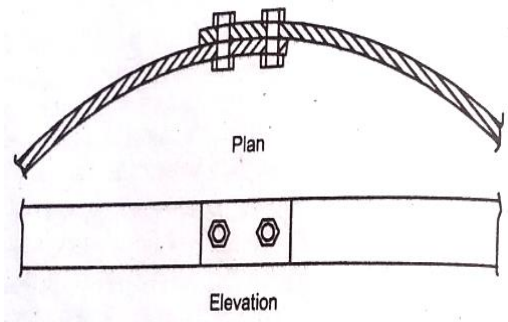


Fig-Wrought Iron Curb

for assembling in its proper places in the excavation.

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- The segments of 100 mm X 25 mm in section are joined together by fish plates or lap joints and each one is numbered for assembling in its proper places in the excavation.
- Also the segments are assembled at the surface before taking these rings in the excavation for support.
- The first skeleton ring to be inserted is suspended by chains from the steel girder frame or heavy wooden frame at the surface.

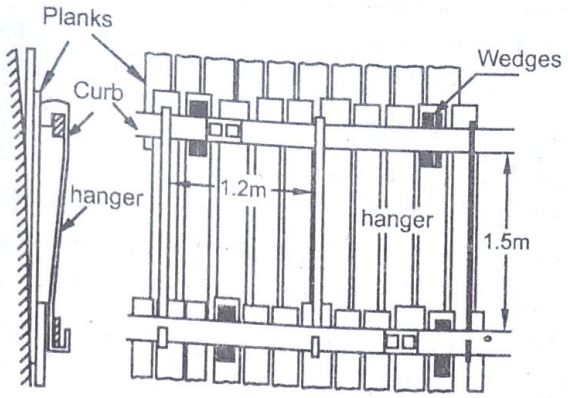


Fig-Temporary lining

- The wooden planks are of Sal, 2m long, 215mm wide and 38mm thick and are securely held against the side of excavation by wedges driven between the rings and planks.
- Each ring is suspended from the ring above by hangers or S shaped iron hooks of 25 mm diam. Placed at intervals of about 1.2 to 1.5m around the shaft circumference and every 4^{th} or 5^{th} ring is supported on plugs driven into holes drilled horizontally into the shaft sides.
- Friction with the ground keeps the planks in position and cavities behind the planks are packed with wood.
- Blasting should be avoided in the area where temporary lining is essential.

PERMANENT LINING

- When strong rock is reached the excavation is reduced to the finished diameter of the shaft and continues thus for 3 to 4m below.
- Arrangements are then made for construction of permanent lining which may be of **brick, concrete or special steel tubing.**
- Brick walling is a common practice for ordinarily compact and moderately wet strata.
- The brick of first class and well burnt quality of a size of 225mm length X 115mm breadth X 75mm height are used and usual thickness of brick lining varies from 0.4m to 0.6m.
- The leveling is to be done by picks and chisels not by explosives to avoid shattering of the strata from where the permanent lining has to be commenced.
- Sinking is usually stopped when walling is in progress.
- A 150mm layer of concrete is then laid to form a level bed and the inside edge of the concrete being the finished diameter of the shaft.

- The **bricking curb** is made of cast iron is then placed on the hardened concrete floor and shaped to conform the finished diameter of the shaft.
- In the shaft the **curb segments** numbered earlier are lowered and assembled on the concrete floor, correctly centered, leveled and bolted together, each joint being wedged against the sides of the shaft to hold it in correct position.

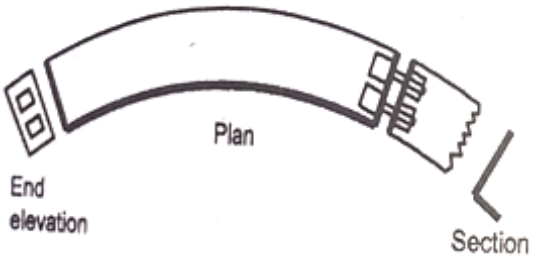


Fig-Segment of walling curb

- Brick walling is then started above the curb and inner surface of brick wall is kept vertical and true to the circumference of the shaft by plumb wires suspended from 4-5 reels at the surface.
- As the brick walling proceeds the temporary lining is dismantled in stages.
- The space between the brick lining and the excavation is filled with ash, sand, or loose bricks.
- If water percolates from the strata which have been lined, the packing allows percolating and this prevents build up of hydro static preserve behind the brick wall.
- Weep holes are left in the brick wall at the curb level during their construction for escape of such water which is collected in the water garlands at the curb and then piped down the shaft.
- The **bricking curb comprising the water garland** is a special construction as shown in the figure.

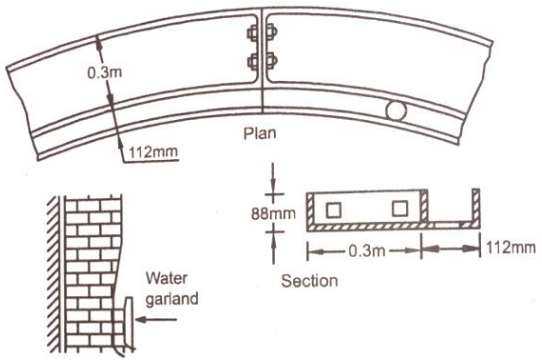


Fig- Water garland curb

- All the temporary supports are removed as the walling rises and during walling operation a temporary scaffold must be provided which can be raised or lowered by chain blocks slung by ropes or chains from girders placed across the shaft top and resting on the long timbers to distribute the weights.
- Permanent lining is generally not required where the shaft sides are of strong rock.

Fig - Permanent Concrete lining

Walling scaffold:-

- Construction of brick wall is carried out from a walling scaffold or platform.
- This consists of a frame of Sal wood having 0.3m X 0.3m square members covered with stout sal planks.
- It has an opening of 2m X 2m square for passage of the sinking bucket.
- The scaffold is suspended by chains from two ropes hanging in the shaft, one in each side of the winding rope, and it is raised or lowered by a double drum winch to which the scaffold ropes (locked coil) are taken.
- The diameter of the scaffold is slightly less than the finished diameter of the shaft.
- Four sliding bolts are used to keep the platform steady when in use and the bolts are pushed on to the top of the brickwork or into vertical recesses cut in the brickwork
- About 1.3m of walling is completed from one position of the scaffold.
- In the shaft sides buntons have to be fixed at interval of 9 m to 16 m for support of cables, water delivery pipes, compressed mains, etc.
- The positions of buntons where they are to be fixed in the permanent lining are marked by plumb wires suspended from the surface and holes are left in the lining for fixing the buntons.

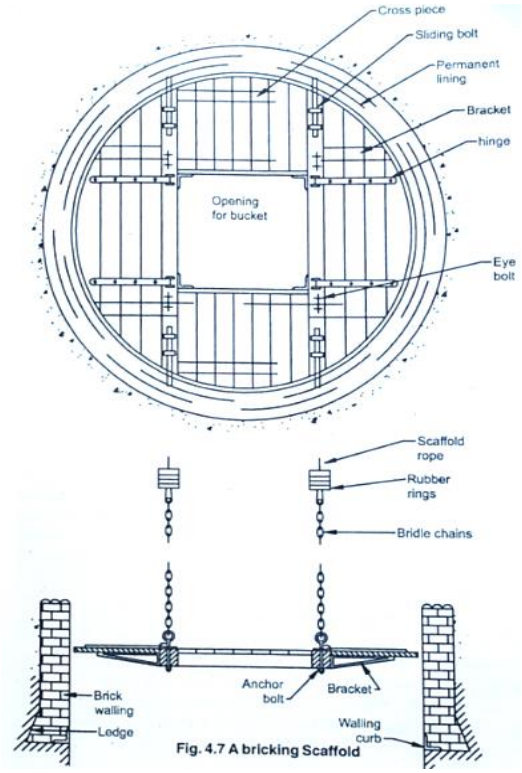
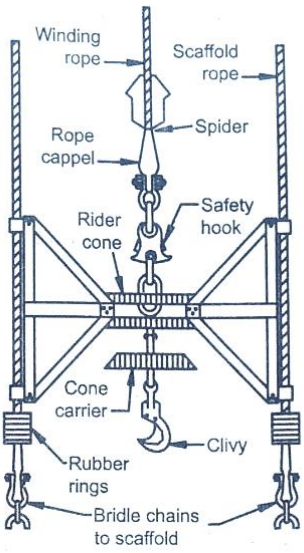


Fig. 4.7 A bricking Scaffold

- These are designed which allows sinking and walling operations at the same times.

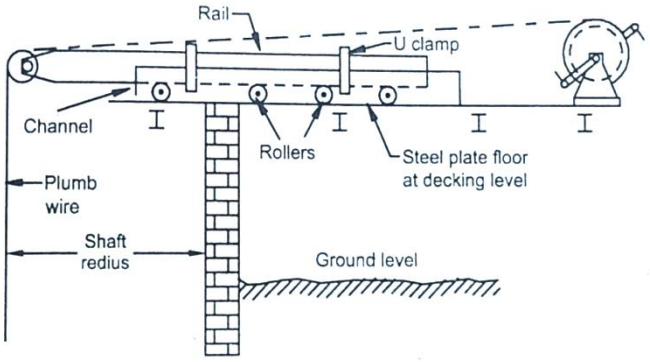
Rider:-

- It is a common practice to use guide ropes in a sinking shaft and to prevent undue swinging of the bucket during its travel a **rider** is used in addition to the use of a locked coil rope for winding.
- The rider runs on the ropes supporting the walling scaffold and guides the bucket during its travel as cited in the right side figure.
- The rider cone is so placed through it. When the bucket has to be lowered below the walling scaffold, the rider rests on the capels of the scaffold rope, and the rope passes down though rider cone, guided by the loose guide sheaves called spider.
- The spider is so constructed as to collapse when passing through the detaching plate at the header in case of over wind.
- The rider serves its purpose only between the bricking scaffold and the surface.
- It enables a bucket is to be raised & lowered at a much greater speed and with greater safety than if no rider is used.



SHAFT CENTERING

- The vertically and radius of the shaft are checked from time to time, usually once every day.
- At the time of such checking plumb wire is suspended from the surface in the shaft and the radius is measured by a light weight radius rod.
- The usual shaft centering arrangement is as shown in the figure.(right side)
- At the decking level, riveted to the steel plates of the floor, is a channel with clamps in which a light section rail can slide on rollers.
- The clamps prevent overturning as well as lateral movement of the rail.
- At the end of the rail is a pulley over which piano wire from a reel can pass.



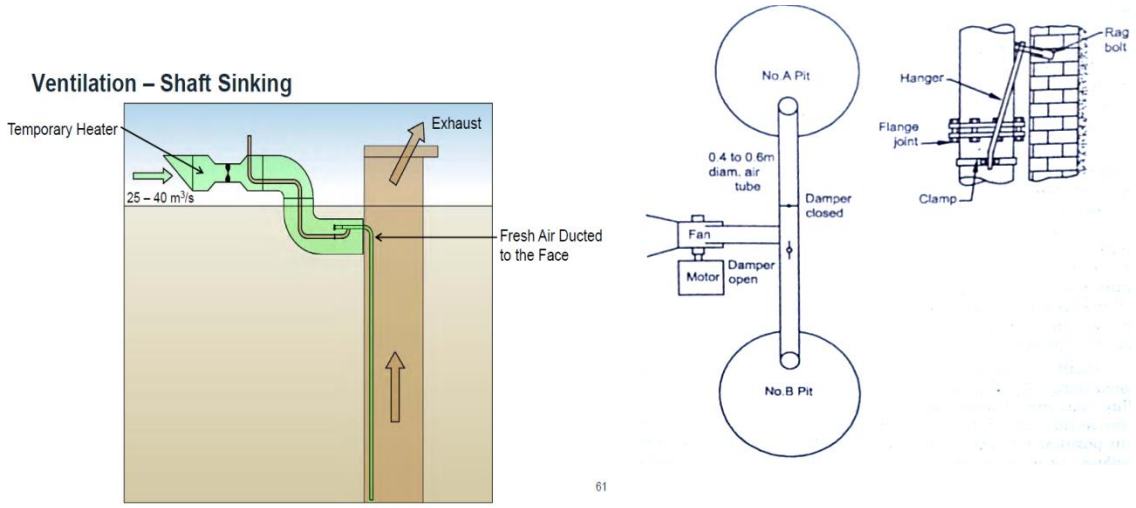
- On the rail and the channel there are two marks which coincide when the wire on the groove of the pulley attached to the rail is exactly in the centre of the shaft.
- When lowering the plumb wire, a light plumb-bob is attached to it but it is replaced by a heavier one of nearly 19 kgf at the shaft bottom.
- When checking of verticality and radius is completed, the plumb-bob is raised to the surface and rail withdrawn.
- The arrangement may be provided at the ground level where there may be no disturbance due to sinking operations.

DEWATERING

- When the make of water in the shaft exceeds about 100 liters / minute, pumps are used.
- For smaller make of water the bucket used for debris may be convenient, which is filled by a small pump and then emptied at the top.
- Centrifugal pumps are commonly used to dewater the shaft and the pump may discharge water right at the surface.
- The common practice, however is to install a semi-permanent pump in an excavation in the shaft side (called inset) and the small pump at the shaft bottom delivers the pit water to it.
- This arrangement is adopted when some of the permanent lining of the shaft is completed as the delivery column of the main pump (installed in the shaft side) can be the supported on permanent buntons.
- Sinking pumps, which are supported from the surface by power operated winches and are of centrifugal type with a maximum of eight stages.
- In the initial phase of sinking, only one or two stages are utilized, the rest replaced by dumpy impellers and as the depth increases, further stages are added.
- For a deep shaft, the delivery column of a sinking pump is supported on buntons fixed permanently in the shaft sides and the bottom-most connection to the delivery range from the pump is made by a flexible hose pipe.
- The suction of the pump is flexible armoured hose fitted with a retaining valve and strainer.

VENTILATION

- In a shaft exceeding nearly 25 m in depth, ventilation during sinking is produced by a mechanical ventilator which is commonly a forcing fan of 300 m^3/ minute capacity.
- The air tubes are of sheet iron, nearly 0.6 m diameter, suspended from the shaft side as shown in figure.
- The bottom-most length of an air tubing is a canvas hose



LIGHTING OR ILLUMINATION

- The workers use electric cap lamps, but the shaft bottom is illuminated by a cluster of 4 to 6 bulbs, each 100 watts and 110 volt.
- The cluster is supplied power through an armoured cable suspended from a cable reel at the surface.

SPECIAL METHODS OF SHAFT SINKING

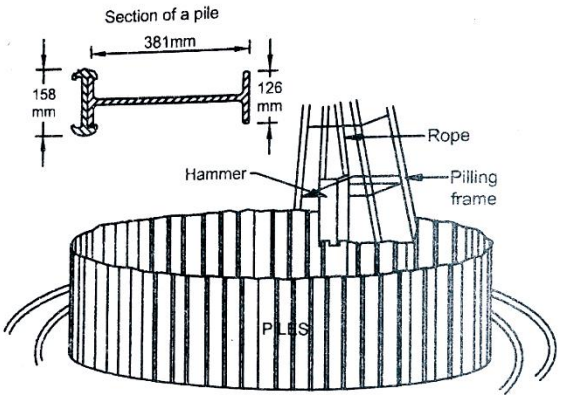
Ordinary methods of shaft sinking are not suitable in some cases and special methods have to be adopted under following conditions.

1) Loose or unstable ground, such as sand, mud, etc.
2) Excessively watery strata.
3) A combination of the above two.

a) (Wood/Steel Piling) The Piling System:

- The methods is known as simply **piling** or **sheet piling** and is suited sinking through loose deposits of sand, mud or alluvium near the surface up to a depth of 20m.
- Interlocking steel piles, 6m to 10m long are used and they are practically water tight.
- Additional length may be available by welding or riveting two or three length of piles.
- At the surface the piles are set up to form a ring then they are hammered down in rotation, each member being driven a few meters at a time by a direct acting state pilling hammer.

- As the piles descend in the loose ground, the latter enclosed by the piles is excavated and cleared up, but it should be remembered that the bottom ends of the piles are kept sufficiently ahead of the excavation to prevent inrush of water or loose sand.
- When the excavation reaches strong rock permanent lining is constructed and the sinking then proceeds in the manner describe for normal condition.



b) Caisson method:

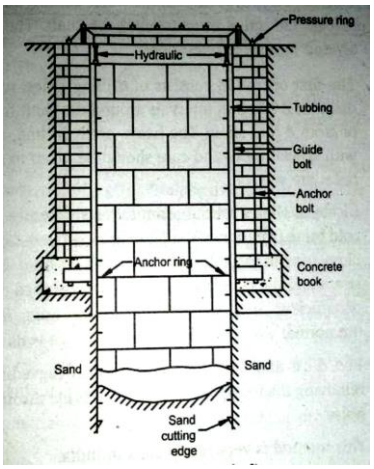
This method can be divided into three classes—

1. <u>Sinking Drum process or Open caisson method:</u>

- This consists of a cylindrical well of brick work 0.3m to 0.4m in is thickness over an M.S. ring having a steel cutting shoe.
- The shaft is excavated and the drum sinks down gradually by its, own weights.
- As the drum sinks down further brick is added on the top.
- Concrete sinking drums also can be used.
- Care must be taken to see that the drum descends vertically and the additional weight may be placed with this object over the drum.

2. <u>Forced drop shaft method:</u>

- This is commonly adopted where the strata consists of alternate tough and loose ground.
- And also when the drop shaft refuses to sink furthers due to very high skin friction.
- In these cases sinking is carried out with the help of hydraulic rams which force down the cast iron drums.
- This method can be used for depth up to 60m.



3. <u>Pneumatic Caisson method:</u>

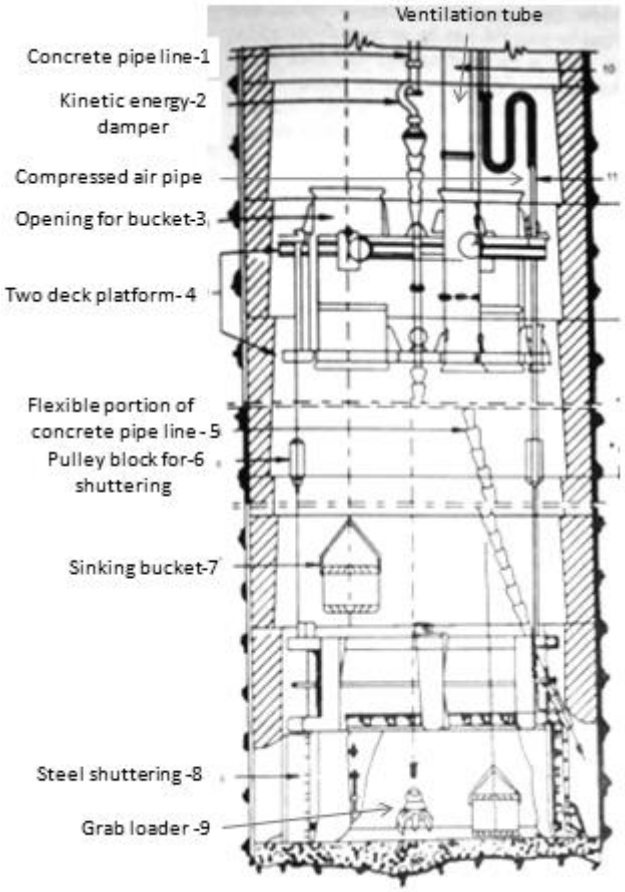
- This method is adopted when there is a danger of ground filling up the shaft.
- In other case where there is considerable inrush of water under a small head.
- Compressed air is led into the chamber formed by means of a partition. 1.8 to 2m above the cutting shoe compressed air keeps back the water and sand.
- An air lock is mounted on top of the partition as passage for men material.
- The limit of the pressure of air is 4 kgf/cm^2 beyond which persons cannot work.
- This method can be used for depths of more than 30 m.

These caisson methods are commonly adopted for the construction of foundation of bridges, tall buildings, etc.

c) Cementation process:

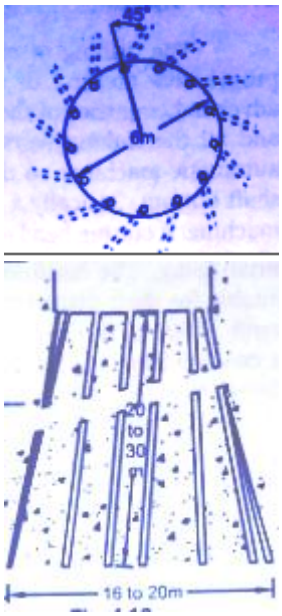
- This process can be used in all cases of shaft sinking.
- Particularly in any fissured water bearing strata except on coming sand or lose ground.
- It can be successfully applied in sinking even when the inrush of water is heavy.
- Treatment of ground around the shaft is carried out to achieve one or more of the following objects.
  1) To stabilize the collapsing ground.
  2) To reduce the inflow of ground water.
  3) To avoid flooding.
  4) To prevent sand boiling.
- The operation is usually carried out in two phases, one before the sinking and the other after shaft sinking.
- Ground conditions usually dictate the pattern of treatment.

The pre-sinking treatment reduces the surprise stoppages of sinking due to un favourable ground conditions. Further, by reducing the amount of water inflow it not only saves expenditure on the dewatering pumps but substantially enhances the rate of sinking and quality of work.



- On occasions post-cementation treatment may be necessary to have improved working conditions in the mine. Otherwise humidity in underground excavation would create serious ventilation and corrosion problems.
- This method consists in drilling the holes as shown in figure and then injecting a slury of water and cement under high pressure about 300 kgf/cm^2 through the holes till they are completely sealed off.
- The water-cement ratio can be changed according to the requirement.
- A process known as pre-silicatisation, which reduces the friction of the rock to the passage of cement is necessary in certain type of rocks.
- Extra holes are drilled for the purpose and are treated first with silicate of soda and then with alluminium sulphate.
- This process of treating the holes with the chemicals is known as sillicatisation. The holes may be treated with chemicals are known as product holes.

After cementation of holes the shaft sinking proceeds in the usual manner.

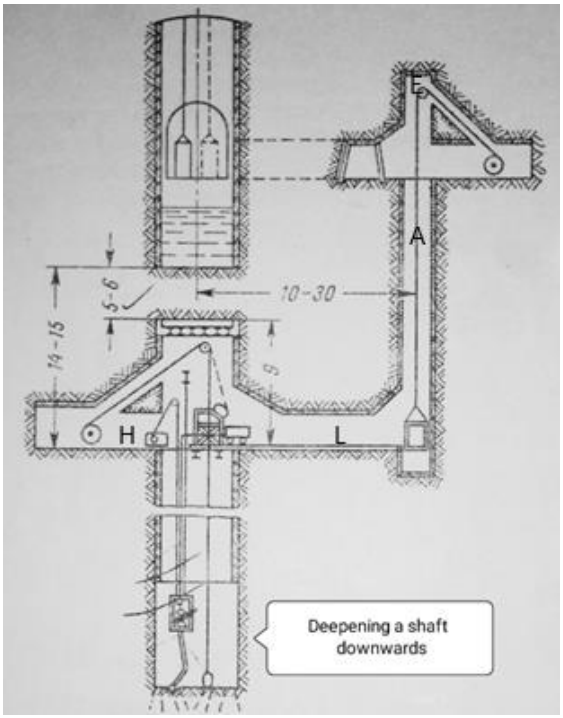


d) Freezing method :

- This method is used when the sinking is proceeding through an unstable or friable strata with heavy in rush of water or sand connected with inflow of water and essentially involves the formation of a large block of frozen ground in the water bearing strata.
- The formation of large block of frozen ground in water heaving strata helps to prevent in flow of water into this shafts.
- The whole process can be divided into three operations.
    1) Drilling holes usually 150 mm diam. holes as 2.2 to 3m interval around the shaft from the surface or from a fore shaft. The holes, after drifting are to be lined with special tubes and care should be taken to see that all the holes are vertical or water tight.
    2) Inside the holes special small tubes are inserted to enable the cold brine (solution of $CaCl_2$) to be circulated. Cold brine, while circulating in the holes, extracts the heat from the surrounding strata and the circulation is continued till a wall of ice of sufficient size is formed. Sinking and lining is carried out in the normal way after the formation of ice wall.
    3) The last and final operation is thawing which consists in removing the ice wall by sending hot brine through the existing holes.
- This method is very rarely used in India.

DEEPENING AND WIDENING OF SHAFT

Deepening of existing shaft



- A regular coal winding shaft, 6 m in diameter has to be deepened to touch the bottom seam 100 m below without affecting normal working operations.

Major Equipments

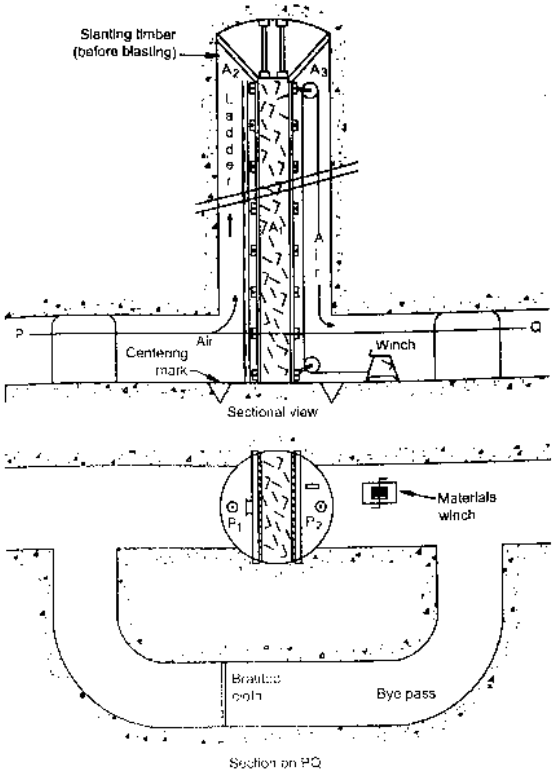
1. Electric winding engines -2
2. Hoisting sheaves-2
3. Sinking buckets -3
4. Single tub cage-1
5. Tubs
6. Jack hammer-6
7. Pneumatic picks-4
8. Pneumatic face pumps-2
9. Electric pump
10. Platform with folding doors for shaft top
11. Shuttering for concreting
12. Pipe, cables, ropes, etc.

DEEPENING OPERATIONS

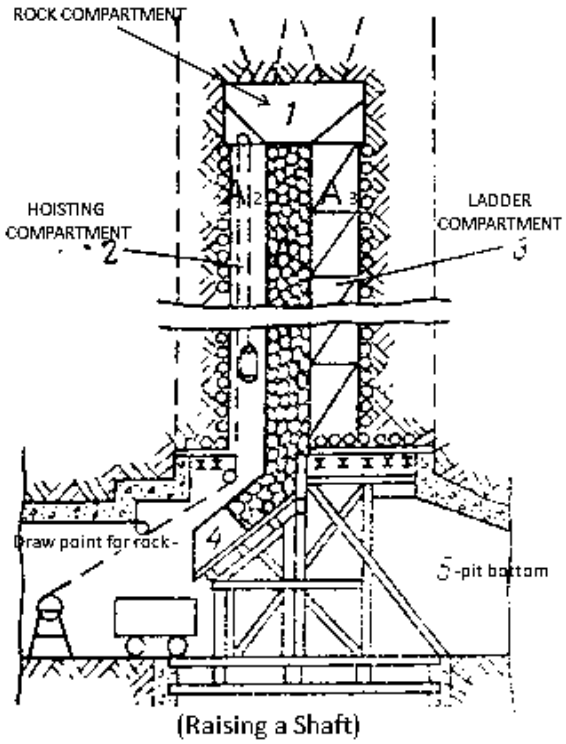
- Small shaft "A" is sunk near the coal winding pit on the side, away main haulage level. Head room is made for installation of winding sheaves of the hoist "E". The depth should be enough to reach beyond the sump of the old shaft, cross the safety rock plug "P" and allow sufficient head room for the installation of the sheaves of the second hoist is driven.
- Level roadway "L" to the position on shaft deepening. The place is widened and heightened for installation of winding engine "H", its sheaves and other equipment. Additional hoists are installed for carrying the suspended sinking equipment.
- The shaft center is marked accurately by correlation through the shaft "A". The perimeter to be excavated is marked on the rock surface.
- After deepening the shaft to some depths, the platform with folding doors is installed at its mouth.
- Sinking proceeds in the normal manner. The rock from sinking buckets is dumped into mine tubs and hauled up through shaft "A". The debris can be packed into underground galleries or hoisted to the surface through the main winding shaft for disposal.
- On completion of sinking, plug P is removed in sections.

Raising a shaft upwards

- Necessity of upward drivage for a distance of up to 15 m may be carried out because of the difficulties involved; great care and experience are required to execute the work.
- At the proposed site of the pit a bye-pass is driven first. The roof is then blasted for a few meters and girders or beams are placed across the gallery width to divide cross-sectional area of the drivage into three compartments, A_1, A_2 and A_3.
- The larger middle compartment A_1 serves the purpose of collecting the rocks dislodged after blasting and also acts as a platform, prepared by extending thick wooden planks vertically to the girder or beams, on which the workers can stand.
- The other compartments A_2 and A_3 serves for the movement of workers by ladders of angle iron and winch for taking of materials to the work site A_1 & also acts as the course of ventilating air.
- To maintain verticality of shaft two iron plugs P_1 and P_2 each marked with punch are driven into the floor. The center point of P_1 P_2 is transferred to the drivage face by suspending plumb lines over the plugs and center point marked at the roof.
- The side figure shows the course of drivage. Holes of 1m deep are drilled in the roof by workers standing over the debris in compartment A_1.
- Before blasting compartment, A2 and A_3 are protected by slanting timbers. Shots are fired electrically from a safe place in the roadway. The surplus debris in compartment A_1 is removed through other compartments.
- A pair of wooden beams and vertical planks is fixed in position on top of A_1 when it is sufficiently advanced.
- When the drivage is completed, the debris in compartment A_1 is cleared up.
- Then wooden beams & planks are removed to clear up the desired passage.



Upward drivage of the Shaft



(Raising a Shaft)

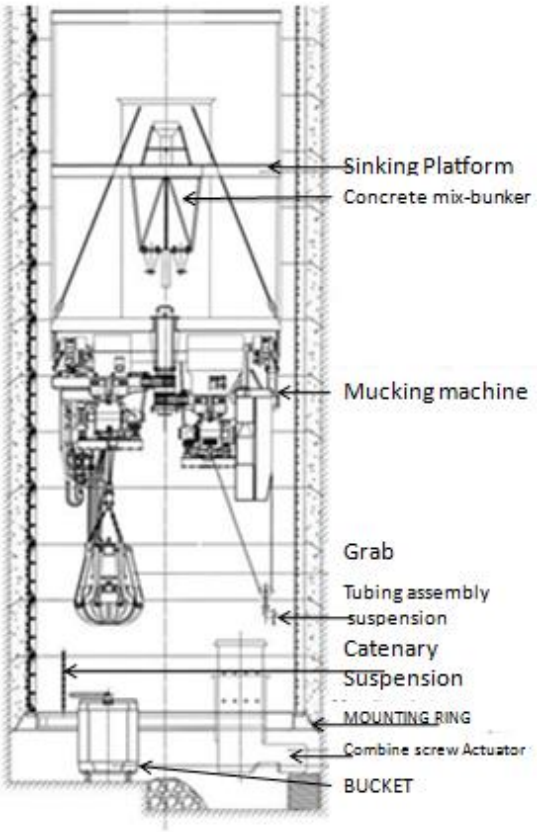
WIDENING A SHAFT

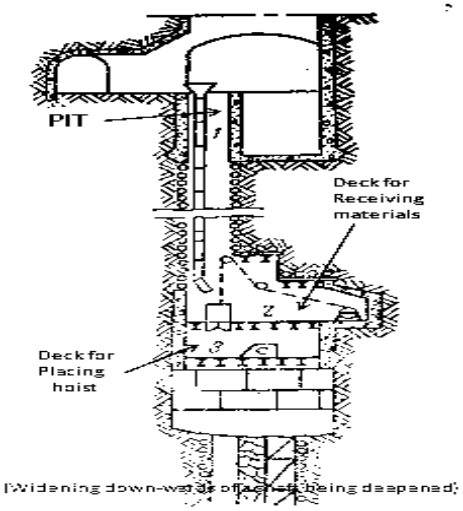
Widening a shaft used for coal winding: -

In this case entirely different procedure must be adopted, one of the essential items of equipment being a strong cylindrical steel shield which fits inside the old shaft and does not interfere with the travel of cages.

Preliminary Work: -

- Sufficient ground at the surface must first be excavated behind the old shaft walling down to depth of 30m to enable a concrete wall 1m thick and 6m internal diameter to be erected all around the shaft. This wall should be founded on steel girders and provided with pockets which receive other girders for support of existing pit-top frame, receiving guides etc.
- The next step is to erect a strong platform on girders at the depth of 3.6m and to widen the shaft to this depth, the debris being raised to the crab engine and kibble. The platform then removed and re-erected at the depth of 6m.
- The shaft being widened to this depth in similar way. The widened shaft should be supported temporarily by steel ring and backing deals, the first ring being hung from the girders at the base of the concrete walling is built up and the platform removed all together.
- All this preliminary work is necessary to enable the protecting shield walling platform to be installed in the shaft.





Widening down-wards of the shaft being deepened