Underground Mining of Metalliferous Deposits

Professor Kaushik Dey
Department of Mining Engineering
Indian Institute of Technology, Kharagpur

Lecture 15
Shaft-I

VERTICAL SHAFT

Let us understand first what is vertical shaft? Vertical shaft is the construction just like a well, and this is a very large size excavation so that the man and material can move with this and that can be hoisted along this. So essentially a vertical shaft is vertical that means 90 degree to the horizontal in angle. The benefit of this vertical shaft is that it is giving minimum direction, minimum length of construction. As it is minimum length, the transportation and time is also minimum as well as the construction time is also minimum because the length is minimum. Now if we are looking at applicability, generally vertical shafts are universally applicable but there are some certain conditions where comparison – cost comparisons are made while the choice between the vertical shaft and the inclined shafts are carried out.

APPLICABILITY

- As it is a perfect vertical opening the orebody preferred:

  (i) either to be horizontal/near horizontal (to have single level mining) or (ii) to be vertical or dipping significantly (to have multi-level mining with minimum cross cut distance) .

- Moderate to very deep mines

- Higher production target (than incline shaft)

LOCATION

Now choice of location of the shaft is very, very important. Whether the shaft has to be placed at this position or may be a little bit closer to this or maybe in this site. So what will be the position of the shaft? In general always the all the openings whether it is inclined vertical whatever it is, all the opening has to be carried out in the footwall side because it is much more stable. It must be positioned such that this cross cut distances should be minimum. Shaft is basically the ingress and egress of the material. So that is why its dimension should be sufficient to accommodate those ingress and egress material.

- Must be such that the transportation cost should be minimum

- Or alternately the total material cost ingress/egress should be minimum

- Competent rockmass condition
- If used as intake/return ventilation shaft, condition must be favourable
- Head gear stability is important (wind related issues)

Note- Capacity of a shaft = Load × no of cycle = Load × (available time/cycle time)

EXCAVATION TECHNIQUES – VERTICAL (Downward)

Shaft/winze:

Method of excavations

1) Discrete
2) Continuous

Major operations

1) Excavations
2) Material loading/transportation
3) Wall/Roof control/support
4) Auxiliary operations - pumping, ventilation, electric, water, road/line/ extension,

Size: As per the requirement, Number of compartments space requirement, 3m 5m 10m ……

Shape: Rectangular or Circular

Generally, rectangular and circular shapes are available and size depends on the number of compartment space required. So depending on that in general we go for considerations of the size. So circular in general provide the best stability because it is more supporting the horizontal stresses, so circular is most stable in nature than rectangular but rectangular shaft is having better space utilization.

Influencing factors

- Strength of rockmass: Weak rock Circular
- Cost and method of excavation: Less cost in drilling Circular
- Maintenance cost: Circular is more stable less maintenance cost
- No. of compartments : More compartments Rectangular

- Ventilation requirement: Less resistance Circular
- Capacity requirement: More capacity (more compartments) Rectangular
- Depth of shaft: High insitu rock pressure (more stable) Circular
- Space requirement: Better Rectangular

SHAFT SINKING

Of all the headings driven in hard rock mines, shafts are the most costly and time consuming.

Moreover, the shaft sinking procedure is intricate and arduous.

While a few shafts are advanced by big-hole drilling methods, the great majority use the traditional "drill and blast" cycle.

Shafts for smaller mines have traditionally been sunk rectangular and relied on timber for support.

Larger mines have typically employed circular shafts lined with concrete poured in place as the sinking advances.

On the surface of an underground mine, a collar is required for a shaft or raise entry, while a portal refers to the entrance for an adit, decline, or ramp.

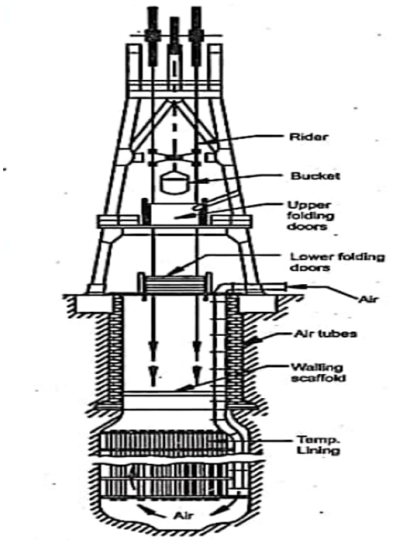
Sinking a shaft in solid rock usually consists of the following cycle:

- Drilling a round of holes
- Blasting
- Removing the broken rock
- Trimming the shaft to form
- Placing the sets in position
- Preparing to drill the next round.

A full shift cycle from blast to blast is common.

Concrete is mixed on the surface and conveyed down the shaft in a pipe. The shaft bottom is cleaned after mucking, the center line fixed by plumb bob, and the next round drilled. The stage is lowered if necessary. During mucking, the forms for concrete are placed in position.

SHAFT SINKING - Surface plant and equipment



So if we are first considering the surface requirements. In surface we have to provide the headgear. So first we have to provide a temporary or permanent headgear and in this headgear as can be seen in the figure above – in the headgear, we provide different attachments such as riders, air tubes etc. The bucket is used to take the man and material, also there must be a door so that no one can fall down into the constructing shaft so that door must be there and this a folding door. Whenever this bucket is taken out, it is allowed to land on this door only so that the people can move out. If the bucket is taking out the muck, then bucket is allowed to dislodge the muck in a side window from which the fragmented rocks are going out. The following arrangements must be provided.

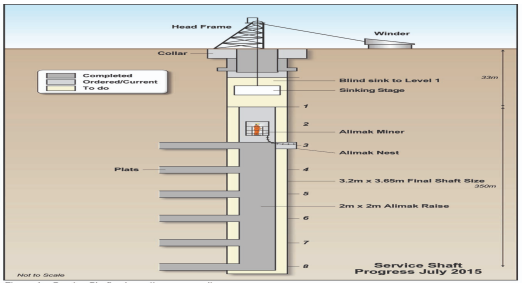
- The surface plant and equipment required for sinking is as follows:
    - Steam boilers or diesel engines for winding engines, pumps etc. unless electric power is available.
    - Winding engines and winders fitted with locked coil ropes.
    - Steel headgears. The headgear may be temporary nature and after the sinking is over, it is replaced by a permanent headgear and a permanent winders to suit the output.
- Double drum winches for walling scaffold, and other winches for lighting cables, pump suspension ropes and pump cables.

- Air compressor for jack hammer drills used for drilling into rock and other compressed air operated equipment.
- Fan of nearly 300 m^3 per minute capacity.
- Generator with diesel or stem engine for lighting.
- Folding doors to cover the shaft top.
- Shaft centering arrangement.
- Signaling arrangement from pit bottom to pit top and from pit top to winding engine.
- Pumping
- For disposal of debris, chutes, buckets, and tipping tubs with tramline etc.
- Workshop including smithy shop, mortar mill and other usual machines.
- Lamp room, first aid room, magazine, stores, office, etc.
- The center of the shaft is marked by concrete pillars, each having a plate with center line scribbed on it.
- These pillars are required always as reference marks when sinking. They should therefore be so placed as not to ne damaged by sinking operations or covered by debris.
- The strata through which a shift has to be sunk may be divided into three groups.
    - Sub-soil alluvium.
    - Hard rocks below the alluvium and above the mineral bed (generally consisting of sandstone, shale, thin coal seams, etc. in coal mining areas).
    - The coal seam, or the mineral bed.
- The perimeter of excavation is marked by pegs. The radius of such excavation is equal to <u>finished radius of shaft + thickness of brick or concrete lining + a clearance of 230 to 300 mm.</u>
- The starting point of a vertical shaft at the ground surface is called collar or shaft collar. The sub-soil or alluvium and weathered rock are excavated upto the strong rock by earth cutting picks, chisels and hammers, without resource to blasting.
- In most of the cases the thickness of the such sub-soil varies from 3 m to 20 m. The excavated material is lifted to the surface through bucket hoisted by ropes. A crane with a long jib or a grab is sometimes used for clearing the debris.

Collar

Collars are also required for ventilation shafts, service shafts, and for all raises that reach surface.

Constructing collars in a rock outcrop or in shallow overburden is relatively straightforward; however, if the soil overburden is deep and especially if it is water bearing, collar construction can become a major project. Shaft and raise collars are normally lined with concrete.



If the nature of the ground above the bedrock is not known, it is advisable to drill test holes. Sandy or running ground, especially if wet, offers difficulties in shaft sinking. A shaft-sinking plant consists of a headframe, hoisting equipment, an air-compressor for drills, concrete mixing equipment and suitable pumps.