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UNDERGROUND MINE DEVELOPMENT

1.0 INTRODUCTION OF MINING

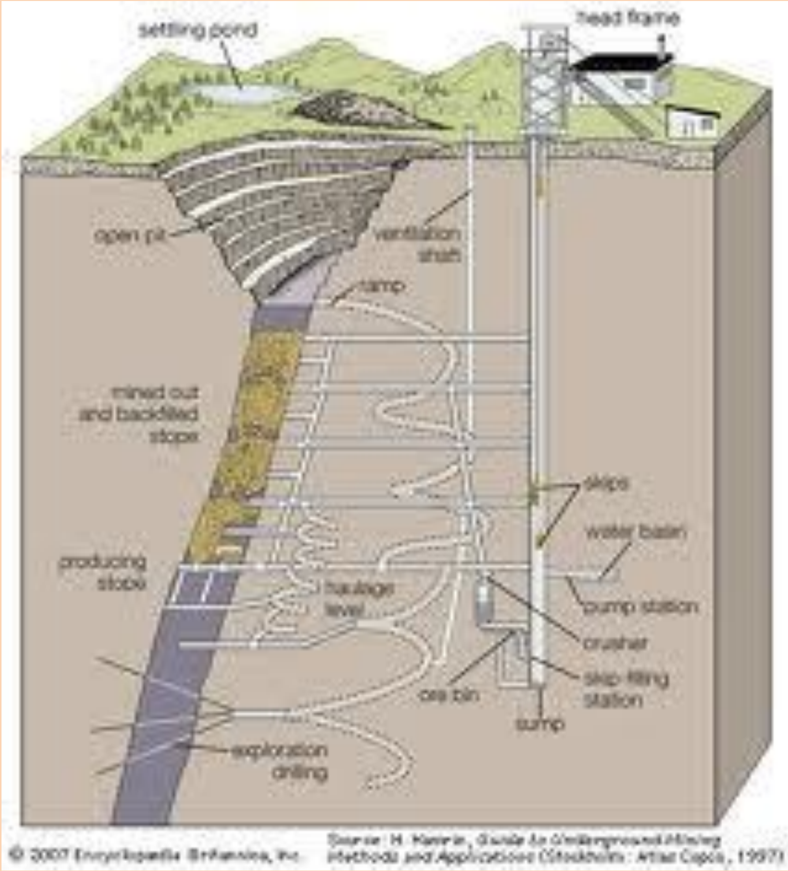
Mining is the process of extraction of minerals of economical values from the earth crust for the benefit of mankind. Mining is the extraction of valuable minerals or other geological materials from the earth, from an ore body, vein or (coal) seam. The term also includes the removal of soil. Materials recovered by mining include base metals, precious metals, iron, uranium, coal, diamonds, limestone, oil shale, rock salt and potash. Any material that cannot be grown through agricultural processes, or created artificially in a laboratory or factory, is usually mined. Mining in a wider sense comprises extraction of any non-renewable resource (e.g., petroleum, natural gas, or even water).

Mining techniques

Mining techniques can be divided into two common excavation types: surface mining and underground mining.

Surface mining is much more common, and produces, for example, 85% of minerals (excluding petroleum and natural gas) in the United States, including 98% of metallic ores. Targets are divided into two general categories of materials: *placer deposits*, consisting of valuable minerals contained within river gravels, beach sands, and other unconsolidated materials; and *lode deposits*, where valuable minerals are found in veins, in layers, or in mineral grains generally distributed throughout a mass of actual rock. Both types of ore deposit, placer or lode, are mined by both surface and underground methods.

Underground mining is done by removing (stripping) surface vegetation, dirt, and if necessary, layers of bedrock in order to reach buried ore deposits. Techniques of surface mining include; Open-pit mining which consists of recovery of materials from an open pit in the ground, quarrying or gathering building materials from an open pit mine, strip mining which consists of stripping surface layers off to reveal ore/seams underneath, and mountaintop removal, commonly associated with coal mining, which involves taking the top of a mountain off to reach ore deposits at depth. Most (but not all) placer deposits, because of their shallowly buried nature, are mined by surface methods. Landfill mining, finally, involves sites where landfills are excavated and processed. Sub-surface mining consists of digging tunnels or shafts into the earth to reach buried ore deposits. Ore, for processing, and waste rock, for disposal, are brought to the surface through the tunnels and shafts. Sub-surface mining can be classified by the type of access shafts used, the extraction method or the technique used to reach the mineral deposit. Drift mining utilizes horizontal access tunnels, slope mining uses diagonally sloping access shafts and shaft mining consists of vertical access shafts. Mining in hard and soft rock formations require different techniques.



2.0 VARIOUS STAGES OF MINING

STAGE I: PROSPECTING

- STAGE II: EXPLORATION
- STAGE III: EXPLOITATION
- STAGE IV: BENEFICATION

Stage I: Prospecting

Prospecting is necessary for the assessment of ground conditions before starting any excavation. The purpose of the prospecting is to provide information about the area of the mine to be excavated, and to help determine what measures should be taken to control ground movement, including the type of free-standing support system appropriate to the circumstances.

Steps of Prospecting

a. collecting relevant information;
b. assessing that information
c. recording the findings of the assessment
d. deciding the area over which the assessment is considered valid

Step 1 - Collecting the information

The collected information includes :

- ✓ geological information, such as the type, thicknessand condition of the rock beds adjacent to the proposed extraction, including any geological disturbances;
- ✓ the properties of the coal seam and of the rocks above and below the seam;
- ✓ whether or not water is present and, if so, its likely effect;
- ✓ relevant historical data.

Step 2 - Assessing the information

Once sufficient information has been collected, some suitably competent person assesses it to take into account as appropriate:

- ✓ the effects of vertical and lateral stresses, that are likely to be caused by mineral extraction in the same or other seams;
- ✓ the effect of surface features, such as rapidly increasing or reducing cover in hilly areas;
- ✓ the magnitude and nature of expected ground movement;
- ✓ the potential for support system failure;

- ✓ the possible effects from, and on, other working places.

Step 3 - Recording the findings

When the assessment has been completed, it issummarized in a document containing the assessment procedure, including, where relevant, details of the type and nature of any site investigation; assumptions made;significant findings; and conclusions.

Step 4 - Deciding the area over which the assessment is valid

The area of the mine for which a particular assessment can be considered valid depends on the amount and quality of information available at the time the assessment is made.

Where a seam is being worked for the first time, information on the type and nature of the strata and general mining conditions are limited. Therefore it is difficult to assess confidently what the ground conditions will be like across the whole of the area to be worked. An assessment made in these circumstances is reliable only on during the early stages of excavation.

Stage II: Exploration

Exploration is the process of finding ore (commercially viable concentrations of minerals) to mine. Exploration is a much more intensive, organized and professional form of mineral prospecting and, though it frequently uses the services of prospecting, the process of mineral exploration on the whole is much more involved.

Exploration methods vary at different stages of the process depending on size of the area being explored, as well as the density and type of information sought.

- ❖ Area selection

Area selection is a crucial step in exploration. Selection of the best, most prospective, area in a mineral field or geological region will assist in making it not only possible to find ore deposits, but to find them easily, cheaply and quickly.Area selection is based on applying the theories behind ore genesis, the knowledge of known ore occurrences and the method of their formation, to known geological regions via the study of geological maps, to determine potential areas where the particular class of ore deposit being sought may exist.

This process applies the disciplines of basin modeling, structural geology, geochronology, petrology and a host of geophysical and geochemical disciplines to make predictions and draw parallels between the known ore deposits and their physical form and the unknown potential of finding a 'lookalike' within the area selected.

Area selection is also influenced by the commodity being sought; exploring for gold occurs in a different manner and within different rocks and areas to exploration for oil or natural gas or iron ore. Areas which are prospective for gold may not be prospective for other metals and commodities.

Areas with small-sized deposit styles are ruled out based on likely economic returns. This occurs because often smaller deposits are more expensive to run, and hence, carry greater risks of closure if commodity prices fall significantly..

- Target generation

  The target generation phase involves investigations of the geology via mapping, geophysics and conducting geochemical or intensive geophysical testing of the surface and subsurface geology.

  - *Geophysical methods*

    Geophysical instruments play a large role in gathering geological data which is used in mineral exploration. Instruments are used in geophysical surveys to check for variations in gravity, magnetism, electromagnetism (resistivity of rocks) and a number of different other variables in a certain area..

    Geiger counters and scintillometers are used to determine the amount of radioactivity. This is particularly applicable to searching for uranium ore deposits but can also be of use in detecting radiometric anomalies associated with metasomatism.

    Airborne magnetometers are used to search for magnetic anomalies in the Earth's magnetic field. The anomalies are an indication of concentrations of magnetic minerals in the Earth's crust. It is often the case that such magnetic anomalies are caused by mineralization events and associated metals.

    Ultraviolet lamps may cause certain minerals to fluoresce, and is a key tool in prospecting for tungstenmineralization.

  - *Remote sensing*

    Aerial photography is an important tool in assessing mineral exploration tenements, as it gives the explorer orientation information.

Satellite based spectroscopes allow the modern mineral explorations, in regions devoid of cover and vegetation, to map minerals and alteration directly. Improvements in the resolution of modern commercially based satellites has also improved the utility of satellite imagery.

- *Geochemical* methods.

  The presence of some chemical elements may indicate the presence of a certain mineral. Chemical analysis of rocks and plants may indicate the presence of an underground deposit. For instance elements like arsenic and antimony are associated with gold deposits and hence, are example pathfinder elements. Tree buds can be sampled for pathfinder elements in order to help locate deposits.

❖ Resource evaluation

Resource evaluation is undertaken to quantify the grade and tonnage of a mineral occurrence. This is achieved primarily by drilling to sample the prospective horizon, lode or strata where the minerals of interest occur.

The aim of resource evaluation is to expand the known size of the deposit and mineralisation and to generate a density of drilling sufficient to satisfy the economic and statutory standards of an ore resource.

❖ Reserve definition

Reserve definition is undertaken to convert a mineral resource into an ore reserve, which is an economic asset. The process is similar to resource evaluation, except more intensive and technical, aimed at statistically quantifying the grade continuity and mass of ore.

At the end of this process, a feasibility study is published, and the ore deposit may be either deemed uneconomic or economic.

Stage III: Exploitation

Exploitationis associated with the actual recovery in quantity of mineral from the earth. While some exploration and development work necessarily continues throughout the life of a mine, the emphasis in the exploitation stage is on production. Only enough development is done prior to exploitation to ensure that production, once started, can continue uninterrupted throughout the life of the mine.

The mining method selected for exploitation is determined mainly by the characteristics of the mineral deposit and the limits imposed by safety, technology, and economics. Geologic conditions, such as deposit dip and shape and strength of the ore and wall rock, play a key role in selecting the method.

Traditionalexploitation methods fall into two broad categories based on locale:

a) surface
b) Underground.

Stage IV: Benefication

All the steps in processing raw minerals that occur following extraction from the earth comprise *postmining operations.*
Storage and Transportation: Materials handling as a unit operation continues beyond mining through processing. At each phase or transition, bulk-material storage and transportation must be provided. Bins, silos, hoppers, and stockpiles may be required for storage, with attendant transfer feeders, stackers, and reclaiming machines. Transportation occurs by rail, road, barge or ship, or conveyor (belt, hydraulic, or pneumatic). Selection of these facilities is responsibility of the operating mineral or metallurgical engineer.

Mineral Processing: It is termed cleaning or washing if the mineral is coal and milling or concentrating if it is an ore. Interfacing directly with mining, mineral processing requires close communication and coordination with the extraction activities. Almost continuous monitoring of the run-of-mine product as to tonnage and grade is mandatory; feedback control loops permit adjustments in mining practice to meet processing demands.. Disposal of wastes (tailings, culm, reagents) must always accompany mineral processing.

3.0 MINING TERMINOLOGY

<u>ORE</u>

- It is a natural aggregate of one or more minerals which can be used for economical extraction of metal after processing to separate mineral from gangue.

- Generally, the ore and the gangue are mined together—i.e., taken out of the host rock in a mass by either mechanical or manual means. Then the ore is separated from the gangue by various operations known collectively as mineral processing, or ore dressing. The desired metallic element is then extracted from the ore by various smelting, roasting, or leaching processes.

- Although more than 2,800 mineral species have been identified, only about 100 are considered ore minerals. Among these are hematite, magnetite, limonite, and siderite, which are the principal sources of iron; chalcopyrite, bornite, and chalcocite, the principal sources of copper; and sphalerite and galena, the principal sources, respectively, of zinc and lead. Copper, molybdenum, and gold are commonly found in disseminated deposits—i.e., scattered more or less uniformly through a large volume of rock.

FOOT WALL

- The block of rock lying under an inclined geologic fault plane.
- The mass of rock underlying a mineral deposit in a mine.

HANGING WALL

- The overlying block of a fault having an inclined fault plane.
- The mass of rock overlying a mineral deposit in a mine

ORE BODY

- A natural concentration of valuable material that can be extracted and solid at a profit.

DIP

- Dip is the angle of the bed with the horizontal plane.
- The dip direction is perpendicular to the strike direction.

STRIKE

- The direction of the line formed by the intersection of a fault, bed, or other planar feature and a horizontal plane. Strike indicates the attitude or position of linear structural features such as faults, beds, joints, and folds. Trend is the direction of the line formed by the intersection of the planar feature with the ground surface; trend is the same as strike only if the ground surface is parallel to the horizontal plane.

MINERAL

- A naturally occurring homogenous substance having different physical properties and chemical composition and, if formed under favourable conditions, a definite crystal forms.
- There are several thousand known mineral species, about 100 of which constitute the Rock which serves as a host for other rocks or for mineral deposits.

HOST ROCK

- Rock which serves as a host for other rocks or for mineral deposits. It may be defined as those pre-existing rocks over which the magma or lava deposited at the time of volcano.

GRADE

- It is a qualitative indicator of metal content in ore. The grade or concentration of an ore mineral, or metal, as well as its form of occurrence, will directly affect the costs associated with mining the ore. The cost of extraction must thus be weighed against the contained metal value of the rock to determine what ore can be processed and what ore is of too low a grade to be worth mining.
- The grade of a typical heavy mineral sand ore deposit is usually low. Within the 21st century, the lowest cut-off grades of heavy minerals, as a total heavy mineral (THM) concentrate from the bulk sand, in most ore deposits of this type is around 1% heavy minerals, although several are higher grade.

CUT-OFF GRADE

- In mining, the mine cutoff grade is the level of mineral in an ore below which it is not economically feasible to mine it. The mill cutoff grade is the level below which already mined ore is not worth processing.
- The mine cut-off grade is estimated or chosen during a mining feasibility study.
- The cut off grade for different elements is: Iron - 55% Aluminium - 30% Copper - 5% Gold - 0.0001% Uranium - 0.0003.
- In other words, we can say that there is a certain grade below which it is not profitable to mine a mineral even though it is still present in the ore. This is called the mine cutoff grade. And, if the material has already been mined, there is a certain grade below which it is not profitable to process it; this is the mill cutoff grade.

GEOLOGICAL RESOURCES

A concentration or occurrence of material of intrinsic economic interest in or on the Earth's crust in such form, quality and quantity that there are reasonable prospects for eventual economic extraction. The location, quantity, grade, geological characteristics and continuity of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge. Mineral Resources are sub-divided, in order of increasing geological confidence, into following categories:-

1. INFERRED MINERAL RESOURCE.
2. INDICATED MINERAL RESOURCE.
3. MEASURED MINERAL RESOURCE.

Inferred Mineral Resource (Possible Reserve):-

That part of a Mineral Resource for which tonnage, grade and mineral content can be estimated with a low level of confidence. It is inferred from geological evidence and assumed but not verified geological and/or grade continuity. It is based on information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes which may be limited or of uncertain quality and reliability.

Indicated Mineral Resource (Probable Reserve) :-

That part of a Mineral Resource for which tonnage, densities, shape, physical characteristics, grade and mineral content can be estimated with a reasonable level of confidence. It is based on exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes. The locations are too widely or inappropriately spaced to confirm geological and/or grade continuity but are spaced closely enough for continuity to be assumed.

Measured Mineral Resource (Proved Reserve):-

That part of a Mineral Resource for which tonnage, densities, shape, physical characteristics, grade and mineral content can be estimated with a high level of confidence. It is based on detailed and reliable exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes. The locations are spaced closely enough to confirm geological and grade continuity.

Minable Reserve:-

It is a part of measured mineral resource which can be mined legally and profitably and safely after permission taken from government.

PANEL

A coal mining block that comprises one operation unit is termed as panel

GALLERY:

A horizontal or nearly horizontal under ground passage either natural or artificial is termed as a gallery.

Gallery is mainly classified in two types.

1. Level gallery

2. Dip gallery

In a dip gallery, the gallery is parallel to the dip of the coal seam, where as in level gallery it is perpendicular to the dip of the coal seam.

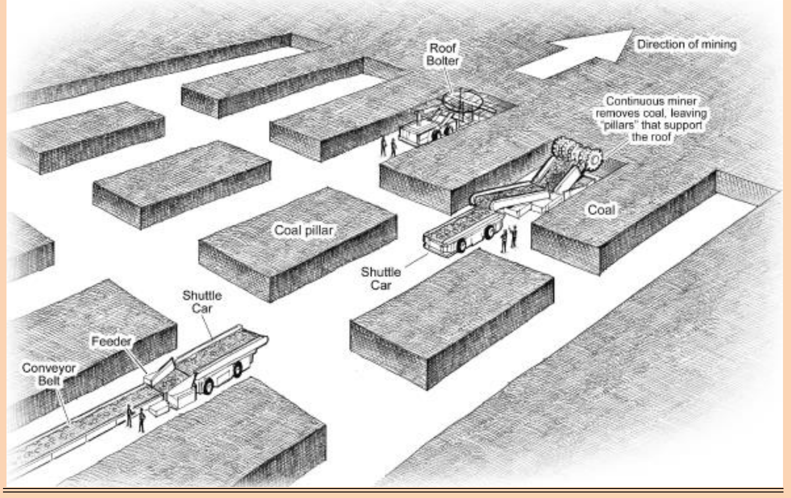
PILLARS:

Pillars of different kinds practically form a near-rigid type of supports.in some methods they form the integral part of the stope design such as board and pillar; room and pillar; stope and pillar; post and pillar, where as in other they are used to maintain the stability between the stopes.ore pillars are left either forever or for the duration of working of a given section. depending upon the purpose and arrangement, the pillars can be classified as under:

1. protective pillars

2. level pillars

3. rib/block/side pillars



GOAF:

The area remained after depillaring is termed as goaf and the shape formed along the removed pillars is termed as goaf edge.

BORD AND PILLAR MINING SYSTEM:

Bord and pillar mining methods comprises two phases that is development and depillaring. Sometimes both these processes proceeds simultaneously. in development ,pillars are formed by driving a network of galleries of which one set is generally parallel to the dip and other is parallel to the strike cutting the former at right angles.

The bord and pillar system of mining can be done in three ways.

1. Develop the entire area into pillars and then extract the pillars starting from the boundary.
2. Develop the area into panels and then extract the pillars subsequently panel wise. This is called panel system of mining
3. “whole” followed by “boken” working in which the mine is opened out by a few headings only and thereafter development and depillaring go on simultaneously starting from boundary.

LONGWALL MINING

Longwall mining is one of two basic methods of mining coal underground. The other is room-and-pillar mining, historically the standard method in the United States. Both of these methods are well suited to extracting the relatively flat coal beds. The basic principle of longwall mining is simple. A coal bed is selected and blocked out into a panel averaging nearly 800 feet in width, 7,000 feet in length, and 7 feet in height, by excavating passageways around its perimeter. A panel of this size contains more than 1 million short tons of coal, most of which is recovered. In the extraction process, numerous pillars of coal are left untouched in certain parts of the mine in order to support the overlying strata.

The mined-out area is allowed to collapse, generally causing some surface subsidence. (or coal seam).Extraction by longwall mining is an almost continuous operation involving the use of self-advancing hydraulic roof supports, a sophisticated coal-shearing machine, and an armored conveyor paralleling the coal face. Working under the movable roof supports, the shearing machine rides on the conveyor as it cuts and spills coal onto the conveyor for transport out of the mine. When the shearer has traversed the full length of the coal face, it reverses direction (without turning) and travels back along the face taking the next cut. As the shearer passes each roof support, the support is moved closer to the newly cut face. The steel canopies of the roof supports protect the workers and equipment located along the face, while the roof is allowed to collapse behind the supports as they are advanced. Extraction continues in this manner until the entire panel of coal is removed.

SPONTANEOUS HEATING

Spontaneous heating occurs when the heat produced by the low temperature reaction of coal with oxygen is not adequately dissipated by conduction or convection, resulting in a net temperature increase in the coal mass. Under conditions that favor a high heating rate, the coal attains thermal run away conditions and a fire ensues. In spontaneous heating events in underground coal mines, large coal masses may be involved. The spontaneous heating of coal in mines often occurs in a gob area and may not be easily detected. The amount of coal that accumulates in these areas and the degree of ventilation can combine to give optimum conditions for spontaneous combustion

STOPE:

Stope is an excavation from which ore has been removed in a series of steps. Usually applied to highly inclined or vertical veins. It mainly refers to the area where we plan to extract mineral. The term is same as panel in coal mining. Stoping is the removal of the wanted ore from an underground mine leaving behind an open space known as a stope. Stoping is used when the country rock is sufficiently strong not to cave into the stope, although in most cases artificial support is also provided. As mining progresses the stope is often backfilled with tailings, or when needed for strength, a mixture of tailings and cement.

RIB PILLAR:

To limit the size of a stope along its length of a continuous orebody, it needs to be separated by an ore pillar, known as rib or intervening pillar. This pillar can be blasted completely at a time by designing a heavy blast. Sometimes rib pillars of the adjacent open stopes are liquidated together. But the rib pillars of cut and fill stopes are usually mined in the similar manner as the stope has been mined i.e. by taking slice by slice of ore and filling the void by some kind of filling material. In mining, a rib pillar separates one stope from the other. It is used in mining to increase the strata stability of the stope. It is also made to support the raises, winzes or shaft of the mine. These are vertical pillars on the side of stope. Generally their length is large compared with its width.

CROWN PILLAR:

Crown pillar: In order to support the workings of the immediately upper level of a stope, the horizontal pillar left is known as crown pillar. This pillar can be blasted in stages or at a time by designing a heavy blast. Sometimes crown pillars of the adjacent stopes are liquidated together. It can also be taken together with overlying stope's sill pillar. An ore pillar at the top of an open stope left for wall support and protection from wall sloughing above. It is horizontal pillar.

RAISE:

A secondary or tertiary inclined opening, vertical or near-vertical opening driven upward from a level to connect with the level above, or to explore the ground for a limited distance above one level. It basically refers to a vertical or inclined excavation that leads from one level, or drift, to another. A raise may also extend to surface. There are four excavation methods for raises:

1. Conventional or open raise
2. Long-hole or drop raise
3. Alimak
4. Raise boring

Raises serve a number or purposes including:

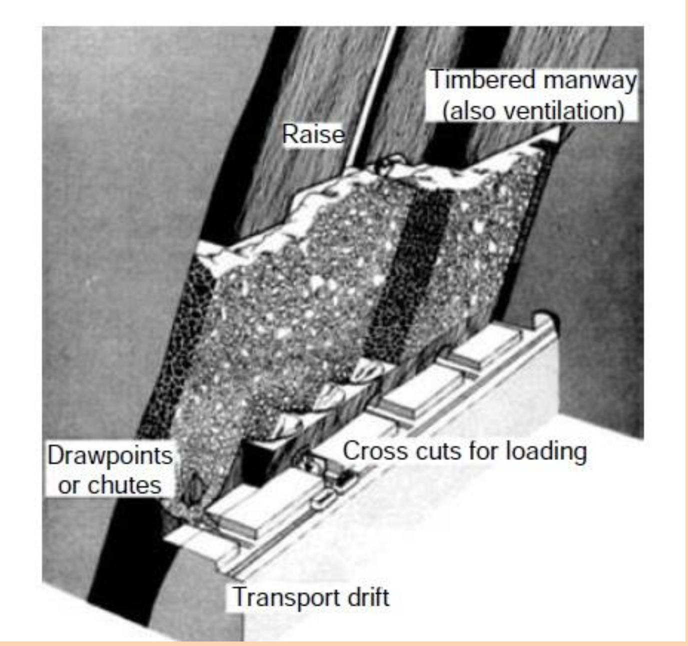
1. Transportation of ore and waste rock
2. Ventilation
3. Creating a free face for mining
4. Movement of workers via manway ladders

WINZE:

A winze is an opening in an underground mine that is sunk downward (as opposed to a raise, which is mined upward) from inside to connect lower levels. The top of a winze is located underground, in contrast to a shaft where the top of the excavation is located on surface.

CROSS CUTS:

Cross cuts are horizontal (sometimes inclined) underground mine working that has no direct outlet to the surface and is driven into the rock at an angle to the line of strike of the deposit (that is, it approaches or intersects the bed). Crosscuts are intended for stripping minerals, for transporting goods and personnel (for which rails are laid and conveyors are mounted), and for ventilation and water drainage. A drift running parallel to the ore body and lying in the footwall is called a footwall drift, and drifts driven from the footwall across the ore body are called crosscuts. In other words it is a horizontal or near horizontal underground opening driven to intersect an ore body.



ORE PASSES:

Ore passes are used to drop mined ores in to underground bins and loading points. From there the ores can be hoisted to the surface.

The ore in ore passes can be unloaded through side discharge chutes (box fronts), or underflow chutes. Essential features of Ore Passes

Although the basic principles of bulk solids flow are now well established, flow in ore passes is subject to special problems. The essential features of ore passes are as follows:

1. small diameter (typically 1.5 to 2.8 m)
2. very tall shafts (60 - 100 m)

3. large lump size (typically 1/5 of shaft diameter)
4. hopper - minimal
5. chute width - about of shaft diameter
6. sides of shaft - rigid and rough
7. water in ore pass - a constant problem
8. properties of ore vary
9. loading of the ore pass is generally not central
10. ore passes may be vertical or inclined

DRAW POINT:

In simple words draw point can be defined as the place where ore can be loaded or removed.It is located beneath the stoping area and gravity flow transfers the ore to the loading place.

LEVEL:

In simple words a level is system of horizontal underground workings connected to the shaft.it forms the basis for excavation of ore above or below.

4.0 DIFFERENT TYPES OF MINE ENTRIES

In underground mines we use several types of mine entries according to our requirement for transporting men and materials. They are generally:

- Shaft
- Adit
- Incline
- Ramp/Decline

ADIT:

If coal seam is horizontal or nearly horizontal is situated in hill or mountain, an opening known as adit can be made directly into the coal seam. It is the easiest and cheapest method to open in such a case because no excavation through rock is required. Transportation of coal to the outside may be done by belt conveyer, locomotives or by rubber-tired vehicles. If coal seam is incline than we make an adit in the rock if it is suitable and cheap.
In metalliferous mine for shallow, outcropping horizontal deposits or steeply inclined deposits located in a hill or mountain adit can be used, transportation of deposit ore can done by conveyer, truck or rail haulage. Adit access is essentially horizontal, slightly inclined

outwards to facilitate drainage and haulage. It has an advantage of eliminating the need of hoisting and head frame. As we know that ventilation is also require for working of men and machinery in adit so we make pair of adit and combination of underground mine entries for provide suitable ventilation system.

SHAFT:

For deep, horizontal, vertical or steeply inclined conditions for high production and for long life of the mining Shafts are preferred to inclined for bringing ore out of the mine. In case of coal seam depth is more than 100 m. The two vertical shafts have functions of transporting ore and mineral, water material, means for transport of miners, machinery and other material. Also arrangements are made in shaft for ventilation, drainage, power and water supply and communications (signaling). Normally production shaft is compartmented if hosting is used. Ore carriers called skips are suspended in the shaft on wire ropes and the two are operated in balance with one another (one descends when other ascends). Ropes are connected through the head-frame to the hoist on the surface. Guides are installed on the shaft to facilitate fast travel of the skip without any to and from movement in lateral directions. Persons or materials ore transported in cages that operate in another shaft. We need to sink at least two shafts from the surface to the seam for ventilation. One of these would be a main winding shaft (intake shaft) and another ventilation shaft (return air shaft). They are also known as downcast shaft and upcast shaft.

Location of shaft also very important and we consider following factor for location:-

i. Geological and topography consideration- The site should be free from geological disturbances – such as faults, dykes, washout etc and rock should be competent. There should not be high make of water and the topography should be as far as possible level.
ii. High flood level – The mouth of the shaft must be above the high flood level.
iii. Bearing strength of the ground – The ground should have adequate bearing strength so as to support the structure and buildings.
iv. Loss of coal in shaft pillars – The shaft should be so sited that may not be necessary to leave lot of coal area as shaft pillar so that it does not fall.
v. Land slide in hilly terrain – In hilly terrain there may be the real risk of land slide. This must be foreseen when locating the site of the shaft. Apart from the geological, hydrological and topographical consideration discussed earlier. The location of main, ventilating and auxiliary shaft is influenced by economic consideration and the efficiency with which auxiliary or ventilating shaft can perform in their respective location. Considering these latter aspects there could be four models.
    (i) Two shafts sunk in the centre of the property;
    (ii) The minimum distance between two shaft is more than 13.5 meter.

Advantages of vertical shaft (Compared to incline):-

a. High speed winding and hence larger capacity for the same cross section.

b. It create less resistance for ventilation and stronger and better in weaker ground.
c. Less cables, pipes etc. are required due to shorter vertical length is required.

Disadvantages:

a. Shaft – pillar is required.
b. In inclined seam, large distances of cross-cuts are required.
c. Shaft sinking requires high cost for.

INCLINE:

Incline is an underground mine entry which is used to transport men and material. An incline may follow the ore body if the ore body is itself inclined out crafts or the inclined may be driven parallel to ore body below it. Transportation of ore from an inclined mine can be by a belt conveyer (up to 180 gradient) or by an electrically driven rope haulage (up to 700) or by trolley wire locomotive if the gradient of an incline is gentle one (very mild, 1 in 25 to 1 in 100). For moderately inclined, moderate ground conditions, to low moderate production and life and shortens the horizontal cross-cuts. Hoisting is done by means of a skip by rope. Another skip is used to balance the hoisting skip and also for transportation of man and material. It is no necessary that incline is made from the outcrop or along the true dip.

RAMP/DECLINE:

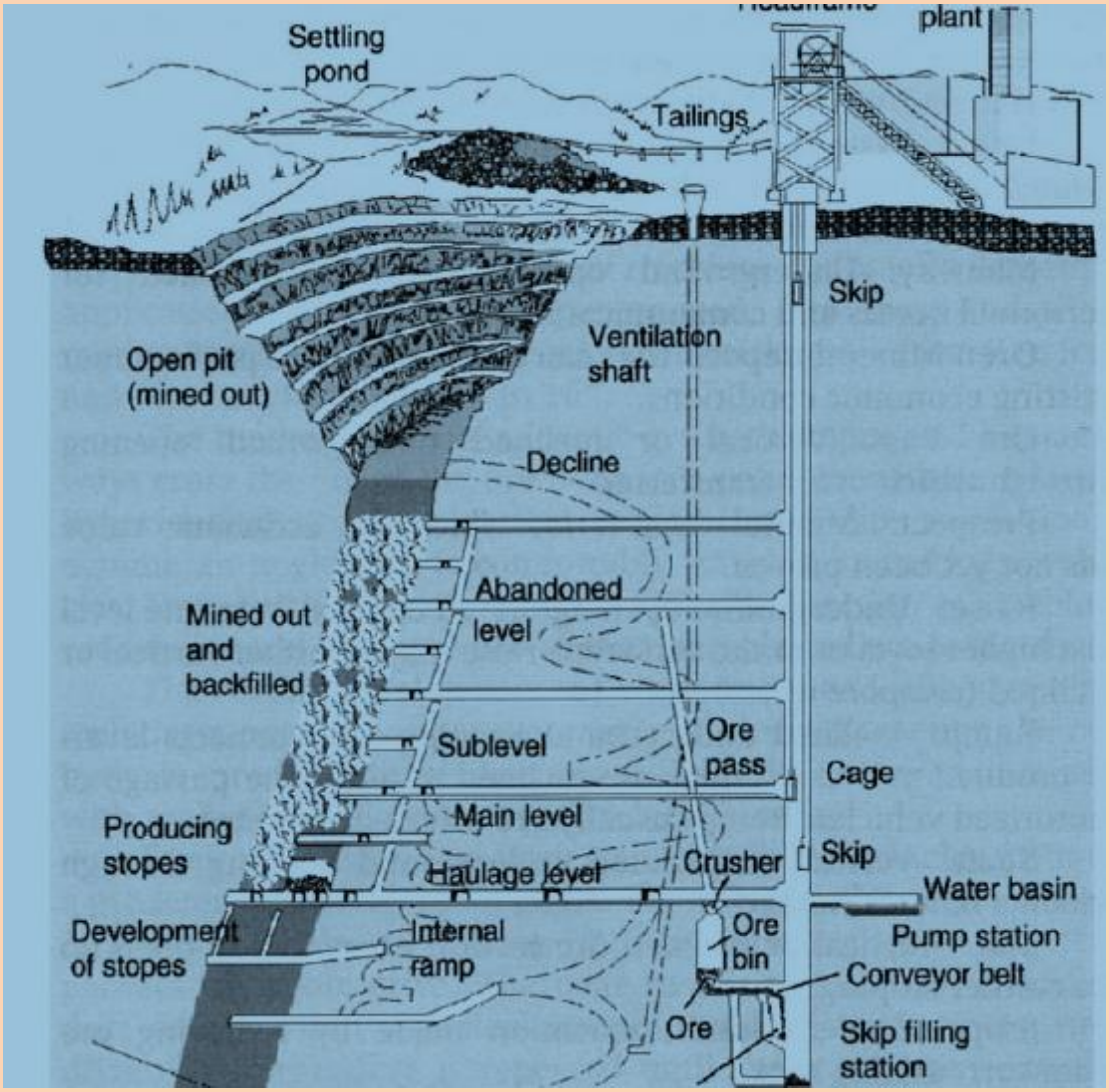
Ramp is a spiral shape opening used as underground mine entry and ore deposit is connect threw the cross cut level to the ramp. In coal mine incline are also known as secondary or tertiary inclined openings. They are driven in downward direction to connect different levels and are also used for haulage. For higher depth decline is not suitable.

ADVANTAGES OF INCLINES:

a. Cross cut lengths are short.
b. No shaft pillar is required and hence no coal is lost.
c. Cost of driving an incline is less than that of a vertical shaft, even when the dip is higher.
d. We can start production early by incline than shaft.

DISADVANTAGES:

a. Sensitive to structural disturbance specially folds.
b. Not suitable for high inclinations.



Choice of Mine Entry:

A mineral deposit which is at a shallow depth can be approached by incline or adit. An incline is a sloping road driven from the surface to the deposit through the alluvial and the rocks overlying the mineral deposit.

If a deposit is at a higher level than the general level and outcrops, the access to it is by a level or a slightly rising roadway from the ground level. This type of nearly level roadway is known as Adit.

Acess to a mineral deposit at depth is by a well, known as Shaft. If strata overlying the seam are soft, and excavation cost is not high, an incline may be driven to enter deposits upto about 30m depth.

Making an incline is cheaper and quicker than shaft sinking as it does not need skilled men, costly headgear and heavy capital cost. Inclines are safer than shafts; maintenance and repairs of inclines are easy and cheap. But an incline has the disadvantage of heavy make of water during rains due to large catchment area if the deposit is worked by quarry on the outcrop side. The choice of site of an incline is limited to the outcrop region, while a shaft may be located at any convenient place in the property.

Gestation period of a shaft is 2-3 yrs. So, if production is to be started in early phase to support the mining activities,an inclined is made.

Selecting site of an incline or shaft:

A number of factors have to be considered before selecting the site of a shaft or incline:

(1) In mountainous regions, inclines and shafts should be away from possible path of landslides.
(2) The site should be above the highest flood level of a river or pond and the slope of the highest flood level of a river or lake in the areas and the slope of the ground away from the ground to facilitate drainage and movement of mineral loaded tubs to the crusher and tippler.
(3) A shaft or incline should be situated close to efficient transport facilities like rail,road or canal.
(4) The space near the shaft should be adequate for dumping the debris during sinking for the services.
(5) The minimum distance should be 13.5m.

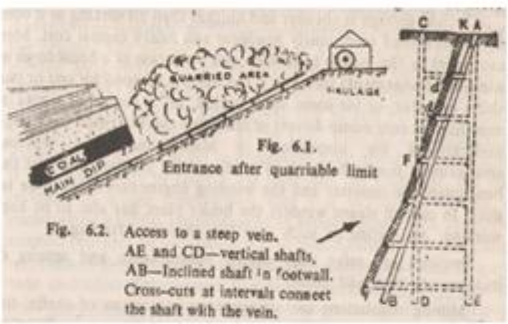


Fig. 6.1. Entrance after quarriable limit

Fig. 6.2. Access to a steep vein. AE and CD—vertical shafts, AB—Inclined shaft in footwall. Cross-cuts at intervals connect the shaft with the vein.

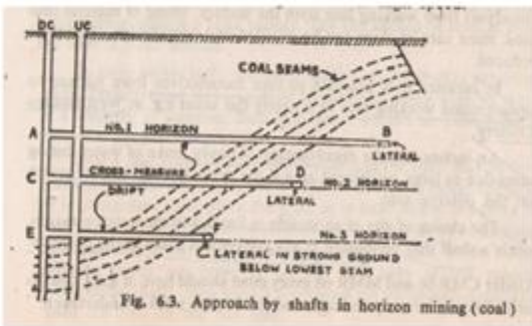


Fig. 6.3. Approach by shafts in horizon mining (coal)

Location of shaft:

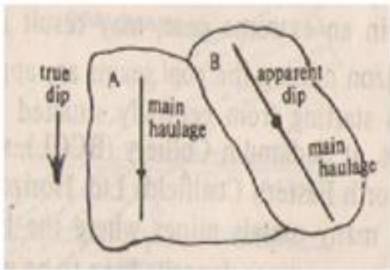
The following factors will affect the location of shafts:

a. *Geological, Hydrological and Topographical considerations:* The site should be free from geological disturbances like faults, folds; dykes etc. and the rock should be competent. There should not be high make of water and the topography should be as far as possible level.
b. *High Flood Level:* The mouth of the shaft must be above the highest flood level occurred in the area.

c. *Bearing strength of the ground:* The ground should have adequate bearing strength so as to support the structure and buildings.

d. *Loss of coal in shaft pillars:* The shaft should be so sited that it may not be necessary to leave large coal area as shaft pillar. Shafts sunk in the footwall to work the highly pitching seams do not require any coal shaft pillar.

e. *Landslides in hilly terrain:* In hilly terrain there may be the real risk of landslides. This must be foreseen when locating the site of the shaft.



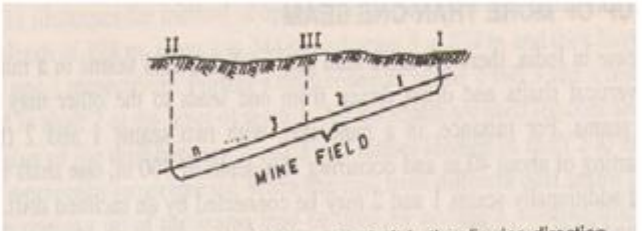


Figure 4.9 : Location of the main shaft in the dip-rise direction.

Apart from these factors, the location of main and auxiliary shafts is also influenced by economic considerations and the efficiency with which the auxiliary or ventilating shaft can perform in their respective locations.

Size of mine entries:

An incline is usually steeply dipping at 1 in4 or 1 in5.The inclines are normally made along the true dip of the deposit but it may vary according to the available leasehold area. The trend nowadays is to approach mineral upto 200.0 m vertical depths by inclines. There should be horizontal stations in between the incline for the rest of people during walking through the incline. Shafts have a finished diameter from 4.2m to 6.7m.

Under the mining Regulations each seam should have at least two outlets to surface separated by atleast 13.5m. It prevents damage of one shaft from another and also prevents short circuiting of mine air current. The shafts other than the main shaft are called auxiliary shafts. Shafts are used for deep underground mines.The deepest shaft in coal mines in our country (600m depth) is at Chinakuri Colliery.

5.0 UNIT OPERATIONS:

The unit operations are referred as the basic operations that need to be carried out to Dig out or excavate ground and dispose off the spoil so generated to a particular destination during mining, and tunneling operations. These basic operations can be grouped into two classes: dislodging rock from the rock massif or deposit which is known as *primary breaking,* and *handling of material* so generated.

Production cycle during mine development)-_ *shot hole drilling _ blasting _ mucking _ (hauling _ hoisting)*
Hauling and Hoisting are considered in transportation.

In the techniques to fragment the rock we have drilling and blasting. So let's start with the drilling-

DRILLING:

Drilling is the operation to make holes in the earth surface for various purposes.
The drilling with few exceptions such as: exploration, to provide drainage, in fixing rock Bolts, in stabilizing slopes and to test foundations, is employed in mining and tunneling for placement of explosives.

OPERATING COMPONENTS OF THE DRILLING SYSTEM:

There are four main functional components of a drilling system, working in the following manner to attack the rock.
1. *The drill*: it acts as prime mover converting the original form of energy that could be fluid, pneumatic or electric into the mechanical energy to actuate the system.
2. *The rod (or drill steel, stem or pipe)*: it transmits the energy from prime mover to the bit or applicator.
3. *The bit*: it is the applicator of energy attacking the rock mechanically to achieve penetration.
4. *The circulation fluid*: it cleans the hole, cools the bit, and at times stabilizes the hole. It supports the penetration through removal of cuttings. Air, water or sometimes mud can be used for this purpose.

Types of drilling according to the situation:

Using the drills the rock is attacked mechanically either by percussive or rotary actions. Combinations (roller bit, rotary-percussion) of these two methods are also used. The resulting action of the bit in each case is almost similar i.e. crushing and chipping; what differs mainly is that the crushing action predominates in percussion drilling and chipping action in the rotary drilling, and a hybrid action in the combination of the two systems. Based on this logic the drills are manufactured *as percussive*, *rotary-percussive* and *rotary*. Classification is as follows:

(a) Top hammer drilling
(b) Down-the-hole drilling
(c) Rotary drilling
(d) Augur drilling
(e) Rotary abrasive drilling

Classification on basis of motive power:

(a) Electric
(b) Pneumatic
(c) Hydraulic

Types of holes made during drilling:

Detaching the large rock mass from its parent deposit is known as rock breakage. Since prehistoric time man devised several ways to achieve this task and he made the greatest technological advance in mining history when eventually he discovered explosive and used it for rock breaking purposes. Application of explosive in the rock is carried out by means of drilling holes, which are known as *shot holes, blast holes or big blast holes* depending upon their length and diameter. Holes of small diameter (32–45 mm) and short length (upto 3 m) are termed as *shot holes,* and they are drilled during tunneling and drivage work in mines. The *blast holes* are longer (exceeding 3 m to 40 m or so) and larger in diameter (exceeding 45 mm to 75 mm or so), and that are drilled as cut-holes in tunnels and drives, and in the stopes. Besides their use in surface mines, recently use of very large diameter (exceeding 75 mm) long holes, known as *big blast holes*, have begun for the raising and stopping operations in underground mines too. This terminology to designate production drilling will be used throughout this book. Thus, to dislodge the rock from its rock-massif use of suitable drills, explosives and blasting techniques, is made.

Blasting:

Blasting is the unit operation, done with the help of explosives. Now why the explosives are used?

Because An explosive is a substance or mixture of substances, which with the application of a suitable stimulus, such as shock, impact, heat, friction, ignition, spark etc., undergoes an instantaneous chemical transformation into enormous volume of gases having high temperature, heat energy and pressure. This, in turn, causes disturbance in the surroundings that may be solid, liquid, gas or their combination. The disturbance in the air causes air blast and this is heard as a loud bang. The disturbance in the solid structure results in its shattering and demolition. During wartime this property is utilized for destruction purposes but the same is used for dislodging, breaking or fragmentation of the rocks for quarrying, mining, tunneling, or excavation works in our dayto-day life. The energy released by an explosive does the following operations:

- Rock fragmentation
- Rock displacement
- Seismic vibrations
- Air blast (heard as loud bang).

DETONATION AND DEFLAGRATION

As stated above that when an explosive is initiated, it undergoes chemical decomposition. This decomposition is self-propagating exothermic reaction, which is known as an explosion. The gases of this explosion with an elevated temperature are compressed at a high pressure. This sudden rise in temperature and pressure from ambient conditions results into a shock or detonation waves traveling through the unreacted explosive charge. Thus, *detonation* is the process of propagation of the shock waves through an explosive charge. The velocity of detonation is in the range of 1500 to 9000 m/sec. well above the speed of sound. *Deflagration* is the process of burning with extremely rapid rate the explosive's ingredients, but this rate or speed of burning, is well below the speed of sound.

Common ingredients of explosives

Items	Ingredients
Explosive itself	Fuels _ Oxidizers _ Sensitizers _ Energizers _ Miscellaneous Agents
Common fuels	Fuel oil, carbon, aluminum, TNT
Common oxidizers	AN, Sodium nitrate, Calcium carbonate etc
Common sensitizers	NG, TNT, Nitro-starch, aluminium etc
Common energizers	Metallic powders
Common miscellaneous agents	Water, thickeners, gelatinizers, emulsifiers, stabilizers, flame retarders etc.
Main elements of these ingredients	Oxygen, Nitrogen, Hydrogen and Carbon, plus, certain metallic elements such as: aluminum, magnesium, sodium, calcium etc.

Classification of explosives:

- Primary
- Secondary
- Pyrotechnic
- low
- commercial of high

blasting properties of explosives:

- strength
- detonation velocity
- density
- water resistant
- fume characteristics or medical aspects
- oxygen balance

- completion of reaction
- detonation pressure
- borehole pressure and critical diameter
- sensitivity
- safety in handling
- explosive cost

Mucking:

Material (rock or ore) fragmented with or without aid of explosives from a working face (which may be a tunnel, large underground chamber, open cut excavation at any working site or mines) is known as muck. The process of loading this muck into a conveyance for transportation away from the face is known as mucking.

When this muck is discharged to an adjacent area, practically without moving the mucking equipment, and simply by swinging it, the process is known as casting. Excavation is the process of digging ground from its bank face (in-situ) and elevating by an excavator to discharge it either to a haulage unit, or an adjacent area.

Thus for mucking, ground excavation and casting locales are many and so is the varied requirements in terms of output, capital available, size of excavation and few others.

Due to this reason, today, many companies are in arena to manufacture equipment of different range and specifications to suit industries' requirements.

MUCK CHARACTERISTICS

Muck characteristics such as shape, size, volume, hardness, moisture content, angle of repose, abrasiveness, dryness and stickiness are dependent on number of factors.

These characteristics influence the material handling system.

The material in its existing state remains in triaxial state of compression, but the excavation changes this triaxial to uniaxial state of stress that results in volume expansion. Bulking is measured by this percentage of volume expansion.

Stickiness is a very undesirable feature for muck removal. Loading, dumping and cleaning of sticky muck is very time consuming and expensive process. Sometimes, inert material like sand has to be added to a sticky muck to make it workable. Lump size of muck is important characteristic for transportation by conveyor, pipelines and bucket wheel elevators. Wetness and stickiness are important considerations for all mode of transportation except those by hydraulic transportation. Abrasiveness is an important consideration for pneumatic transportation.

A good mucking and transportation system must respond and confirm to the changes in muck size, shape, weight, and flow rate that might be expected during the excavation for underground structure.

CLASSIFICATION

Based on the locale of their applications, mucking equipment can be classified into following two classes:
1. Underground Mucking Units
2. Surface – Excavation, Loading and Casting Units

UNDERGROUND MUCKING UNITS

For mucking from the underground openings including tunnels several types of equipment are available. Some of the prominent sets of equipment are described below:
● Overshot loaders – Rocker shovel
● Autoloaders – Hopper loaders and LHDs
● Arm loaders
● Scrapers
● Dipper shovels and hydraulic excavators (shovels)

AUTOLOADERS – HOPPER LOADERS AND LHDs

These are mucking and transporting machines under which following two types of loaders are available:
1. Mucking and delivering.
2. Mucking and transporting.

ARM LOADERS

- GATHERING-ARM-LOADER (GAL)
- ARM LOADERS FOR SINKING OPERATIONS
- Riddle mucker
- CRYDERMAN MUCKER
- CACTUS-GRAB MUCKERS
- BACKHOE MUCKER

SCRAPERS

A scraper unit consists of a scraper, a wire rope for filling, a wire rope for pulling, a return sheave, a driving winch, a loading slide and power unit. The power unit has motors, coupling, gear systems etc. There are mainly two type of scrapers: Box and Hoe. Box type of scraper is employed for small size rocks of low specific gravity. Its capacity is in the range of 0.3–0.35m3. Hoe-type scraper finds application in loading large size muck of higher specific gravity.

WHEEL LOADERS – FRONT END LOADERS

These wheel loaders are similar to LHDs, described in the preceding sections. The difference between them lies due to the fact that FELs are longer in length, taller in height and narrower in width than LHDs. This feature makes them suitable for their use at surface where working space is unconfined and ample. They differ from dipper shovels, which have dipper in place of bucket to carry the load. A shovel can revolve to discharge contents of its dipper, whereas, a FEL has to travel to discharge its bucket to a muck pile

or haulage unit.
BACKHOE
These loaders find their use where it is expedient to keep the loader at the original ground surface (level) and excavate the ground from the subsurface below this level. The situations of this kind are the trenching, canal excavations and building foundation works. These are available with wheel as well as crawler mountings. The later is for the large sized units of more than 1.5m3 bucket capacity from the stability point of view. The muck can be loaded into a haulage unit or it can be cast at the sides of the excavation. Thus, it can be used as a loading as well as casting machine.

HYDRAULIC EXCAVATORS
Use of this machine gained popularity during 1970s. This is also known as hydraulic shovel. It differs6 from Front End Loader with respect to mounting (crawler in place of tyres), greater digging force and less fuel cost/unit loading and more rugged structure of the main components. As compared to dipper shovel it has greater mobility, higher travel speed, higher cutting force and improved steerability. Hydraulic pumps and motors play an important role in the functioning of this unit. This unit can be diesel or electrically (a.c) driven. Thus, its application lies at all those locales where FEL or dipper shovel can be deployed, both at the surface as well as underground.

SHOVEL
This is one of the most important excavators that is available today. It is available with very small to very large capacity buckets which are capable of excavating any type of muck or ground. This unit is known as face, crowd or dipper shovel. The one which is of large bucket capacity (usually more than 5 yd3) is known as strip shovel. It is used for casting the ground in the adjacent area within its reach. This feature find its application in opencast mines, where it strips the ore deposit (coal or any other mineral) by removing the over burden and casting or back filling it in the worked out space i.e. the place where from the ore (useful mineral) has been removed. Cycle time of strip shovel is shorter than a face shovel.

DRAGLINE
Dragline stands on the bench, which is to be dug. First, the load line (drag rope) is slackened, the bucket is lowered to the floor of the face (bench) and then pulled by the drag rope towards the equipment (dragline itself). During pulling it is filled by digging a strip of about 80–500 mm deep. This process is repeated 2–4 times, depending upon the type of material (ground). By keeping the load-line taut, the bucket is pulled by the hoist line (5), at the same time stabilizing by the dumping line or rope (8). The hoisting rope gradually raises the bucket and the drag rope is slowly slackened.

Transporting At any mine, tunnel, or civil construction site once the rock has been dislodged from its original place, it need to be removed immediately to its final destination at the surface
which could be a waste rock muck pile or ore’s stock pile to feed to the processing plant, or final dispatch destination point which is the users. From the working face

of the excavation site which carries it through horizontal, inclined, vertical, or combination of both horizontal and vertical routes, to the discharge point. Movement of the muck through a horizontal or inclined path is known as haulage, and through the steeply inclined to vertical path (up or down) as hoisting.

HAULAGE SYSTEM

This can be described under two headings – track and trackless. Track haulage includes rope and locomotive haulage, which run on rail or track. Trackless system includes automobile, conveyors and transportation through pipes.

Types of haulage system:

- Main rope
- Direct rope
- Endless rope haulage
- Gravity
- Main and tail
- Locomotive haulage :
  (a) electric
  (b) battery
  (c) combination
  (d) diesel
  (e) compressed air
  (f) other fitting

TRACKLESS OR TYRED HAULAGE SYSTEM:

- Automobiles
- LHD
- Shuttle cars
- Underground trucks

CONVEYOR SYSTEM:

1. Belt conveyor
2. CABLE BELT CONVEYORS
3. SCRAPER CHAIN CONVEYORS

HOISTING OR WINDING SYSTEM:

Hoisting or winding operation is carried out in the vertical or the inclined shafts in the mines. Thus, it establishes a link between the surface and underground horizons, and used to transport man, material, equipment, ore, and waste rocks. Practically this is a lifeline for the miners. Also the shaft, hoist and the fittings, when combined together, constitutes the major capital expenditure of the total investment made for a mine. Earlier the hoist engine used to be steam driven but now it is obsolete and only the electrically driven hoists are operating. These are basically of two types: Drum and Koepe (friction).

In order to make these systems operational, the shaft need to be designed, driven (excavated, sink) and equipped accordingly.

- HEAD-FRAME OR HEAD-GEAR
- SHAFT CONVEYANCES
- ROPE EQUIPMENT14

AERIAL ROPEWAY:

● Mono-cable
● Bi-cable
● Mono-cable – In this system an endless rope is used. The rope used is so strong that it can carry the loaded and empty buckets/cars when it moves. The cars are attached to the ropeway by means of brackets that could be attached or detached when needed. When the cars are detached from the rope they travel on the rails at the terminal stations. These cars are provided with wheels that run on the rails at the loading, unloading and intermediate stations when cars detached from the continuously running haulage rope.
● Bi-cable – aerial rope way : In this system the cars or buckets under circulation travel on a fixed rope of large diameter called tack rope, and these are hauled by a continuously running low diameter rope called traction rope. The cars are attached to the traction rope by means of a lock or grip. One-track rope is laid each side i.e. one on return side and one on the loaded side, but the traction rope is endless that runs continuously.

TRACK AND MINE CAR.

DRILLING MACHINE
(JUMBO DRILL &COAL DRILL)
The development mine entries such as levels, drifts, cross-cuts and sublevels; and civil tunnels may have varying cross sectional areas and gradient, and to suit these varying conditions different types of drill jumbos have been developed. For example, a jumbo of about 2.1 m width is used in the mines with narrow drifts, tight turns and frequent crosscuts. This type of jumbo is commonly known as Mini-bore jumbo.
A jumbo5 with 2.0 m overall width is used for sublevel driving but it is capable to drill the faces as large as 9 m wide _ 4.5 m high.5
A jumbo having 2.4 m overall width is most common for its use in hard rock mining. It can also be used for rock bolting, room and pillar stoping operations. This jumbo can be used for drifts and tunnels' configuration in the range of 3.7m _ 3m to 9.8m _ 6.7 m.
A typical jumbo, includes an energy system, operator's station, chassis and boom equipped with a drifter or drill. Conceptual diagrams of hydraulic drifters have been

- Lack of specified manpower

- Lack of tools(sockets, rachet, extension rod, thread taps, hand drill, hand grinder, etc.)
- Lack of spares
- Lack of trailing cable
- 

Specifications

Hydraulic Drilling Jumbo:
1. kind of hydraulic cralwer drill machine;
2. Efficient and energy-saving;
3. Long service life...

SHAFT JUMBOS

It is a compact unit designed to suit the narrow space available during shaft sinking operations. This jumbo is usually consists of a column with a horizontal top platform to which the drill booms are attached. The vertical column acts as the air header and the top platform serve as storage space for the hydraulic power unit.

shaft drill jumbo be used to make well,pile foundation work of bridge,air condition well, the shaft drill jumbo is convenient
1,rotate speed :30r/m

2,promoting weight:5tonne

3,the highness:8meters

4,rod:89x8mm steel pipe

5,power:22horsepower(hp)

RING DRILLING JUMBOS

To achieve longhole drilling with maximum speed, accuracy and safety at low cost there has been consistent improvement in the design of ring drills. Earlier column and bar mounted ring drills have been replaced by single ring drill or the double (twin) drill ring jumbos either skid or pneumatic-tyred under carriages. The feed mechanism is either screw, chain or cable type. The mechanism for rotation is usually independent from the one governing the percussion, so that feed can be regulated depending upon the rock conditions. The controls are separated from the machine and can be placed

1. remotely. The ring drilling work consists of drilling the blastholes radially from a drill drive keeping the drill at a fixed position in a plane that may be vertical, horizontal or inclined.

FAN DRILLING JUMBOS

In sublevel caving the drilling work is considerably high and this calls deployment of highly productive drills. One to three boom jumbos are available for this purpose. A fan shaped drill hole pattern is drilled using these jumbos.

WAGON DRILL JUMBOS

The main consideration in cut and fill stoping operations while selecting drilling equipment is the firmness of the fill, width and height of the working area of the stope. The pneumatic tyred three wheels, or four-wheel chassis carriers are used to mount the drills for this purpose. Air motors propel these carriers. Such drills are known as wagon drills.

DTH DRILL JUMBOS

Besides their use as non-blasting holes the principal application
of these drills is in the primary blasthole drilling. Prior to the advent of these drills, extensive development work was required in the stopes before the production drilling could be started. Sublevels were required to have the access to the fan or ring drills to the stopes; which in turn amounts more development work. To utilize a DTH drill only top heading and draw points are necessary.
Various configurations of DTH drills are available. The basic energy source for this drill is compressed air but other functions are powered either by the compressed air or by air powered hydraulic power pack. The pneumatic rigs utilize several basic air motors and conventional feed systems and they are more familiar. The hydraulic systems are better with respect to the speed, force and accuracy, and becoming common for underground applications. The DTH drills are mounted either on crawler track or rubber tyre vehicle and the tramming power is provided either by the DRILLING
ROOF BOLTING JUMBOS

These jumbos are meant for roof bolting. In some designs of multi boom jumbos one or two booms are exclusively meant for rock bolting so that along with the face drilling rock bolting of the immediate roof can be undertaken.

MOTIVE POWER OF ROCK DRILLS

In addition to the above-mentioned basis, there are several other ways to classify the rock drills. Depending upon the motive power they can be classified as pneumatic, electrical and hydraulic rock drills, as illustrated in figure
ELECTRIC DRILLS
These are used for the rotary drilling of the shot holes These can be hand and coloum mounted.
Handhold drills are suitable for drilling in soft rocks having
weight: 15–25 kg; motor rating 1–1.5 kw; and rotation speed 300–900 rpm. Column mounted drills can be used for the blast-hole drilling and for the core drilling, e.g. diamond drills for exploration and prospecting purposes.

COAL DRILLING :

Hydraulic, hand-operated for production and utility work. The Irwin Hand-Held Coal Drill makes quick work of shot holes. It gives you dependable, fast drilling with complete operational safety—no spark, no kick. And it's simply designed with a minimum o The following equipment is all that's required for application to most hydraulic machines.

- One CDB-978 diversion valve
- One HDI-81 relief valve
- One #8858 pressure gauge
- One A-HDI-88 junction block
- Two HDI-83 drill hoses
- One HDI-91 auger drive socket, twisted shank (recommended)
- One HDI-92 chuck adapter for standard chucks (available)

f parts to reduce maintenance costs.

Description

The RANA CD/2 Electric Drill Machine is a powerful flameproof hand held drilling machine used worldwide for short hole drilling applications. Fully supported by fast response repairs and spares service. The RANA Electric Drill forms part of a range of hydraulic, electric and compressed air drilling products.

Advantages of the Coal Drill

- Hand held rotary drill
- Constant high torque over wide speed range
- Flameproof
- Rugged design
- Reliable/low maintenance
- Lightweight
- Low noise output
- Provides immediate support

TECHNICAL SPECIFICATIONS

Model	RANA CD2 Flameproof Electric Drill Machine
ELECTRICALS	125V, 50Hz, 3 Phase
POWER	1.1 KW/1.5HP
CHUCK FREE SPEED	NORMAL GEAR BOX – 450 – 500 rpm SLOW SPEED GEAR BOX – 300 rpm
SUPPLY VOLTAGE	110/125 VOLTS,3 Phase AC Supply
SYNCHRONOUS SPEED OF MOTOR	3000 rpm
WEIGHT	22 Kg (100% steel fabricated)
TORQUE	68 Nm
DRILL	

Haulage And Hoisting

Movement of the muck through a horizontal or inclined path is known as a haulage whereas if through a steeply inclined or vertical path,it is known as hoisting.

The Haulage system can be described under two headings:

- Track – includes rope and locomotive haulage.
- Trackless- automobiles, conveyors and transportation through pipes.

1. Main Haulage Locomotives.

Locomotives of this type are the heaviest of those used anywhere in the mine. The type of work they perform requires high traction effort and a speed rating of six to eight miles per hour. Such locomotives range in size from 6 to 8 tons minimum to 25 tons maximum. The majority of the locomotives are of the electrically driven type receiving their power from an overhead trolley wire carrying either 250 or 500 volts DC. These locomotives have two sets of driving wheels, with each set driven through gearing by a motor. Locomotive size will be determined by haulage problems in the mine. This can be a number of things not limited to: rail size and weight, radius of rail curvature, road bed conditions, physical size of the tunnel, haulage distance, power requirements and so on. A few locomotives are of the storage battery type. Storage battery main haulage locomotives are designed primarily for operation in gassy mines where conditions are so hazardous that even trolley wire on a main haulage way must be excluded as a possible source for ignition. Their design differs from electric type locomotives in that the battery carried with the chassis gives a weight greatly in excess of that possible with electric type locomotives with the same drawbar pull. Use of this type of locomotive requires small trains and numerous trips, but work performance when this is done compares favourably with that of electric locomotives of higher drawbar pull. Where graded favor loads the great weight of these locomotives allows them to haul and keep under control trips equal in size to those which would be handled by electric locomotives. Storage battery haulage locomotives have a speed rating of six miles per hour and battery voltage ranges from 80 to 250 volts.

2.Rope or Track Mounted haulage:

Table 7.1 Comparison of Rope haulage system.

Parameters	Rope haulage Direct	Endless	Main & tail
System	Loaded tubs are hauled up the gradient using power, whereas empty tubs are hauled down the gradient using gravity. Bad track may cause derailment.	System consists of an endless rope running on two tracks. On one side of rope loaded mine cars and on the other empty cars run. Rope moves with a speed of 0.4 to 1 m/sec in one direction only. Rope tensioning devices required.	System consists of double drums for two ropes (which may be of different dia.); one is attached at the leading end of a train of cars and the other at its tail end. The train runs on a single track and loaded cars are hauled up the gradient.
Haulage roads required	Uniformly graded (not below 5–6°), straight single tracked road.	Straight roads laid with double track. Gradient below 1 in 10.	Roads may be undulating single tracked.
Applications, output & mode	For low output in u/g mines usually at the development districts. Batch system.	Low but continuous output, installed at the main haulage levels in u/g mines.	Low output from the main haulage roads those are undulating and rough in u/g mines.

Skip:

A skip is a large open-topped container designed for loading .

Hoist (mining)

In underground mining a hoist or winder is used to raise and lower conveyances within the mine shaft.There are three principal types of hoists used in mining applications:

Drum hoist:

When using a drum hoist the hoisting cable is wound around the drum when the conveyance is lifted. Single-drum hoists can be used in smaller applications; however double-drum hoists easily allow the hoisting of two conveyances in balance (i.e. one skip being lifted while a second skip is being lowered).Drum hoists are mounted on concrete within a hoistroom, the hoisting ropes run from the drum, up to the top of the headframe, over a sheave wheel and down where they connect to the conveyance (cage or skip).

Advantages:

- require less routine maintenance than a friction hoist
- can continue to operate if the shaft bottom gets flooded
- less shaft depth is required below the loading pocket
- because drum hoists do not have tail ropes, the hoisting system is more suited to slinging beneath a conveyance.

Disadvantage:

- take up more space than a friction hoist
- require rapid fluctuations in power demand.

Friction hoist:

Friction hoists are mounted on the ground above the mine shaft, or at the top of the headframe. Friction hoists utilize tail ropes and counterweights and do not have the haulage rope fixed to the wheel, but instead passed around it. The tailropes and weights offset the need for the motor to overcome the weight of the conveyance and hoisting rope, thereby reducing the required horsepower of the hoisting motor by up to 30%, with the overall power consumption remaining the same. Friction hoists, unlike drum hoists, can and normally do use multiple ropes giving them a larger payload capacity, however since they require a larger safety factor, they are impractical for very deep shafts.

Advantages:

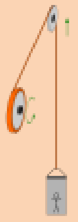
- are less expensive than new drum hoists
- the lead time for delivery may be shorter
- Multi-rope friction hoists have a larger lift capacity than a drum hoist
- A friction hoist is smaller in diameter than a drum hoist for the same service, making it easier to ship and install than a drum hoist.

Disadvantage:

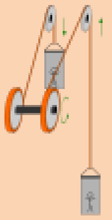
- Balanced friction hoists are not suitable for hoisting from multiple loading pockets on different horizons within a shaft, and are generally not suitable for deep shafts.
- Friction hoists cannot operate at normal speeds if the shaft bottom is flooded and water reaches the tail ropes.

Blair Multi-rope Hoist:

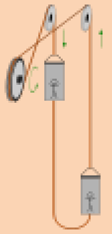
The Blair multi-rope hoist is a variation of the double-drum hoist. It is used in extremely deep shafts as the second drums cable are used to balance the primary load.



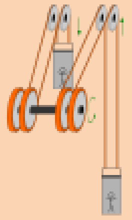
Single-drum hoist



Double-drum hoist



Friction (Koepe) hoist



Blair-multi rope hoist

Belt Conveyor:

Widely used amongst the conveyor system of haulage are the belt conveyors which have their applications both for surface as well as underground mines.Belt conveyor is basically an endless strap stretched between two drums.The belt carries the material and transmits the pull.

A belt conveyor system essentially consists of steel structure all along its length.To this structure,carrying idlers which can be from 2-5 can be mounted.The spacing betweencarrying idlers varies from 1.2 to 2.1 m and from 2.4 to 6.1 for return idlers. In order to achieve a trough shape to accommodate more and more fragmented or loose material,the carrying idlers mounted on the side are fixed at 20˚-30˚ to the horizontal. A driving unit installed at its one of ends having a motors,gears,driving drums and other fittings to start,stop or run the belt.At the other end a take pulley is fitted to provide necessary tension to the system. At the discharge end a belt cleaner cleans any adhered material.

The belt conveyors can be classified as stationary,mobile or portable based on their mobility from one olace to another. As per their path ,they can be classified as horizontal, inclined or their combnation.

The belt consists of plies that are made of rough woven cotton fabrics. The process of vulcanization using natural and synthetic rubber bonds them.Sometimes plies are made of extra strong synthetic fiber like capron,parlon,nylon,etc.The rubber protects the belt from moisture, mechanical damage, and abrasive and impact action of material.

Cable belt Conveyors:

In this type of conveyor system the belt is relieved from the tractive force and it is transferred to the ropes, which are attached at both sides of the belt all along its length.The belt conveyor needs to carry and bear load of the material that is to be conveyed.

Chain Conveyor:

- These types of conveyors have been designed to withstand rigorous mining conditions particularly at a working face,which is always advanced ahead.
- These conveyors can negotiate gradient of more than 18˚ i.e. more than the belt conveyors usually negotiate.
- These conveyors are easily extendible without their dismantling but their length is limited and usually not more than 200 m.

A scaper chain conveyor consists of the following parts: Troughs; Endless chains(may be 1 or depending on design); sprocket wheel ; Drive head having motors , gears , tensioning devices and other parts.

<u>Classification:</u>

Mainly there are two types scaper chain conveyors:

- ✓ Conveyors that are conveying material only, these are usually the conventional chain conveyors. These conveyors are either rigid, which means they need to be dismantled before their advance;else they could be of snaking or flexible types which can be shifted without dismantling.
- ✓ Conveyors that are conveying material plus cutter loaders; the armoured chain conveyor falls under this category. They are also used along with coal ploughs .These conveyors form the part of self-advancing type of supports and the mechanism that is used on longwall faces. These conveyors are usually having two chains.

The main features of these conveyors include:

- Large weight, longer length in the range of 120-150 m;
- High capacity and power
- Installed adjacent to face and pushed forward without dismantling
- Capacity could be up to more than 200 tons/hr.

Chains are the important part of the scraper chain conveyors.Chains should be of high breaking strength and longer life. Also their design should be such that the damaged links can be easily replaced.Following type of Chain designs are in use:

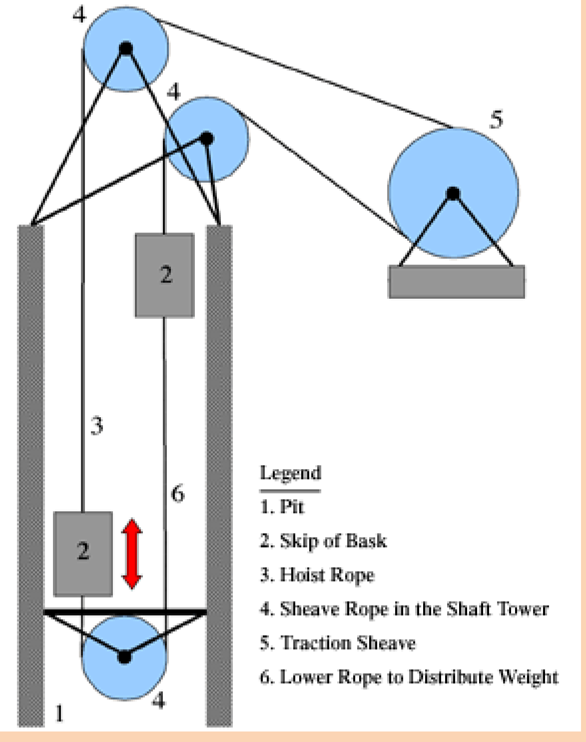
- Simple flat link and pin type
- Detachable chains with punched links.
- Modern conveyors are having round steel link chains

These conveyors can be pushed forward by one of the following devices:

- Hand operated jacks
- Compressed air or hydraulic cylinders
- Using a steel wedge
- Special advancing devices, which are pulled along the face by winches.

Belt Conveyors


Chain Conveyors



Hoisting system

Transportation

Mining operations employ 4 major auxiliary operations completing the production cycle, namely, Drilling and Blasting, Roof Support, Mucking and, Transportation.

Mucking and Transportation can be mechanized by using side dump loaders, gathering arm loaders, load haul dump vehicles, Low profile dumping trucks.

1. *Side dump loaders (SDLs) :* SDLs are small in dimensions and work at gradients upto 14° (i.e. 1 in 4).
   The minidev 600/90 side dump loader has a bucket of 600 litre capacity and is operated by a 30 KW motor. It is indented for application in underground mines and tunnels where the space is rather restricted.
   The tracks are independently powered by a hydraulic axial piston motor through the medium of an epicyclic gearbox which also incorporates an automatic disc brake and this is of particular advantage in gradient operation. The loader can be employed o gradients rising or dipping up to 18° (1 in 3).
   The machine s totally flame proof and is fitted with powerful flood lights both in the front and in the rear. And gives a break out force of 2,730 kg at the tip of the bucket. The machine travels at a speed of 2.7 km per hour

2. *Load haul dump vehicles (LHD):* LHD are the autoloaders used for both mucking and transportation. They don't offer top travel speeds but have greater bucket capacity, and better emission exhaust characteristics.

   constructional detail:

   - Its *lower, longer, and narrower profile* makes it particularly adaptable to development drifts where width is important and in flat-bedded deposits where the height is vital.
   - Its *greater size* reduces maneuverability but it improves axle weight distribution and allows an increase in bucket size.
   - It has *heavy planetary axles* and a *four wheel drive*. The *central articulation* provides perfect tracking and greater maneuverability.
   - Powered by diesel engines of power 78 hp, for small models, to 145 hp or more. These engines are either air or water-cooled.
   - Service, Emergency and parking brakes with fire resistant hydraulic fluids are common in LHD units.

   Special provisions:

   - Diesel exhaust treatment device

- Automatic shutoff fuel device

Specifications:

- *Bucket dimension*- LHDs are available in buckets of various sizes(or payload) ranging from 0. To 10 m^3 with a payload of 1.5 to 17 tons, but the general trend is for 1.53 m^3 and 3.83 m^3 LHDs.
- *Tyres*- Treaded or smooth tyres, with or without chains, having an average life of 750 to 1000 hours are fitted to LHD units. Retreading can be done more than eight times.
- *Operating gradient*- It is defined as the maximum gradient at which loaded LHDs operate. Flat surface should be used so as to improve machine's life and operating cost, but these are usually operated at 10-20% gradient.

Advantages:

- *Higher productivity*- Due to better availability, better utilization point and requirement of less man power to handle large tonnage.
- *Flexibility*- These equipment can be used for any kind of operation may be in the development of small tunnels, large excavations including chambers, stopes and cavens.
- *High productivity*- Due to the availability of high capacity loading and hauling units and their flexibility in operation, large output from concentrated areas can be achieved.

3. *Low profile dumping truck (LPDT):* Low profile dumping trucks are the ones whose content can be emptied without handling, and the front end of the platform can be pneumatically raised so that the load is discharged by gravity.

   These are widely used for making an ease in transportation of the muck to the belt conveyors. Because of the large size the material can be easily transported, saving huge time and labour.

Fig 1. Side dump loader

Fig 2. Dumping of the muck through SDL.

Fig 3. Load haul and dump vehicles employed in underground mining.

Fig 4. Low profile dumping trucks

SHUTTLE CAR

A shuttle car is essentially an automobile, rubber-wheeled, single-pan chain conveyor. The discharge end has an adjustable hinged-boom for a convenient discharge into the belt conveyer (or mine car). However, the receiving end is not hinged, and it is of same breath as the central section. Capacity of the car is 5-10 t, which can be increased by fitting the side-boards. For the given conditions, largest capacity cars should be used.

As the coal at the face is loaded at the receiving end of the car, the chain conveyer runs immediately at a low speed, until the pan (body) is full. The car is then driven off at a low speed of min 1.5-1.9ms^{-1} (depending on the floor conditions and clearance) to the dumping point – where, the chain conveyer (of the car) is run at a controlled speed, to discharge its contents over the elevated boom. Then, the driver reverses his seating position, and drives the car back to the face. Tramming distance should not exceed 150m. It should, preferably, be kept within 120m, to reduce the waiting time of the loader.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Mine Car

Size:

The size of mine cars may be determined by the physical conditions of the mine. Low-coal seams demand low height cars. Poor roof requiring timbering close to the track will often limit the width of the cars. The radius of the smallest curve will limit the length of the car. In low-coal mines, large capacity is obtained by increasing the length and width to counteract the low height. Also by using special designs, which permit low car bottoms. By the use of side and end boards, the miner can remove these boards to shovel coal from the end or side without interference. After which the boards are raised and a topping is placed on the cars. In mines where the physical conditions do not limit the car size, this is usually determined by the cars use. Anthracite mines employing loading chutes from breasts use high, large capacity cars. Mechanical loading demands the largest possible car consistent with haulage and loading conditions so as to reduce the number of car changes and time delay. When the car must be designed for the colliery, shaft size may limit the car length and width.

Wood or Steel

Mine car bodies may be built of Wood or steel, or may be a combination of both. All steel cars cost from 50 to 100 percent more to build than wooden cars but their longer life quite often offsets this initial disadvantage. Maintenance costs are estimated at one fourth of wooden cars. Also, for the same outside dimensions the steel car gives 10 to 20 percent more inside capacity. Steel cars have greater durability and can withstand shock that would crush wooden cars.

Wheels and Bearings

Wheel material may be either cast iron or cast steel. Cast iron wheels have a hard flange and tread that discourages turning on a lathe, so the wheels are used until a groove is worn in the tread and then discarded. Wheels of cast steel do not break as easy as cast iron and are one-third lighter in weight but wear more readily. They can be machined when they become grooved and this increases their service life. Manganese steel wheels are hard and tough and will out wear many other types. They cannot be turned on a lathe however, and do not have the scrap value of cast iron or cast steel. Wheel size has a bearing on car height. In low-coal mines, small diameter wheels are necessary. In high coal mines, the common diameter is 14 to 18 inches. Large wheels have considerably less friction on the track than smaller wheels and are preferable. Less friction means less wear for the same distance travelled and this means a longer life for the larger diameter wheel. On the other hand, the larger wheel adds more weight to the car, and gives additional height to the car without giving it additional capacity.

Body Designs:

The end gate style of body design consists of a car with a gate hinged on a bar at one end of the car and with means of securing it in place. This type of car requires end tilting to be dumped and may be built either of wood or steel and is the most common in the anthracite field. The gate end is not as strong as the tight end and the sides will tend to spread open after time permitting spillage of fine coal onto the roadbed when the car is in motion. The coal might become crushed under the car wheels and increase wheel friction as well as contribute to the coal-dust hazard. Tight end cars have no gate but are tight on both ends, requiring a rotating car dump, which will turn the car upside down to remove the coal. Their construction is more substantial than the gate end car of the same size and material. They do not “leak” fine coal to any extent unless car maintenance is poor and allows cracks to appear in the bottom and sides of the car. They are likewise constructed either of wood or steel.

DRILLING PATTERNS FOR BLASTING

Drilling pattern, also called shot hole patterns, are named after the type of cut holes used and the principle pattern. Various drilling patterns have been developed for blasting solid rock faces, such as:

i. Wedge cut or V cut

ii. Pyramid or diamond cut

iii. Drag cut

iv. Fan cut

v. Burn

Here we discuss only about wedge, pyramid and drag cut.

-
- Wedge cut:-

Wedge cut takes the form illustrated in fig. 1 in which two or four pairs are drilled to form a wedge, each pair starting from two sides of the drift centre and inclined at an angle less than 45° towards the centre almost meeting at the back of the cut along a line.

It is also named as V cut. In this type of drilling pattern, blast hole are drilled at an angle to the face in a uniform wedge formation so that the axis of symmetry is at the centre line of the face.

The cut displaces a wedge of rock out of the face in the initial blast and this wedge is widened to the full width of the drift in subsequent blasts, each blast being fired with detonators of suitable delay time.

The apex angle is as near as possible to 60°.

This type of cut is particularly suited to large size drifts, which have well laminated or fissured rocks. Hole placement should be carefully preplanned and the alignment of each hole should be accurately drilled.

- Pyramid or diamond cut:-

The pyramid or diamond cut is a variation of the wedge cut where the blast holes for the initial cavity may have a line of symmetry along horizontal axis as well as the vertical axis.

Pyramid cut consists in drilling holes (in the centre of the drift axis) at corners of square, 0.7 to 1m sides, almost to meet at a point at the back of the round. In a modified design known as cone cut, illustrated in fig.2, holes are drilled forming corner of a polygon with a centre holes, all nearly meeting at a point at the back of a cut. The depth of a pyramid cut is generally restricted to 50% to 60% of the width of the width of the drift.

- Drag cut:-

The drag cut is particularly suitable in small sectional drifts where a pull of up to 1 m is very useful. Drag cut used for small drifts, 1.8 to 2.4m wide, consists in drilling holes at an angle to the cleavage so that strata break along the cleavage planes (fig. 3). This pattern, being dependent on the direction of cleavage planes, calls for frequent changes, which are detrimental to systematic work and the pattern is, therefore, not favoured for large excavations.

Sequence of detonation

For both fragmentation and throw, blasting efficiency depends on the delay sequence of blast hole detonation. Delayed detonation improves load ability of the entire cut, contributes to a better strata control and reduction of blast-induced vibrations.

It is often desirable or necessary to have a series of changes firing at intervals. This can be achieved by either using delay detonators. If fired electrically or plastic igniter chord is fired with safely fuse. The choice between the long delay and short delay detonators depend upon the profile of the rock pile desired. Where shovel loaders are used long delay firing is preferable since the rock pile lies close to the face, whereas short delay firing which gives a flatter rock pile profile is preferred if loading is done by a scrapper loader. Generally special gelatins are best suited for this work, Consumption of special gelatins varies between 0.7 to 2.5 kg/m^3 of rock broken, depending on the nature of the rock and size of the excavation.

If charges are fired electrically, great care must be taken in wiring the circuit. Since more than 100 detonators can be involved in each blast, they are connected either in parallel or in series-parallel.

It is therefore, important to ensure that the resistance of the circuit is properly balanced and that no charged hole is omitted from the circuit.

Due to higher risk of such errors in the generally unfavourable shaft sinking environment, Nonel type detonators are increasingly preferred for initiation.

Drilling pattern used for blasting in coal under-ground mine.

When a coal seam is blasted using cut to provide a free face before blasting or a cut face. The depth of the hole should be 15 cm less than the depth of the cut. If however the shot holes are too short compared to the cut, it will be found that the coal at the back is not properly broken and secondary blasting may be necessary.

A typical round of hole is used in blasting and undercut face is shown in the figure. The depth of holes equal to 1.5 m and no. of holes 8 and charge per hole equals 200 gm.

Total yield of coal = 14 tonnes.

Yield per kg = 8.75 tonnes.

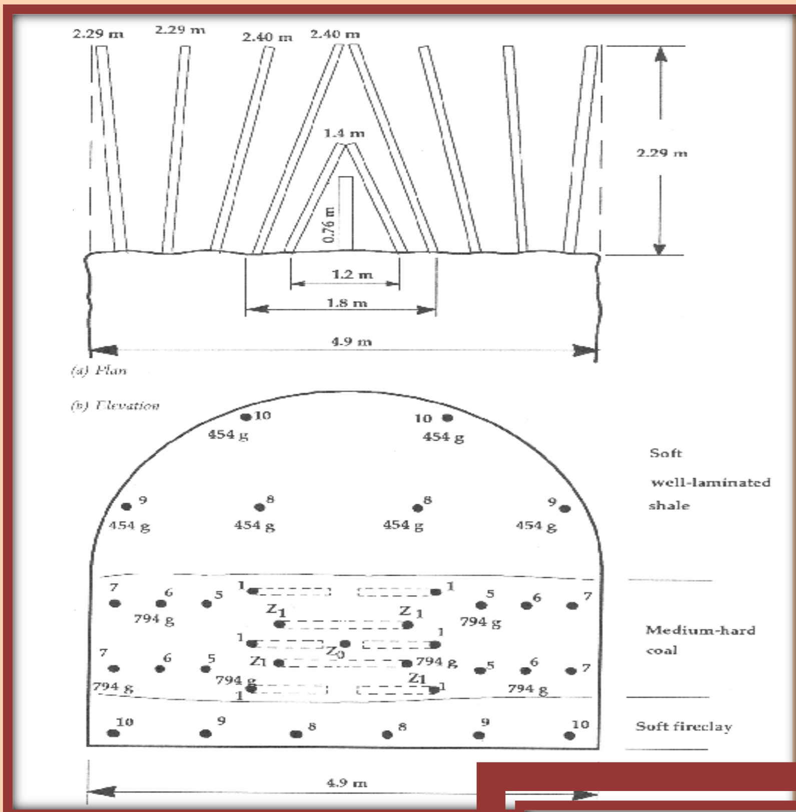
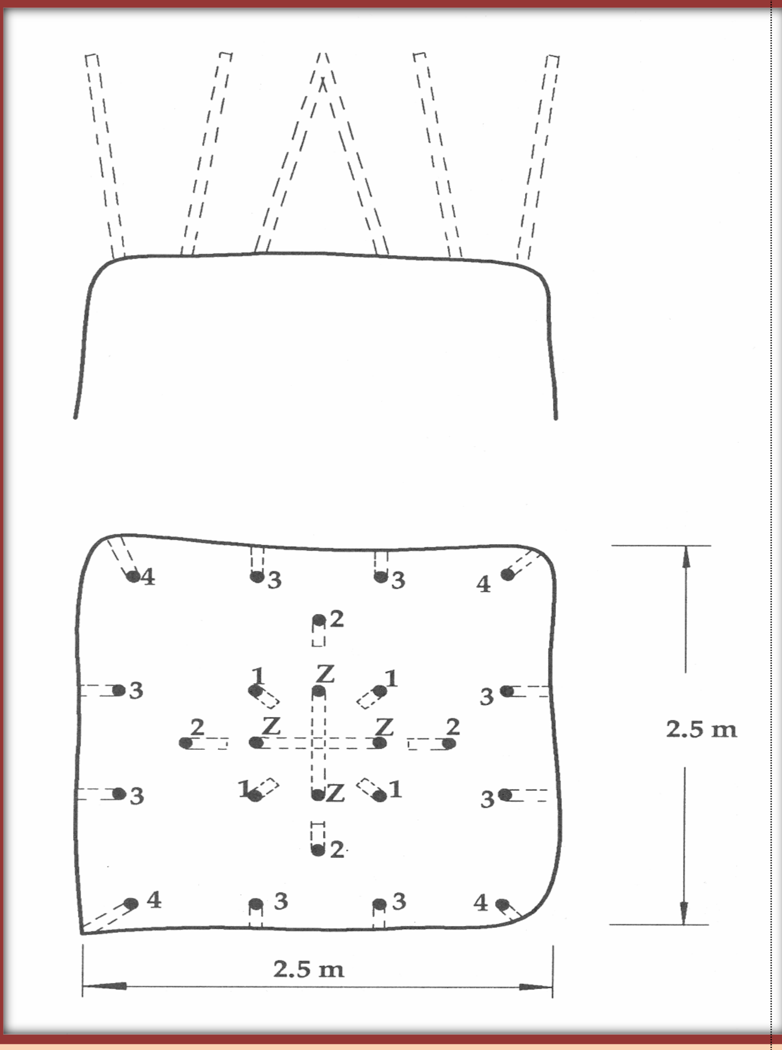


FIG.1:- WEDGE CUT

FIG.2:-PYRAMID CUT



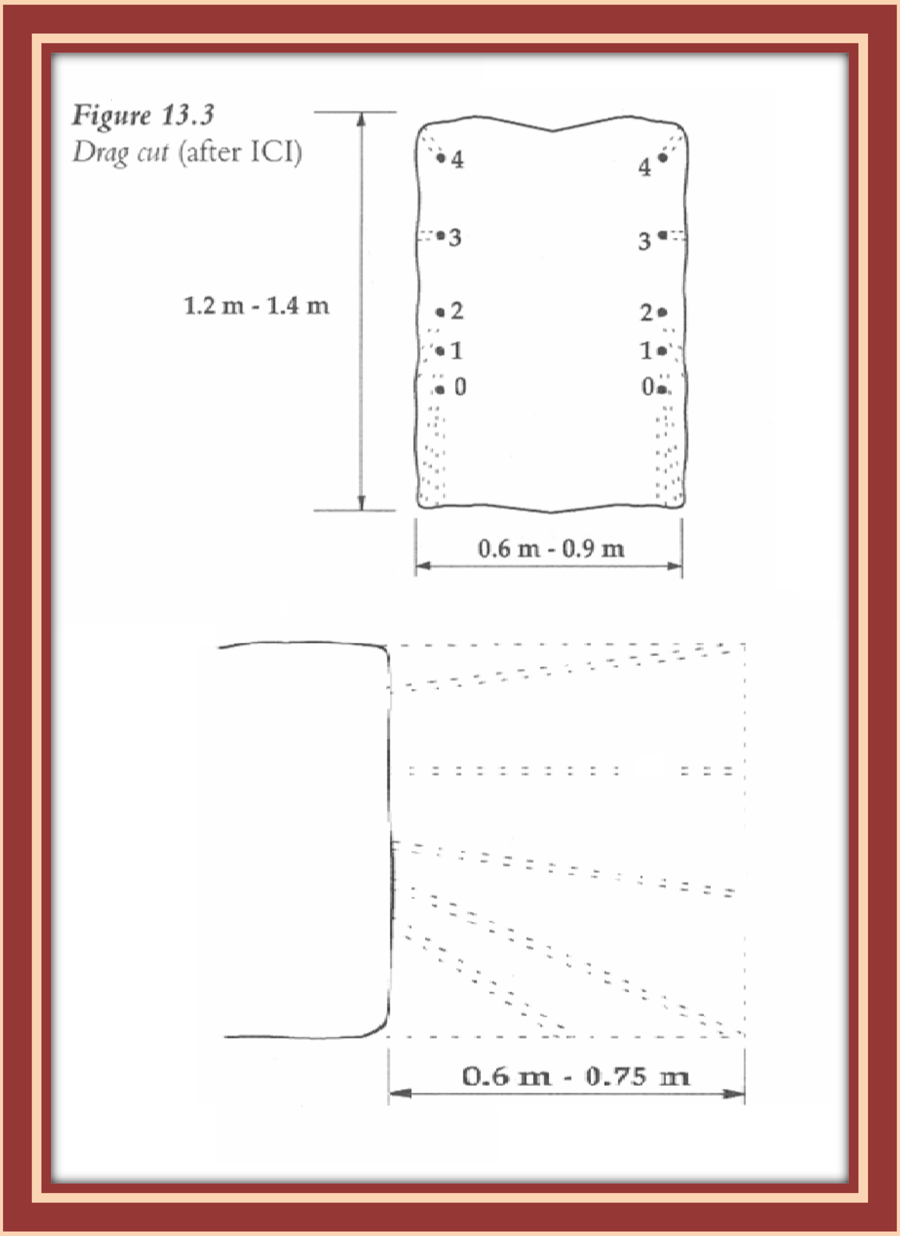


FIG.3:-DRAG CUT

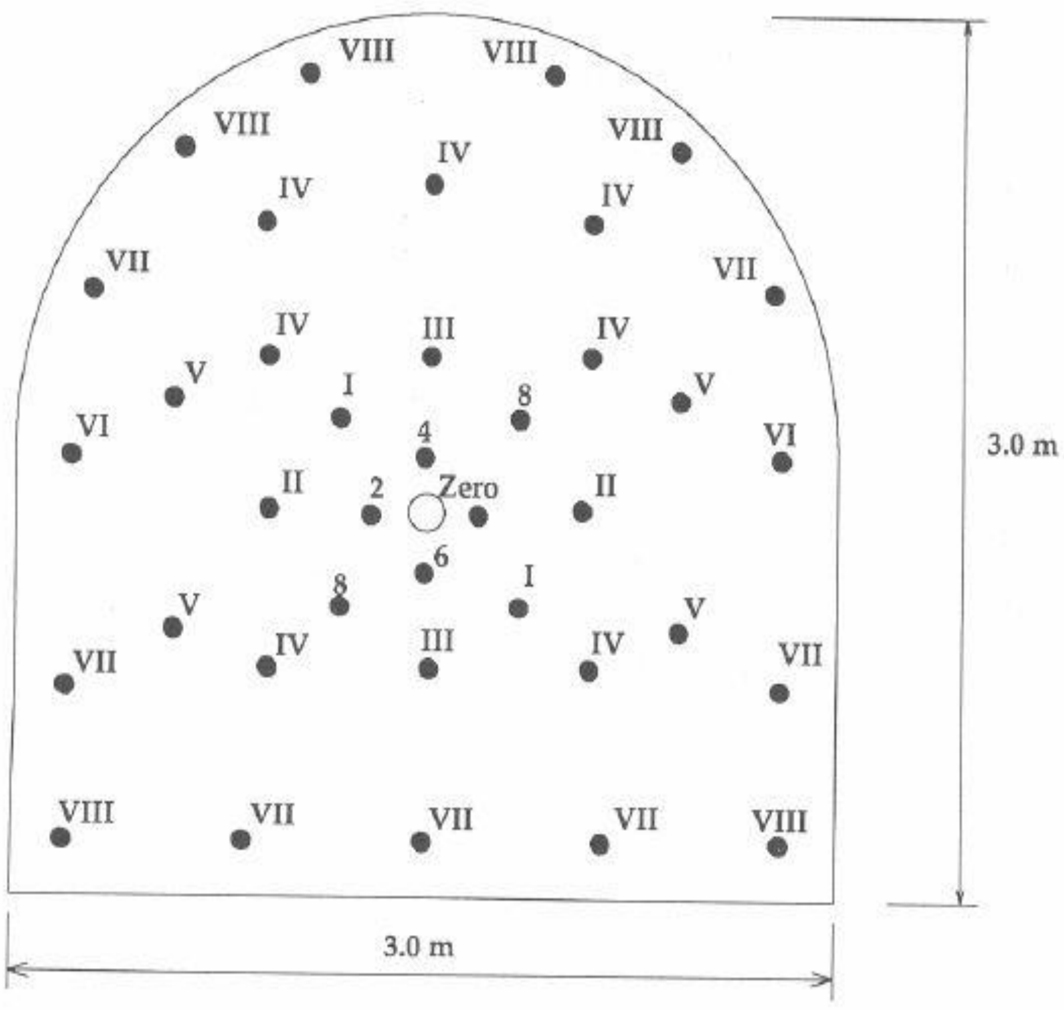
Burn cut

A series of parallel holes are drilled closely spaced at right angle to the face. One or more holes at the center of the face are uncharged. This is called the burn cut.

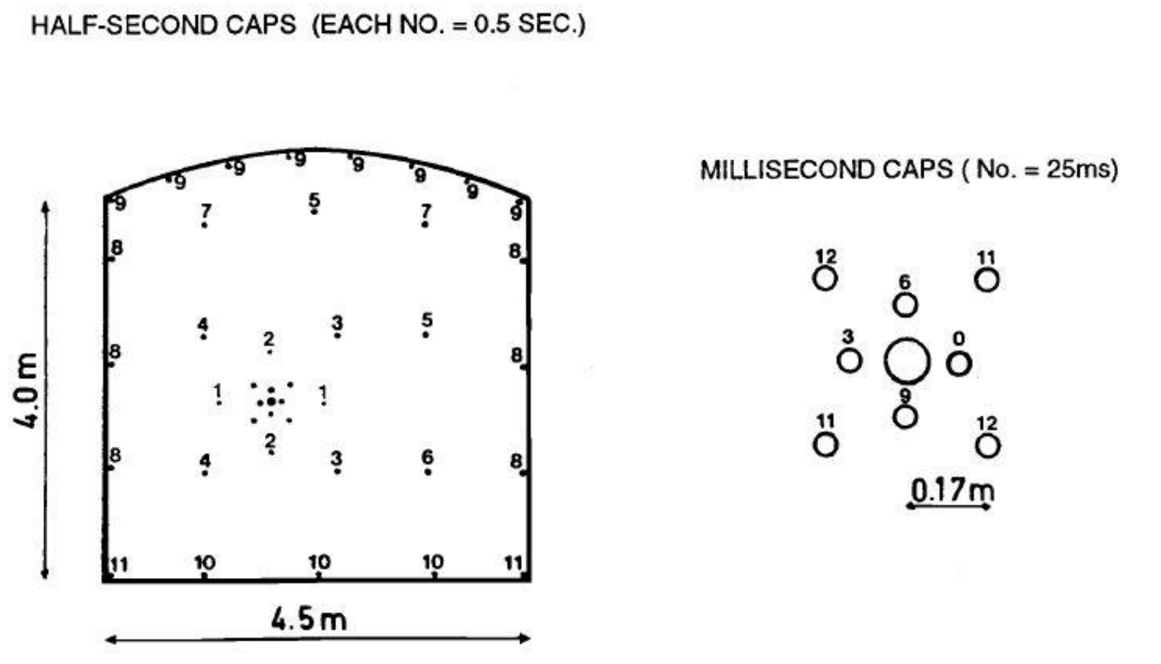
The burn cut uses parallel holes , most often four holes close together with only two loaded, or one or two large diameter holes,usually up to 125 mm (5 in.)in diameter, unloaded and form zones of weakness that assist theadjacent charged holes in breaking out the ground. Since all holes are at right angle to the face, hole placement and alignment is easier than in other types of cuts.

The holes set off just after the cut are the stopping holes, also called easer, relief (reliever), or enlarger holes. The last holes to be detonated are the contour or trim holes around the periphery. The ones in the invert are called lifters.

With the other drill patterns such as drag cut, pyramid cut and wedge cut, it is normally difficult to drill deeper than half the width of the tunnel because of the angle of drill, but with burn cut advances equal to width of the drift can be obtained. The burncut is particularly suitable for use in hard, brittle, homogenous ground which breaks evenly such asgranite, basalt etc. but cannot be used in springly plastic ground.



Arabic numerals: short delay periods
Roman numerals: half-second periods



(Adapted from Persson et al., 1993)

Figure 5-1. Blasting round with burn cut blastholes 3.2 m, advance 3.0 m

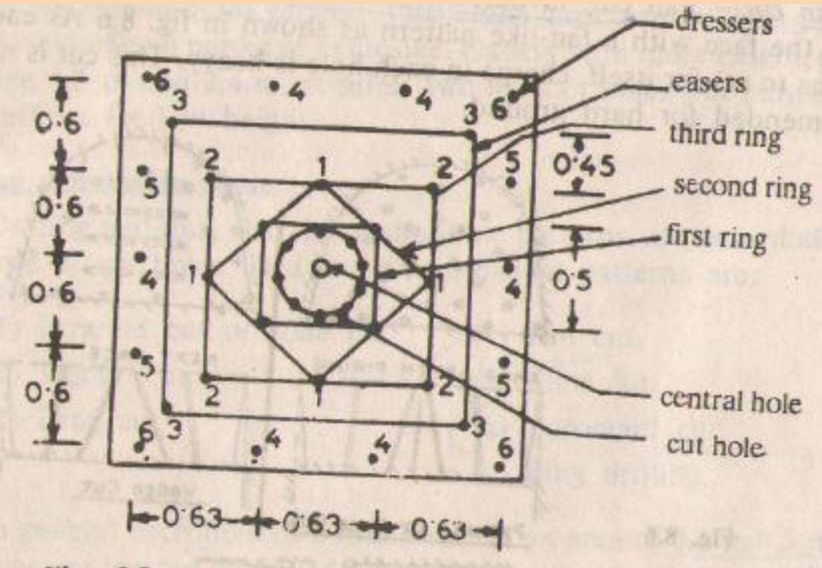


Fig. 8.7. Burn Cut

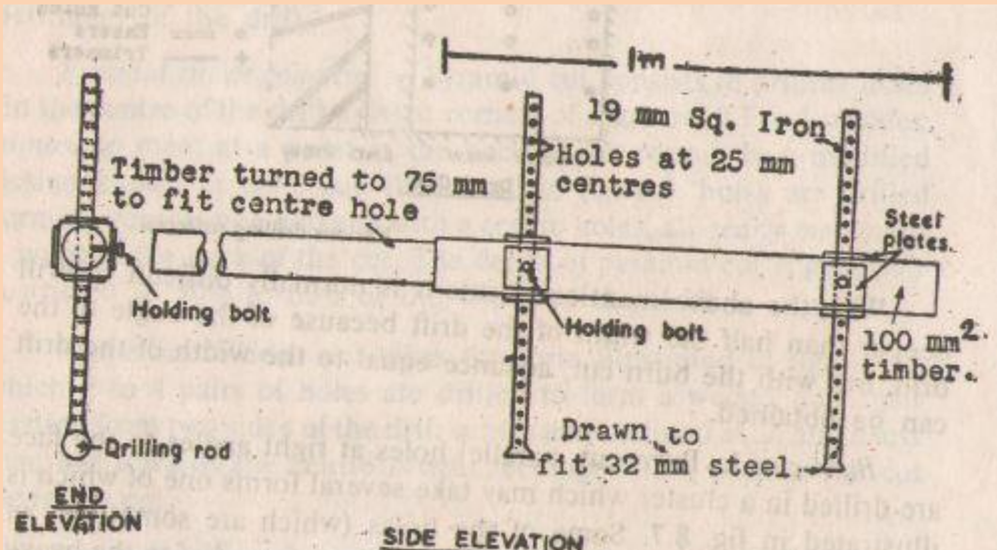


Fig. 8.8. Drill guide for holes on burn cut pattern.

All the holes, charged as well as uncharged ones, may be drilled by the same drill and those to be left uncharged may be reamed by a reaming bit. At Mosaboni mine, shot-holes for burncut in the drives are 32 mm dia. and the central hole which is not charged is reamed to 58 mm. dia.

The advantages claimed for this cut are:

(1) Drilling time is considerably reduced and supervision in drilling is easier as holes are straight.

(2) Depth of pull is independent of the size of the drift, and

(3) The quantity of blasted material is not projected far with a suitable form of cluster.

Coromant Cut

The latest development in parallel hole cut blasting is the coromant cut which gives the widest opening. It has been worked out with the object of achieving greater advance per round in tunnels or drifts of small area.

In principle, the Coromant cut consists of a slot, which is left unloaded, together with 6 outer cut holes, the location of which are carefully calculated. All the drilling is done with the same pusher-leg drill. The slot is produced by the contiguous drilling of two holes.

Drilling is carried out using a 20 mm drill rod with taper and a special drill bit of 57 mm diameter. The upper hole is drilled first, being directed slightly upward to assist in the disposal of cuttings. Contiguous drilling calls for guidance in drilling the second hole. For this purpose a guide tube is used, being inserted into the first hole and secured by means of an expander.

In the coromant cut two overlapping holes of 57 mm are drilled with air leg drills to give a slot roughly 101 mm x 51 mm to which the easer holes can fire. A 51 mm diameter steel guide tube with a groove which the bit can follow when drilling the second hole is introduced in to the first hole and fixed in position by means of an expanded. T o achieve the necessary pattern when drilling the easer holes a simple drill rig or template is used. Short delay detonators are used for the easer holes and ½ sec. delays for the rest of the round. Average length of pull of 3.04 m per round has been obtained in strong rocks with 3.2 m holes.

Burn cut and coromant cut are known as parallel-hole cuts. In drilling parallel-hole cuts, precision is always an important factor. A special drill jig or template which gives the desired precision and facilitates drilling, has, therefore been designed for the outer cut holes. This template also makes drilling considerably faster. The template normally used is the 6-hole template which fits in with the standard drilling pattern of the coromant cut. The two center tubes of the template are slid into the finished slot, and the template is then secured in place by means of an expander in one of the tubes. The drilling of peripheral holes in the cut is then carried out using ordinary integral steels.

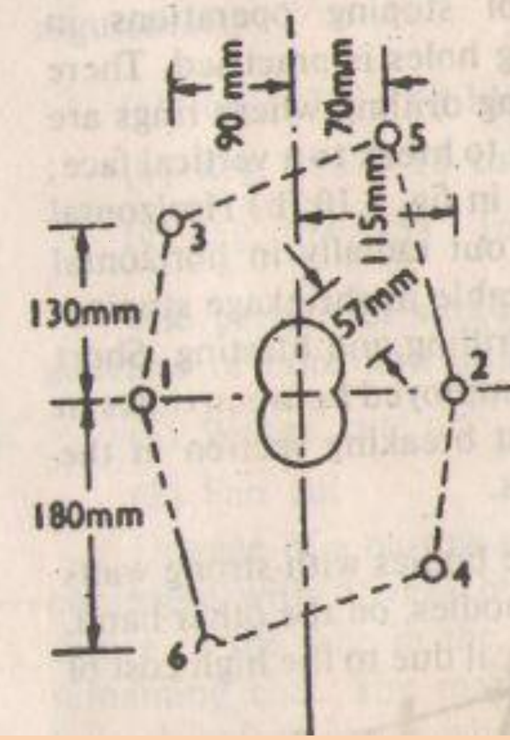


Fig. 8·9. Coromant Cut pattern

It may be possible to have only one center hole depending on the nature of the rock. The charge varies with the dia. of the empty hole and in the case of the pattern shown, the recommended charge is 0.3-0.4 kg/m length of the hole. The holes are fired in a sequence shown by delay numbers in the pattern.

The cut holes and the rest of the holes in the drift are normally blasted in the same round with the help of millisecond delay detonators. The standard coromant cut pattern covering six cut holes has been found to be good for the great majority of rocks. The arrangement of the holes and the firing order have been so chosen that the dislodged rock is given sufficient room to expand.

REGULATIONS OF BLASTING IN MINES

Blasting regulations basically comprises of standards that are kept in mind while blasting. These regulations cover blasting techniques and before hand strategies in coal or non coal mines. Now there are blasting practises on the basis of the fact whether it is a coal mine or not for instance there are some specialrequirements for blasting on acoalface belowground

as follows:

1. Holesmust end, not lessthan150 mm before the end of the cut Thisis to ensure that the bottom of thehole is not constrained.

2. Before the holes are charged the cuttings must be scraped out of them; and the walls of the holes tested for the presence of the cracks(after the detonation of the charge the gaseous pressuremaycompress the methane in the crack adiabatically and ignite it) .Thedual function of the hole anddetecting the cracks isby a simple devicecalled the scraper and crack detector cannot detect a crack on the end-face of the holeHowever, it issealed by the two clay cartridgespushed to theend of the hole before charging the hole.

3. The maximum permissible chargeper shothole is 800g of P1 explosives are usedin the gasiness Degree of and 1000 g, if P3are used in the any degree of gasiness.

4. The primedcartridge(the cartridge containing the detonator) with the detonator base pointing towards back of the hole, is inserted last leading to the direct detonation of the charge. Then, in the event of the hole cut off, by the detonationof the adjoining hole, there is no detonator in the hole-stumpleft.{rather the detonators) must be connectedin series, so that the firing circuit canbe tested for continuity.

5.Before charging and before the actual firing, the place must be tested for thepresence of gas (methane).

Further, the shot must be designed to limit the fragmentation of the coal. The over fragmented coal has a lower market value.

Furthermore Blasting off the solid(BOS), presents hazards, peculiar to itself, necessitating following requirements:

1 Only the category P5 explosives(like soligex and solimax of IEL Ltd.will be used.

2. The maximumpermissible charge perhole shall be 1000 g ingassiness category 1mines; and 565 g in themines of gassiness categories 2 and 3.

3. The delay detonatorshall be of the nonincendive type,like the 'carrick' short delay detonator of IEL Ltd.

4.The delay between thefirst and the last shot shall not exceed 150ms in mines ofgassiness categories 1 and 2, and 100 ms, incategory 3 mines Also the delay between twoconsecutives holes shallnot exceed 60 ms.

5 The distance betweentwo adjacent shots, with different delay numbers, shall not be lesser than 0.6 m, at the explosiveends.

6. Full face firing shall benecessary.

7. Stipulatedventilationstandards shall be met.

Shothole Patterns based on wedge cut and fan cut have been widely used in lndian collieries. Specificdrilling Length has been 1.2-1'5 m-3 and the specific consumption of explosive 0.45-0.60 kg m-3.

In the view of these drawbacks of BOS, there appeareda need for a middle course between

The coal-cutter-based blasting and the BOS.

Seams more than 2m thick, auger-cum-drill machines are available. The machine

Drills1 -2 auger holes 300mm diaand 2 m long, in the centre of theface around these holes, ordinary shotholes are drilled by the boom-mounted drill, on the same machine. Auger holes provide the necessary free faces for the shotholes. A model for thinner seams is available. Also, thecapabilityfor 450 mm dia. auger holes is available.

Apart from those mentioned above blasting techniques are also specified as mentioned below:

1.Bord and Pillar workings

Initially, cut is created to which the rest of the shots fire. The most satisfactory pattern will depend on the size of headings, nature of coal, coal seam structure, etc. and should be deiermrned by extensive trials in the field. Generally the initial cut is created by the following patterns:

l. Wedge cut: The shotholes are inclined at an angle of less than 45 towards the centre almost meeting at the back.

2. Fan Cut:The first few shotholes are drilled in a fan formation, so that when blasted, they Create a cavity on one side of the face.

3. Pyramid Cut : The shotholes are so inclined towards the centre as to appear to meet at one point and when blasted create a pyramid.

(ii) Longwall Faces

The objective of blasting off the solid on the longwall faces may be:

Either for coal winning, the shotholes being charged and laid out in such a way that part of the coal brought down is thrown on to the conveyor, the remainder being loaded manually,or

2. In order to loosen the coal mass, the coal being merely broken up and dislodged by the

shot so that afterwards it can be easily worked with a pick.

PANEL WITH FIVE/ SIX HEADING SYSTEM
(CONTINOUS MINER WITH CHAIN CONVEYOR)

If the dip of the deposit is flat to 25° or so, the deposit is divided into rectangles known as panels. Size of each panel is a function of incubation period (in case of coalmines; incubation period is the duration between the dislodging coal to begin with in a panel and appearance of fire in it due to self oxidation), output, degree of mechanization and productivity to be achieved. In coal mines its usual dimension is 800–1500 m along strike direction and 800–1000 m across it. In some specific situations such as: extension of the deposit along strike within 3–3.5 km. and if area is opened by inclined shafts, in place of division by panel system, level system (described below) of mining can be recommended. Usual underground mining/stoping methods adopting panel system are room and pillar, board and pillar and longwall mining. The panel system provides an intensive way to mine a deposit in per unit time, thereby, better productivity can be achieved; but the development work required for developing the property increases considerably in the dip-rise direction comparing the same with level system.

CONCEPT OF CONTINOUS MINING

In the so called, conventional mining method of drivage of heading systems, we have just studied: the coal won at the face by pick mining or blasting was loaded on the face haulage by manual or mechanical loaders. In the continuous mining method, however, the operations of winning and loading have been taken over by just one machine, called the continuous miner.

CONTINOUS MINERS

The continuous miner, in the current use, is essentially a gathering-arm loader with a cutter type cutting-head assembly. The assembly comprises the spiral drums, mounted on either side of a ripper mat. The cutting-head is raised to the roof level, and the tracks are used to sump it into the face, for about 0.6m. It is, then, gradually, lowered in the floor level, tearing the web off the face. Weight of the machines contribute to the forward thrust of the cutting-head. Some machines, however, cut from floor to roof. Broken coal falls on the loading apron (it can be raised/lowered by about 0.5m), where the gathering arms push it onto the central single-strand chain conveyor. It carries coal over the boom conveyor (loading jib) – which can be raised to over 2m from the floor, and can be slewed by 45° on either side of the miner centreline – loading onto the face haulage.

PARTS OF CONTINOUS MINER PACKAGE

Continuous Miner - Main body

Size(width x length x height):3m x 8m x 2.1m

Weight:25tonne

Continuous Miner – Cutter head

Size: 3m x 6m x1.2m

Weight – 15 Tonne

Continuous Miner - Gathering head

Size- 3.3m x 4m x 1.2m

Weight – 8 Tonne

- Shuttle Car - 19

Size –2.5m x 9m x 4.2m

Weight – 20 Tonne

Shuttle Car - 20

Size - 2.5m x 9mx 2.4m

Weight – 20 Tonne

- Quad Bolter

Size - 3m x8mx 2.4m

Weight - 22 Tonne .

- Feeder Breaker

Size – 3.3m x 10mx 2.1m

Weight – 25 Tonne

- Load Center and Plat form

Size - 1.2m x 7m x 1.5m

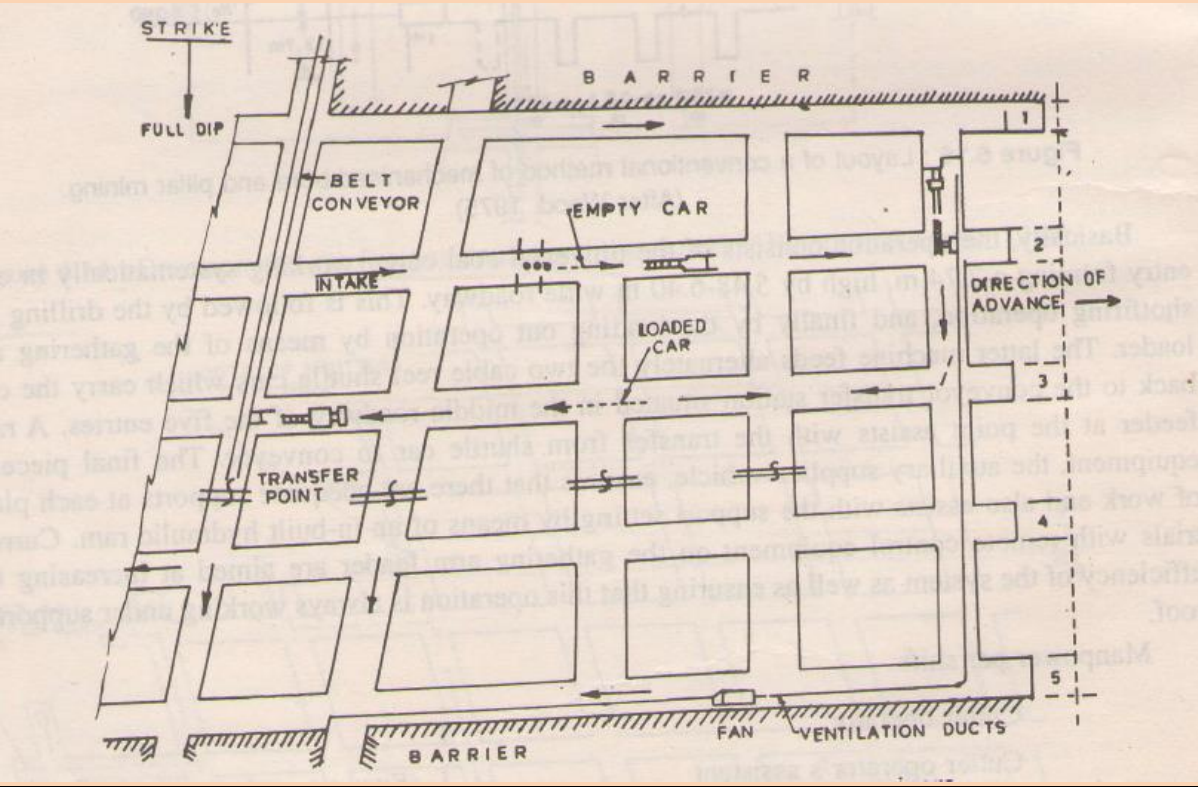
Total Weight – 20 Tonne.

DEVELOPMENT USING CONTINOUS MINERS

Figure shows a panel with five headings on the strike in a seam 8.53m thick dipping at 1 in 14. The galleries were 4.8m wide x 3m high driven along the floor and the pillars were 27.4m x 27.4m from centre to centre. The miner cut the full width of a gallery in two settings. First, 2.59 m was cut and then the miner was shifted to the position to cut the other half of the gallery, the overlap being 30 cm.

The coal, thus cut, was loaded into a Torkar, three of which were provided to a miner. Such that when one was being loaded the other was discharging coal on the belt conveyor and the third was standing in Que to be loaded. The face was ventilated by overlap ventilation.

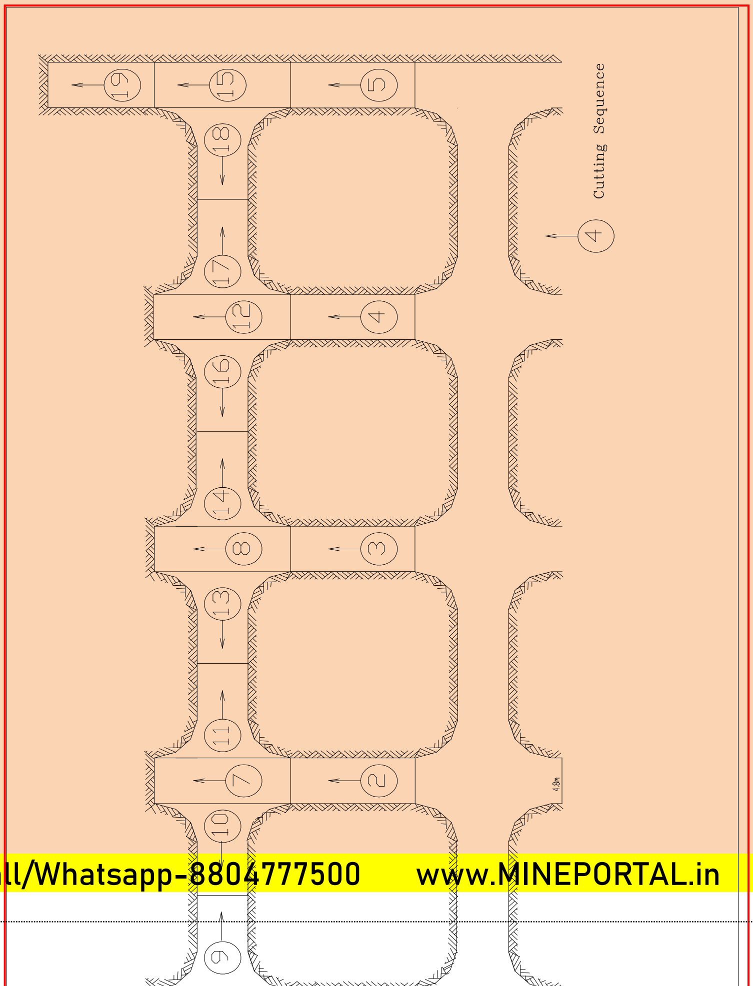
With this arrangement a maximum progress of 39.62m per day was obtained. Each panel had the capacity to produce 20000 tonnes of coal per month.



CONTINOUS MINERS - 12 CM 15

CONTINOUS MINER IN WORKING

A TYPICAL CONTINOUS MINER CUTTINNG PATTERN



STONE DRIFTING

After the shaft the reaches about 2m below the coal seam to be worked out or below a particular level in a metalliferous, the formation of roads for ventilation, transport, stowing and drainage is carried out according to worked out plan. The normal procedure is to introduce sumping holes in the round which are fired first providing free face from which the remaining surrounding holes can act, their number and position are designed around the sumping holes.

If the blasting is not off-the solid the position, direction, depth and number of holes at a face are governed by following factors

1. Position and depth of cut: Hole should be 150mm shorter than the depth of cut made by coal cutting machines. In coal mine tunnels the amount of advance is limited by the depth of cut. This is dependent largely on the amount of explosive per hole. The depth of hole should be such as can be pulled by the cut employed, to obtain a pull of 90% of the depth of holes; in hard shales 95% or even more could be obtained; while in soft shales pulls of 100% or even more could be obtained .However, it has been found that in very soft ground there is a tendency for the ground to pull in holes and not present a plane face.
2. Type of roof: if immediate roof is shale hole should terminate 0.3m below the roof ,if it is sandstone the hole should terminate 150m below the roof.
3. Type of band and their position: the hole should be drilled near the band and if the is of hard rock, it should be drilled towards it, slightly below or above so that the inclined hole terminates near the band where the explosives force is maximum.
4. Cleavage in the soil: shot holes should cross the cleavage planes as near to right angles as possible.

Some of the common designs of cut holes are described below

The wedge cut: the drilling pattern is in the form of a triangular wedge which is generally vertical. The holes placed on either side of the centre line of the drift are inclined at an angle of less than 45°. The holes are so placed that they will meet some 15cm beyond the desired pull of the drift. The depth to which the wedge holes can be drilled is limited by the width of the drift and the longest drill rod which can be made available. Maximum concentration of charge at the apex of the cut holes, which are fired first to create a free face for the rest of the shot, which are fired next with the help of delays. If cross-section of tunnel allows, for deep pulls, burden should be reduced by giving another shallow wedge cut known as 'Baby Cut' (Double V-Cut). These relieving holes (Baby Cut) should be fired prior to the main wedge cut pattern.

Pyramid or diamond cut: Pyramid cut consists in drilling holes at the centre of a square, 0.7 to 1m sides almost to meet at a point at the back of a ground. In a modified design known as cone cut, holes are drilled forming corners of a polygon with a centre holes, all nearly meeting at a point at the back of the cut. It is used in uniform or thickly bedded rocks which may be horizontal or inclined. It uses smaller explosive charge. Maximum concentration of charge is at the apex of these cut holes, which are fired first to create a free face for the rest of the shot, which are fired next with the help of delays.

Drag cut: The drag cut is suited to well cleated rocks which allow the holes to be placed at an angle to be placed at an angle to the cleat so that the cut breaks along the strata cleavage planes. When the strata is horizontal and the drift is being driven either with the cleat or across the cleats, the use of a top sumping cut or bottom sumping cut is important. With cut holes placed at an angle to the cleat. The strata breaks along the cleavage planes and the subsequent shots can act upon the free face, both upwards and downwards. The cut holes should not be drilled past the cleavage parting.

Parallel holes Cut (*Burn Cut*): Burn cut makes it possible to increase the depth of the round much more than is possible with angled cuts such as wedge/ cone/ pyramid cuts. Burn cut usually need more holes per round and a somewhat higher charge factor; but by increasing advance per round, economies result from ability to take advantage of the optimum depth of round to be fitted in the most economical cycle for drilling, blasting and mucking. Clusters of parallel shot holes are drilled at perpendicular to the face to blast out a cavity in the centre of the heading. Some of the holes are heavily charged with explosives while others are kept empty to provided free face for reflection of shock waves. There is specific geometrical relationship between the diameter of empty hole and spacing between the centres of empty hole and charged holes in a given rock, which gives the essential condition of free breakage. It is most important that Burn Cut holes be drilled parallel as possible and at the design distance from each other. Deviations can result poor blasting of the cut. The burn cut should be drilled at least 150 mm longer than the blast holes in the remainder of the round.

Fan cut: fan cut of sumping rounds is suited for soft and laminated strata the holes in this case are drilled to cover the face width with a fan like pattern in one plane and are diverted towards the bottom. But the explosive used in this type of blasting is very high.

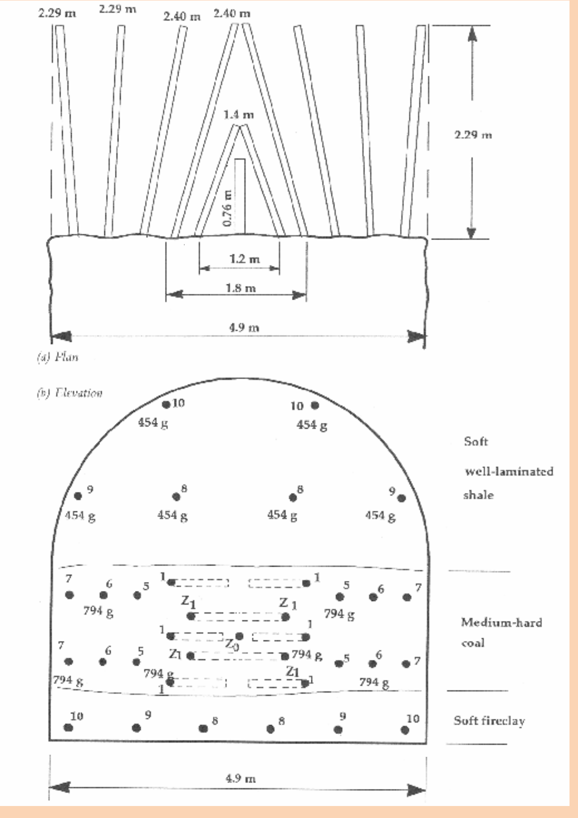
The coromant cut: In the coromant cut two overlapping holes of 57 mm are drilled with air leg drills to give a slot roughly 101mm x 51mm to which the easer holes can fire. A 51 mm diameter steel guide tube with a grove which the bit can follow when drilling the second hole is introduced in to the first hole and fixed in position by means of an expander.

All types of rock expand on breaking, the amount of expansion tending to increase with degree of fragmentation. Some time, the drilling pattern and explosives usage may cause a swell of broken rock that is sufficiently high to solidly freeze the cut. Burn cut having sufficient number of uncharged holes (Relief holes) reduce chances of such freezing. A suitable selection of Delays in

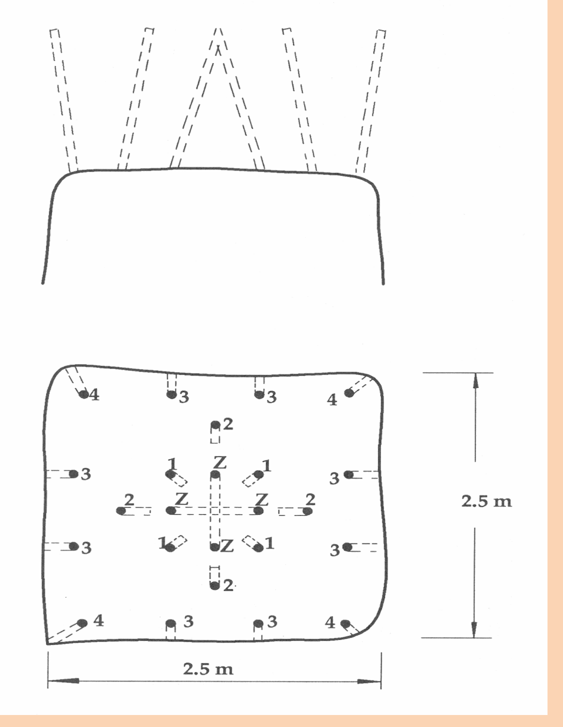
the round also prevent freezing. Burn cuts can be drilled anywhere in the face. Fundamentally, all the variations of burn cut utilize the same principle. Unlike the angled cuts which are designed to break out a wedge or cone of material, burn cuts are intended to shatter/ pulverize the rock, breaking into small fragments which are expelled by blast to leave a roughly cylindrical opening.
It is a good practice to incorporate one or more large diameter uncharged relief holes together with smaller diameter charged blast holes in Burn Cut. Larger the diameter and more the number of uncharged relief holes in the cut, less serious is the consequence of drilling deviations, less chances of freezing and better advance per round of blast.

It is very important that proper delay sequence is used in blasting. Each hole should be fired with delays of different timings. For cut holes, a delay period of about 100 ms between successive holes is recommended. The objective is to provide ample free face before firing commences in a particular hole. Therefore, the delay timing should be selected in such a way, to allow the fragmented rock to come out before a hole being fired. For Easer and Trimmer holes, it is a good practice to use longer delays, preferably half-second delays.
One of the parameter for good advance of the blasted round is the diameter of the large empty hole. Larger the diameter, the deeper the cut may be drilled and a greater advance can be expected. One of the most common causes of short 10 advance is too small an empty hole in relation to the hole depth. An advance of approximate 90% can be expected for a hole depth of 4m (45mm dia.) and one empty hole of 102 to 120 mm diameter. If several empty holes are used, a fictitious diameter has to be calculated in accordance with the formula $D = d\sqrt{n}$, where D= fictitious empty hole large diameter, d=diameter of empty large holes and n=number of holes. In order to calculate burden in the first square, the diameter of large hole is used in the case of one large hole and fictitious diameter in the case of several large diameter holes. The distance between the blast hole and large empty hole should not be greater than 1.5 d for opening to be clean blasted. If the distance is longer, there is merely breakage and when the distance is shorter there is great risk that the blast hole and empty hole will meet. Therefore, $a = 1.5\ D$, or $a = 1.5\ d$.

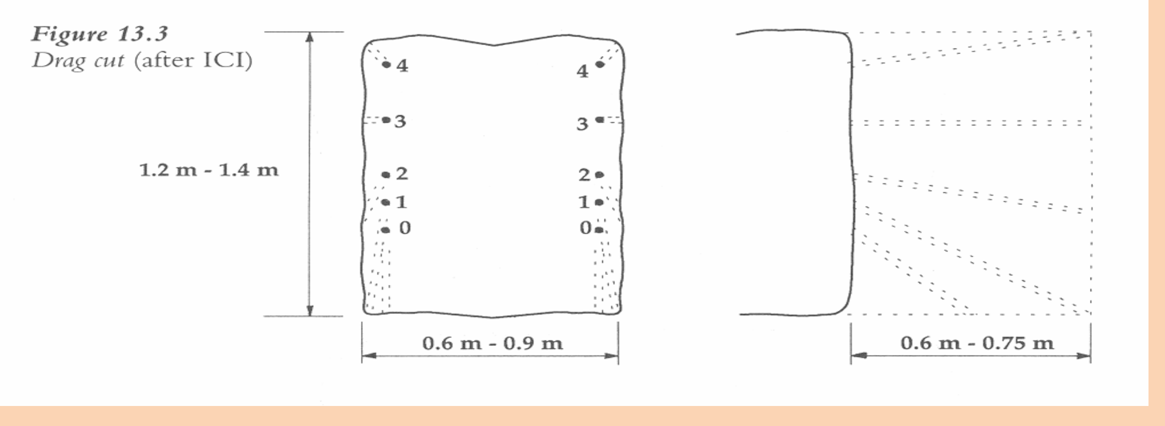
Holes closest to the empty holes must be charged carefully. Too low a charge concentration in the hole may not break the rock, while too high a charge concentration may throw the rock against opposite wall of the large hole with such a velocity that the burden rock will be recompacted there and not blown out through the large hole. Full advance is restricted then. In parallel cuts, three relief holes provide a larger expansion volume for blast holes. Three parallel relief holes provide better results in medium to soft rock formation also and prevent freezing than single relief hole system.



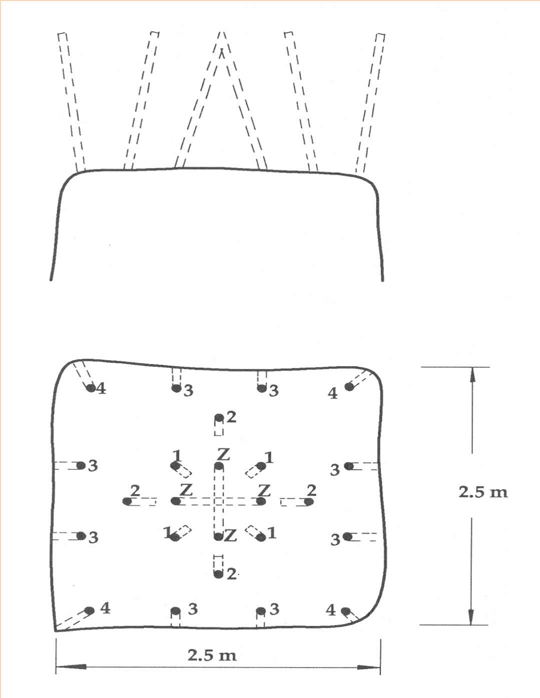
Wedge cut

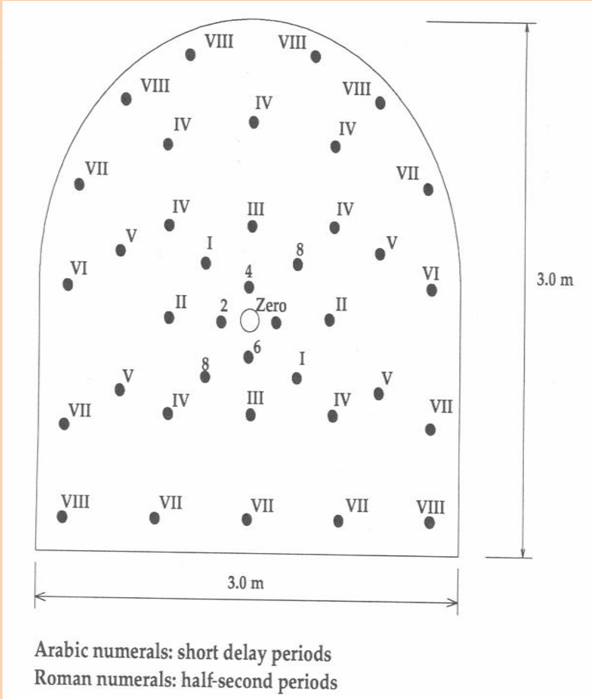


pyramid cut



Drag cut





Burn cut

Fan cut

ROOF SUPPORT:-

The most common supports used in underground mines are wooden props ,steel props, cog and chock, safari support, lagging and girder. Occasionally concrete lining and cement chocks are used, which are very rare

Proper selection of roof support is very vital for mines and tunnels. In mines it determines safety of work, production cost, losses and dilution, productivity of mine

WODDEN PROP:-

1. Timber support are most common in Indian mines ranging over to 90% of mines using wood for underground roof support.
2. Kind of wood is most commonly teakwood,sal wood and sankohn wood.
3. It’s load bearing capacity depends on length, diameter, moisture content, presence of defects and type of wood.
4. This type of props are stronger when force acts parallel to its length.
5. Here the props acts as beams and timber is placed in holes of minimum depth of 500mm in side of coal piller if sides are strong.
6. Flat wodden laggings are used in case of uneven roof.

SETTING PROP:-

Timber prop when erected under the slightly to support the roof should yield slightly under the roof weight. The prop almost as such is unyielding but certain yield is obtained by

- tapering it at the foot or top
- providing a lid on the prop as a aompressible cushion between the roof and the end of the prop.

STEEL PROP:-

Even though steel is expensive material it is widely used in u/g mine support due to following reasons.

- Free from natural defects
- High young’s modulus of elasticity
- Least affected by temperature and humidity
- Can be reused

Steel props are basically two types and they are (a)rigid props (b) yielding props

Rigid prop:-

- Ordinary H section steel girder with web cut away and flanges turned at one or both is the common type of rigid roof
- Rigid roofs may cause damage to the roof or altenatevly they themselves get buckled and damaged.
- Once full weight is obtained withdrawal of the rigid props is difficult

Yielding prop:-

- As name itself implies yield as the roof weight comes upon them while offering constant resistance to them
- They helps in maintaining good roof conditions
- Withdrawal of yielding roofs is easy once the maximum weight is achieved
- This type of props has rising characteristics
- This yielding props are mainly two types
    1. Friction prop
    2. Hydraulic prop

COG AND CHOCK:-

- A cog, chock or chockmate is a combination of sleepers above one another in a criss cross manner

- It supports much larger stretch than a prop and is in places where the roof is bad over a wide area and needs a substantial support
- These are also erected where main roads have to pass through area having coal piller of inadequate size
- These are required at goaf edges at junctions of splits and galleries in depillaring areas in board and pillar workings
- only rectangular sleepers or sleepers having their two opposite sides chopped flat, should be used
- the chock should be tight against the roof and this may be tested by hammering wedges
- built with sawn sleeper or if the round timber is used , then their ends are flatterned
- cogs should not be normally erected on loose floors or debris, but on natural floor or on secure
- when withdrawing a chock, withdrawal of such wedge loose the chock and withdrawl the sleepers become easy

general application of chocks are in following cases

1. where the roof is very bad
2. at goaf edges of gallery
3. at junctions of galleries
4. if floor is sleeper then 1 in 5

SAFARI SUPPORT:-

- this is an example of active type support
- in this support a girder made of steel or wood is generally kept above to props and are fixed in the coal pillers
- this type of support is used when a lot of cack are found in the roof of gallery
- it is the conventional method for supporting galleries in coal mines by means ofwooden cross bars
- for fixing these bars holes are made in coal pillers manually by crow bar
- generally the steel type girders are used because they do not break but bend when the load suddenly falls in them
- The manual cutting of holes in the coal pillars is eliminated by drilling holes with usual coal drills and support, known as Safari support
- It consists of pair of clamps of mild steel on which a cross bar is placed to support the roof
- Each clam consists of an angle iron frame to which semicircle m.s bracket is welded as a seat for wooden cross bar
- The cross bar is placed in position over the two brackets and tightened against the roof with wooden wedges.
- The clamps can be easily recovered and used again for several times

- One of its applications is too support the split galleries in depillaring areas in thick seams and extract the floor coal.

TABLE REPRESNTING SUPPORT REQUIRMENTS

	Advantages	Disadvantages	Limitations
Wooden Prop	Light in weight Easily installed Give indication before failure Easy to handle and low maintenance Cheap and transport easily	Cannot be used in watery condition Less load bearing capacity Deteriorate with time	Cannot be set on loose floor Interfering transportation
Bar	Light in weight Easily installed Do not Interfere transportation spread load of roof over a larger area	They rot with time	Cannot be used when roof is arched
Cog and Chock	Cover and support large area Cheap and easy to install	Interfere and restrict transportation	Cannot be used, where floor is loose or in pooper position
Steel prop	Greater load bearing capacity Incombustible	Heavy in weight Cannot be modified at face	
Friction props	They can be bear fairly heavy loads	Costly	Setting and withdraw of prop need much time
Hydraulic prop	Capable of withstanding heavily load	Costlier Heavy and difficult to carry	Cost-factor
Rock Bolt		Cannot give indication before failure	

WOODEN PROP SUPPORT

STEEL PROP SUPPORT

Yielding prop

Friction props : Friction prop was first developed in germany.Because of the yielding characteristics ,they can be used repeatedly , thus results in saving and give better roof control and enhance safety of men and machine. These props were most common at long wall faces till the advent of powered supports.

Principles of design : The design of friction props is based on friction and deformation of material. They are based on the principle of the frictional force that acts between the two bodies , whenever there is a relative motion between the two.the bearing capacity i.e the support provided is $P = 2Q\mu$,which can be increased by increasing Q or μ or both. However the friction is regular when the pressure between the surfaces is relatively low or when the surfaces are lubricated. Props used in bituminous coal mines works more smoothly because of the lodgement of coal dust on the friction surface which provides the necessary lubrication.props used in sub-bituminous coal mines yield in short steps accompanied by noise .while reusing the props which has been lying idle for some time,rust must be cleaned before they are pressed into services. The load carried by the props underground is always less than that at the laboratory as the dampness reduces the friction offered when combined with coal dust.

Various design have been tried to obtain the desirable characteristics of the friction props:-

- Wedge with tapered surface between the upper and lower member of the props.
- Insertion of deformable materials.
- Servo mechanism
- Use of rings inserted into the lower members.

The objective in the design have been to have controlled frictional resistance and to controlled frictional resistance and to control an early bearing prop , $i.e.$., the prop must reach its full bearing capacity after no more than 13 to 19 mm yield, and maintain it or only increase it slightly during further yield .

Hydraulic prop : Hydraulic props are also the yielding props. They are easily set and withdrawn .they have an early bearing characteristics,i.e..,the prop builds up its full bearing load with an yield of less than 2.54cm or so. Once the full load has been reached ,it remains at that level with further increase in yield . Unlike the friction props, the hydraulic props have nearly uniform characteristics. It is thus possible to design support system at a face with more accuracy than it can be possible with friction props. The setting load of these props is 5-8 tons and the yield load 20-25 tons.

Dowty hydraulic prop is a common type of hydraulic prop .also known as duke prop,this prop has an outer cylinder ,the pressure cylinder and an inner tube ,which acts as a reservoir and contains the mechanism of third tube known as the guard tube ,protects the pressure cylinder. A split is located in the belled end of the pressure cylinder and forms an outcrop should the inner tube reach limit of its travel. A metal scraper ring and a wiper ring which form part of the bearing assembly , prevent dirt and water from entering the pressure cylinder . The piston ,welded to the lower end of the inner tube, houses the pump suction and delivery valve and the initial and main return valves.besides,it carries the relief valve capsule and the pump cylinder , a gland ring ,an anti extrusion ring and a piston ring which forms a high pressure seal assembly. The pump valve bell and spring and the high pressure seal assembly are kept in position by a detachable plate.

Pumps and release mechanism are operated by a control shaft mounted across the top of the inner tube . An oscillation of the shaft operates the pump and an outward movement operates the release mechanism. The single acting pump is driven via a connecting rod by a crank on the end of the shaft. Rotary motion of the control shaft is limited by a lobe on the crank which comes into contact with the inner tube . The connecting rod is pin jointed to the piston . Outward movement of the control shaft , which operates the release mechanism is transmitted by an operating lever which is pivoted from a lug on and above the control shaft housing . One arm of the operating lever is linked with the push rod assembly and the other contacts the crank flange.the push rod operates the initial release valve and via a spring , the main release valve. The push rod is spring loaded and returns to its original position when free. Similarly , the spring loaded control shaft returns to the pumping position when released. The gravity operated breather valve unit is housed in the top of the corner tube where it is sealed by an 'o' ring and retained by a spring clip. The detachable top extension fits over the end of the inner tube assembly and is secured by a curved bolts and nuts . It embodies a hand grip for men handling the prop and for a rapid entension in conjuction with pump handle. If the prop goes solid the extension will abut on the outer cylinder, thus preventing damage to the inner tube and its mechanism. Extension may have either a domed head with a friction cap or integral prong top.

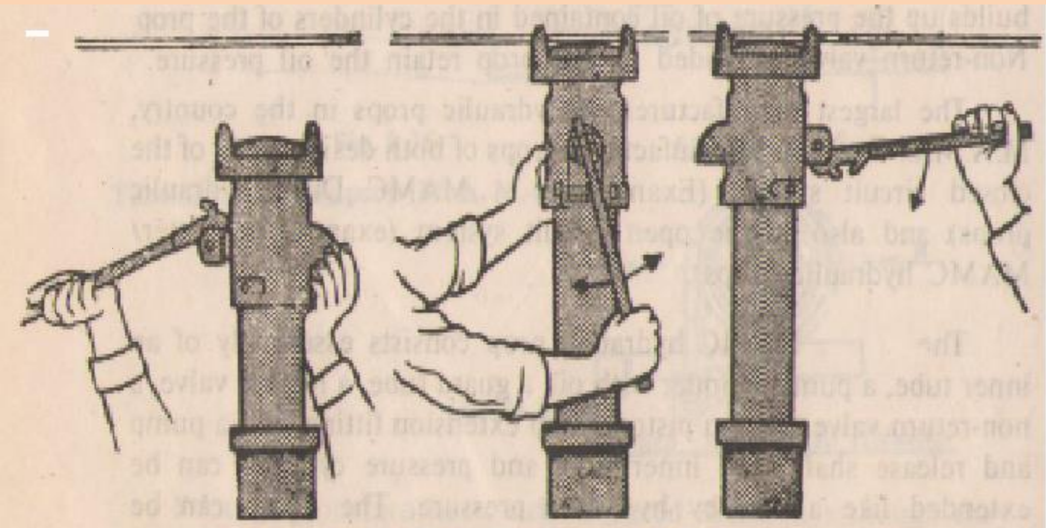


Fig. 9.18. Hydraulic prop, with built-in pump.
Left—extending the prop, Middle—setting the prop, Right—withdrawal of prop.

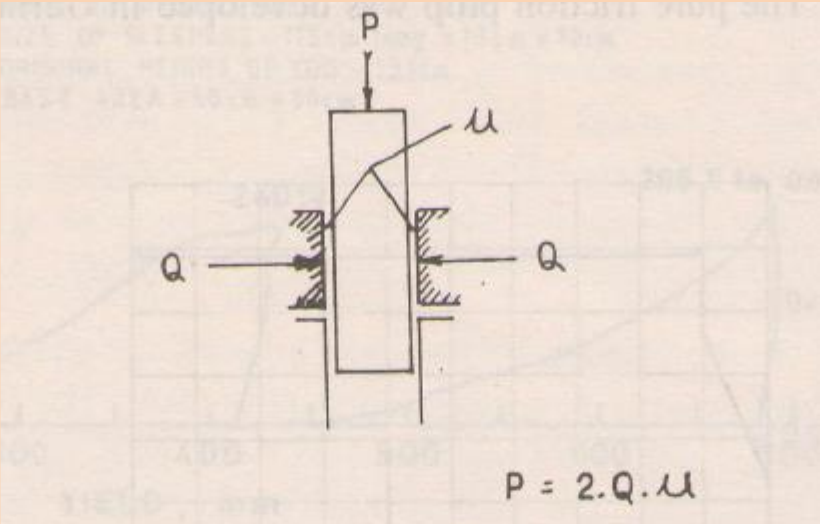


Figure 12.36 : A simple design of a friction prop

Alimak raise climbers

DEFINITION

It is a Raise climbers, commonly known as Alimak raise climbers after the company that first introduced them in 1957. These are used to drive vertical or inclined raises in underground development and mining operations. Raises up to 1000 metres are possible with this method, but practically, raises less than 300 m are more common.

The method of excavation has been used successfully on many project applications, including ore and waste pass raises, ventilation shafts and airways, main shaft excavating, communication shafts and materials handling shafts.

Important aspect of such climbers is that they are both Air motors driven climbers and Electric powered raise climbers.

ALIMAK RAISING METHOD

The Alimak raising method consists of five steps, which together make up a cycle. The five steps are all dependent on the Raise Climber, which serves both as a working platform and a means of transport up to the work site. The five steps are:

1. DRILLING – Drilling is done from a platform on the Raise Climber. The platform is adapted to fit the size and shape of the raise required.
2. LOADING - Loading is also done from the platform. Explosive charges are placed in the holes by hand.
3. BLASTING - Before blasting, the Raise Climber is moved down to the nest for protection against falling rocks. Then the blast can be triggered from a well protected spot close by.
4. VENTILATION - Noxious gases and dust created by the blast are cleared by spraying a mixture of water and air from the top of the guide rail.
5. SCALING - When the air is free of dust and gases, the crew can ascend to the face to begin scaling and installation of a new guide rail section. This is also done from the platform, under the protection of the safety canopy.

IMPORTANCE OF ALIMAK RAISE CLIMBER

1. Compared to open raise construction, there is no restriction on raise angles.
2. Compared to raise boring, there is not as high a power requirement and no need to pour reinforced concrete foundations.
3. Alimak raising provides the safest of all entry methods involving the least risk to the miner and can excavate safely through all types of ground conditions supporting the face after each blast is taken ensuring the integrity of the excavation during all stages of development.
4. The method enables raise development approaches that cannot be carried out using raise borers.
5. It has the added advantage of in raise access to allow for the installation of ground support and grouting of water inflows as the raise is excavated, unlike raise boring

where boring through highly stressed or bad ground conditions only ends up in ultimate failure or costly and time consuming remediation

RAISE CLIMBER IS A SAFETY DEVICE

1. Raise climbers have a very good safety record.
2. The drive gear of air driven raise climbers is equipped with an air operated brake which is activated when air for the motors is shut off.
3. The raise climber climbs along a pin rack welded to a guide rail which is also used to supply air and water for the drills.
4. The rail is extended in 1 or 2 metre sections as the raise is extended. The rail is fastened to the wall of the raise with rock bolts.

WORLD SCENERIO

- Worldwide more than 2,300 Alimak raise climbers have been distributed since 1957, being used to drive more shafts and raises than any other system.
- Even multiple raises with directional changes in the raise of up to 90° can be carried out easily making this method the ideal choice for ore passes, crusher chambers, split level ventilation raises or any difficult excavation profile.

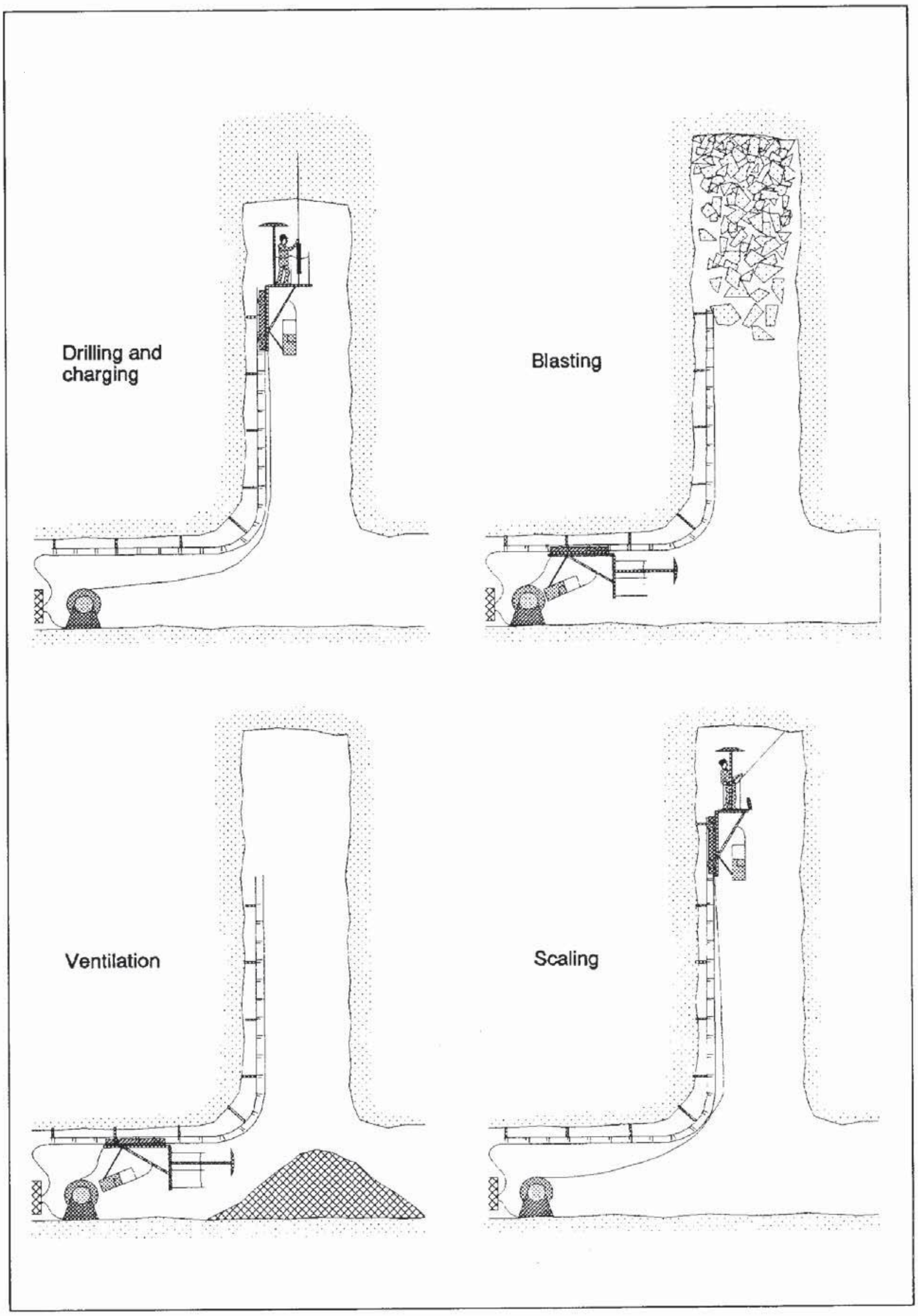


Figure 25 - Alimak Method of Shaft Excavation

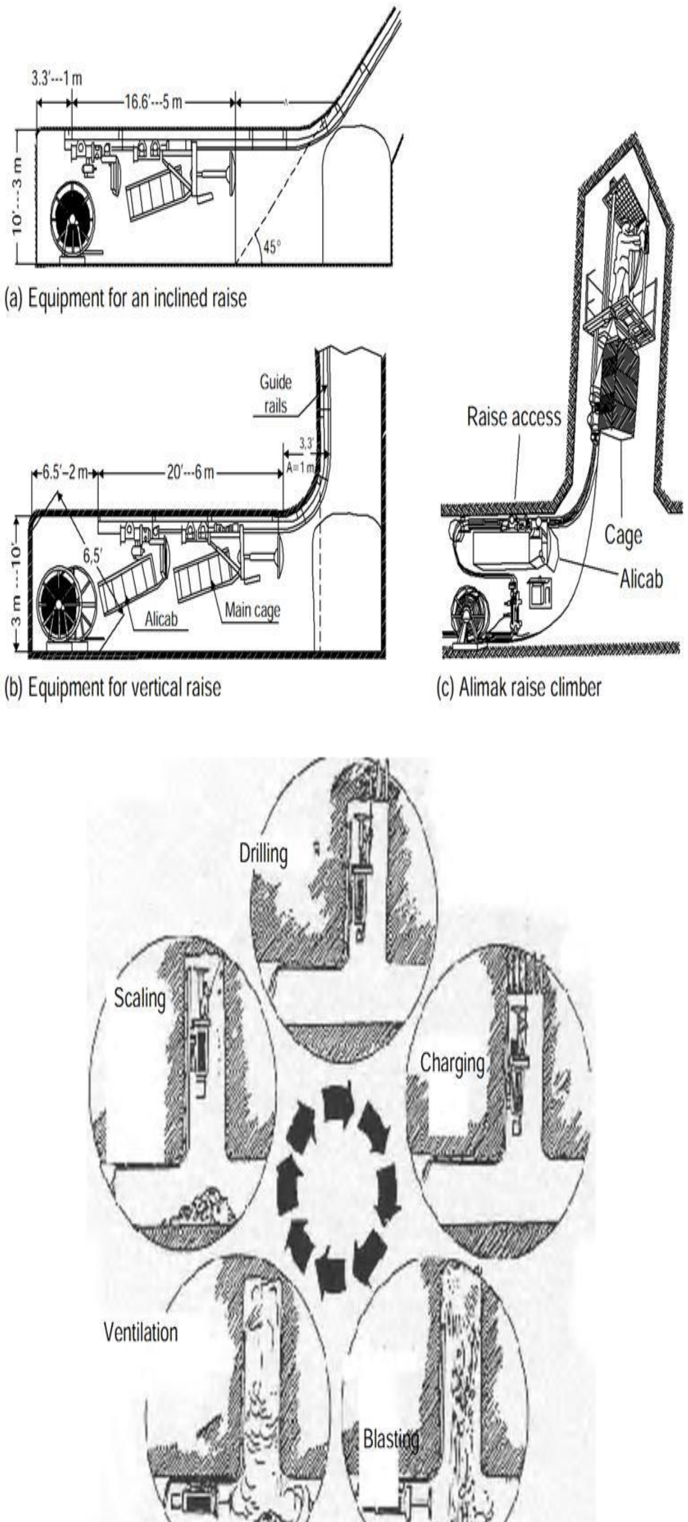


Figure 13.5 Alimak raise climber – some details.

curved guiderails used are: (8°, 25°, 25°, 25°, 8° i.e. the sum should be around 90°). First a vertical raise by conventional method is driven for a length of 5 m. To install the

RAISE

A raise is a vertical or steeply-inclined opening that connects different levels in the mine. It may serve as a ladderway access to stopes, as an ore pass or as an airway in the mine's ventilation system.

RAISING

The process of formation of raise is known as Raising. Raising is a regular operation in the development of metalliferous mines.Raising is a difficult and dangerous job, but it is necessary. It is associated with danger of accidents – due to fall of roof rock, inadequate ventilation resulting in poor visibility at the work site and uncomfortable working conditions. There are various methods of raising-

1. Open Raising
2. Compartment Method
3. Alimak Raise Climber
4. Jora Hoist
5. Long Hole Raising
6. Drop Raising
7. Raise Borers

DROP RAISING METHOD

Drop raisingis an excavation which is completely pre-drilled over its full length, then charged from the top, or bottom, and finally blasted from the bottom in practical lengths for an effective advance per blast.This is a method of making a raise connection between two adjacent levels, nearly 60 m apart, by drilling large dia. holes(150 – 165 mm).The raise is usually vertical but many also be steeply inclined. In this method after making drills they are charged in such a manner that the ratio of length charged to that of the diameter of the mine is generally 4:1 and do not exceed 6:1. Thus, for holes of 165 mm dia. a charge of 990 mm length would constitute a spherical charge. After the charging procedure they are blasted off.

Various steps involved in this method are:-

1. DRILLING: -

   In this technique use of these drills is made to drill the parallel holes in the intended direction of the raise to be driven. All holes are drilled to get through into the next lower level up to which the raise is to be driven with careful drilling hole deviation should not exceed 1–2%. Five to six holes of dia. 100 mm or more are drilled.On completion of drilling holes' survey for their deviation is undertaken. Raises of longer lengths up to 150 m can be drilled with the application of the drills used for this method.

2. BLOCKING THE BLASTHOLES: -

This process involves securing two wedges (rectangular or conical wooden blocks) at the desired location near the bottom of the blast hole i.e. from the free face. Explosive is charged on top of the blocking. Angles of holes determine where the hole is to be blocked.

3. BLASTING: -

The hole is then loaded with the explosive. Its amount depends upon its density and ratio of hole diameter to length so that a spherical charge can be obtained. For example for a 165 mm dia. hole, the charge amount of an explosive of 1.40gm/cm3 densityworks out to be 27.2 kg.The hole is then stemmed, for a length of 1–2 m or so, using suitable material. The same procedure is repeated while charging rest of the holes.This may be noted that the low density explosive such as ANFO is not suitable for this technique, and therefore usually slurry explosives, which can also be used in the watery holes, are used.

Some of the Advantages of this method are-

Drop raising is commonly used world-wide in the development of rock and ventilation passes over a length of generally up to 60m in the vertical mode and around 15m in an almost flat mode. Drop raising offers a safe method of excavation at relatively economic cost. Major advantages of this method include not exposing people to the dangers of entering a pass from underneath, and, the ability to blast short passes of up to10m in one blast.

1. PERFORMANCE: -

Since drilling and blasting are the independent operations so better productivity can be achieved by this technique. While drilling performance depends upon the usual parameters such as rock factor (type of strata), operating factors (drill’s power, blow energy, speed and flushing mechanism), drill hole factors (hole dia., length and inclination) and service factors (working conditions, skill of operator etc.).But after completion of drilling, by a trained crew, a blasting round of 3–4 m/shift or at least a round in the alternate shifts can be achieved.

2. SAFETY: -

The raise needs never to be entered once blasting commences, thus hazards posed by falls of ground, fumes, poor working conditions etc. are avoided.

3. SPEED: -

Drilling of the raise is much faster than handheld operations. Once drilling has been completed,blasting can take place without the interruptions of making safe and drilling the next round.

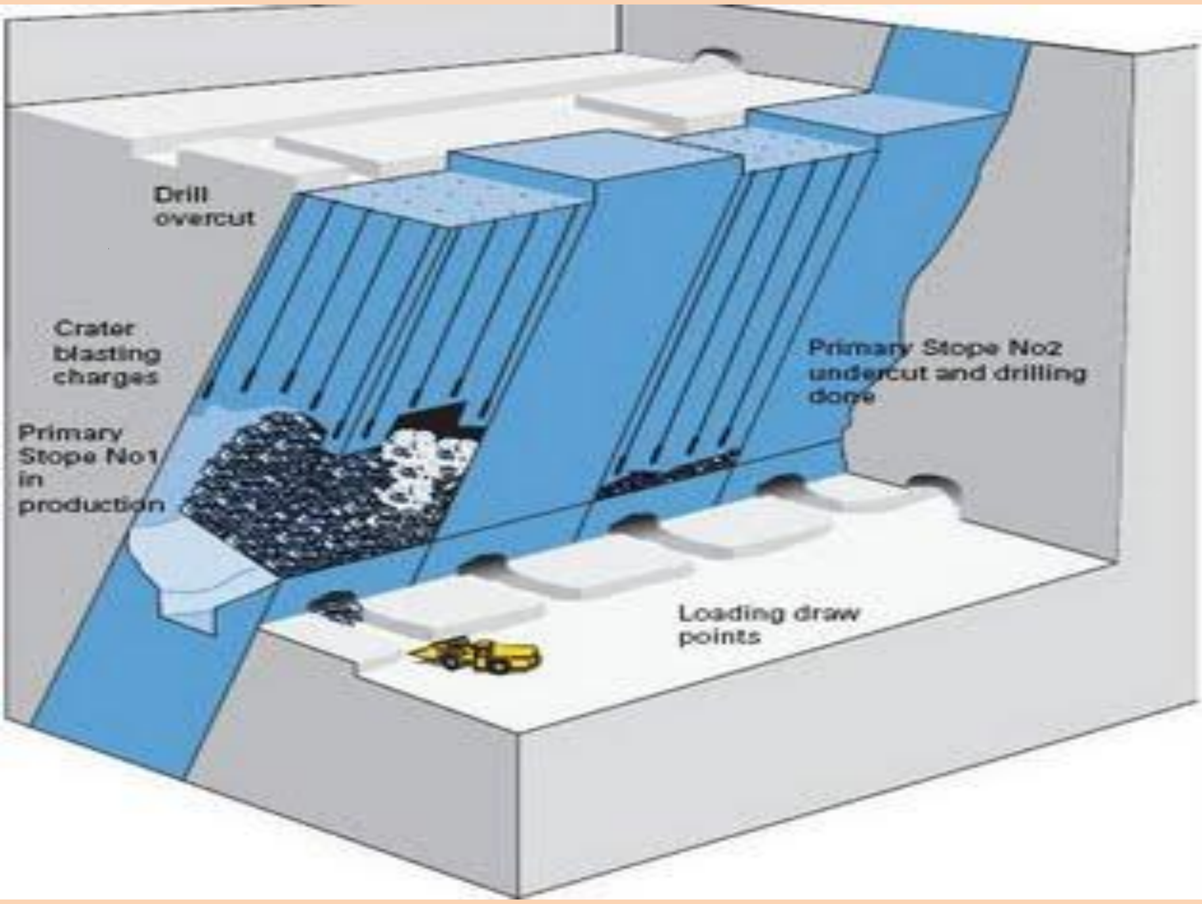
RAISE BORING MACHINE

The Raise Boring Machine, RBM is a powerful machine breaking rock with mechanical force. The RBM installs on top of the planned raise and drills a pilot hole, breaking through at the target point at the level below. The pilot bit is then replaced by a reamer head, with the diameter of the planned raise. The RBM pulls the reamer head upward, with strong force, while rotating, to break a circular hole in rock.

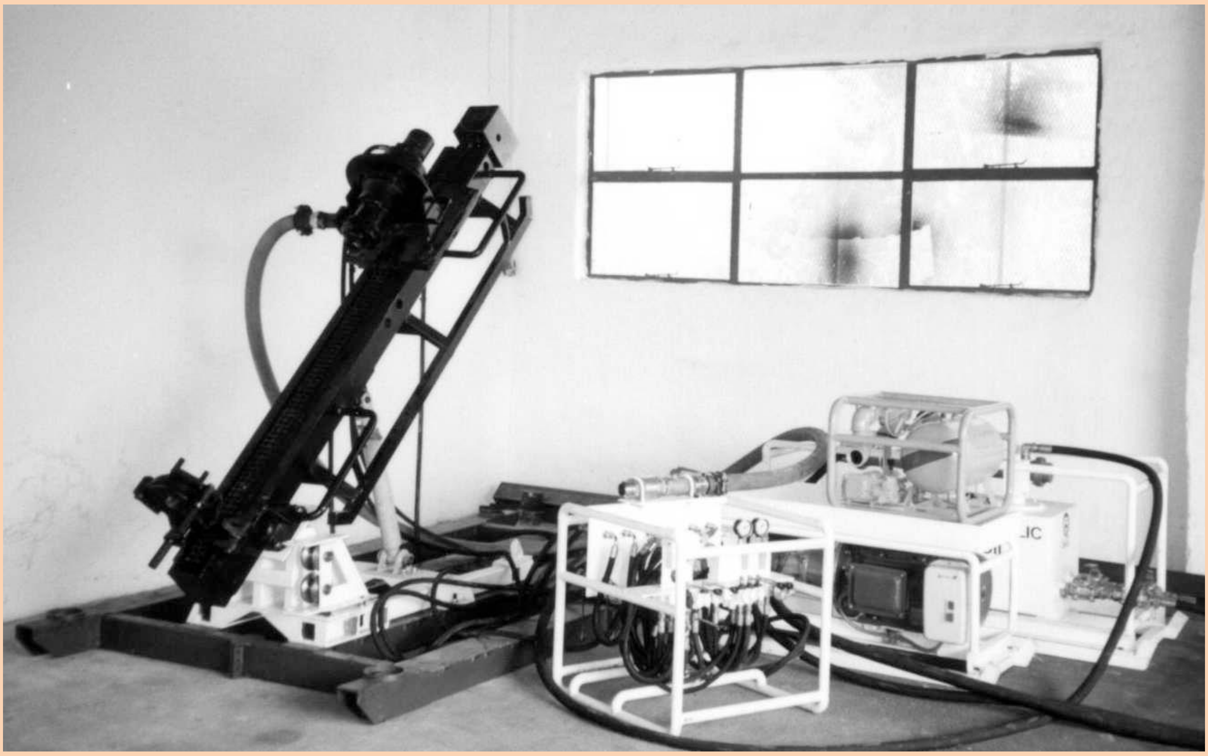
With this method, the raise is excavated from the upper level downward using a down reaming system connected by a drill string to the machine above. Stabilizers are located above and below the weight stack to ensure vertical boring. A reverse circulation system, or a vacuum system, is typically used to remove the cuttings out of the shaft. Down reaming begins by drilling a conventional pilot hole, and then enlarging it to the final raise diameter by reaming from the upper level to the lower level as shown in Figure 5. Larger diameters can be achieved by conventionally reaming a pilot raise, and then enlarging it by down reaming.

During reaming, the cuttings gravitate down the pilot hole, or reamed hole, and are removed at the lower level. To ensure sufficient down reaming thrust and torque, the down reamer is fitted with a non-rotating gripper and thrust system, and a torque-multiplying gearbox driven by the drill string. Upper and lower stabilizers ensure proper kerf cutting, and reduce drill string oscillations.

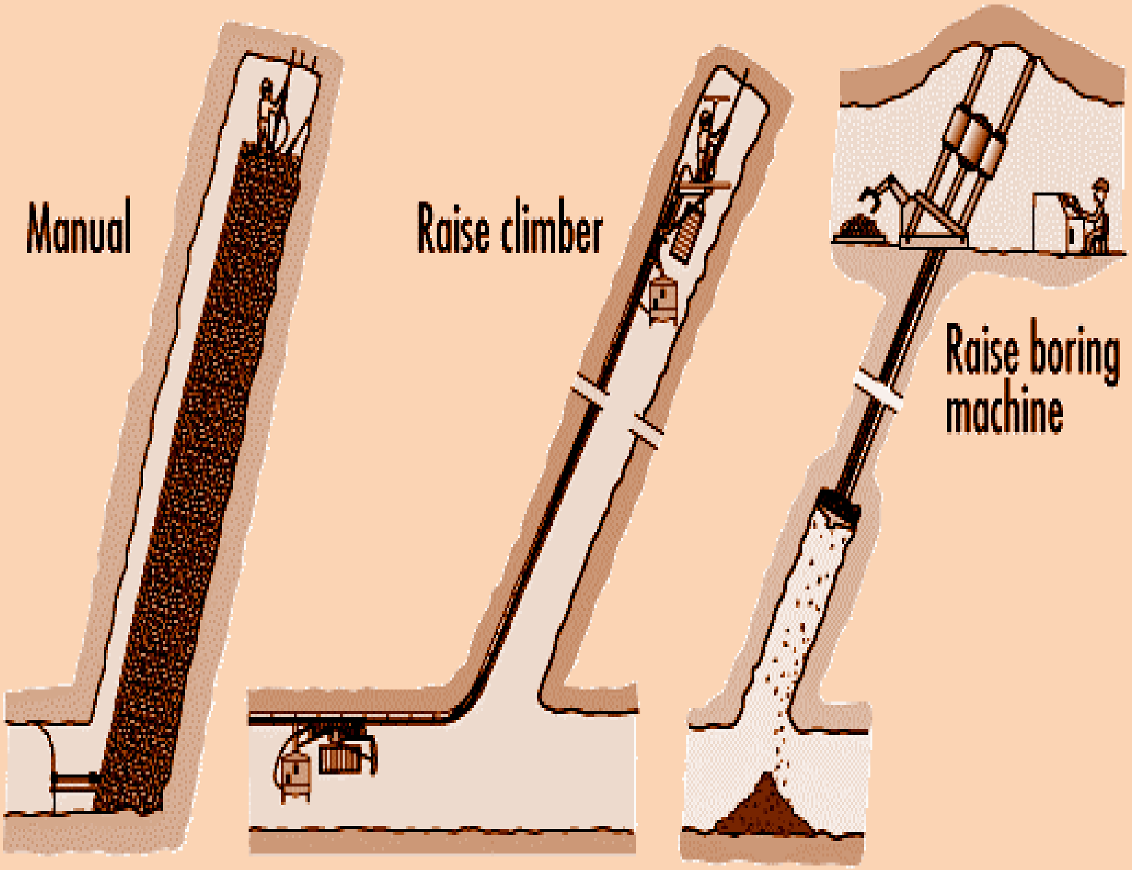
This method, also known as hole opening, is used to enlarge an existing pilot hole with a small-diameter reamer. The operation is similar to pilot hole drilling, the only difference being that a small reamer is used instead of a pilot bit. The small reamer is designed to use the existing pilot hole to guide the drilling. Stabilizers are used in the drill string behind the reamer to prevent it from bending.

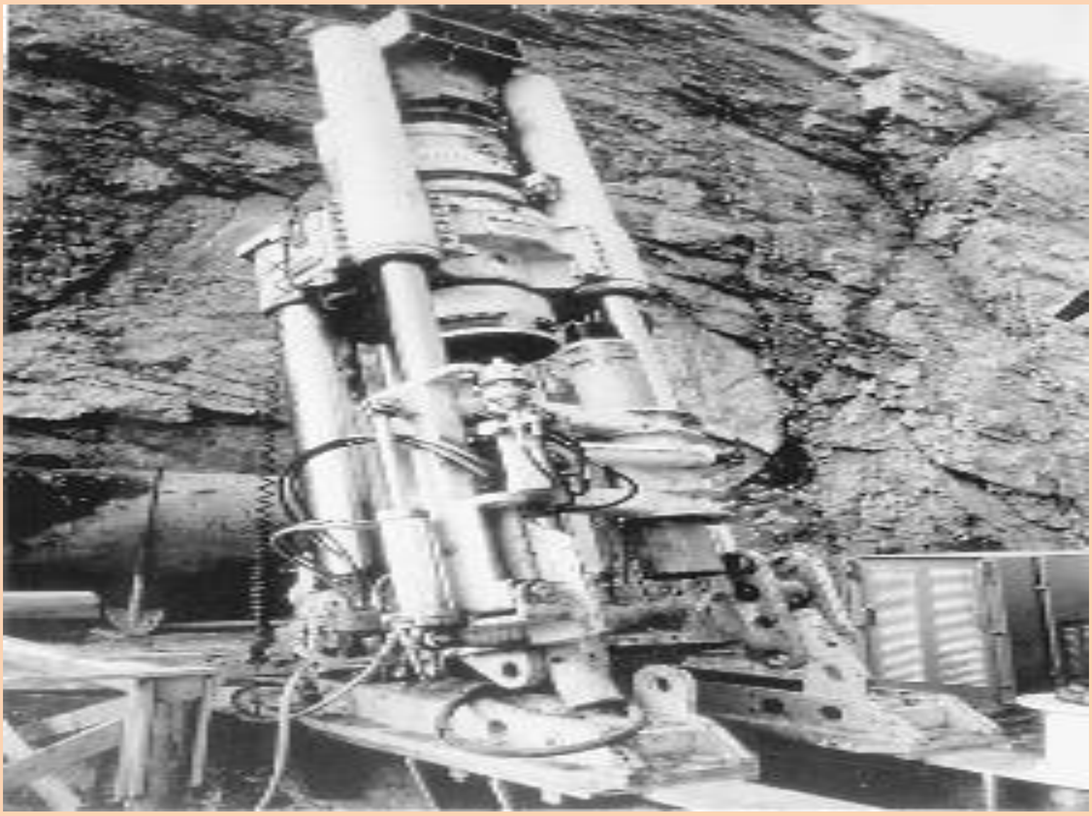


DROP RAISE METHOD

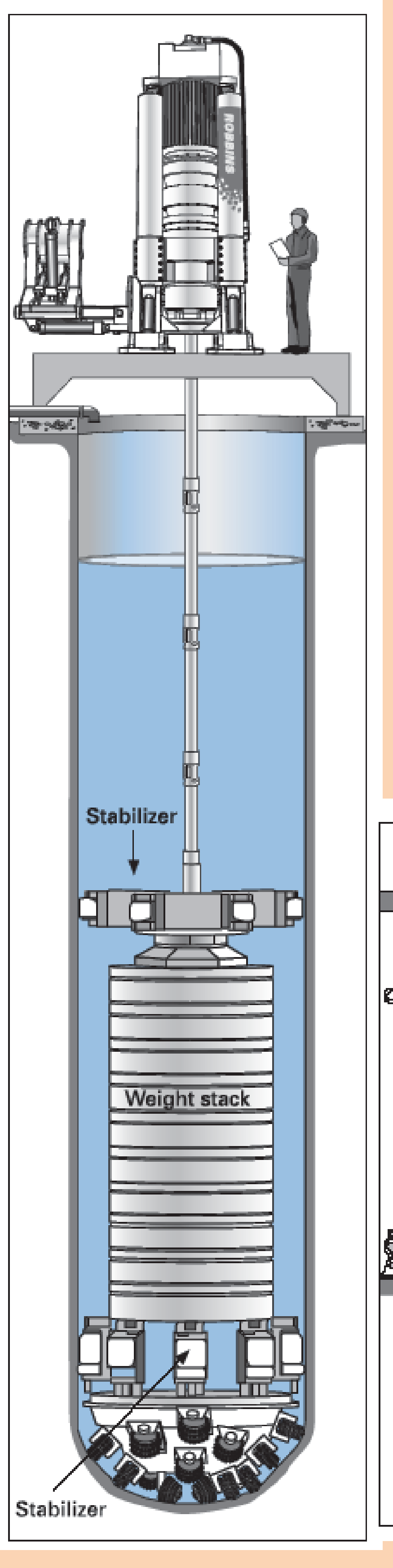


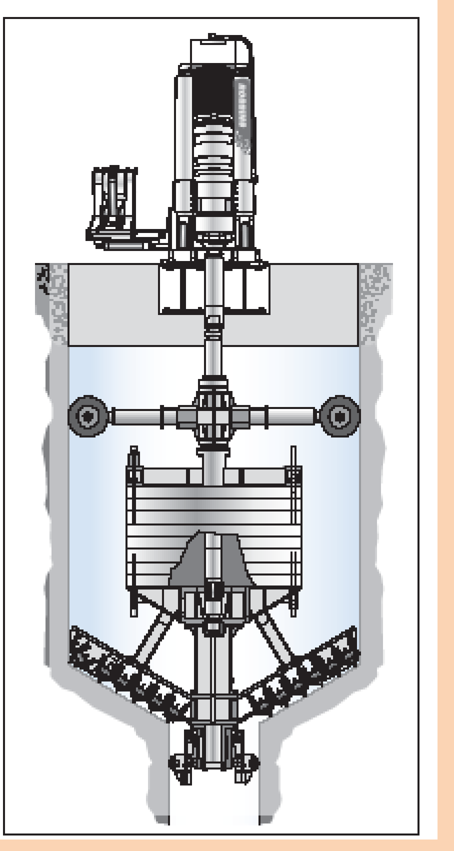
DROP RAISE DRILLRIG

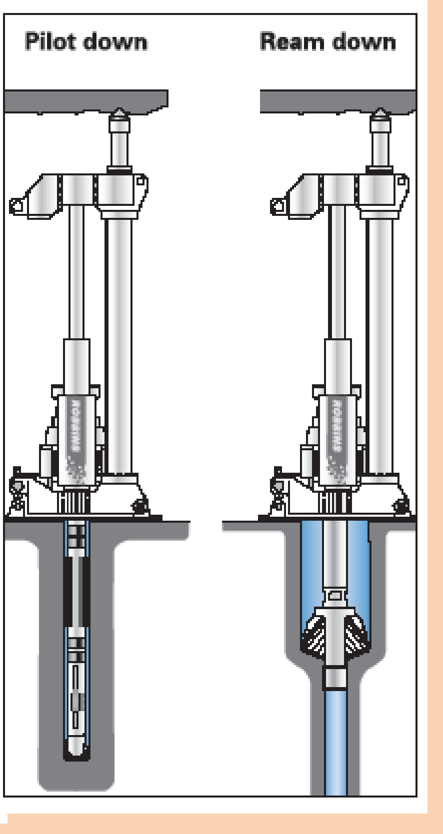




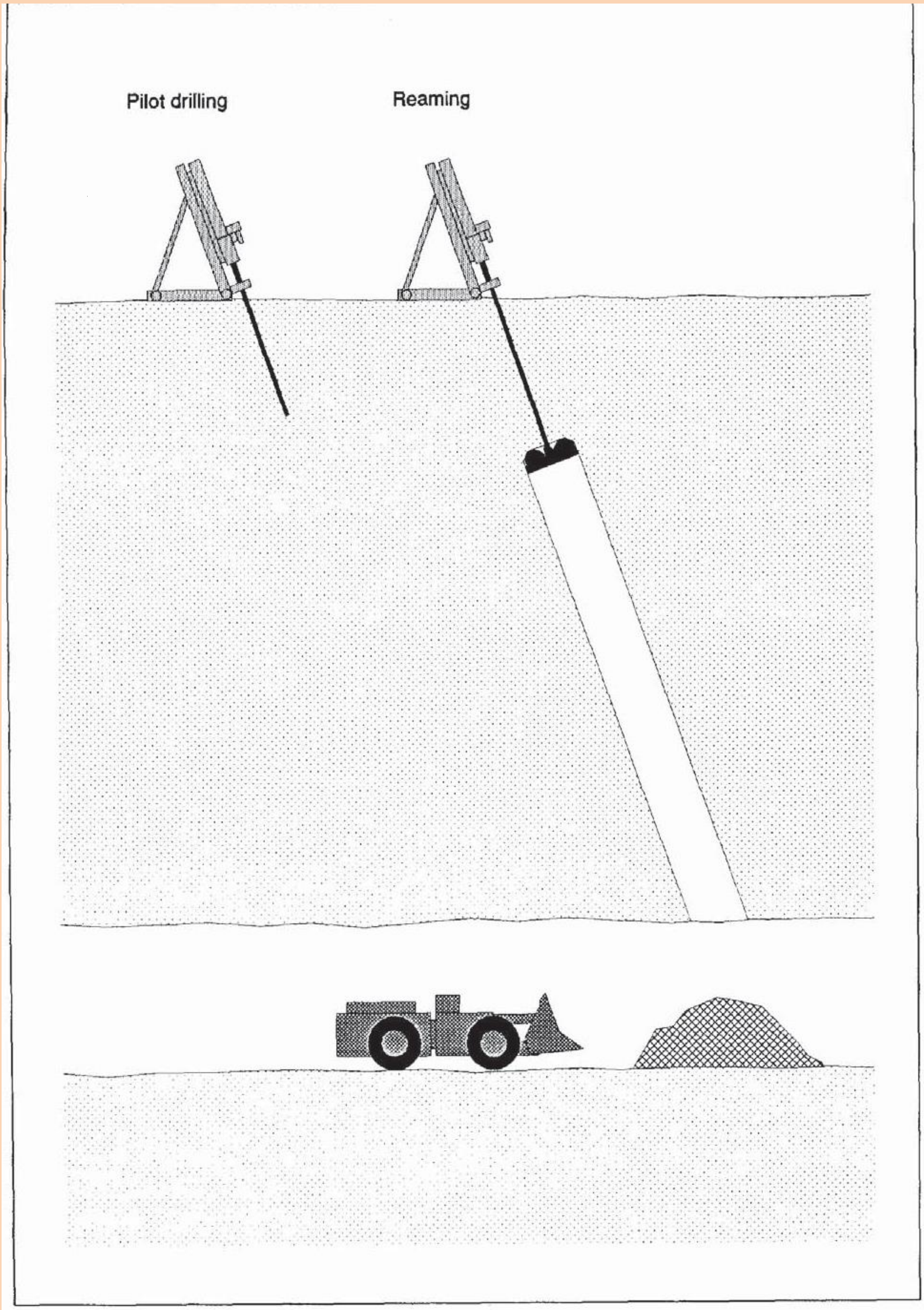
RAISE BORING MACHINE







RAISE BORING MACHINE



Shaft Excavation by Raise Boring

- *Rapid Excavation*:-It is defined as underground excavation by means faster than conventional methods. Two major organizations in the United States promote the use of rapid excavation techniques for civil and mining applications.

1.Rapid Excavation System performance:- A short section on system performance evaluation is provided for each rapid excavation method described. Simple empirical techniques, which utilize existing case study data and qualitative information, are used to estimate the probable range of system performance.

2.Cost Estimating:- Since the inception of mechanized mining, many papers have been published which enumerate the absolute cost advantage of mechanical vs. conventional construction. However, technical advancement in equipment design, owner experience, and increasing competition among contractors decreases the utility of absolute cost estimates especially when presented in a medium with an anticipated useful life of a decade or more.

- MECHANICAL ROCK CUTTING TECHNIQUES AND THEIR APPLICATION TO MECHANICAL MINING EQUIPMENT

There are five basic cutting methods and their application to mechanical mining equipment.These basic cutting methods, defined in terms of tool type, are given below:

1. Drag bit cutting.
2. Point-attack bit cutting.
3. Disk cutting.
4. Button cutting.
5. Roller cutting.

1.Drag Bit and Point-attack Bit Cutting:- The application of both drag bits and point-attack bits is similar. The tools are inserted in tool holders (boxes), which are integral parts of the cutting head, and may be held in place by a circlip or spring. Point-attack bits are commonly free to rotate in their holders. During cutting, the bits are pushed into the rock, developing cutting forces parallel to the direction of head rotation and normal forces parallel to the direction of head thrust. Roadheaders use drag and point-attack bits almost exclusively.

2.Disk Cutting:- Disk cutters generally consist of solid steel alloy discs with a tapered cutting edge. The disk is mounted in a bearing and is free to roll in response to applied forces acting parallel to the rock surface. These rolling forces are analogous to the cutting forces applied in drag bit cutting. Thrust and drag forces are applied to the disk through the bearing and act normal and parallel respectively to the rock surface.

3.Roller or Mill Tooth Cutting:- Roller or mill-tooth cutting is similar to disk cutting except that instead of a tapered disc edge, the tool is equipped with circumferential teeth . As the cutter moves in response to rolling forces, each tooth in turn is pushed into the rock, acting like a wedge, and causing local failure.

4.Button Cutting:- Button cutters consist of cylindrical or conical tool bodies inset with tungsten carbide buttons . The tool is mounted in a bearing in the same way as disk cutters or roller cutters and is free to roll in response to applied forces acting parallel to the rock surface.

- SHAFT CONSTRUCTION SYSTEMS AND EQUIPMENT

Three major rapid shaft excavation systems are described in this subsection, namely, blind shaft drilling, vertical tunneling mole or V-mole, and raise drilling. Data are included to provide the reader with a means of comparing the relative merits of each system and to assist with method selection.

1.Rotary Blind Drilling Systems:- Large-diameter shaft drilling systems are an extension of conventional rotary drilling techniques used extensively for oil well boring. Blind drilled shafts have since provided rapid access for underground mining projects throughout the world and are proven under a wide range of operational and site conditions

SHAFT COLLAR AND FOUNDATION :-A shaft collar is typically excavated using either an auger rig or conventional drilland blast mining during mobilization of the blind shaft drilling equipment.

DRILLING RIG:- Major components of the drilling rig include a mast and substructure, drawworks and tugger hoists, rotary table, crown and traveling blocks, hook, swivel and kelly.

DOWNHOLE DRILLING TOOLS:- These include the drill pipe and bottom-hole drilling assembly. Drill pipe is selected based on maximum tensile and torsional loading conditions and consideration of mud circulation requirements; data sheets are available from the pipe manufacturers.

The bottom hole drilling assembly:-It includes a drill bit, mandrel,stabilizers, and donut weights. Cutters are mounted in cutter mounts or saddles and bolted to the underside of the flat bottomed drill bit.

2.Other Blind Boring Systems:- A manned blind-shaft boring (BSB) system, with operators located underground, was developed and demonstrated by the Robbins company in the late 1970s. A 24.5-ft (7.5-m) diameter shaft was sunk to a depth of 587 ft (179 m), proving the application of horizontal tunnel boring methods to vertical shaft boring.

3. Vertical or V-mole System:- The V-mole is a horizontal tunnel boring machine modified for vertical deployment by the German firm Wirth. First introduced to construct large diameter (16 to 21.5 ft, or 4.88 to 6.55m) shafts in Europe in the early 1970s, it has since been used to construct four 23-ft (7-m) diameter shafts for an Alabama coal mine.

4. Raise Boring Systems:- Raise boring has been used to drill shafts ranging in inclination from horizontal to vertical with a majority of applications involving large-diameter holes steeper than 45° .
Setup and Equipment—A raise collar is sometimes used to support the raise drill and provide sufficient vertical clearance for the reaming head during holing through. Conventional shaft collar excavation and lining techniques typically are used to construct the raise collar.

5.Selection of Shaft Construction Method:- Selection of the appropriate shaft construction technique for a given site involves an in-depth analysis of site geomechanical and geohydrological conditions, design criteria (e.g., diameter
and depth, shape, use, life, etc), and availability and location of equipment, plus a determination of their relative impact on project cost and schedule.
SITE-SPECIFIC DATA REQUIREMENTS. The geotechnical data set required for shaft design and construction bid package preparation is essentially the same for all shaft construction methods.

- RAPID EXCAVATION SYSTEMS FOR HORIZONTAL AND SUBHORIZONTAL MINE DEVELOPMENT

1.Full-face Tunnel Boring Systems:- Full-face boring systems or TBMs have been in common use in civil tunneling for many years but are used less frequently in mining projects. Constant development and improved tooling have resulted in machines that are capable of advancing large-diameter openings in strong igneous
and metamorphic formations at rates that compete favorably, and in many cases exceed, conventional drill and blast methods. Tilley has reported advance rates up to 165 fpd (50 m/day) and 700 ft/wk (213 m/wk) for operations at the Stillwater mine.
SETUP AND EQUIPMENT. Full-face boring machines consist of a rotating cutting head fitted with disk cutters, drag bits, button bits, or various combinations of these. Advanced machines are available on which the tool type can be changed and tool spacing varied.

2.Mobile minor:- A proto type of the robbins mobile mine was introuduced in1984 for the development of a 3773-ft(1150m) decline at Mt.Isa mine,Australia. Advances of up to 12 ft/shift(3.66m/shift) were made while mining a 12ft(3.66m) high 21ft(6.4m) wide section in high strength quartzite (10000 to 39000 psi and 100 to 269 Mpa).

3.Roadheader system:-Roadheader have been in use in mining tunneling for many years and are known as under a variety of names including boomheaders, boom-type tunneling machines and selective tunneling machines. Roadheaders were originally developed as a means of advancing roadways in underground coal mines and early machines were limited to cutting relatively low-strength strata. Roadheaders offer a number of advantages over full-face tunneling machines, chiefly related to flexibility. Roadheaders can cut a variety of cross sections, limited only by the basic dimensions of the machine, and are able to cut tight curves or corners.

4.Selection of Tunnel Construction Method:- Selection of the appropriate tunnel/drift construction technique will involve an in-depth analysis of site geomechanical and geohydrologic conditions, design criteria (e.g., diameter, length, shape, use, and life, etc.), availability and location of equipmentand qualified labor, project schedule requirements and cost. The approach in this Handbook is considered to be applicable at a conceptual level of project planning.

SITE-SPECIFIC DATA REQUIREMENTS. Field data required for design and construction bidding are essentially the same for all tunnel construction methods. The site investigation program should include geologic mapping and fully logged corehole along the tunnel alignment; in certain circumstances, horizontal
boreholes are the most cost effective method of evaluating in situ conditions.
METHOD SELECTION GUIDELINES. Mechanical mining systems are now available that can rapidly mine a broad range of rock types at gradients up to 25%, while negotiating relatively tight and variably curved alignments. Further innovations and developments in cutting technology, especially with regard to water and particle-assisted rock cutting; mucking systems.