

Lecture Note on Under Ground Drilling



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UNDERGROUND DRILLING

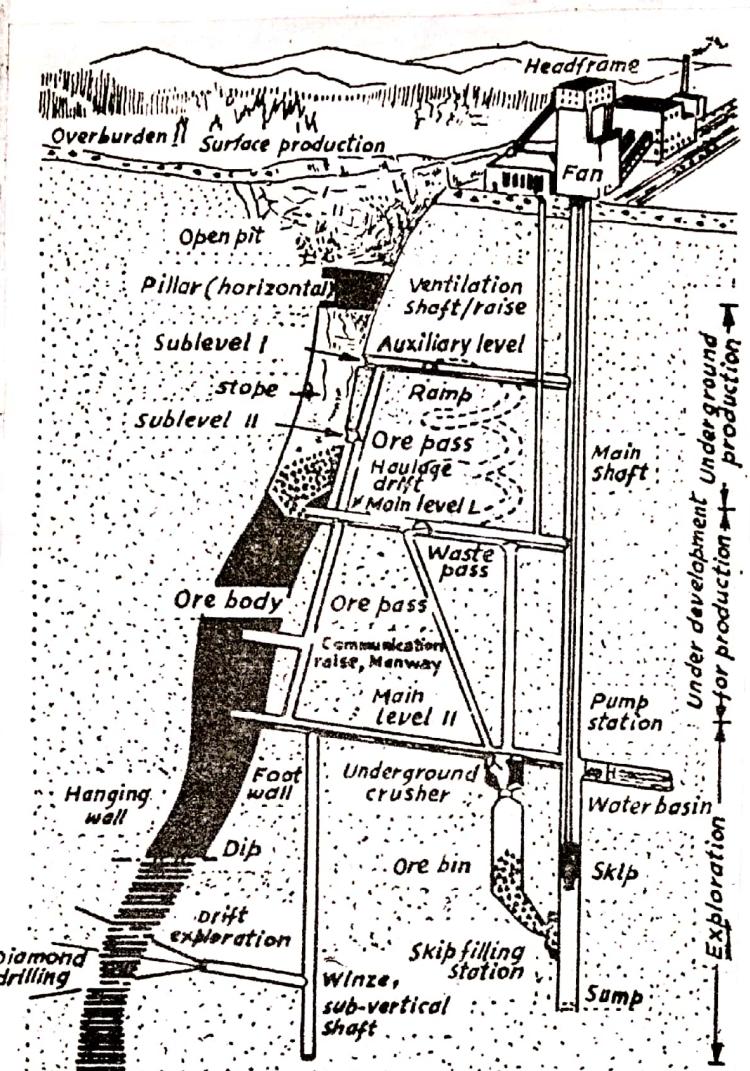


Fig. 9.1. Principal layout of a mine with steeply inclined orebody.

Underground drilling

The drilling operation which have to be carried out in underground mine for ^{blasting purpose to} excavate ore/minerals and ^{for some other} purposes such as rock bolting, roof stitching is known as underground drilling.

Blast hole drilling for U/G coal mines

The drilling operation which have to be carried out in underground coal mines for blasting purpose is known as blast hole drilling for underground coal mines.

Blasting & drilling patterns in stone drifts

Speed of drifting depends upon the "depth of pull" (or advance per round) of blasting. The greater the pull, the faster the speed as "mucking".

After the alignment and gradient is fixed, the drifting starts with drilling shot holes according to a specified form, called "drilling pattern", which consists of three groups of holes, namely,

- (a) cut holes / sumpers
- (b) Easers
- (c) Trimmers/ ring shots

Shot Holes

(a) cut holes/ sumpers

These are fired first to produce a free face for subsequent shots. They make the initial opening in the solid face and determine the depth of pull.

(b) Easers

These are placed around the cut holes to enlarge the excavation. They are in two or more rings depending on the size of the drift & are known as first & second easers.

(c) Trimmers/ ring shots

These are fired last to trim, dress and thus complete the excavation to the planned size.

- Sumpers or cut holes
- — Easers
- + — Trimmers or ring shots

* Shot holes → The holes which are used for blasting only and known as ^{blasting} holes.

Maximum depth of pull obtained in a normal size of driftage has been of the order of 2 meters in the recent past but, of late, with "burn cut" pattern, a pull of 3 meters has been achieved.

Various drilling patterns for U/G mines with sketch

Drilling patterns are named after the type of cut holes used, and principal patterns are,

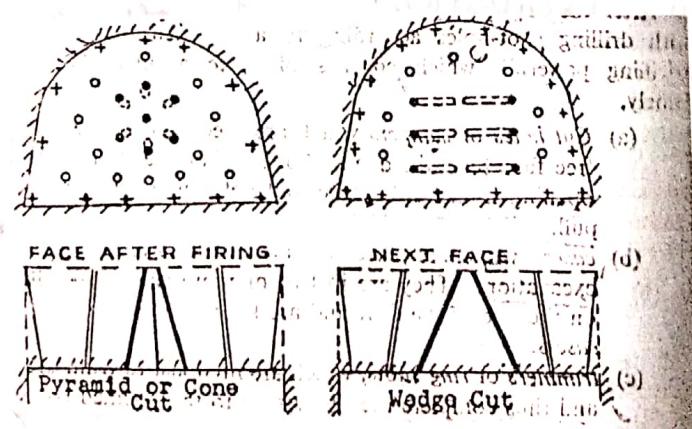
1. Pyramid or cone cut
2. Wedge cut
3. Drag cut
4. Fan cut
5. Burn cut

In general, each hole in a round covers an area of 0.3 to 0.5 sq. meter; cut holes are located about 0.45 meters vertically apart, and spacing 0.5 to 0.6 meters; trimmers are drilled at intervals of about 0.6 meters round the perimeter of the drift.

(1) Pyramid cut or cone cut

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

Pyramid cut is the most commonly used form, is suitable for uniform, thickly bedded and hard rocks. It consume the least total quantity of explosives but the depth of pull restricted by the width of the drift.

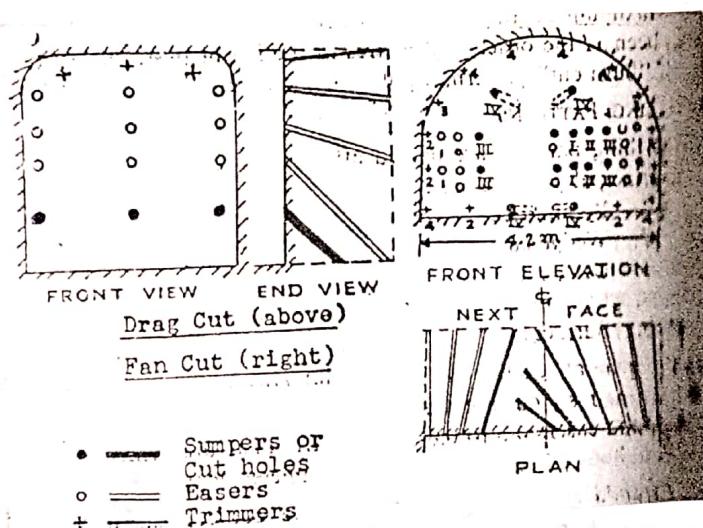


② Wedge cut

In wedge cut 2 to 4 pairs of holes 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.

A double wedge cut shown in the figure consists of two wedges formed, one in the centre and the other next to it, may be noted.

Wedge cut is the most commonly used forms, is suitable for uniform, thickly bedded and hard rocks. It consumes the least total quantity of explosives but the depth of pull restricted by the width of the drift.



③ Drag cut

Drag cut, used for small drift, 1.8 to 2.4 m wide, in well-cleaved rocks, consists in drilling holes at an angle to the cleat so that streaks break along the cleavage plane. This pattern being dependent on the direction of cleavage planes, calls for frequent changes, which are detrimental to systematic work & the pattern is therefore, not used for large excavations.

(4) Fan cut

Fan cut, favoured for laminated strata, mostly soft, covers the face with a fan like pattern as shown in the figure. As each shot has to act for itself, charge in each hole is heavy. This cut is not recommended for hard ground.

• 2 methods
forward break back
• for plastic
soft ground

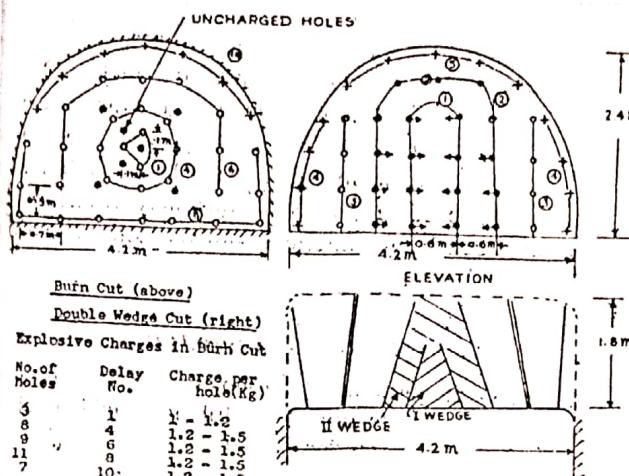


Fig. 10, 11—Double wedge cut and burn cut.

(5) Burn cut

In Burn cut, parallel holes at right angle to the face are drilled in a cluster which may take several forms one of which is illustrated in the figure. Some of the holes (which are sometimes of larger diameter than the rest) are left unchanged to give relief to the heavy concentration of explosives in the charged holes.

This cut is effective in hard, brittle, homogeneous ground which breaks evenly but cannot be used in springy plastic ground.

The advantages of this cut are,

- ① Drilling time is considerably reduced (as holes are straight drilling is easier).
- ② Depth of pull is independent of the size of the drift.
- ③ The quantity of material is less with suitable form of the cluster.

To ensure correct breaking line, the drilling pattern must conform to a fixed plan with correct depth and angles. For this marking of the drill rods, use of a template hole director or drill guide is recommended.

Various sources of power supply for U/G coal mines

Various sources of power had been come to use for the purpose of drilling in underground. They are

- (a) Steam engine.
- (b) Electric motor.
- (c) I/C engines.
- (d) Pneumatic power.
- (e) Generator operated by I/C engines.

About 1780 steam engines were increasingly used & boilers came to use upto 1850. During this time boiler were often used below ground. Afterwards compressed air were introduced in underground for the purpose of power sources. The power available for U/G maybe electricity at 450 / 550V or compressed air in most of the metaliferous mines. Development of air motors on the drills are safe under explosive conditions and in damp hot & corrosive, atmosphere that shorten the life of electric motors, resulting in hazards. Hence for underground drilling air motors prove more suitable.

Terms (used in U/G coal & metal mines)

Draft (Drive)

A horizontal tunnel or roadway parallel to the strike of the lead / vein but it can located in the country rock, either in the footwall or in the hanging wall.

Raise

A connection between two level in an ore body driven in an upward direction in underground mine.

Shaft

A shaft is a passage way to give access to, or permit contact with, underground workings. The shaft can be used to hoist waste rock and ore, to transport personnel/materials and for ventilation etc.

Incline

It is serving as haulage drifts. Inclines of the mine facilitate connecting different levels. The inclination is normally between 1:7 and 1:10 which makes it possible for self propelled, rubber tyred machines to move quickly and easily.

Tunnel

It is an access in underground whose both the ends are open to the atmosphere.

District

A district is an area in a mine having a no. of working places.

Stopes

An area from where ore has been extracted and the hangwall allow to over / supported by filling some materials like sand, blocks of granite etc.

Rotary drill machine for coal and soft stone

Compressed air hand held drill machine were applied for drilling in coal and soft stone. The introduction of compressed air rotary drill combined with the use of Tungsten Carbide bit has solve the problem of faces supplied only with compressed air power.

The machine consists of (a) main carrying at back which houses the power unit to which a handle is attached at each side. (b) The front casing which involves gear & the crank. The casing is of special, an air rotor is set eccentrically within the motor chamber & light vein of chesten centrifugal force in the radial slots of the rotor. Air enters to the rotor tums and the vein fly out to maintain rubbing contact with the liner of the chamber. The compressed air expands and finally escapes at the exhaust port. But before a vein reaches the 1st exhaust port another vein is under high pressure from the feed port. One of the handle of the machine functions as twist control for the admission of air. The rotor motion is transmitted by epicyclic gears to the chuck.

Two types of gears are available, one for coal gives a rotation to 700 rpm and another for soft stone gives a rotation to 350 rpm. chucks are made to suit the shank of the drill rod for coal and stone. But where wet drilling is employed, a special chuck fitted with a wet drilling adapter is used. Mechanical feed is desired, can be arranged most simply by the use of (i) a special feeder mounted on sprocket to run inside through a channel of iron, (ii) an extensible prop fitted with a fitting screw.

Electric rotary drill for coal and stone

As with compressed air rotary drill so with these driven by electrical drill machine design suitable for coal are with slight modification, also suitable for soft rock. It must be remember that the complete requirement at the face for the electric drill machine, that is complicated and expensive. In general electric machines are similar in appearance to the compressed air machines, the cables replace the hoses, a gate and drill pannel with an ac transformer to give the required voltage & air motor is replaced by an electric motor.

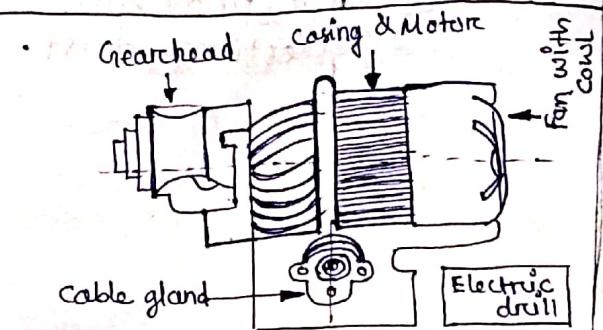
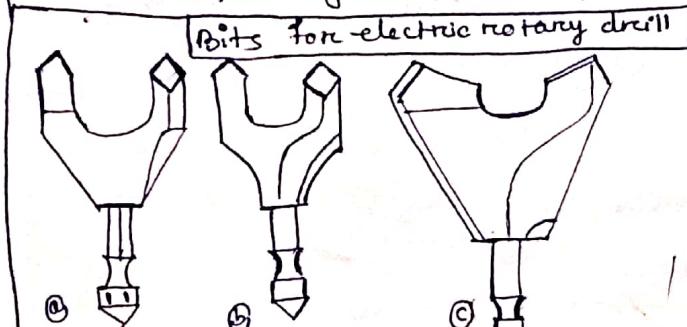
Working principle

An electric drill is a fan cooled drill suitable for drilling in coal or soft stone. The main casing is of light metal and is ribbed for strength and dissipation of heat, although the light metal fan housed under the cowl at the back of the machine ensures efficient cooling of the casing envelope. A squirrel cage motor in a flame proof machine which incorporates the two hand grips, a suitable chamber with cable gland and a gear box. The standard motor is of 114 HP. The switch is operated by a lever mounted on one of the hand grip and used in coal face, it operates the main switch in the gate in the gate & pannel by remote control. The gear box and motor are separated in a flame proof manner by an intermediate plate.

There are two types of machines, one is suitable for coal gives reduction of motor speed down to 700 rpm & other is for rock gives reduction of speed between 600 rpm and 320 rpm. In actual practice speed adopted being in accordance to nature of work or rock.

* Drills for U/c metal mines

- ① Hand drills are jumper, shucker, drifter, stoper etc.
- ② Powered rock drills are jack hammer, airleg, drifter, stoper & wagon drill.
- ③ Mobile crawler mounted drills are jumbo-boomer, + 170 hydraulic & stoper-boomer.



* Drill bits are used for underground metal mines.

- ① X bit, ② chisel bit, ③ cross chisel bit, ④ oblique chisel bit, ⑤ Double chisel bit, ⑥ pointed bit, ⑦ scoop bit & ⑧ Double bits are X-bit, starbit, Rose bit, cross bit.

Comparison between airleg and electric drill

Airleg Drill

① In U/G metal mine & other hardrock areas for drilling horizontal holes.

② Source of power is pneumatic.

③ Airleg held & pusher feed.

④ Steel body, heavier than electric drill.

⑤ Compressed air is used as flushing medium.

⑥ Chisel & cross chisel bits are used.

⑦ The drill rods are called drill steel which are hexagonal / square in cross section & hollow.

⑧ Holes can be drilled to greater depth by adding extension drill steel up to a depth of 5 meters.

⑨ Suitable for drilling in any direction.

⑩ Airleg has no cooling arrangements since it runs pneumatically.

⑪ Lubricating oil is required for air lines.

⑫ There is a provision for collecting dust.

Electric Drill

① In U/G coal mine & other soft rock areas. It cannot be used in hard rocks.

② Source of power is ac motor.

③ Hand held & manual feed.

④ steel and aluminium body, light weight

⑤ No flushing medium is required due to diamond section/auger section.

⑥ Auger bit & fish tail bits are used.

⑦ The drill rods used are square diamond section.

⑧ Holes can be drilled up to a depth of 1.5 meter only and no extension rod can be used.

⑨ Suitable for drilling horizontal holes.

⑩ There is a fan to cool the drill section.

⑪ Lubricating oil is not required.

⑫ No provision of dust collecting devices.

Rock Bolting & Roof Stitching

Rock Bolting @ Roof Bolting

The term rock bolting applied to the practice of drilling vertical holes in the roof & fixing steel bolts into them so that the bolts grip the strata and support the roof.

Tools & equipments required for U/G rock bolting

- (I) Drill machine
- (II) Bolt with nut
- (III) Breather tube
- (IV) Grout mixture (Cement mixture)
- (V) Reciprocating pump
- (VI) Cotton/ Jute
- (VII) Wrench
- (VIII) Wedge/ wooden block

Rock Bolting

Theory

Rock bolting is a practice of supporting the immediate roof of a roadway or work place by clamping the bedded strata of the roof by a mild steel bolts so as to cause them to act as one thick beam; one end of each bolt is anchored at the top of the bore hole drilled in the strata and the other threaded end holds a plate or bar which is tightened against the roof by a nut.

Functions of roof bolts / rock bolts

The roof bolts help in holding up the ground by several mechanical actions such as -

- (I) suspending loose materials from strong self-supporting ground.
- (II) building a stronger beam by tying together a series of strata to resist the movement or sag.
- (III) reinforcing the skin area of an excavation to counteract the effects of tensile, compressive and shear stresses.
- (IV) strengthening the walls of roadways, pillars or shafts against shear and compressive stresses.

Advantages of roof bolting / rock bolting

- (I) It is simple to apply, easy to mechanise and moderately cheap in cost; manpower required for fixing supports is less than with conventional supports.

- ⑩ It gives greater headroom and clearance in the roadway. This facilitates easy manoeuvring of the machines.
- ⑪ The hazards due to accidental dislodgement of conventional supports caused by derailed trolleys, blastings etc are reduced if systematically carried out. It results in greater safety and less accidents due to roof falls.
- ⑫ The supports are fireproof.
- ⑬ Handling & transport of heavy support materials involved in conventional supports are eliminated.
- ⑭ Storage space required is small.
- ⑮ The protruding ends of bolts can be used to suspend water/circ pipes and cables.
- ⑯ Stability of the support does not depend upon the condition of floor and this is a considerable advantage where floor is soft.
- ⑰ Where excavations are wide i.e. open stopes in metal mines, underground engine rooms, pit bottom excavations etc roof bolting is useful.
- ⑱ Bolts can be used to secure sides in headings and sinking pits.

Disadvantages of roof bolting/Rock bolting

- ① It cannot be applied in all cases.
- ② It gives no warning of impending failure.
- ③ Some types of bolts are not recoverable i.e. slot & wedge type.

Applicability

This method is applicable in situations where the roof is supported on solid or homogeneous sides to form a beam, such as in headings in pillar-and-stall method of working or in gateroads in coal, or with consolidated solid packs on both sides. In most cases bolted roof can span the roadway without requiring any further support. In others, roof bolts are used in conjunction with conventional arches or bars to improve the conditions and to enable spacing between consecutive arches to be increased with consequent savings in support cost.

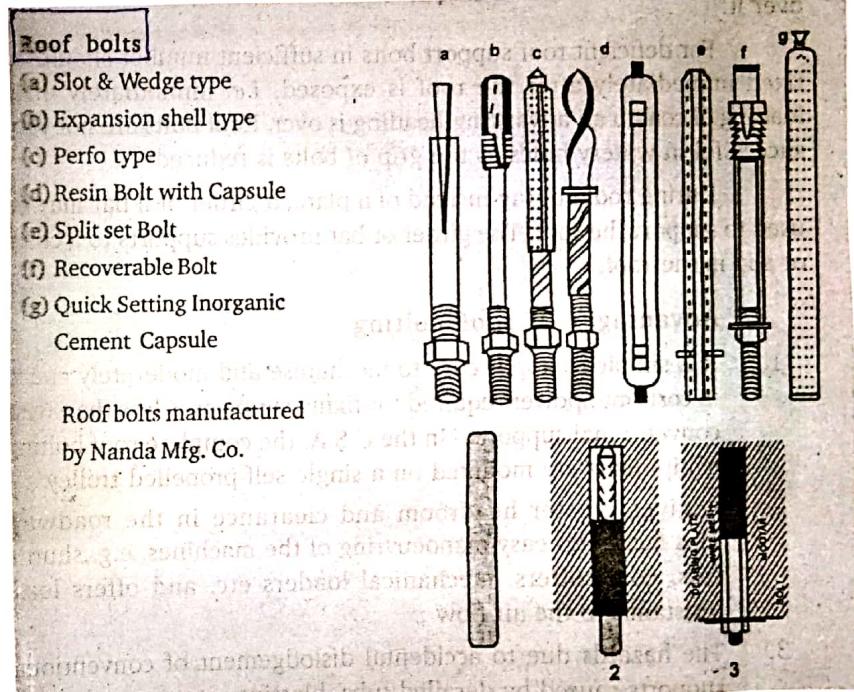
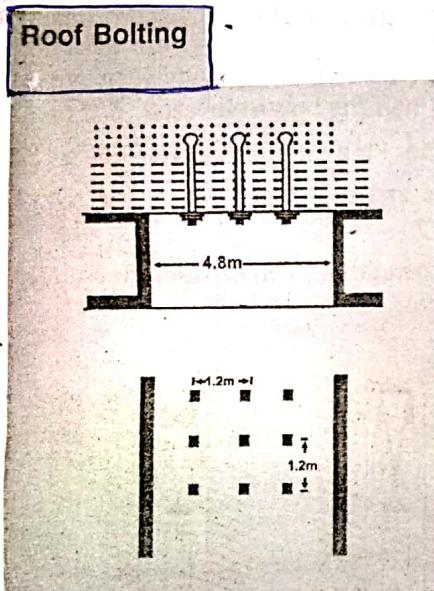
Advance bolting

• Inclined holes have been drilled for advance bolting of roof in weak strata before blasting at the face. This has proved effective where roof is so bad that it comes down after blasting.

Side bolting

In roadways at greater depths where lateral pressure is not insignificant, bolts have been used to support the sides. In such cases, smaller bolts have been used. Bolts can also be used for supporting the shaft sides permanently.

Types of roof bolts/Rock bolts



There are two types of roof bolt in common use.

(a) slot & wedge type

It consists of a ms rod 25 mm dia, nearly 1.3 m long, split at one end for nearly 160mm to 190mm and threaded at other end about 125mm to 150mm. In to the slot is fitted a wedge 150 mm long with 15° to 19° angle at the apex. This is not recoverable type.

(b) Expansion shell type

In this type one end of the steel is in the form of a wedge, when pulled it separates the two sides of a split sleeve which, pressing against the wall of the bore hole, achieves anchorage by friction. It is recoverable type. It is used in the strata which are weak or not suitable for the wedge type.

Roof stitching or cable bolting

Roof stitching is a method of roof support. Two holes are drilled from 1.4 to 1.5 meters deep. To fit the hole a wire is in the form of a tube is inserted into the hole. The wire is cut into suitable length to cover the depth of two holes and the distance between them.

$$\text{Length of the wire} = 2 \times \text{depth of the hole} + \text{distance between two holes}$$

procedure of roof stitching

(a) Drilling - A two man crew can drill 57mm diameter holes for a single strand steel cable of 7 wire strand construction uncoated cable of 16.2 mm diameter. The hole diameter allows 20mm on either side of the cable strand, so that grout can be set between the cable strand and the inner surface of the hole. Initially drilling was done at 1.9 m x 3.0 m spacing at 80° angle with the horizontal with holes varying in lengths between 6 to 18 meter.

(b) Cable replacement -

cable with its top end two wires having diameter of 5.36 mm was open and reversed to form an anchor of a fishing hook pattern. A 15mm PVC breather tube with its top end cut and tapered to 45° and tied at regular intervals of 1 to 1.5 meter with cable was pushed manually inside the predrilled hole and the other end of the breather tube kept inside a tank of water. The breather tube was used for emptying the hole from dirt & trapped air in the hole while the grout mixture is pumped through the drill hole. Escaping air bubble in the water tank indicated steady displacement of trapped air in the hole which was finally replaced by the cement mix.

(c) Circuiting - To grout the cable into an uphole, the grouting tube (20mm diameter) was inserted to a depth of 1.5 to 1.7 meter in to the hole collar. Cotton waste (soaked in thick grout) with wooden plugs was placed around the pvc tube to act as a seal near the collar, at least 24 hours were allowed to pass between plugging of the hole and starting of pumping of grout mix. cement and water in the proportion of 1: 0.5 mixed in a mixing tray & the same was pumped into the hole by using a double acting reciprocating pump. Grouting of hole continued up to until the

cement grout come out of the breather tube. The grout & breather tubes were then folded over and tied off to prevent drainage from the holes.

Tools and equipments required for U/c roof stitching

- ① Drill machine
- ② Cables
- ③ Breather tube
- ④ Grout mixture (Cement mixture)
- ⑤ Reciprocating pump
- ⑥ Cotton or jute
- ⑦ Wrench
- ⑧ Wedge / wooden block

Upward Drivage

An underground mine, in its early stages requires a carefully planned network of shafts, drifts & raises which serves for the following purpose.

- ① Enable ones to know the quality of mineral and extent as well as shape, thickness and dip of ore body, nature of the country rock, strength of ore, wall rock, nature & extent of overburden etc.
- ② Permit prospecting to be carried out from underground workings.
- ③ Provide access & transport facility for men, materials & excavated minerals.
- ④ Permits arrangement for drainage of water and ventilation of mines.
- ⑤ Enable mine planners to decide upon the method of stepping!

The formation of such network of shafts, drifts and raises mentioned above is known as development of the mine.

The opening up of a level from the shaft is essentially a matter of drivage of level roadways. These roadways are dipping at a mild gradient (between 1 in 100 & 1 in 150) towards the shaft for drainage and favourable grade for transport load from in by workings. The method of driving such roads in stone, wheather levels, drifts & cross cut with the help of compressed air operated drills with required pattern of drilling.

Raise drivage on the other hand is a regular work in metal mines. These methods have been much developed

from the traditional method of drilling & blasting. The latest method of raising includes raising by Alimak raise climber & mechanical drilling of raises.

Alimak raise climber

The method of driving long raises with the help of long machine is called Alimak raise climber. It is based on rack and pinion drive with a guid rail bolted to the hanging wall by expansion bolts. A cage for the workers and working platform attached to it climbs along the guid rail and drilling & charging of blast holes are carried out from platform.

The Alimak raise climber consists of

- ① A reel with air hose to provide compressed air to the twin air motors causing travel of the cage. The reel automatically winds up the hose when raise climber descends and feeds it during ascend.
- ② Compressed air hoses.
- ③ Guid rail with reeve and pinion. The guid rail comes in lengths 1 or 2 meter. Some pieces are covered for a smooth profile. The guid rail pieces are bolted into rock bolts fitted into the sides of the raise. The guid rails have recesses to carry 2 compressed air tubes, one water tube and a telephone cable which is also used for blasting.
- ④ The rock bolts are of expansion shell type, recoverable pressures are provided to cover up the lengths between the rock bolt & guide rail.
- ⑤ A cage that travels along the guid rail and carries the driller and other crew to the face of the raise.
- ⑥ The working platform on top of the cage, materials are transported on the platform.
- ⑦ Compressed air drive unit with air motors for travel of the cage.
- ⑧ Protection canopy.

The Alimak raise climber can be used only where the raise is driven at an angle of 45° or more to the horizontal since the rock blasted at the face of the raise has to come down by gravity.

The cage along with the platform and canopy can be made to travel along the guid rail by the drilling crew from the cage with the help of air motors. At the face of the raise the driller drills the shot hole with the jack hammer standing on the platform and well protected by the canopy. Two jack hammers are connected

at a time. Drilling over, the holes are filled with explosive from the platform. Before blasting the workers are come down in the cage so that the cage and platform can be lower and parked at a safe place away from damage by blasted rock. After blasting water and air are supplied through the glide rail to clean away the fumes by a mist of water and air and to ventilate the face. The workers are then climb up to the face in the raise climber. They dressed down the loose rock pieces at the face and the glide rail is then extended by lifting the rock bolt to the side & then anchoring the rail extension piece to it. The cage and platform can then be placed close to the face for operation of drilling & blasting etc.

Method of raise drilling or raise boring

The method of raise drilling or raise boring consist essentially of drilling a pilot hole of 230 mm to 300 mm diameter between two levels at the site and in the direction of the proposed raise and then reaming the pilot hole by a reaming bit to the size of the raise. If the pilot hole is reamed from the upper level to the lower level, known as down reaming method. If the pilot hole is reamed from the lower level to upper level, known as up reaming method. The up reaming method is commonly adopted.

The rock cuttings fall down from the face by gravity and the pilot hole need not be of a large diameter.

Down reaming method demands pilot hole of a large diameter to permit rock cuttings to pass through the hole in the space between the drill rod and hole size. Normally diameter of most of the raises drilled varies from 1 m. to 3.7 m. as raised drill bits are available in these size. But lined shaft of 5m diameter up to depth of 238m has also been drilled by the raise boring method in foreign countries.

Raise boring bits

(a) flat bottom bit.

(b) flat bottom raise bit.

Advantages of raise boring

- (a) Safety - Raise boring is much safer than driving raises by the other methods.
- (b) Mine development layouts are possible with raise boring equipments.
- (c) Speed - Raise boring is often faster, generally requiring only $\frac{1}{4}$ th time required for conventional raises.
- (d) Physical characteristics - stability of hole wall.

Water logged area in underground mines

- ① Possible occurrence of ground water in the structural features like faults. Faults might serve for the accumulation of larger quantity of water.
- ② The porosity of rock masses in the zone of surface drainage, tributary to the deposit is an important element.
- ③ Mines, wells, springs, streams and lakes in the vicinity of mine may supply much evidence of U/G water.
- ④ Deep seated springs, that feed fishes may supply water to the underground workings.
- ⑤ Water from deep seated sources ascends until it flows out from some surface vent.
- ⑥ Alluvial material permit free movement of water & an agent of supplying water to U/G workings.
- ⑦ Limestones are often cavernous and water bearing.
- ⑧ From topographic point of view basins and valleys contain water in their lowest level.
- ⑨ On mountain ranges the distribution of the U/G water is irrespective and sometimes unexpected quantities are encountered in mine working.
- ⑩ Abandoned U/G mines and open cast mines get filled with water and create a problem for working of mines below and near such water logged areas.
- ⑪ Old shafts, boreholes or drifts connecting old galleries full of water.
- ⑫ Sudden collapse of water bearing strata.
- ⑬ Sudden bursting of dams which holds large quantity of water.

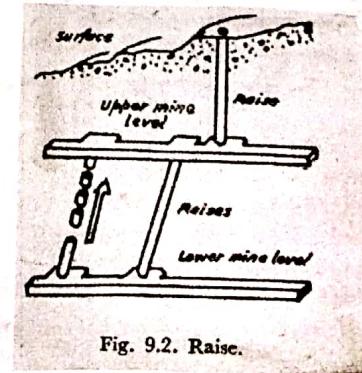
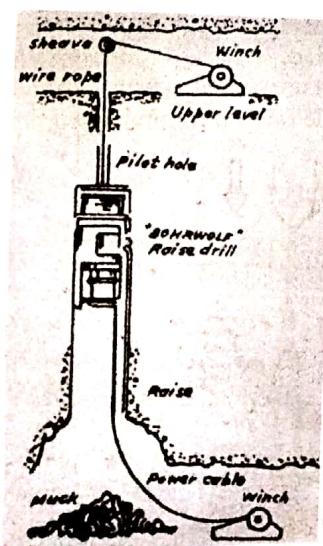
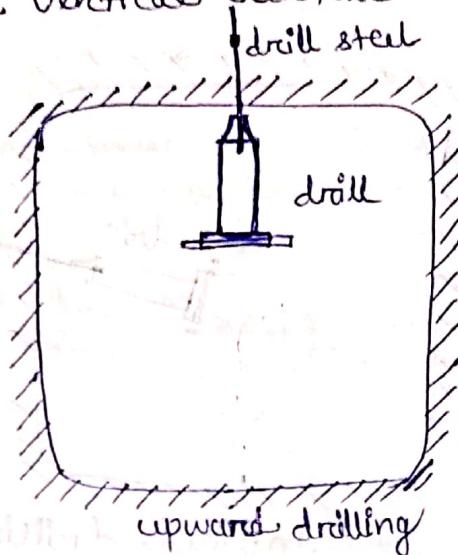


Fig. 9.2. Raise.

Difference between upward, vertical, inclined and horizontal drilling

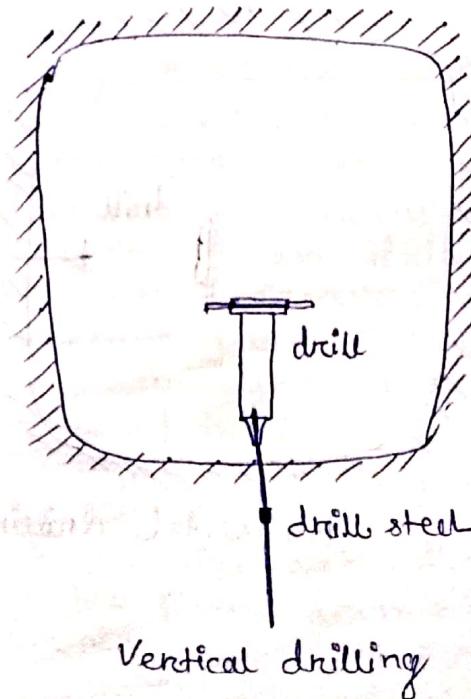
(A) Upward drilling

In upward drilling, the drill steel or drill string is held in vertically upward direction which makes an angle 90° with the overhead/roof plane or surface and parallel to the vertical plane or vertical surface.



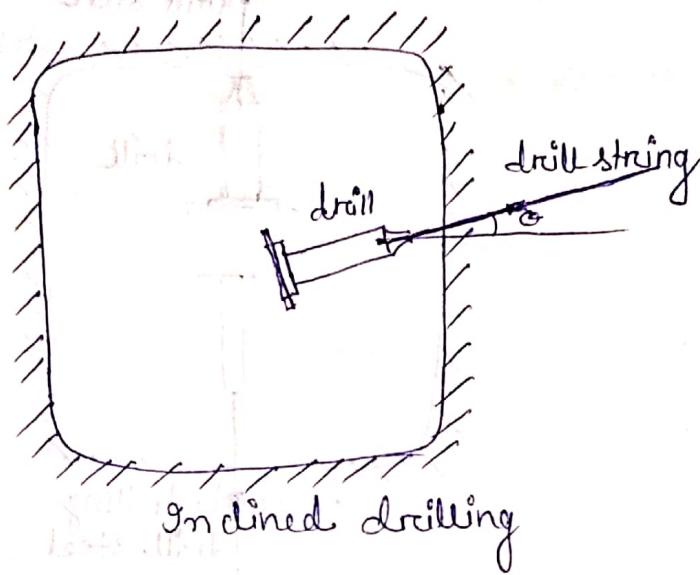
(B) Vertical drilling

In vertical drilling, the drill steel or drill string is held in vertically downward direction which makes an angle 90° with the horizontal plane/horizontal surface and parallel to the vertical plane or vertical surface.



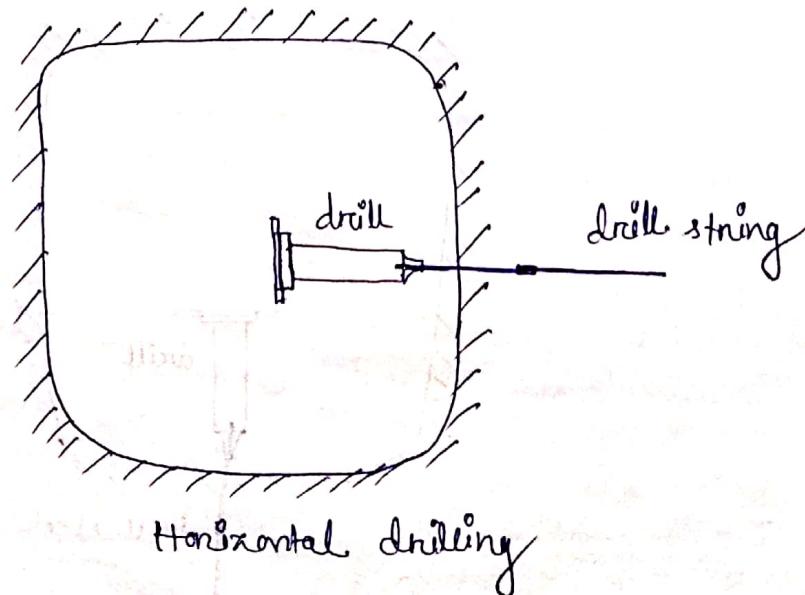
(C) Inclined drilling

In inclined drilling the drill string or drill bit is held in any direction which makes an angle ' θ ' with the horizontal surface or vertical surface but is not equals to 0° or 90° or 180° .



(D) Horizontal drilling

In horizontal drilling the drill steel/drill string is held in horizontal direction which makes an angle 90° with the vertical plane or vertical surface and parallel to the horizontal plane or horizontal surface.



Drilling for Coalfield Degassification

Methane Drainage Drilling

Methane gas exists under pressure in micro pores, joints and fractures of gassy coal beds. If methane gas can be drained from coal field/coal seams before mining begins, production from gassy mines can be greatly increased and mining can be done more safely.

As deeper coal beds are mined, the need for advance methane drainage becomes a necessity instead of an option. Proper planning in the early stage, long before the mine is opened, not only results in a safer work environment, but in a potentially more profitable operation by reducing ventilation costs & increasing production.

The observations made by the U.S. Department of the Interior, Bureau of Mines, Pittsburgh for Horizontal Drilling Technology for methane drainage and Directional Drilling Technology for coal bed degassification.

I) Horizontal Drilling Technology

Horizontal wells are constructed by drilling horizontal or slightly inclined hole into a steep slope, installing casing and screen and grouting as required. The principal difference between horizontal and vertical wells from their attitude are

- ① All horizontal wells drain by gravity.
- ② Their location depends upon the presence of steep slope.

Almost any hydraulic rotary drilling machine can be modified to drill horizontal holes. Horizontal drilling technology has been developed by the Bureau to the point where length of 1000 feet / 300 meters are easily attained. In some cases holes have been drilled to 2100 feet / 640 meters but with difficulty. Surveying to determine bit angle is an important part of horizontal drilling. Bore hole should be surveyed at least at every 20 feet / 6 meters to determine bit inclinations. If the bit begins to deviate from its programmed trajectory, bit thrust and rpm must be changed to keep the bit within the coal bed. Bit inclination can be determined by using commercially available pump down equipments such as single shot instruments.

At the start of drilling, a 6 inch/152 mm diameter hole is drilled to a depth of 22 feet/6.7 meters and 4 inch/101 mm casing is then cemented in the hole. A gas water separator that provides the means for controlling methane during drilling is attached to the steel casing. All hydraulic rotary drill to meet the demand for a high effective drill unit to relieve coal seams of methane gas. The rotary drill consists of a carrier and a trailer mounted and parked up to 100 feet/30.5 m from the carrier. By means of two hose umbilicals, the power pack transmits hydraulic power to the drill carrier. The carrier's gear type hydraulic motors are used to propel independent drive front wheels. The maximum carrier height is 39 inches/one meter. The drill head is hydraulically powered and includes a fourspeed variable controlled rotary assembly. The drill head is hinged to swing away from the line of drilling to permit room for installing a 6 inch/152 mm casing at the entrance of the hole. The drill is designed for drilling 3 inch/76 mm diameter holes to 2000 feet/609 meters horizontally with drag type or diamond crown drilling tools. Its drill head has an 11 feet/3.35 meters travel to accommodate the use of 10 feet/3 meters rods, casings or cone bunnels. Hydraulically elevated frame allows drilling angle holes or horizontal holes from 30 inch/762 mm floor level to 76 inch/1930 mm. positive or negative hole incline is 15 degrees.

② Directional Drilling Technology

The concept of directionally drilled degassification holes was originally considered by the Bureau of Mines as a means of combining the techniques to the best advantage. From a single surface site, a vertical or near vertical well could be progressively deviated to intersect coal vertically. It would also be possible to orient the drill rig in several other directions on the same surface site, and drill a succession of the directional degassification holes.

The Dyna-Drill is ideally suitable for directional drilling. The dyna drill is an essentially positive displacement mud motor enclosed in a housing and attached to a drillbit. The drill bit is driven by

the down hole motor without drill pipe rotation. Because the drill pipe does not turn, it is possible to orient the drill pipe and attached Dyna-Drill tool to control the direction of penetration. The amount of deviation achieved by Dyna-Drill can be varied by using either interchangeable bent subs or housings of various angles. Bent housings of 30 to 45 minutes have been used as directional holes drilled by Bureau of Mines. The higher the sub or housing angle, the greater the amount of deviation. A stand off ring also can be incorporated as a part of the tool above the bent assembly to hold the tool slightly off bottom on the low side & thereby increase the penetration angle. Control of azimuth is obtained by turning the bent housing.

Core & Dewatering Holes

Before beginning a directional hole, a core hole was drilled near the anticipated coal bed intercept. The core was used to confirm the presence, thickness & elevation of the coal bed, and to provide stratigraphic information for correlation to the directional hole.

The efficient production of gas from coal beds is dependent upon the dewatering of coal, which necessitated drilling of a dewatering hole. This dewatering hole is cased with 7 inch or 178 mm OD casing to a depth of 114 feet or 35 meters below the bottom of the coal bed. Communication between the cased hole & coal bed was accomplished by slotting with jet tool using a high pressure jet of water and sand.

After the directional hole was cased, the dewatering hole was stimulated using foam & sand. This procedure is designed to increase the permeability around the dewatering hole. The dewatering procedure is not scheduled to actually begin until the horizontal drilling portion of the project is completed because of the increased potential for plugging the coalbeds permeability by the drilling fluid & cuttings.

Since the dewatering hole should behave as a conventional vertical degassification well and produce gas as dewatering proceeds, it has been engineered to produce and monitor gas as well as water. So a flare stack with a flame arrestor to safely vent gas and a protective enclosure for the well head equipment. A deep holding pond will be located near the hole for disposal and required treatment of the produced water.

Some vertical bore holes is to be drilled in the coal bed in the area to be degassified by the directional hole. These holes will be used primarily to monitor the coal bed formation pressure by observing changes in water level in each hole.

A number of holes equipped with continuous recording water level devices spaced throughout the horizontal drilling pattern will allow both the degree & a real extent of degassification to be monitored.

Burnside Apparatus (Burnside safety boring apparatus)

An underground drilling machine which has replaced by burnside drilling equipment used when approaching water-logged underground working. It can drill holes of 500mm or 75 mm in diameter upto a depth of 150m at any angle upto 360°. It is powered by an electric flame proof motor of 15 H.P. A separate pump unit of 7.5 H.P. is used for water circulation but a pump to develop hydraulic pressure for hydraulic controls is integral part of the drilling machine and it has a capacity of 73 rpm at 25 Kg/cm². The drilling pipes are only 1.5 m long due to underground limitations on lengths. The safety boring attachment of the machine can shut off water at a pressure up to 45 kg/cm² and avoids possibility of danger from cecetera inundation. A pair of anchoring buckles has been provided as a safety measure to ensure that the attachment does not come out of the borehole under pressure encountered due to water logging on the other side. AW's drill rods can be inserted through the packing's of the stuffing box - this being water tight during the time of boring. After the water is tapped, the full lengths of rods.

with the horizontal with holes varying in length between 6 to 18 m and occasionally beyond 18 m. In the Surda Mine of Indian Copper Complex in India, a square pattern of drilling could not however be accomplished as the cross-bar on the drill wagon limited the spacing of two drifters to a maximum of 1.9 m. The limitation on the hole length was 20 m since longer lengths would have resulted in deviation of the holes which was not desirable.

Cable placement—Cable with its top end two wires/rods (having a diameter of 5.36 mm) was opened and reversed to form on anchor of a fishing hook pattern (Fig. 4.33). A 15 mm PVC breather tube of 1–1.5 m with the cable was pushed manually inside the pre-drilled hole and the other end of the breather tube kept inside a tank of trapped air in the hole while the grout mix is pumped through the drill hole. Escaping air bubbles in the water tank indicated steady displacement of trapped air in the hole which was replaced finally by the cement-mix.

Grouting—To grout cable into an uphole, the grouting tube (20 mm diameter) was inserted to a depth of 1.5 to 1.7 m into the hole collar. Cotton waste (soaked in thick grout) with wooden plugs was jammed around the PVC tubes to act as a seal near the collar. At least 24 hours were allowed to elapse between plugging the hole and starting of the pumping of grout mix. Cement and water in the proportion 1 : 0.5 was mixed in a mixing tray (to hold sufficient grout mix for at least one hole) and the same was pumped into the hole by using an air-powered double acting ram pump. Grouting of the hole continued until the cement grout came out of the breather tube. The grout and breather tubes were then folded over and tied off to prevent drainage from the holes. The crew kept a record of all these operations.

During grouting, the back around the hole was kept under observation for leakage etc. In case of detection of leaks, the grouting should be stopped till the leaks are plugged completely before resuming full column grouting of the hole.

Review and analysis of problems—Some of the experiences are recounted as follows:

- 1) Initially, ordinary flexible wire rope was pushed inside the 15–18 m long hole but it was difficult to push since the rope would coil inside the hole and even get jammed in available crack/fissure

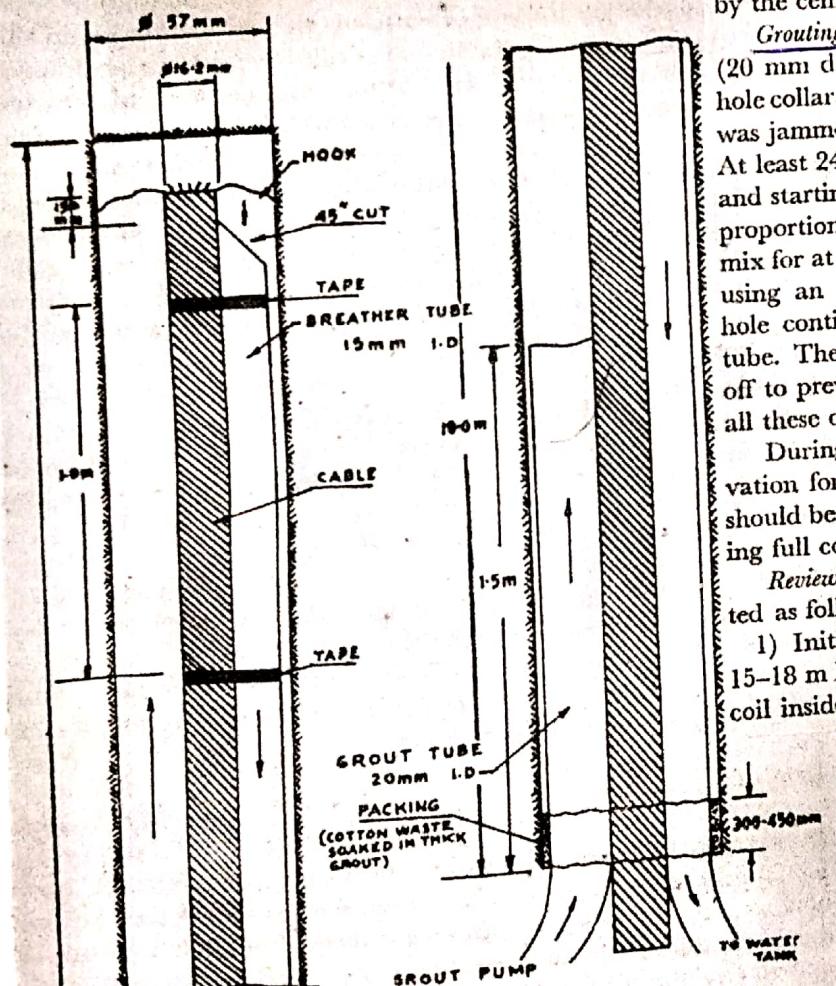


Fig. 4.33. Single cable bolt installation.

Drilling—A two-man crew can drill 57 mm diameter holes for the single strand steel cable (prestressed and relieved) of seven wire strand construction uncoated cable of 16.2 mm diameter. The hole diameter allows 20 mm on either side of the cable strand so that grout can set between the cable strand and inner surface of the hole.

Initial drilling was done at 1.9 m × 3.0 m spacing at 80° angle

Types of drilling fluid to be used in underground

The medium which is used to clean/wash the bore hole is known as flushing medium. The medium is also used to remove and transport cuttings from the bottom of the hole to surface.

Drilling fluid is a substance which is capable of flowing and act as a flushing medium to remove & transport cuttings from the bore hole to surface.

There are mainly 3 types of drilling fluid based on the composition of liquid phase.

(a) water based, (b) Emulsion type, (c) Oil based

But in underground mine, the main sources of power are (a) electric power and (b) pneumatic power.

In case of electric rotary and electrically operated rotary drills no flushing medium is required due to diamond or carbide section. But in case of electrically operated blasthole drills compressed air can be used as a drilling fluid.

In case of rock drills and combine percussive - rotary action drill, only compressed air is used as flushing medium. Sometimes foam can be added with air to increase concentration and up hole velocity.

THANK YOU