Lecture Note on Exploratory Drilling-I

BRUSHABHANU SAHOO

Dept. of Drilling Engineering.

OSME, Keonjhar

EXPLORATORY DRILLING - I

Drilling

Drilling is the cuct of digging a hole on the surface of the edrth for obtaining the corce of the strata & for other purposes which arce economical.

(a) What is corce?

It is a cylindrical shape rock piece which is cut from its mother rock by a diamond bit orc a corce bit.

Core = Geological sample obtain by drilling (coring).

(b) Explorcatorcy Drilling

The drilling operation which have to be carcried out to know the details of the mineral deposit such as thickness of the deposit, depth of the deposit, quality of the deposit, extension of the deposit & total volume of the mineral deposit is known as explorcatorcy drilling.

(c) Overburden -

The loose unconsolidated material lying over the bedrock (Hard rock formesh) is known as overburden.

(d) Bedrock - It means the hardrock which is consolidated that exists at some depth below the ground surface.

(e) Strata - The deposits of layers/subsurface layers arce called strata.

(f) vein - It is the mineralised zone. (width can be determine)

(g) vug - The empty space in the vein is called as vug.

(h) Lode - It is the dggrigate of veins. (width cannot be determine)

(i) Rig - Collectively the drilling machine and equipment set such as derrick, drill string and circulating pump etc is known as rig.

(j) Machine - Machine is a mechanical device which main function is to transmit the power orc works on the power.

(k) Engine - Engine is also a mechanical device which main function is to genercate power.

(l) Prospecting - prospecting means looking for an orce body orc a mineral body. Searching for mineral & proving its existence is known as prospecting.

(m) placer - Accumulation of heavier minerals in some places is known as placer.

All the heavier minerals arce placer minerals.

Any gravel deposit perticularly gold not found in one place.

(n) Stratified Mineral deposit

Mineral deposits formed during the accumulation of sediments on the bottom of riverbed & seabed.

These are layer by layer mineral deposits.

Purpose of Exploratory Drilling for Mining Engineering work are as follows →

The following informations are obtained from exploratory drilling for commencing mining activities.

1- Existance of the mineral deposit.
2- Depth & thickness of the mineral body.
3- Quality of the deposit.
4- Extension of the mineral body, both in depth and laterally
5- Types & Characteristics of associated rocks & minerals.
6- Present of fault & other geological disturbances.
7- Dip & strike of the mineral body.
8- Hydrological condition.
9- Stratigraphy of formation.

The above informations are put in to the following uses.

1- Knowing the market availibility.
2- Fisibility of opening a mine.
3- Deciding mining method.
4- Calculation of reserves & hence the life of a mine.
5- Planning of quality control measures.
6- Deciding pumping capacity.
7- Location of dump yard, township & stock yeard.
8- Deciding mineral benification process.

Purpose of Exploratory Drilling for Civil Engineering work are as follows →

1- To prove bed rock, benith alluvial deposit.
2- To explore geological structure on the site, Perticularly to explore for zones of faulting & brachiation.
3- Testing Load capacities of overburden.

Before commencing heavy engineering construction like multistaged building, roads, dams etc. It is required to examine the bearing capacity, tensile stress & compressive stress etc

4- Testing bed rock.

Information is required on rock formation for the foundation of heavy engineering projects that's why the bearing capacity, tensile strength, compressive strength etc of the bed rock is required for construction of projects.

5- Diamond drilled holes have another numerous applications such as making holes for pipes & cables in structure and on briges to anchore hand rails.

Concepts

Concept on size of the borce holes

Starting diameter is 200mm (8") for diamond drilling for mineral explorcation.

For oilwell explorcation the maximum diameter is 800 mm (32") for hydraullic rotarey drilling.

Concept on depth of the borce holes

For diamond drilling the maximum depth of the borce hole is 3000 meter for mineral explorcation.

For hydraullic rotarey drilling maximum depth of the borce hole is 7000 meter for oil explorcation.

concepts on deposits

① Flat deposit → coal deposits, iron orce deposit etc

② Inclined deposit → vein deposits, Cu, Ni, Gold & platinum etc

According to deposits there arce mainly two types of borce holes

① Verctical borce holes

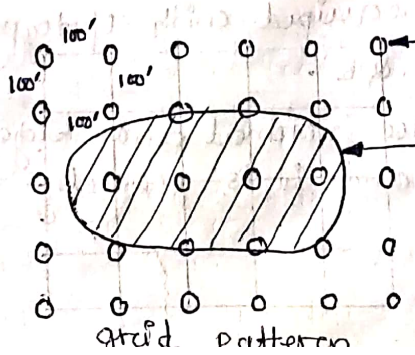
② Inclined borce holes

Verctical borce hole is adopted for verctical or flat deposits and inclined drill hole/ borce hole is adopted for vein deposits.

Spacing

Hole to hole distance is known as Spacing.

Patteren



Pattern for diamond drilling

There is a pattern for exploration of minerals is known as grid pattern or prespecified form of arrangement.

In this type of pattern, first survey the total area in which mineral maybe available. Then devide the total area in to no. of rows & columns which are equidistance (maybe 100 mt / 100' apart from each other) from each other in such a way that they forms a square area (maybe 10000 sq. meter / 10000 sq. feet). After that at each meeting point of rows & column, bore holes has to be done. This is the pattern of drilling holes i.e prespecified form of arrangement.

Example - (100 x 100) sq. meter - General Boring company
(500 x 500) sq. meter - CMPDI Ltd
(1000 x 1000) sq. meter - GSI

Technique of drilling

The technique of drilling is telescopic. It involves drilling telescopically.

Nomenclature

1st → X Series
2nd → W series
Latest → Q Series (Wireline System)

] Conventional System.

Now we are using Q series only. But for flushed coupled casings X - series

For example -

For casings → NX > BX > AX > EX
For rods, bits & barrels → NW > BW > AW > EW

Conventional system

For rods, bits, barrels & casings → NQ > BQ > AQ > EQ

Wireline system

Each rig equiped with 4 types of equipments these are N, B, A & E.

N, B, A are normal and bigger size. E is reserved size and it is rarely used.

In telescopic drilling first bore can be done by bigger size of equipment i.e 'N' and then the smaller size i.e 'B' upto a certain depth. After that hole can be made by using 'A' type equipment which is smaller than N & B type up to the desire depth of the bore hole. E is reserved size & rarely used.

Drilling Type

As we know that diamond drilling is used for exploration of minerals, mining & civil engineering work. so there are 3 types of drilling techniques.

1. Percussive Drilling
2. Rotary Drilling
3. Percussive Rotary Drilling

① Percussive Drilling

Percussive drilling employes the principle of freely falling of chisel bit against the bottom of the hole in succession. In this type of drilling pressure is applied, up and down motion given to the drill string or chisel bit.

The magnitude of motion ranges from 18" to 36" (46cm to 92cm) with a speed of 40 to 60 strokes per min. The starting diameter of the hole is 12" (30cm) & finished with 3" (7.6cm).

This type of drilling is suitable for soft as well as hard formation. If the formation is dry, water is lowered to the bottom of the hole through the bailer. In this type of drilling flushing medium is bailer.

Example - Cable tool churn drilling

② Rotary Drilling

In this type of drilling continuous pressure is applied for cutting the rock with rotary motion.

This type of drilling is suitable for soft, sedimentary, clay & stratified formations. This type of drilling is extensively used in oil field work. The flushing medium used in this type of drilling are air, mud, water etc.

Example - Calyx chilled shot drilling, Diamond core drilling, Reverse rotary drilling etc.

③ Percussive Rotary Drilling

In percussive rotary drilling penitration of drill bit in the rock occures due to the resultant action of both percussive & rotary movements. The rotational movement applies force on the bit end to break the rock particles and percussive action produces longitudinal impact on rocks resulting the penitration of bit driven in rock.

This type of drilling is suitable for hard rock formations. Flushing medium used is air / water.

Example - Jack Hammer drill, Wagon drill, DTH drill etc

Terminology

ⓐ Flushing medium - The medium which is used to wash the bore hole is known as flushing medium or the medium which is used to remove cuttings from the bore hole is flushing medium.

Example - for rotary drill → Air / water / mud
for percussive drill → Bailer / sludger
for rotary percussive drill → Air / water

ⓑ Bailer / Sludger - It is a flushing medium used in percussive drilling.

ⓒ Sludge - The cuttings which are obtained during drilling operation are known as sludge.

ⓓ Feed pressure - The additional pressure which is imparted on the bit to cut the rock is known as feed pressure.

ⓔ Feed mechanism - The mechanism involved in applying additional pressure on the bit to cut the rock is known as feed mechanism.

ⓕ Flush - The operation carried out to wash / clean the bore hole & to remove the cuttings from the bore hole is known as flush.

ⓖ Annulus Space - The clearance between the drill string and the hole wall is known as annulus space for removing & transporting the cutting from the bottom of the hole.

ⓗ Circulation - The movement of drilling fluid from pit, through pump, drill pipe, annular space in the hole & back again to the pit.

Methods of exploratory drilling

It is classified in to two types -

I. Mannual drilling methods
II. Mechanical drilling Methods

(I.)

Mannual Drilling Methods

Field of application

Suitable for exploration of placer deposits which are generally at sallow depth & soft unconsolidated formation.

Advantages

1. Mannual machine is easily assembled.
2. Transported easily to inaccessible hilly areas or rough terrains.
3. Drilling operation can easily be resumed without source of power.

Disadvantages

1. It is usually slow.
2. Holes can be bore up to 30 m in soft formation & 15 m in hard ground/formation.
3. It will also be uneconomical when the depth of the bore hole is more than 30 m.
4. It will also be uneconomical where the labour cost is very high.

Various processor methods of Mannual exploratory drilling

It includes 4 types of process/methods,

(a) Probing by piercing method.
Drive pipe & method.
(b) Wash pipe with drive pipe method.
(c) Hand percussive boring method.
(d) Hand augers

(a) Probing by piercing method and drive pipe method

Field of application - used in soft ground condition at the surface for determining depth of bed rock.

Operational principle or principle of operation

In probing by piercing method a pointed steel rod is used as a pierce. The collar of the particle striking to the rod. After withdraw can indicate the presence of mineral to be explore.

In Drive pipe method 25 to 50 mm diameter, 1.8 to 2.4 m long pipe with a slot of 6 mm width & 1.2 to 2.4 m long is used. The slot helps in griping the soil core inside the pipe when it is driven into the ground. samples are collected after withdrawl & cleaning of pipe.

(b) Wash pipe with drive pipe method (Wash boring)

Field of application - Used in soft strata for knowing the depth of bed rock below the ground surface & for inserting standpipe for diamond drilling.

Equipments used - (i) chisel bit, (ii) wash pipe, (iii) Drive block (iv) manila rope, (v) Water swivel, (vi) Drive shoe, (vii) Drive pipe or casings, (viii) Jar collar, (ix) Derrick leg, (x) Hand winch, (xi) Single acting reciprocating pump.

Figure -

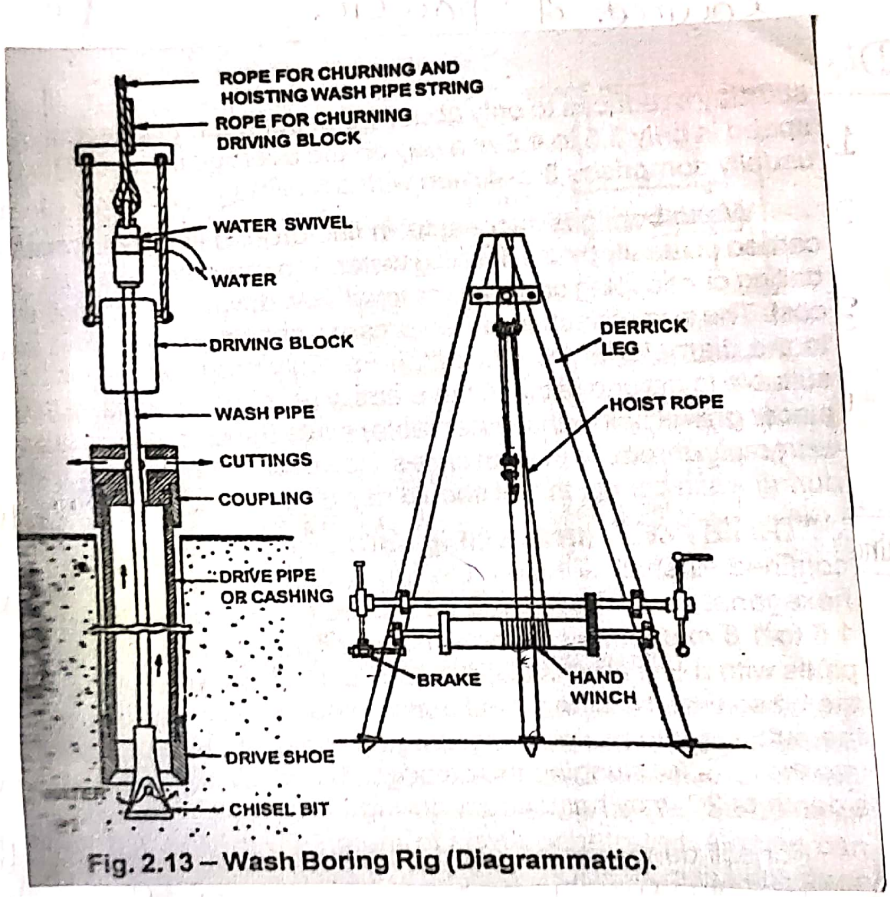


Fig. 2.13 – Wash Boring Rig (Diagrammatic).

Principle of operation or Operational principle

The rig consists of a light portable tripod derrick fitted with a sheave for a manila rope. casings/drive pipe are shunk in the ground. The inside formation is broken up by a jet of water from a string of wash pipe running inside casings. water is fed in to wash pipes through a swivel joint & rubber hose pipe from a hand operated pump. The jet of water is normally work ahead of the casing in the soft ground and the casing sinks by own weight or can be made to sink by rotating it with the help of a pipe wrench. If harden material is encountered during wash boring, a chisel bit can be attached to the bottom of the string of wash pipe which is then churn up & down by hand.

The cuttings are removed from the bottom of the hole by the flushing water jetting out through the nozzole. Gravel & Pables are often left in the hole while the sand is washed out. The pables can be bailed out by a bailer if sufficiently small in size, otherwise they have to be broken up by a cross chopping bit before bailed out. Boulders are drilled through ahead of drill pipe/ drive pipe and blasted by a catrige of explosive before the casings shunk through the broken rock.

The casings in the hared ground, has to be fitted with a drive head at the top & drive shoe at the bottom. casings are shunk by applying successive blows to the drive head by drive block which is churned up and down by means of hand winch. The pipes are pulled up/ pulled out from the holes after the hole has served its purpose.

Wash boring is rarely used for depth exceeding 30 meters.

(c.) Hand percussive boring method (Spring pole drilling)

Field of application – Hand percussive drilling is used for unconsolidated ground for prospecting placers deposit. The drilling is commonly used for alluvial formations.

Figure –

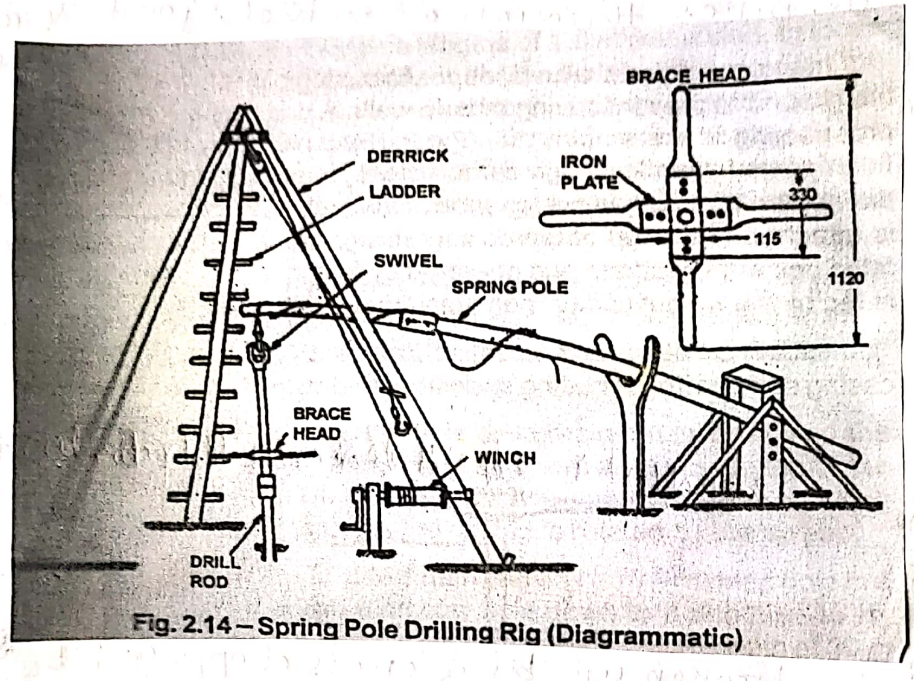


Fig. 2.14 – Spring Pole Drilling Rig (Diagrammatic)

Equipments used – ① chisel bit, ⑪ Drill rod, ⑪ Rocking lever, ⑪ Swivel ⑤ spring pole, ⑥ winch, ⑦ derrick

Operational principle or principle of operation

The rig consists of tripod derrick fitted with a hand winch & crown sheave. A string with a round or hexagonal drill rod with a chisel bit at the end is churned up & down by the rocking lever which is 6 m to 9 m long fulcrum to give a leaver ratio of 1:3 to 1:5. The rocking lever is rocked by one or more men. The rods are turned by a brace head in a direction that would tighten the screw joints. Water is forced in the hole to keep cuttings or sludge. A hand pump with a flapp or ball valve at the bottom is used to bail out cuttings.

(d.) Hand Augeres

There are 4 types of hand augeres,

1. Iwan type auger
2. Ship type augere
3. Closed type aleger
4. Jamaica open spiral type auger

Field of applications of augers-

Iwan type auger is suitable for soils perticularly those that are sufficiently stable. so that hole will remain open.

The ship auger is most effective in clay and cohesive material.

The closed type & Jamaica open spiral type are slitly developed type, used where satisfactory result are not obtained with ship auger.

Figure -

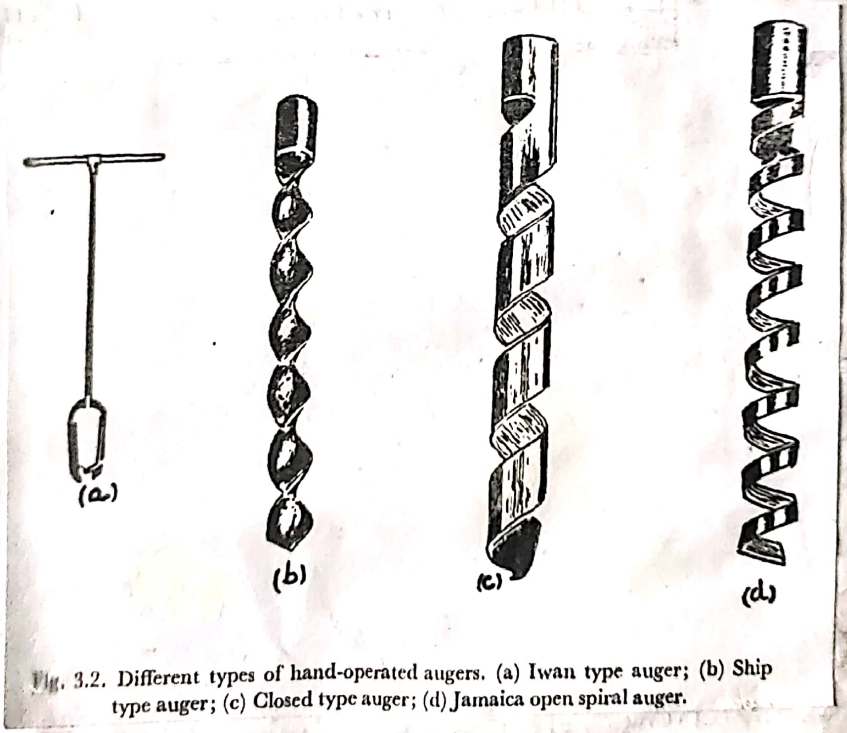


Fig. 3.2. Different types of hand-operated augers. (a) Iwan type auger; (b) Ship type auger; (c) Closed type auger; (d) Jamaica open spiral auger.

Theory (opercational principle)

Iwan type of auger is probably the most popular single tool for hand operation. For soil sampling the Iwan is supplied within sizes from 3 to 8 inch/ 76 to 203 mm in diameter. The sample is obtained by pressing the auger into the ground and turning it at the same time. When the blades are loaded with all the soil that can be held, the tool is withdrawn &

The ship auger is most effective in clays & cohesive materials and is available in 2 inch / 51 mm size. When the earth to be sampled is not self supporting, it can be dug until it starts to cave with an Iwan & then with casing in place, the sampling can be continued with a ship auger of next smaller size or with one of the other augers.

The closed spiral auger and the Jamaica open spiral auger are variations developed for use where satisfactory results are not obtained with a ship auger. The closed or open spiral design of these augers remains the sample in soils where ship auger would give poor recovery.

Both the open & closed spiral augers are available with an outside diameter of 2 inch / 51 mm.

(II.) Mechanical exploratory drilling Methods

Different types of Rotary drill

The different rotary core drills deploy to obtain the core of the subsurface strata are,

1. Diamond core drill
2. Calyx chilled shot drill
3. Hollow stem auger drill
4. Hydraulic rotary drill

Field of applications of rotary drills

(1.) Diamond core drill.

It is suitable for soft to medium and hard rock formations such as sand stone, Laterite, Igneous rocks etc.

(2.) Callyx chilled shot drill

It is suitable for medium hard to extreme hard formations such as granide, dolerite, chert etc.

(3.) Hollow stem auger drill

It is suitable for soft to very soft and partially hard formations such as mud, clay, talk, gypsum, coal, black cotton soil etc.

(4.) Hydraulic rotary drill

It is suitable for Stratified formations or Sedimentary formations such as sand stone, limestone etc.

1. Diamond core Drill

principle of operation

After drrick, rig and pump has been set up, water swivel is fitted to the drill string.

The drill string is griped by tightening the chuck.

The rotary motion & feed presseure is emparted to the drill string.

Then the circulating mud pump is started and the circulating fluid passes downward through the water swivel, rod string and then to the core barrel and emerged out at the bit face.

The water cools the bit & carries the cuttings to the surface through the annulus space.

This return water is channeled to a sludge pit, where the cuttings are setteled down and the clean water is drawn by sucction hose of the pump for recirculation.

The bit cuts a corce of rock and is accomodate in the core barrel.

When the barrel is full with corce the drill string is hoisted up by disconnecting rod one after another, until the core barrel is reached to the surface.

Then the core barrel is emptied and again the barrel is lowed in to the hole by changing the worn bit if it is required.

Drilling operation starts with sinking the standpipe and casing through overburden. In case of lose overburden standpipe maybe driven by wash boring method. A single string of casing can be incerted easily down to the depth of 20 to 30 meter.

Beyond which it is better to drive a 2nd or 3rd string of casing about 25 mm smaller in diameter to the previous casing up to a depth of 80 to 90 meter.

Mechanical features

(i) mounting, (ii) Prime-mover, (iii) clutch, (iv) Gearbox
(v) Spindle, (vi) Hoisting drum, (vii) Cathead, (viii) Dennick
(ix) chuck (x) Pump (xi) Drillstring consists of
- @ waterswivel
- ⓑ Drill Rods
- © Core barrel
- ⓓ Reamer shell
- ⓔ Core lifter
- ⓕ Bit (Diamond / TC)

Figure -

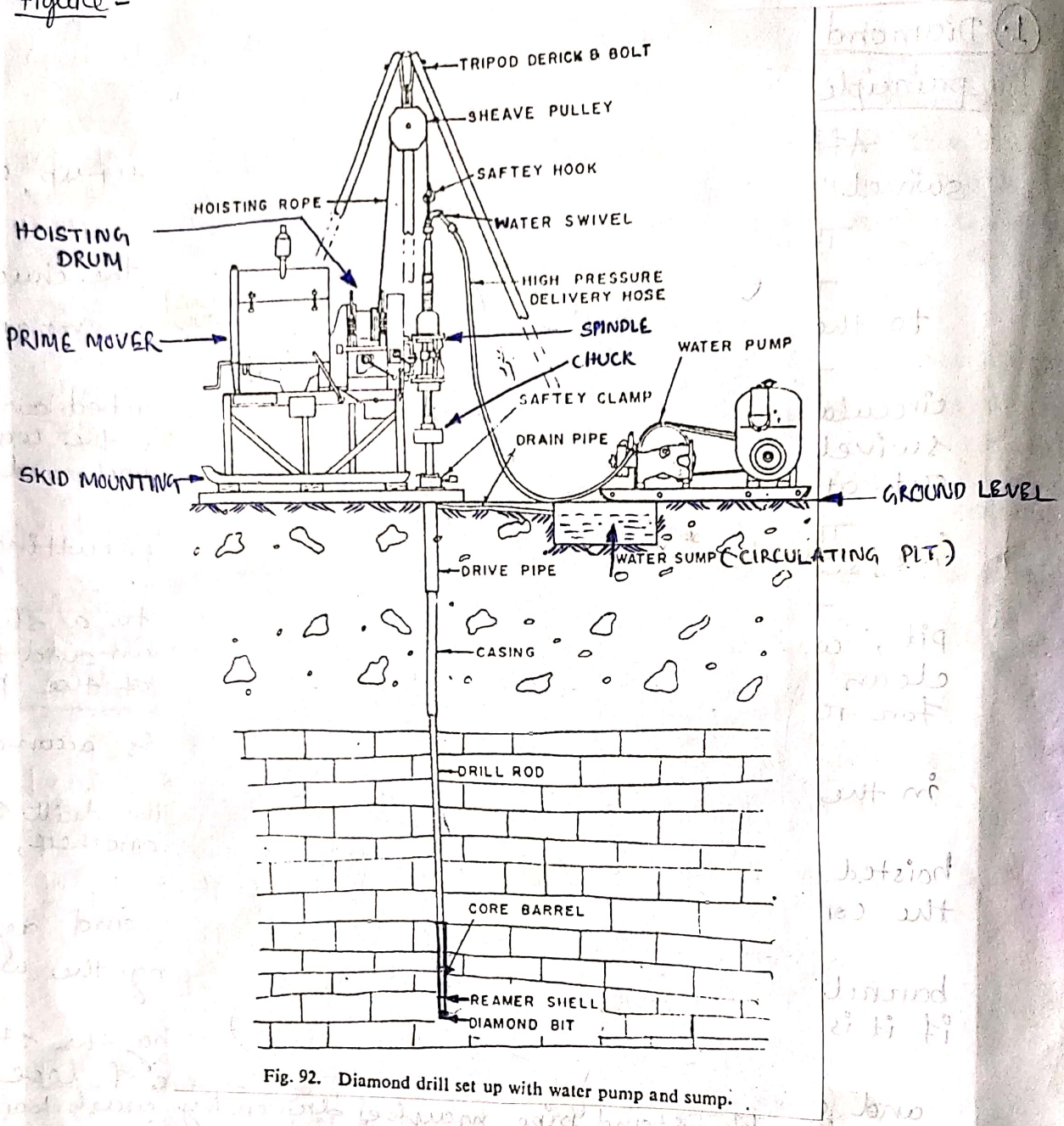


Fig. 92. Diamond drill set up with water pump and sump.

procedure of Diamond core drilling

1- Site preparation or priliminary arrangement.
2- Setting of rig, pump and derrick.
3- Assembling of drill string or drill collumn.
4- Starting of drilling operation.
5- Coring operation.
6- Lowering of drill string and continuing drilling operation.
7- Lowering of casing string.

priliminary arrangement (site preparation)

The area is to be cleaned and levelled by (20-30) x (20-30) feet square.

Digging foundation for rig, pump, circulating pit and settling pit.

Concreting the rig & pump base and cementing pits.

Shifting the drilling equipment to the drill site.

Setting of rig, pump & derrick

The rig and pump are setted in the site.

The derrick is to be irrected and centered with the allignment of the borehole point.

Tightening of the bolts for proper anchoring of pump and rig.

Assembling of drill collumn

For starting of drilling operation, the starting barrel and bit are assembled together with core lifter and reamer shell.

place the above item below the chuck.

Drill rod is to be poured through swivel head and screwed the starting barrel on the bore hole point.

Tiften the chuck and rotary motion is emparted for continuing drilling.

Starting of drilling operation

Apply required feed pressure.

Continuing drilling up to 2', so that the starting barrel is enter in to the ground up to the depth of 2'.

Then it is hoisted up.

The cuttings are to be taken out of the core barrel and kept in the core box.

Assembled the core bit, reamer shell and core lifter to a 5' long core barrel. Then lower the core barrel in to the ground as earlier done.

Lift the drillstring a little up the bottom and continue drilling etc give rotation as well as pressure.

Continuing drilling up to 7' depth and remove the drill string as earlier. Take out the core from core barrel and assembled the core bit, reamer shell & core barrel to a 10' long Nx core barrel and lowered the string. Repeat the process up to 10' that is 17'.

Continuing the operation up to the planned depth or desired depths & keep out the core from the core barrel.

Coring operation

Continuing drilling up to the length of core barrel i.e 10' & then drilling is suspended.

The drill string is hoisted a little up from the bottom by upward feed pressure.

The hole is cleaned throughly.

While upward pressure being empanted to the drill string, it is required to give high pressure for few second. so that the core will broken from its mother rock.

Then the drill string is hoisted up to the surface after disconnecting the rod one by one.

When the core barrel is removed from the hole bit is opened. Keeping the core barrel in inclined position, a slight hammering action is given the core will be get out of the barrel.

Keep the core in the core box and mark its depths.

Lowering the drillstring and continuing drilling operation

Lower the core barrel with bit to the bottom of the hole by adding rods one by another.

Raising the drillstring slightly up and continuing drilling operation by giving rotation and feed pressure as earlier.

Lowering of casing string

No drilling should be continued for the open hole more than 30'.

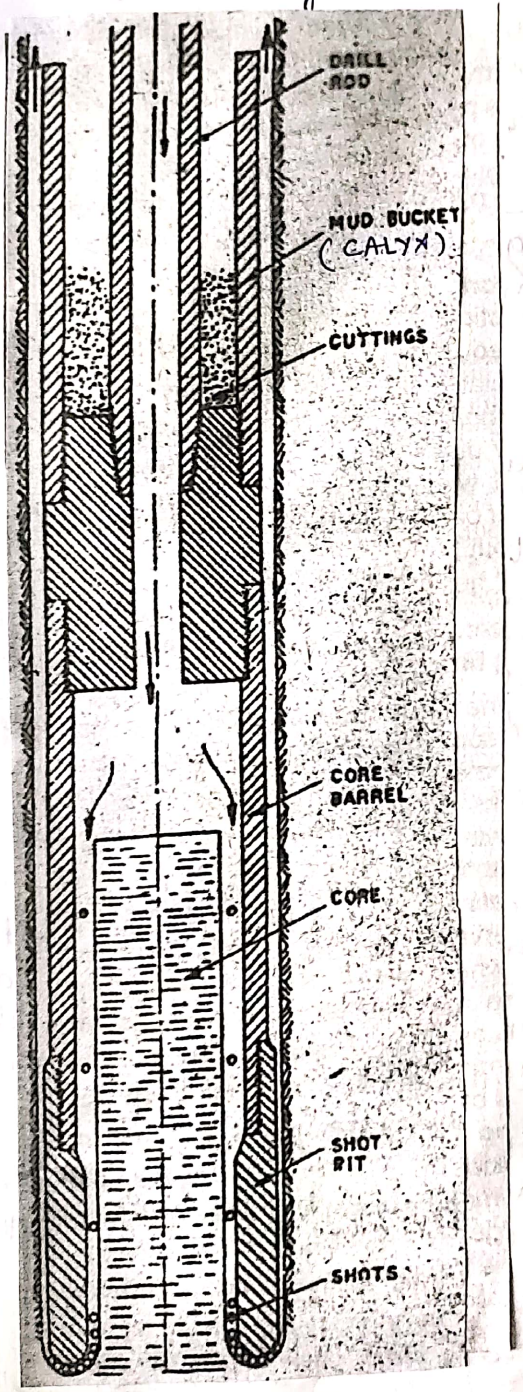
Reaming operation should be continued and the NX-casing should be lowed with casing shoe bit.

For continuing further drilling operation the above are the procedure of diamond drilling.

(2.) Calyx Chilled Shot Boring

Mechanical Features

1. Mounting - Skid
2. Source of power - I/C Engine
3. Belt for power tansmission
4. Rotary table
5. Light tripod derrick with sheave.
6. single acting simplex reciprocating pump
7. Drillstring consists of (i) water swivel
   (ii) Kelly
   (iii) Drill pipe/rod
   (iv) Calyx/mud bucket
   (v) Core barrel
   (vi) Saw toothed cutter
   (vii) Chilled shot



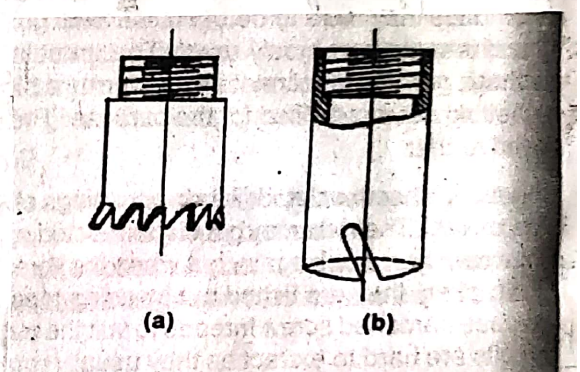


Fig. 2.22 — (a) Toothed Cutter (b) Chilled-shot bit

Important compo...

Drill string of calyx chilled sh...

Chilled Shots

These are finely devided steel particle which are heated to a high temperature and then suddenly chilled in to ice water, so that it will became as hard as diamond and cut rocks which can not be cut by a diamond bit.

Calyx

The inverted cone barrel fited in the barrel head in chilled shot boring for the accumulation of sludge is known as calyx.

There are less annulus space at the core barrel and calyx. The cuttings cut by the cutter with the help of chilled shots are move upward with more pressure due to shortage of space. At the end of calyx there are more annulus space for which the velocity and pressure of the circulating water decreases. Hence the cuttings are moving upward are deposited in the calyx.

Saw toothed cutter

This type of bit is only suitable for boring through sedimentary rock of medium hardness to extreme hard formation.

It consists of a steel tube having teeth at one end. The front of the teeth being vertical and the back of teeth are sloping at an angle that rotated at the rate 50 to 100 rpm. It has jerkewing and chipping action on the rock. It is screwed in to the core barrel to cut the rock formation.

Kelly

The Kelly is a heavier section steel tube. It has one end box thread and another end is peen thread. Water swivel is required to fit on the top of the Kelly for conveying circulating water. It's lower end having peen thread attached to the drillpipe.

Kelly helps to transmit rotary motion from the rotary table which is driven by an I/C engine through the bevel gear arrangement.

The cross section of the Kelly may be square or hexagonal which is meshed with inner axis of the rotary table.

★ Field of application

The calyx chilled shot boring can be bore hole from a 4" to 36" diameter. Important application of this method of boring in mines ventilating shaft & artesian water well boring.

Principle of operation

Like diamond drilling the cutter is rotated by hollow rods powered by an I/C engine.

Chilled shot of $\frac{1}{16}$" and $\frac{1}{18}$" are fed in to the rods with the washed water passed in to the inner periphery of the core barrel and saw toothed cutter. Under the cutter some being crossed and other remaining unbroken and are rolled along under its edge.

Diagonal passage in the cutter allows to pass flushing water to the annulus space without displacing the lifting shots.

The sludge collected in the calyx (hollow cylinder) above the core barrel which is open at the top. As the rod are of smaller diameter than the calyx, the velocity of raising water decreases permitting deposition of the sludges in the calyx.

Rotation to the drillstring is imparted through rotary table which is driven through bevel gear arrangement obtaining power by a belt or chain from an I/C engine.

The weight of the drill rods gives sufficient pressure on the bit as feed pressure. In case of smaller size rod additional pressure is applied by a rock feed sand wheel rotated at 50 to 100 rpm.

Coring operation in calyx chilled shot drill

Instead of using mechanical core lifter as in diamond drilling, the core is gripped by weighing it in the barrel with angular pieces of quartz droped through rotating rod.

★ Disadvantages of Calyx chilled shot Boring

Calyx chilled shot boring is resembles fore diamond dri but fore general boring purposes it suffers disadvantages

1. It is not suitable for boring holes less than 4" diame
2. Inclined hole cannot be bored by this method.
3. It is restricted in certain types of ground such as clay, mud etc.
4. Power cost is higher than diamond drilling.
5. It is suitable for boring in hard ground only.

Difference between diamond and callys chilled shot drill

These two methods of drilling fulfilled some where different purposes although both are used in hard ground & both are used to obtaining the core of the strata. But the difference between them are as followes,

1- Diamond drill is essentially an instrument for boring small hole at any angle quickly & cheaply to get accurate geological information.

Callys chilled shot drilling method cannot bore holes less than 4" diameter or other than vertical downwards much less satisfactory core is obtain due to disintegrating effect of chilled shot on core.

2- The diamond drilling holes can bore more than 36" diameter only for the purpose of obtaining the core of the strata.

The chilled shot boring maybe used for holes upto 36" in diameter or more which canbe used for the purpose of ventilating shaft, boring for artesian water well for irrigation & drinking water and sand line for storing purpose.

3- Callys chilled shot boring offers better results in hard crystalline rock like conglomorate, grits, chert etc specially where there is excessive wear of diamond.

In soft rock chilled shot drilling fails due to shots becoming embarded in to the formation thereby stoping milling action.

Chilled shot drilling is suitable for large and very large hole where an accurate core of the strata is not essential.

4- The callys chilled shot drilling can satisfatory follow diamond drilling in the same hole if it is large enough diameter but it is not usually desirable for the diamond drilling method because of difficulties of removing out all the shots from the hole. As the remaining shots are liable to damage the crown and to loosen the diamond.

5- When diamond drilling is used in succetion to chilled shot drilling. some devices such as clay plug is incerted in to bore hole to remove shotsbefore incerting the diamond crown.

6 - A core lifter is never used in chilled shot because the lifter may be levelled to damage. For this reason core is always taken up by broken piece of crockery. These pieces are angular pieces of quartz which are droped down by circulating water.
These pieces became jammed and wave in between barrel and core and recovered by giving sudden jerk.

Selection and application of drill

The choice of drill has direct relation to the formation to be drilled. It is to be kept in view that correct drill is to be selected for the speedy or sucessful operations for perticular job requirment.

As the condition of ground varies from region to region and to meet the diversed job requirments like different formation including alluvial, semiconsolidated and hard rock, the selection and choice of equipments depends on a no. of factors.

(I) Cost of equipments

Percussion drill is less costly as compaired to rotarey drill. power requirment for percussion drill is less and repare is also cheaper. But power requirment for rotarey drill and repare cost is more.

(II) Choice of equipments

choice of equipments depends on following factors.

(a) Formation to be drilled.
(b) Relative speed of drilling for performance for time bound programme.
(c) Depth to be drilled.
(d) Anticipated drilling hazads.
(e) Approachibility to the site in area of operation.

(III) Mounting

The rig should be mounted on skid or on trailers or on truck. The mobility requirement is to be assesed, before choice of mounting is decided for the drill.

(IV) Source of water

The source and availability of requisite amount of water is to be assured. The requirment of water especially in the zone of lost circulation is more.

(V) Repair facility

In remote areas where repair facility is not available, major repaires cannot be done & hence cost of mitnage will high.

(VI) Capacity Rating

According to the depth and size of the h
rigs of various capacity are available. Hence from
capacity of rating and angle of drill hole, the dri
maybe considered as per depth to be drilled.

(VII) Drilling performance

The rig should gives best operation effici
simplicity of operation, performance and lowere
operating cost should be selected.

(VIII) choice of formation

The choice of formation i.e sand, clay, grav
hard rock has a direct effect on the drill to be

(IX) Labour cost

Rotary drill needs a lesser staff per shift
getting operational efficiency. percussion drill staff
be trained in lesser time for running the machin

where labour cost is low percussive drilling is suitable.
where labour cost is high rotary drilling is suitable.

(X) Terrain

The topographical condition of the ground is
as terrain.

For flat terrain truck & jeep mounted drills a
suitable. for inacesseable mountaneous area skid m
drill is suitable.

Problems encountered during diamond core drilling

The common problems encountered during diamond core drilling are,

(a) Caving of hole wall
(b) Loss of water / water lost
(c) Parting of rods
(d) Jamming of rods
(e) Loss of bit
(f) Loss of diamonds
(g) Reduction in core recovery

(a) Caving of hole wall

Cause - Due to Loosen ground.

I - Sinking stand pipe is lowered to the hole upto 4' to 5'.
II - Casing is lowered to support the wall of the drill hole.
III - Cement grouting maybe done in place of caving.

(b) Water Lost / Loss of water

Cause - Due to broken ground & fissured cavity.

I - Lowering of casings to the borce hole.
II - Pumping down bran, saw dust, cow dung etc.
III - Cement grouting is pumped down to the rock. For this purpose quick setting cement is used.

(c) parting of rods

Cause - Due to fracture & striping of threads of rods.

I - Avoid jerck and high downword pressure.
II - Avoid unscrewed rods.
III - Avoid reverese rotation.
IV - Broken & stripped thread rods are removed from the hole & perfect threaded rods maybe used.

(d) Jamming of rods

Cause - Due to caving formations, mud rush, worn bit, Little clearance

I - Cement grouting and casing in time.
II - Closely watch while drilling against caving formations.
III - Jamming of rods from sudden cave, sometimes over come by reversing rotation and running back the feed without stoping the engine.
IV - pumping water while hoisting until rods are above danger zone.
V - Pumping water before Lowering the rods.

VI- pulling jammed rod by jerk.
VII- Keeping more working clearance between rod casings.

(e) Loss of bit

Cause- Due to breakage below core barrel and unscre

I- Avoid too high downward pressure.
II- Adjust the speed of rotation according to the st
III- Use bit recovery tap (male and female) to recove loss bit.

(f) Loss of diamond

Cause- Due to loose setting, excessive pressure & tem extreme hard ground and excessive rotation.

I- Select the bit according to rock characteristics.
II- Give Low rotation in harder strata.
III- Recover the lost diamonds by lowering old bits or by lowering a bailer with a flapp valve or b reverse flusing medium.
IV- clay plug maybe used.

(g) Reduction in core recovery

Cause- Due to washable formation and broken strat

I- Air flushing medium may used.
II- Reducing quantity of circulating water.
III- Minimising vibration of drill rods.
IV- Use of double tube (D.T.) core barrel.
V- Frequent raising of rods in soft formation.
VI- Running drill with Lower speed and high pr to hard rock.
Running drill with high speed and Low pre to soft rock.

Formation problems

Water lost / Lost circulation

It is defind as the loss of substencial quantities of hole water to an encountered formation.

Causes

I - Lost circulation occoured when the formation permeability is sufficiently great to accept hole water.

II - The voids are too laroge to be filled with water.

III - If the water collum pressure exceeds the formation pressure

IV - Faulted, Jointed and fissured zone may occoured in any type of formation is the most common source of lost circulation.

prevention

I - Lowering of casing.

II - Cement grouting is pumped down to the rock.

III - Lost circulation materials may used which are listed as follows.

(a) Fibrous → saw dust, Black cotton sheeds, cotton, corck etc.
(b) Lamellar → Mica, cellophone etc.
(c) Granular → Nut shells, perdite, plastic etc.

Fibrous & lamellar materials are most effective in coarsely permeable rocks where the voids are reletively small. The granular materials are most effective as a lost circulation preventing agents in fractured rocks where voids are relatively large.

Caving and its effect

Causes

I - Drilling through sedimentary formation has always tendency for the hole walls to caving at a sallow depth. This is due to encountered or untracked water in the void strata & the pressure caused by untracked water finding its own level.

II - Excessive caving results in case of loose sandstone where binding clay matrix is not able to provide sufficient resistance to water action. The water pressure pushes grains and make the sand to flow.

III - The formation which is un stable & vuggy and is contineously libe to caving, there is a constant risk of stuck off bit and drill string.

Prevention

I - The hole must be sealed by casing or cementing.

II - Sinking stand pipes must be lowered (upto 4' to 5') to support the hole wall.

State the effect of excessive temprature on diamond and matrix

The higher we go the cooler we will feel & the deeper we go the hoter we will feel.

The rate of increase in temprature per feet depth varies greatly at different point on earth crust.

It has been observed that the rate is about 1°F per 150' depth.

A bottom hole temprature tested in oil well drilling holes at 20,000' through a 330°F.

The melting point of matrix is always below the temprature at which diamonds are damaged.

Some of the metals in the alloys of matrix melts at the temprature below the melting points of any of the other constituent metal.

for example -

In alloys of TiC, TC has higher melting point where as the metal cobalt which is used as a binding metal has a low melting point to form the solution alloys for holding the diamond.

In order to avoid graphitising of the diamonds close control of the time, temprature and controlled atmosphere.

The temprature is sufficient to cause burning of diamond or melting of matrix are not required to caused trouble.

Sudden chilling of a hot bit (during dry drilling) the wash water will crack or damage the diamonds.

Relation ship between bit pressure, rotational speed & rate of penitration

A given drill bit rotated at a fixed speed in a uniform size of rock which increases its penitration in propention to the pressure applied to the bit up to an optimum for that type of rock.

A further increase in pressure will not produce corresponding increase in given speed or rate of penitration. Faster penitration at this stage can only be attained by increase in rotational speed under idle condition of pull out volume and pressure/flushing volume.

Therefore, the opercater should be able to know where to set the maximum pressure and then increase the speed for the maximum penitration by gaining experience only.

Effect of rotational speed Vs lineal travel on diamond wear

A diamond on outside of the cutting edge of an ex-bit at 1000 rpm travels 393' per min whereas a diamond placed at the centre of the bit travells 0' per min. Hence an ex-bit has peripheral speed of 393' per min and the mean travell is 192' per min.

Diamond wear by polishing is heavy when the rotational speed and unit pressure per diamond are not co-ordinated.

A diamond at the periphery of the bit may travells at the correct speed for efficient rock removal, but a stone at the centre of the bit travells at zero speed. So the stone near the centre of the bit wear faster than the stone near the periphery.

There are two reasons for this

1- The peripheral stone moving at the correct speed, stone nearer the centre of the bit travelling at a less speed tends to polish as already explained.

11- As the centre of the bit approached the rock, these inefficiently working stone is not removed as fast as the rock at the periphery. The heavy load thus imposed on them tends to break them down.

Bit Wear due to rock hardness

Rock may varies in hardness. so that no single bit can of universal use or application. Rock hardness is an important factor in diamond weare. Maximum diamond wear causes due to the following factors.

1- Hardness or unconformities.
2- Admixture of hard & soft layer.
3- Size of cuttings (small, grannular, coarse).
4- Vuggy and fracture formations.
5- Schistose, stratified, fibrous, laminated rock causes bit weare more.
6- Mudding & Talcose.
7- Blocky rock (soft & hard).
8- Soft sulphide ores with bands of hard glaci quartz.
9- Rock with relatively soft band alternating with chert/quartz.

precautions are to be taken while using a new core bit

The following precautions are to be taken while changing a new bit.

1- Do not allow wrench jaws to touch the diamonds in a bit. This is also applied to reamer shell. This is very common form of abuse of bit and reamer shell. Hence use parmelee wrench.

2- Tight the joints of each drill rod properly before lowering in to the hole. otherwise the circulating water will escape through joints causing the bit to run by dry and hot resulting the bit to be burnt.

3- As the rods are lower near the bottom, start circulation to wash out settled cuttings throughly which usually extends up to some distance from the bottom.

4- When pumping is resumed in soft muddy ground, air maybe trapped in the rods by the viscus mud fluid. When this sludge of air passes the bit face, bit is damaged.

5- The remedy is to lift the rod up bottom & pump until any air entered in the rod has passed the bit face.

A new bit sould never put to the bottom of the hole, A new bit should be tapped 3' or 4' above from the bottom and drilled to the bottom. When bottom is reached the new bit should be run at moderate reate and slow feed for one to two feet to give the diamonds a chance to set themselves. This prevents the sharp point from being wipped off.

6- When drilling in very hard, fine grained, Siliceous rock the diamond may polished after drilling few feet. When this happens the diamond bit can not be expected to make any further progress in that perticulare kind of rock and should be removed from the service. This bit maybe used later either in another hole or in that same hole in some different kind of formation.

7- When drilling through high abrasive rock there is a tendency for the metal to wear away from the stone. In these cases when the stones become exposed approx $\frac{1}{3}$rd of their size, the bit should be removed and reset after $\frac{1}{3}$rd of the bunk of each of the stones extend from the metal. There is damage of metal to the point where the stones will droporet if further wearing takes place.

Dry block drilling

Dryblock drilling is reasonably good practice in soft rock but should be done as little as possible in hard rocks.

The zone contains powdery iron ore or blue dust can be drilled by dry drilling up to a shallow depth. But impossible in deep holes which is evidenced by ruin of many bits. Blue dust occasionally contains builders of hard and laminated iron ore.

In order to drilled passed blue dust the technique adopted is,

Short of water and the drill string consists of a single tube core barrel, a casing and a Tc bit is penitnated at a slow rpm (300 rpm) and low feed till blue dust is sintered at the face of the bit. In this drilling straight walk bit without core lifter is used. Drilling continue up to a few min. Then the drill string is raised to the surface, the core in the barrel maybe fallen out to the bit face.

In absence of coolent, excessive force and high rpm has been found to develope high temprature at the cutting edge resulting sintering of the core in the bit quicker & reducing the length of run.

It is customary/optional to add a little water in the hole through drill rod before commencing of ration of drill string, which serves to the moist core packen. If it is dry enough and turns helps in blocking the bit by sintering process.

If water short of while drilling through a long period, it damage equal to or greaten than that from dry blocking can be expected.

Comparison between conventional coring operation and ConCore process of coring operation

Conventional coring operation

As continued drilling operation for a length of le i.e equal to the length of core barrel, it is required to

1- Lift the core barrel a little.
2- Break the core from its mother rock.
3- Hoisted up the drill string or core barrel.

In order to break the core, the drillstring is to lift a little by upward feed pressure. so that the core lifter will grip the core.

By giving high rotation and applying sudden jerk the core will be broken from its mother rock.

After breaking the core, rotation is stoped and the drill string is hoisted to the surface.

The core barrel is kept on the working platform horizontally and disconnect the bit.

After removing the bit, the barrel hold slightly inclined and giving light hammering action, the core will be removed from the barrel and kept in the core b by marking its depth.

'ConCore' process of coring operation

The purpose of 'conCore' coring is to obtained accurate uncontaminated core (geological sample).

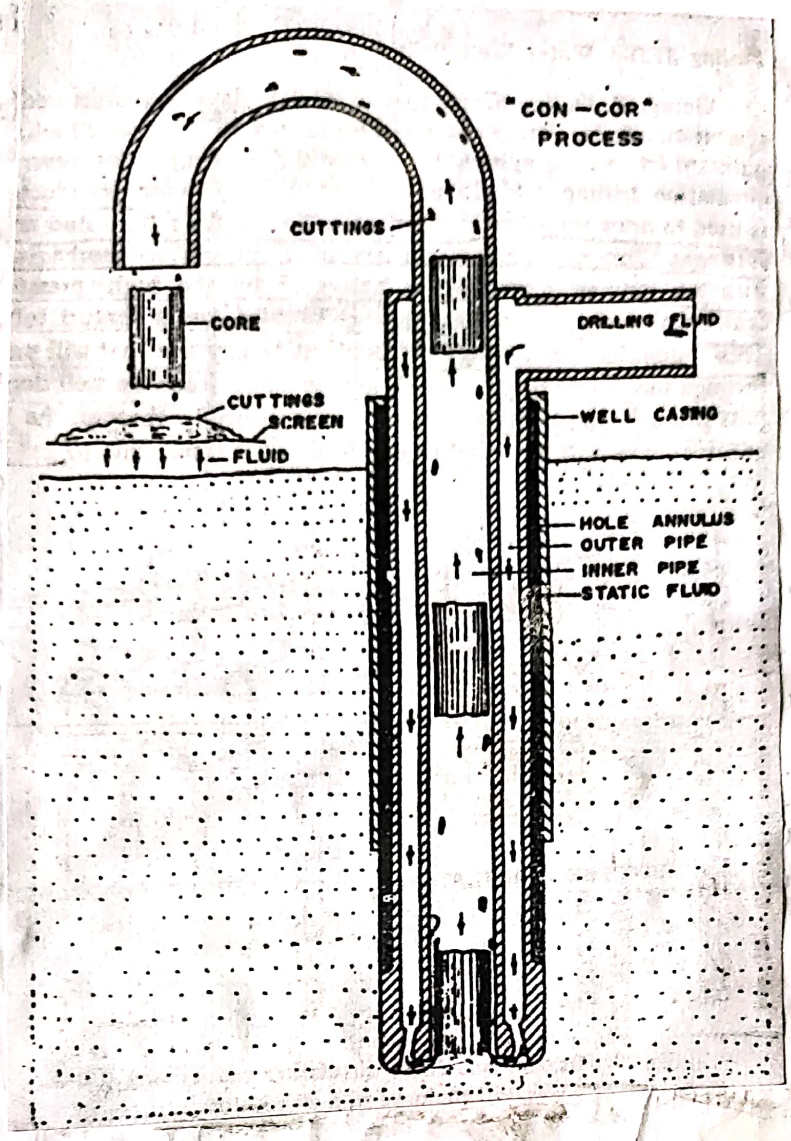
The process utilises a dual pipe with dual water swivel on a drill unit equiped with rotary table.

The drill fluid or air is pump down through the outer tube of the drill pipe and returned through the inner tube with either cores and cutting from a core bit or cuttings from a rotary tricone bit. It is broken off

After the core is cut, at regular interval by non rotating core breaken and pumped to the surface with the cuttings at the same time, by which complete geological information can be obtained from the core.

By using a tricone rotary bit, complete geological information can be obtained from uncontaminated extra large cuttings. Due to the large size of the cuttings it is often unnecessary to core except in zones of most interest. In many cases the geological information obtained from the cuttings is adiquate.

figure



Walker Neer Manufacturing Company INC has manufactured Model - CC 2000 'conCor' drill. This is designed to use the 'ConCor' process to 2000' (600m The CC-2000 equipped with 30' (9m), $4\frac{1}{2}$" (11.4c dualpipe. $4\frac{7}{8}$" (12.4 cm) diameter hole yielding $2\frac{1}{8}$" (5.4cm) diameter core, which is broken approximately 5" (12.7 cm) intervals. The drill is air operated & carrier mounted.

Reverse circulation

Comparision between direct and reverse circulation

In conventional drilling water loss is occoured due to direct circulation of water through drill string in the bore hole. When pumping is stoped negetive pressure and partial vaccum is created in the bore hole and cuttings get accumulated at the bottom of the bore hole. This can cause jamming of core barrel and caving conditions in the bore hole.

However in reverse circulation rotary drilling the cuttings are removed to the surface alongwith return water by installing a centrifugeal type vaccum pump on the surface. There is no caving or collapsing as the hole wall is supported by the hydrostatic pressure of the water collumn inside the hole eliminating the need of cosings.

Field of application – Large diameter ventilation shaft & escape shaft & air shafts. Tube well through unconsolidated form such as boulder, gravel, sand etc.

figure

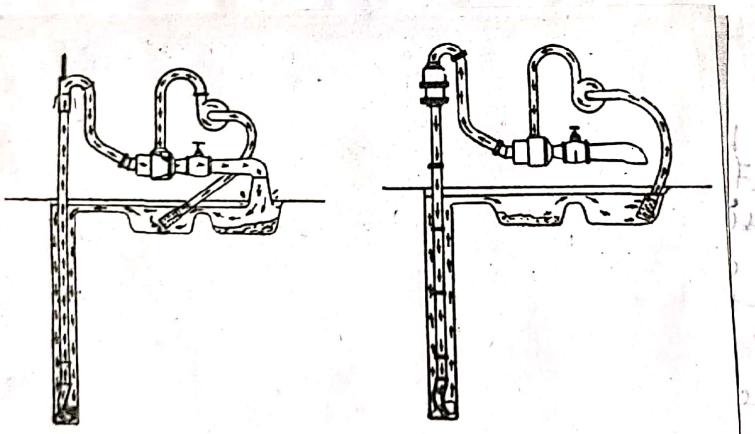


Fig. 8.32. (a) Reverse circulation. Fig. 8.32. (b) Direct circulation.

Jet Eductore

Reverse circulation with a standared jet eductore system fore water well drilling. Fore reverese circulation drilling a 6" (15cm) full open self priming jet eductore is used to dreaw the vaccum fore reverense flow of the return mud and cuttings. The jet eductore consists of a jet venturi mechanism with no moving parts. It is activated by high pressure centrifugal pump discharging through nozzles into a venturi tube. This system handles cuttings and boulders of any size that will pass through the bit opening. fluid and cuttings from the well donot pass through the centrifugal pump but go directly through the jet eductore unit and are discharge directly in to the pit. The jet eductor is instantly self priming.

Reverse circulation rotary drilling

Reverse circulation rotary drilling is done with a flow of drilling fluid reversed as compared with the system used in the conventional rotary method. The suction end of the rig pump – rather than the discharge end – is connected to the kelly and drill pipe through the swivel. The drilling fluid and its load of cuttings move upward inside the drill pipe and are discharged by the pump into the settling pit.

The fluid returns to the bore hole by gravity flow. It moves down the annular space around the drill pipe to the bottom of the hole, picks up cuttings and reenters the drill pipe through ports in the drill bit.

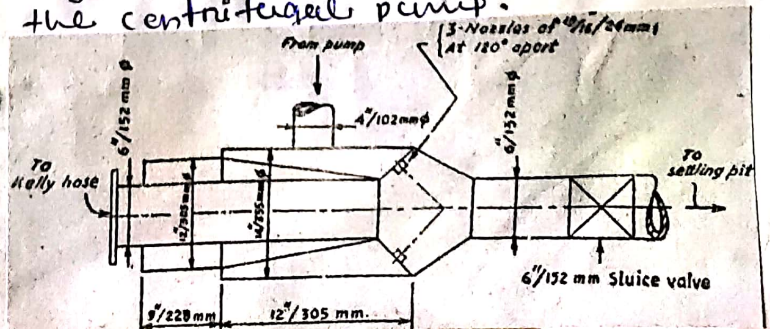
The drilling fluid can be described as muddy water rather than drilling mud. suspended clay & silt which recirculate with the fluid are largely fine materials picked up from the subsurface formations as drilling proceeds.

To prevent caving of the hole, the fluid level must be kept at the ground level at all times. The hydrostatic pressure of the water column plus the inertia of the body of water moving downward outside the drill stem support the bore hole wall. Erosion of the wall is not a problem because annular space is low. Water lost from the hole into all permeable formations that are penetrated. Some of the suspended fine particles in the fluid are filtrated out on the wall of the hole resulting in a thin mud deposit that partially clogs the pores and reduces the water loss. A considerable quantity of makeup water is required.

The settling pit and water supply pit should have a volume of at least three times of the volume of materials to be removed during drilling operation. The circulation rate for the water used in drilling is commonly of the order of 500 gpm / 2270 litres per minute and more.

A centrifugal pump with large passage-ways is employed in order to handle cuttings through the pump. The reverse circulation rotary rig uses an eductor operated like a large jet pump, which avoids passing the cuttings through the centrifugal pump.

Jet Eductor →



Standard reverse circulation drilling machine

The limit of the suction head of the rig makes it necessary to use a drill pipe 10 feet/3 m in lengths. 6 inch/152 mm drill pipe is commonly us that stones up to a little over 5 inch/124 mm can be brought up through the pipe. Flanged joi are used on the pipe. Tricone/ saw tooth type reverse circulation bits with flange connections a used.

Borehole with diameters of up to 60 inch can be drilled. The diameter of the hole must be in relation to the drill pipe in order that the velo of the descending water may be slow.

The bit and drill pipe are rotated at a varying from 10 to 40 revolutions per minute

Reverse circulation offers the cheapest way drilling large diameter holes in soft, unconsolidated formation. Conditions that favour the use of reve circulation method of drilling include: sand, silt soft clay formations; absence of clay or boulder and static water level 10 feet/ 3050 mm or more the ground.

Conditions that limits the use of this m are a too high static level; lack of water supp make up for the loss of drilling fluid; stiff cla shale formations; considerable no. of boulders or Boulders Largen than drill pipe/opening in the drill bit can brought out in drilling

Figure

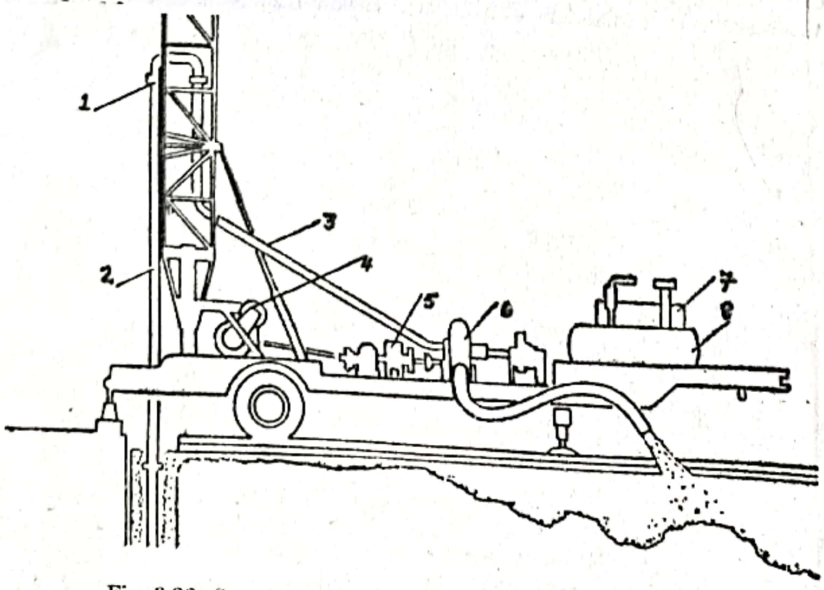


Fig. 8.26. Standard reverse circulation drilling machine.
1—Telescoping kelly and swivel assembly; 2—Square kelly bar; 3—Discharge piping; 4—Draw-works assembly; 5—Vacuum priming pump; 6—Rotary pump; 7—Power unit; 8—Vacuum tank.

(3) Hollow Stem Auger drill

Field of application & advantage of hollow stem auger drill

Both hand opercated and mechanically powered augers are very usefull tools in foundation explorcation primarily because of their economy in making the hole in a hurry.

The use of power augering as a quick and easy method of conducting preliminary sampling, making probings to top of bedrock, in sinking holes for the sampling of mine dumps, mill trailing piles, is increasing in acceptance & popularity. Its advantage is low cost, speed & mobility.

The various designs of cutter heads and augers presently available permit successfull augering in most soils.

Mechanical features

(i) Mounting - Truck, (ii) source of power - I/C engine
(iii) Power transmission mechanism (iv) Hoisting drum, (v) Spindle & chuck

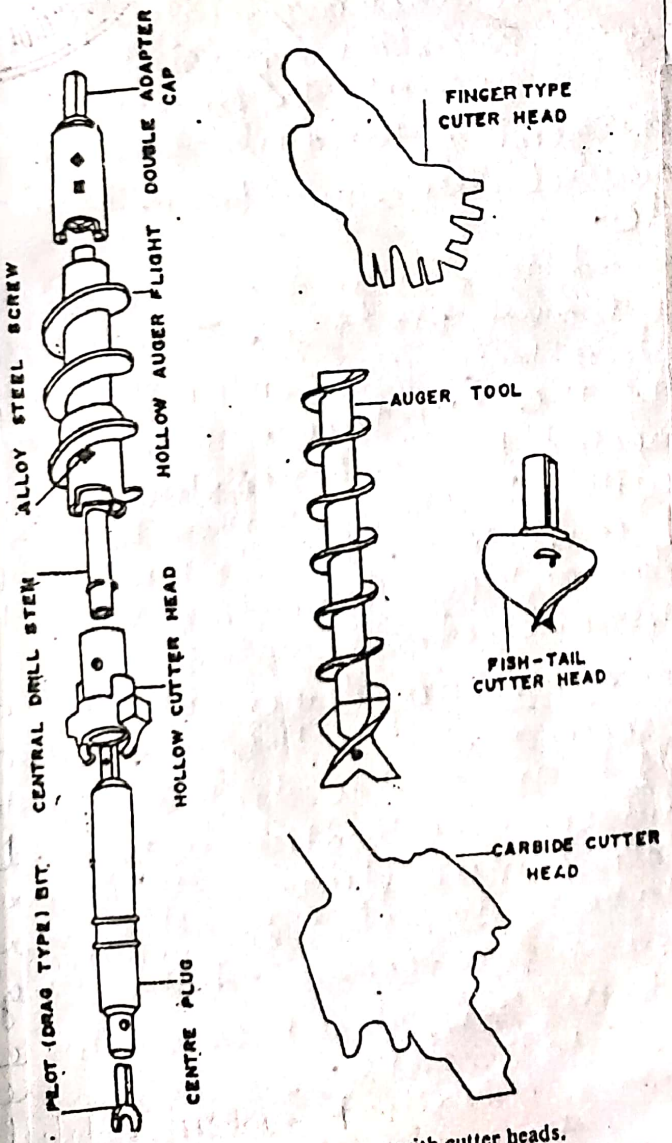


Fig. 16. Hallow stem auger with cutter heads.

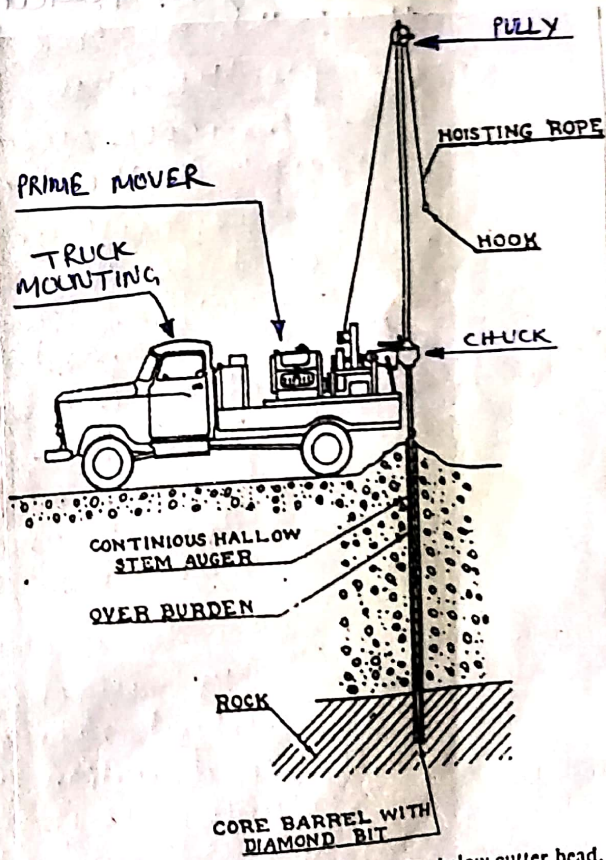


Fig. 17. Hallow stem auger facilitates coring below cutter head.

(vi) Drill string consists of
(a) Drill rod/pipe
(b) Hollow stem augen
(c) core barrel
(d) Bit

Theory & Principle of

In hollow stem auger drill, the double adapter-cap ties inner and outer strings together so that they rotate & progress as one when rotated by conventional drilling rig. The most important feature of hollow stem system is the centre plug which seals the inner opening and supports the centre cutting pilot bit. This plug provides as effective a seal as possible for a wide range of conditions.

Auger sections and corresponding central drill stem sections are manufactured in standard lengths to facilitate handling and ease of operation with conventional auger drilling. Hollow stem augers are made from cold drawn seamless steel tubing with high grade alloy steel tube connector. Spiral flight is uniformly welded to the tubular axle. Each section of the auger flight is interchangeable and ends are fitted with a special pin and box sleeve connection. Two numbers of heavy duty alloy steel set screws secure the inter locking joints. These hollow stem augers feature an interlocking joint which allows the augers to be operated in reverse rotation. Freequently when augering through several layers of shale, rock ore gravel there maybe a tendency to 'lock up' in the hole.

The cutter head is designed with replaceable type carbide fingers and wedges. The hollow bore in the cutter head allows the centre plug with pilot bit to be removed to the surface. The centre plug and pilot are connected to the innerstring which canbe furnished with either pin & socket or with standard drill rod connections. The pilot bit maybe either fish tail or drag type depending upon the type of formation encountered.

Standard operation procedures are to drill down with auger sections, with the inner centre plug duly lowered with centre drill stem string until the elevation under investigation is reached, then to retrive the inner centre plug with supporting string of rod and take a sample ahead of auger string. Once the sample is recovered the plug is replaced and the boring is further Continued until another investigation is to be done. In case where rock is encountered and coring is desired a core barrel and bit can be lowered through the inner bore to the bed rock. The hollow auger is serves as a casing.

THANK YOU