CHAPTER

12a

Construction Planning, Equipment, and Methods

Sixth Edition

DRILLING ROCK AND EARTH

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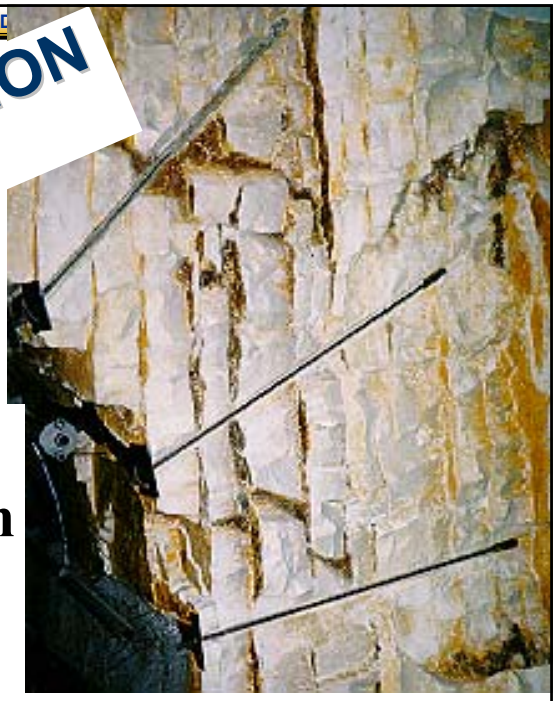
DRILLING ROCK & EARTH

DRILLING ROCK

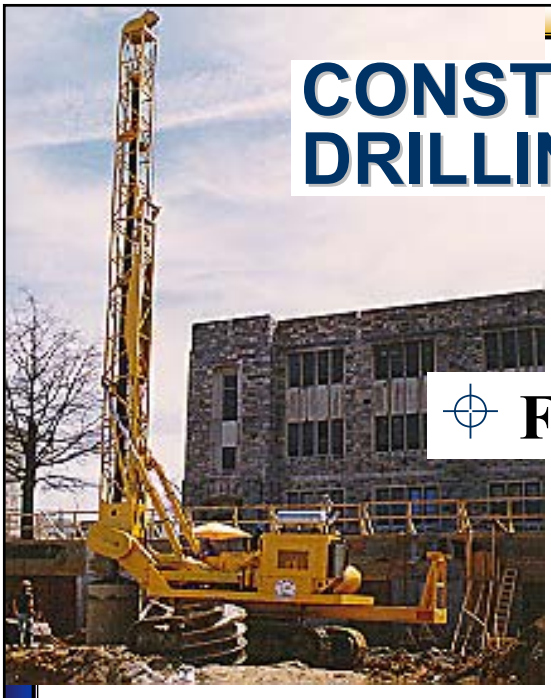
CONSTRUCTION DRILLING

- Blast holes for removal of rock, in a construction excavation or for quarrying

CONSTRUCTION DRILLING



- Rock anchor/bolts in excavations and tunnels



CONSTRUCTION DRILLING

- Foundations

CONSTRUCTION DRILLING

- Foundation grouting

DRILLING EQUIPMENT

- Drilling equipment and methods are used by the construction and mining industries to drill holes in both rock and earth.
- Same or similar equipment may in some instances be used for drilling both materials.

DRILLING EQUIPMENT

- Purposes for which drilling are performed vary a great deal from general to highly specialized applications.
- It is desirable to select the equipment and methods that are best suited to the specific service:

DRILLING EQUIPMENT

- ✓A contractor engaged in highway construction must usually drill rock under varying conditions; therefore, equipment that is suitable for various services would be selected.
- ✓If equipment is needed to drill rock in a quarry where the material and conditions will not vary, specialized equipment should be considered.

DRILLING EQUIPMENT

- ✓In some instances custom-made equipment designed for use on a single project may be justified.

GLOSSARY OF TERMS

Bit: This is the portion of a drill which contacts the rock and disintegrates it.

Carbide-insert bit: The carbide-insert bit is a detachable bit whose cutting edges consist of tungsten carbide embedded in a softer steel base.

GLOSSARY OF TERMS

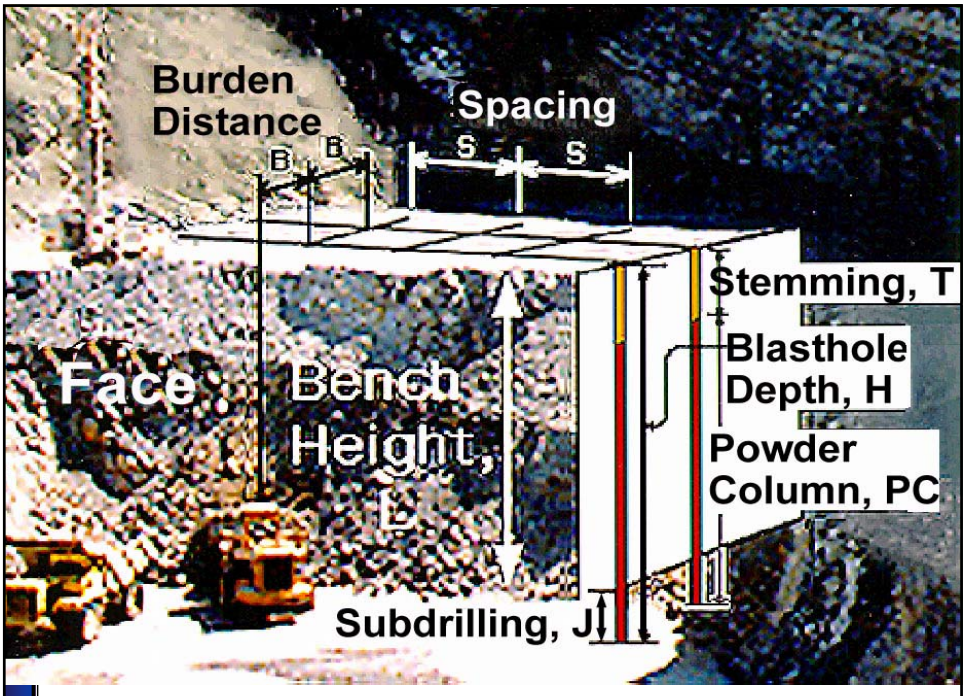
Detachable bit: This is a bit which may be attached to or removed from the drill steel or drill stem.

Diamond bit: The diamond bit is a detachable bit whose cutting elements consist of diamonds embedded in a metal matrix.

GLOSSARY OF TERMS

Forged bit: This is a bit which is forged on the drill steel.

Burden: This is the horizontal distance from a rock face to the first row of drill holes or the distance between rows of drill holes.



GLOSSARY OF TERMS

Coupling: A short, hollow steel pipe having interior threads. The coupling is used to hold pieces of drill steel together or to the shank. The percussion energy is transferred through the steel, not the coupling; therefore, the coupling must allow the drill steel to butt together.

GLOSSARY OF TERMS

Cuttings: These are the disintegrated rock particles that are removed from a hole.

Depth per bit: This is the depth of hole that can be drilled by a bit before it is replaced.

GLOSSARY OF TERMS

Drifter: A drifter is an air-operated percussion-type drill,similar to a jackhammer; it is so large, however, that it requires mechanical mounting.

GLOSSARY OF TERMS

- Types of Drills:
  - ✓***Abrasion:*** This drill grinds rock into small particles through the abrasive effect of a bit that rotates in the hole.
  - ✓***Blast-hole:*** This is a rotary drill consisting of a steel-pipe drill stem on the bottom of which is a roller bit that disintegrates the rock as it rotates over the rock. The cuttings are removed by a stream of compressed air.

GLOSSARY OF TERMS

- ✓***Churn:*** The chum drill is a percussion-type drill consisting of a long steel bit that is mechanically lifted and dropped to disintegrate the rock. It is used to drill deep holes, usually 6 in. in diameter or larger.
- ✓***Core:*** This drilling equipment is designed for obtaining samples of rock from a hole, usually for exploratory purposes. Diamond and shot drills are used for core drilling.

GLOSSARY OF TERMS

- ***Diamond:*** The diamond drill is a rotary abrasive-type drill whose bit consists of a metal matrix in which a large number of diamonds are embedded. As the drill rotates, the diamonds disintegrate the rock.
- ***Dry:*** This is a drill which uses compressed air to remove the cuttings from a hole.

GLOSSARY OF TERMS

- ***Percussion:*** This is a drill which breaks rock into small particles by impact from repeated blows. It can be powered by compressed air or hydraulic fluids.
- ***Shot:*** This is a rotary abrasive-type drill whose bit consists of a section of steel pipe with a roughened surface at the bottom.

GLOSSARY OF TERMS

- ✓***Wagon:*** This is a drifter mounted on a mast supported by two or more wheels.
- ✓***Wet:*** A wet drill is one that uses water to remove the cuttings from a hole.

GLOSSARY OF TERMS

Drilling pattern: This is the spacing of the drill holes.

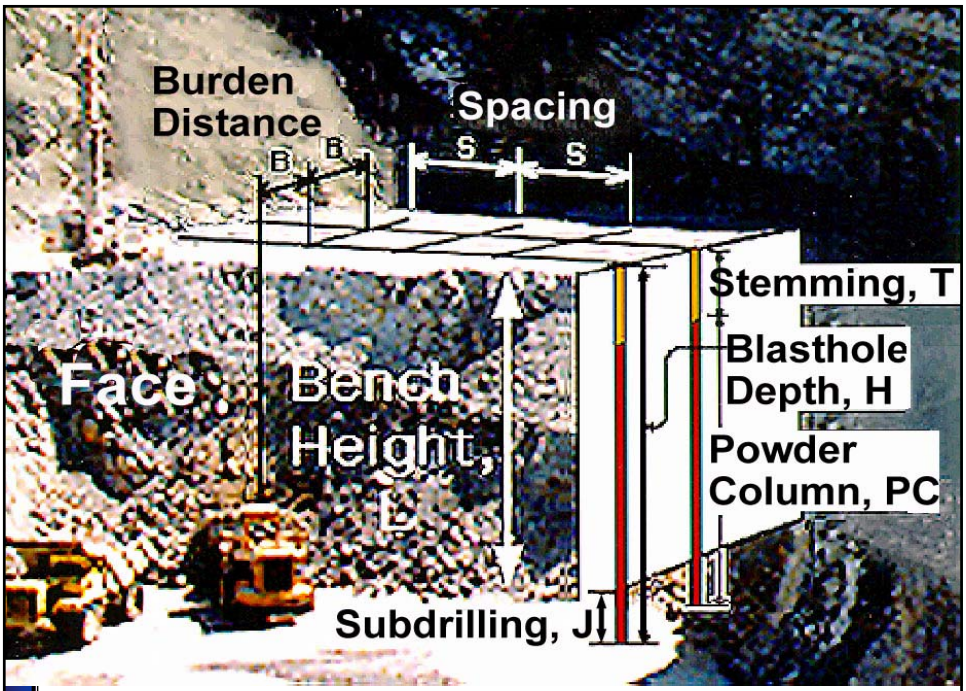
Drilling rate: This is the number of feet of hole drilled per hour per drill.

Drill steel, or rods: These are rods which transmit the blow energy and drill rotation from the shank to the bit.

GLOSSARY OF TERMS

Face: This is the approximately vertical surface extending upward from the floor of a pit to the level at which drilling is accomplished.

Jackhammer,or sinker: This device is an air-operated percussion-type drill that is small enough to be handled by one worker.



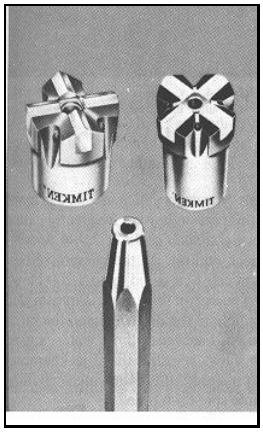
GLOSSARY OF TERMS

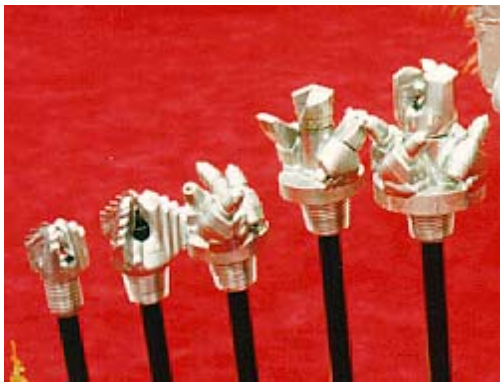
Stoper: A stoper is an air-operated percussion-type drill, similar to a drifter, that is used for overhead drilling, as in a tunnel.

Striker bar, or shank: A short piece of steel which attaches to the percussion drill piston for receiving the blow and transferring the energy to the drill steel.

BITS

Removable Tapered-Socket-Type Rock Bit





BIT TYPE

BUTTON BIT

INSERT BIT

Text p. 337, FIG 12-3 & 4.

BITS

- The bit is the essential part of a drill, as it is the part which must engage and disintegrate the rock.
- The success of a drilling operation depends on the ability of the bit to remain sharp under the impact of the drill.

BITS

- Many types and sizes of bits are available.
- Most bits are units which screw mount to the drill steel.
- Bits are easily replaced and some can be re-sharpened 2 to 6 times.

BITS

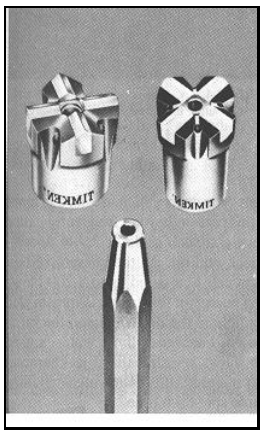
- Bits are available in various sizes, shapes, and hardnesses.
- The depth of the hole that can be drilled with steel bit vary from a few inches to 40 ft or more.

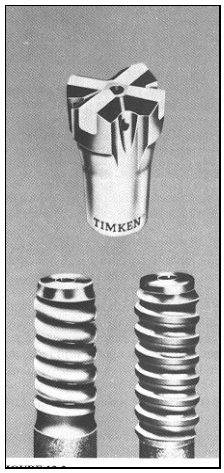
BITS

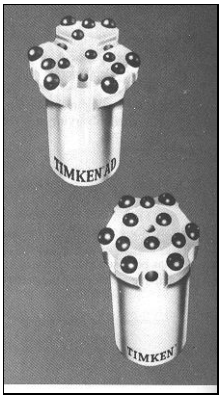
Carbide-insert bits:

- Some types of rock are so abrasive that steel bits must be replaced after they have drilled only a few inches of the hole
- It is more economical sometimes to use carbide-insert bits because the cost of the steel bits and lost time to production in changing bits can be so great
- These bits are illustrated in the following figures.

BITS







BITS

Carbide-insert bits(cont'd):

- As shown in the figures, the actual drilling points consist of a very hard metal, tungsten carbide, which is embedded in steel.
- Although these bits are considerably more expensive than steel bits, the increased drilling rate and depth of hole obtained per bit is economically justified, especially for drilling hard rock.

CARBIDE INSERT BITS

Four grades are usually available.

Increasing Hardness ↓

Grade	Abrasion resistance
Shock	Fair
Intermediate	Good
Wear	Excellent
Extra Wear	Outstanding

BITS

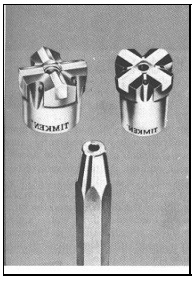
Carbide-insert bits(cont'd):

"A contractor on a highway project in Pennsylvania found that when drilling dibase rock, the depth per steel bit was 0.5 to 2 in. When he changed to carbide bits, he obtained an average depth of 1,992 ft"

BITS

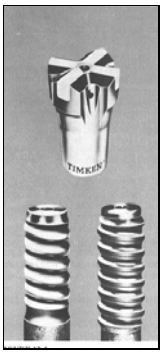
Tapered Socket Bits:

- The figure illustrates removable tapered socket bits, which are available in gauge sizes varying in 1/8-in (3.2-mm) steps from 1 in (25 mm) to 4 in (102 mm)



BITS

- **Bottom-drive Bits:**
  - The figure illustrates the removable bottom-drive bits, which are available in gauge sizes varying from 1.5 in (38 mm) to 6 in (152 mm)



JACKHAMMERS

- Jackhammers are hand-held air-operated percussion-type drills which are used primarily for drilling holes in a downward direction.
- They are classified according to their weight, such as 45 or 55 lb.
- A complete drilling unit consists of a hammer, drill steel, and bit.

JACKHAMMERS

- As the compressed air flows through a hammer, it causes a piston to reciprocate at a speed up to 2,200 blows per minute, which produces the hammer effect.
- The energy of this piston is transmitted to a bit through the drill steel. Air flows through a hole in the drill steel and the bit to remove the cuttings from the hole and to cool the bit.

DRIFTERS

- Drifter drills are similar to jackhammers in operation, but they are larger and used as mounted tools for drilling down, horizontal, or up holes. They vary in weight from 75 to 260 lb and are capable of drilling holes up to 4 in. in diameter.

DRIFTERS

- Drifters are used extensively in rock excavation, mining, and tunneling. Either air or water may be used to remove the cuttings.
- The drifter's weight is usually sufficient to supply the necessary feed pressure for down drilling. But when used for horizontal or up drilling, the feed pressure is supplied by a hand-operated screw or a pneumatic or hydraulic piston.

WAGON DRILLS

- Wagon drills consist of drifters mounted on masts, which are mounted on wheels to provide portability.
- Wagon drills are used extensively to drill holes up to 4.5 in. in diameter and up to 30 ft or more in depth.

WAGON DRILLS

- They give better performance than jackhammers when used on terrain where it is possible for them to operate.
- Wagon drills may be used to drill at any angle from down to slightly above horizontal.

WAGON DRILLS

- The length of drill steel is usually 6, 10, or 15 ft, but longer lengths are available.
- The length selected will depend on the feed reach of the particular wagon drill.

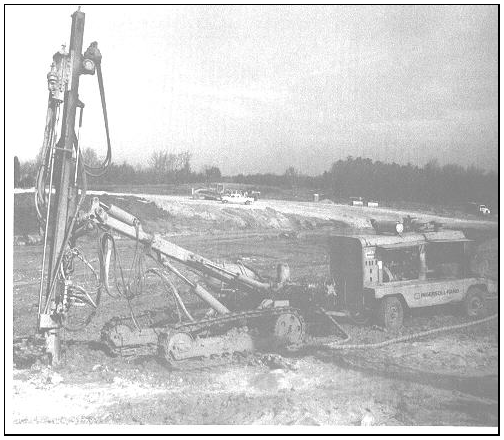
TRACK-MOUNTED DRILLS

- The track-mounted drills have substantially replaced the wagon drill on construction projects.
- Track-mounted drills production rate may be 3 or more times that of a wagon drill because of their ability to move quickly to a new location and the use of the hydraulically operated boom for positioning the drill.

TRACK-MOUNTED DRILLS

TRACK-MOUNTED DRILLS

Air-track Drill and Air Compressor

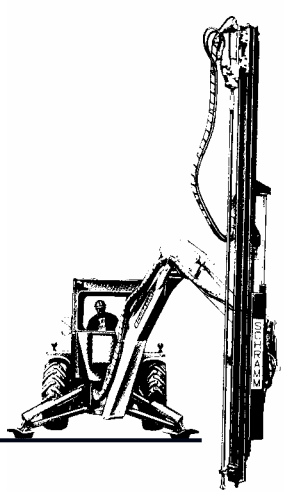


TRACK-MOUNTED DRILLS

- Holes can be drilled at any angle from under 15° back from vertical to above the horizontal, ahead, or on either side of the unit.
- All operation, including tramming (travel), can be powered by compressed air.

WHEEL-MOUNTED DRILLS

- Wheel-mounted drills are similar in sizes and capacities to the track-mounted drills.
- Wheel-mounted drills require a more nearly level ground surface to operate.



PISTON DRILLS

- These are percussion-type drills with the hollow drill tube attached to the piston.
- The stroke and rotation of the piston are adjustable to give the best performance for the particular type of rock being drilled.

PISTON DRILLS

- They are available with carbide-insert bits, which are up to 6 in in diameter.
- These drills have a practical depth limit of approximately 70 ft.

ROTARY PERCUSSION DRILLS

- Rotary percussion drills combine the hard-hitting reciprocal action of the percussion drill with the turning-under-pressure action of the rotary drill.
- Rotation of the rotary percussion combination drill, with the bit under constant pressure, has demonstrated its ability to drill much faster than the regular percussion drill.

ROTARY PERCUSSION DRILLS

- Rotary percussion drills require special carbide bits, with the carbide inserts set at a different angle from those used with standard carbide bits.

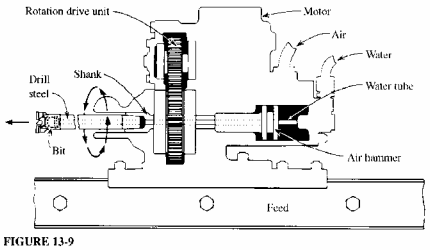
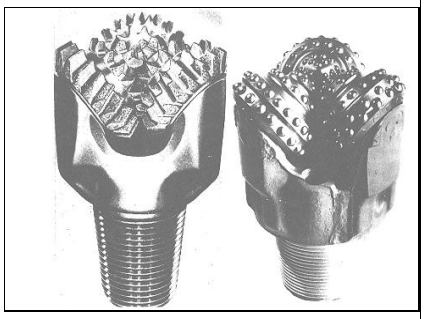
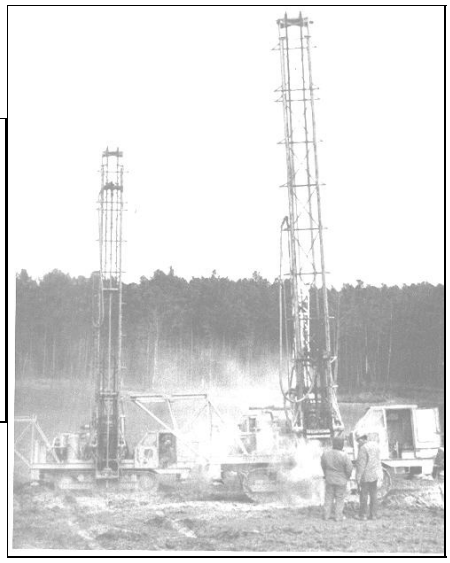


FIGURE 13-9
Rotary-percussion drill. *(Joy Manufacturing Company.)*

ROTARY PERCUSSION DRILLS





ROTARY DRILLS

- A rotary drill is self-propelled drill which is mounted on a truck or on a crawler tracks.
- A tricone roller-type bit is used in the drilling. It is attached to the lower end of a drill pipe.
- As the bit is rotated in the hole, a continuous blast of compressed air is forced down through the pipe and the bit to remove the rock cuttings and to cool the bit.

ROTARY DRILLS

- These drills are suitable for drilling soft to medium rock, such as **dolomite** and **limestone.**
- However, they are not suitable for drilling the harder igneous rocks.

ROTARY DRILLS

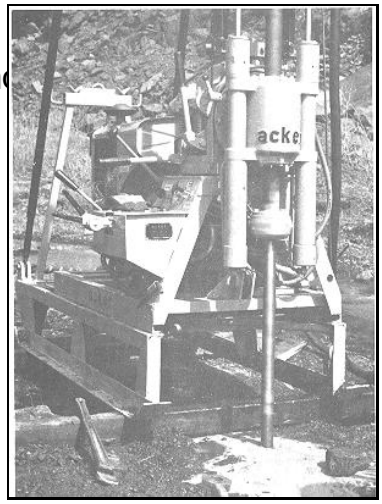
- Rotary drills are available to drill holes to different diameters and to depths up to approximately 300 ft.
- Speeds can be varied from 1.5 fph in dense hard dolomite to 50 fph in limestone.

DIAMOND DRILLS

- Diamond drills are used primarily for exploration drilling, where cores are desired for the purpose of studying the rock structure.
- A drilling rig consists of:
  - ✓ a diamond bit
  - ✓ a core barrel
  - ✓ a joined driving tube
  - ✓ a rotary head to supply the driving torque

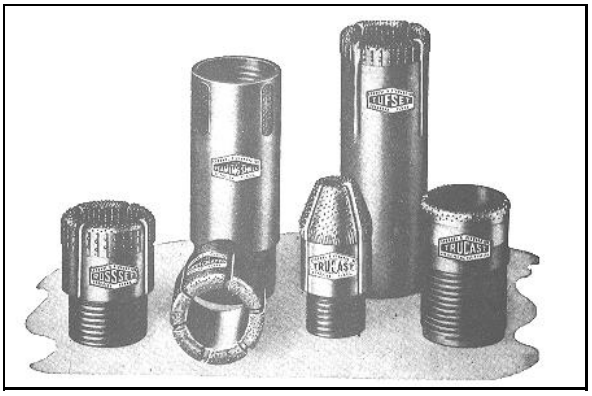
DIAMOND DRILLS

Drilling Unit for Diamond Core Drill
(Acker Drill Company)



DIAMOND DRILLS

Diamond-Point Bits (Sprague & Henwood, Inc.)



DIAMOND DRILLS

- Water is pumped through the driving tube to remove the cuttings.
- Core barrels are available in lengths varying from 5 to 15 ft.
- When the bit advances to a depth equal to the length of the core barrel, the core is broken off and the drill is removed from the hole.

DIAMOND DRILLS

- Diamond drill can drill in any desired direction.
- Diamond drills are capable of drilling to depths in excess of 1,000 ft.
- Bit speeds vary from 200 to 1200 rpm.
- Drilling rate varies from less than a foot to several feet per hour, depending on the type of rock.

SELECTING THE DRILLING METHOD AND EQUIPMENT

- Holes are drilled for various purposes, such as:
  - ✓To receive charges of explosives,
  - ✓For exploration, or
  - ✓For ground modification by the injection of grout.

SELECTING THE DRILLING METHOD AND EQUIPMENT

- Within practical limits, the equipment which will produce the greatest overall economy for the particular project is the most satisfactory.

SELECTING THE DRILLING METHOD AND EQUIPMENT

- Many factors affect the selection of equipment. Among these are:

1. The nature of the terrain.
2. The required depth of holes,
3. The hardness of the rock.
4. The extent to which the formation is broken or fractured.

SELECTING THE DRILLING METHOD AND EQUIPMENT

5. The size of the project.
6. The extent to which the rock is to be broken for handling or crushing.
7. The availability of water for drilling purposes.
8. The purpose of the holes, such as blasting, exploration, or grout injection.
9. The size of cores required for exploration.

SELECTING THE DRILLING METHOD AND EQUIPMENT

- For small-diameter shallow blastholes, especially on rough surfaces where larger drills cannot operate, it is usually necessary to use jackhammers or track-mounted drills.
- Track-mounted, rotary-percussion, or piston drills can be used for blastholes up to 6 in. in diameter and up to about 50 ft deep.

SELECTING THE DRILLING METHOD AND EQUIPMENT

- If cores up to 3 in are desired, the diamond coring drill is the most satisfactory.
- If intermediate-size cores, 3 to 8 in, outside diameter, are desired, the choice will be between a diamond drill and a shot drill. A diamond drill will usually drill faster than a shot drill.

SELECTING THE DRILLING METHOD AND EQUIPMENT

- The pattern selected for drilling holes to be loaded with explosives will vary with:
  - ✓The type and size drill used,
  - ✓The depth of the holes,
  - ✓The kind of rock,
  - ✓The maximum rock breakage size permissible, and
  - ✓Other factors

SELECTING THE DRILLING METHOD AND EQUIPMENT

- Drilling operations for rock excavation where the material will be used in an embankment fill must consider the fill specifications concerning the maximum physical size.

SELECTING THE DRILLING METHOD AND EQUIPMENT

- The drilling pattern should be planned to produce rock sizes that are small enough to permit most of them to be handled by the excavator, such as a loader or shovel, or to pass into the crusher opening without secondary blasting.