Drill Rigs and Equipment

Lesson 4

ODOT MATERIALS & INSPECTION

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- 4 Years at ODOT
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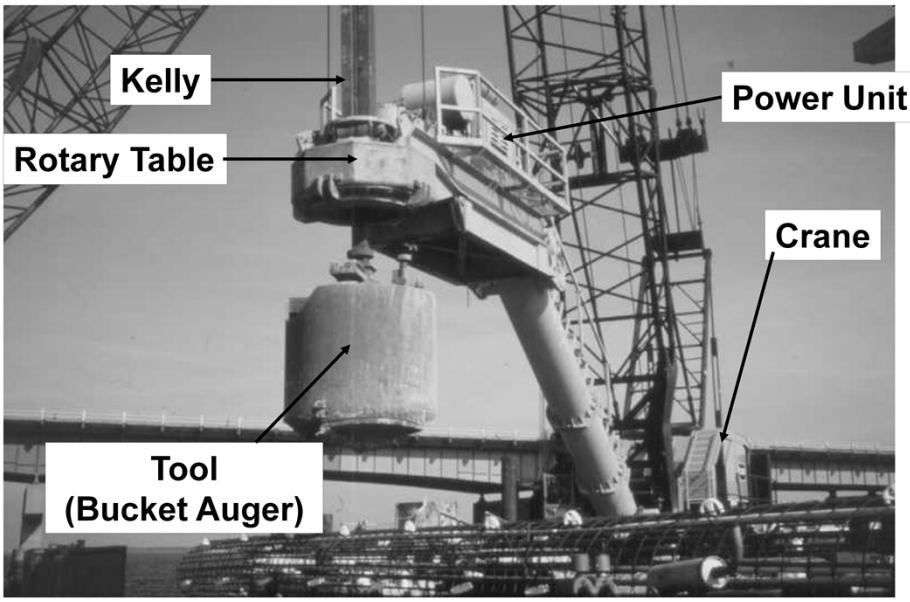
ODOT MATERIALS & INSPECTION

Learning Objectives

- Identify drilled shaft rig components
- Identify different types of drill rigs
- Identify drilling tools and explain their uses

Terminology



Crane – This is the carrier or main component. Most common rotary. Can be truck, excavator, crane or crawler mounted.

Power Unit – This unit provides the power that turns the table and kelly.

Kelly – This is the rod that runs through the table and the tools are attached to. Can be one-piece or telescoping.

Table – This is connected to the power unit and is what turns the kelly.

Tool – These are the bits, augers, buckets, etc. that go down the hole.

Most excavations for drilled shafts in the United States are made by some type of rotary-drilling machine. The machines vary greatly in size and in design as well as by the type of machine on which the drilling rig is mounted. The machine transmits force from the power unit through the rotary table to a kelly bar and then to the tool attached to the end of the kelly.

Terminology

- **Bits** – typically are for excavating (drilling) and can be either auger or barrel type. Certain types are used for soil and certain types for rock.
- **Buckets** – generally two types:
  - Digging - for excavating soils or soft rock
  - Cleanout or Bailing - for cleaning of the shaft

Learning Objective
Identify Auger Rig Components

The capacity of a rotary drilling rig is often expressed in terms of the maximum torque that can be delivered to the drilling tools and the "crowd" or downward force that can be applied. Other factors can have great impact on the efficiency of the rig in making an excavation, particularly the type and details of the drilling tools, but the torque and crowd are important factors affecting the drilling rate.

Torque and crowd are transmitted from the drilling rig to the drilling tool by means of a drive shaft of steel, known as the kelly bar, or simply the "kelly." The drilling tool is mounted on the bottom of the kelly. Kellys are usually either round or square in cross section, and may be composed of a simple single piece (up to about 60 ft long) or may telescope using multiple inner sections to extend the depth to which the kelly can reach. The square kelly bars often require a worker to insert a pin to lock the outer bar to the inner telescoping kelly piece, whereas the round kellys often include an internal locking mechanism. In some rigs the weight of the kelly and the tool provides the crowd. In others, hydraulic or mechanical devices are positioned to add additional downward force during drilling.

Rigs

Predominately

- American Manufacturer Types
- European Manufacturer Types

The variety of auger rigs available to contractors is considerable, particularly when you include both U.S. and European technology. Catalogs from the early 1900's show that bucket type auger drills were available even then, if you owned a horse to power it. Mechanical units were developed in the 1920's with production models in the late 1930's. This early history appears to have had its roots in Texas.

Reportedly the famous Hughes LL Series of diggers were being manufactured at the rate of 70 to 80 units per year in the late 1970's and early 1980's. Beginning in the early 1980's, it was clear that most equipment manufacturers in the U.S. were moving away from mechanical designs to hydraulic powered drilling machines with torque converters to deliver power to the rotary table and kelly bar.

Importing of European designed drills began roughly in the 1990's and is gaining popularity among some contractors. Out of Germany are units built by Delmag and Bauer. SoilMec is one of the leading Italian manufacturers as are Casagrande and IMT. All of these companies now have manufacturers' representatives in the United States.

Perhaps one of the most attractive features of the European designs is the ability of the drill equipment to install casing. Many of these units are capable of drilling holes 120″ (10 ft.) in diameter, to maximum depths of 120 feet. Where casing is required, the drill utilizes a high torque, top-head drive along with down pressure to advance sections of casing which can be easily bolted to the casing adaptor (drive head). An auger or drilling bucket can remain attached to the kelly and used to remove material as required to facilitate advancement of the casing.

American Manufacturers

- Atlantic Equipment Company
- American Equipment and Fabrication Corp.
- Calweld
- Stephen M. Hain Company
- Reedrill/Texoma
- Watson
- LoDril (Bay Shore Systems)

European Manufacturers

- Bauer (Germany)
- Casagrande (Italy)
- IMT (Italy)
- SoilMec (Italy)

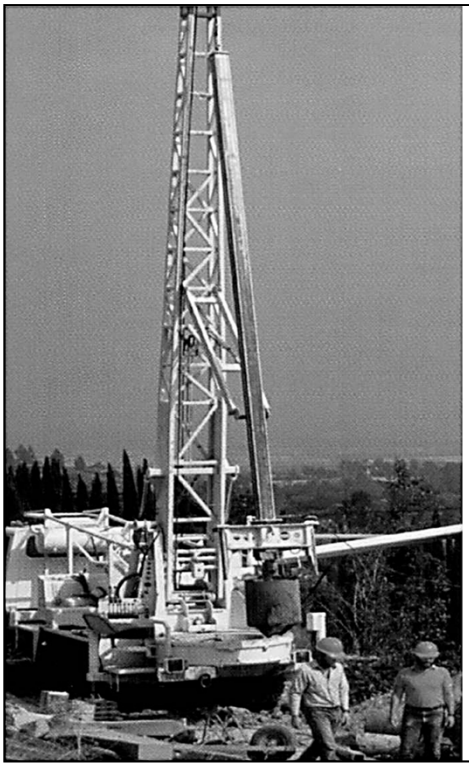
Types of Rigs

- Truck-Mounted Rigs
- Carrier-Mounted Rigs
- Crawler-Mounted Rigs
- Excavator-Mounted Rigs
- Crane-Mounted Rigs

For large projects (large diameter, very deep shafts), crane-mounted rigs in conjunction with large vibratory hammers are very commonly used although other equipment and methods are gaining popularity and versatility. However, contractors tend to own equipment that works best for the type of work they do most often. There also appears to be a certain “mind-set” among some who favor a particular line of equipment and simply won’t consider any other kind.

What this means to us as Inspectors is that we are apt to see a wide variety of drill units on Agency work. In this lesson, the basic types of both American and European equipment are discussed so that the majority of the name brands will become familiar to you and you can better identify the relative sizes and capabilities of the various drill units.

The diameter and depth of the shafts for a particular job, along with the type of access to the shaft location, will largely dictate what types of equipment will be the most economical to use.



Types of Rigs
Light Truck-Mounted

Calweld

Mobility is the greatest advantage of truck-mounted drilling machines, which can range widely in size and drilling capabilities. Truck-mounted rigs can range from small, extremely mobile rigs most suited to small holes to large, heavy rigs capable of drilling rock. If the site is accessible to rubber-tired vehicles and conditions are favorable for drilling with truck-mounted rigs, construction of drilled shafts can be accomplished very efficiently with these machines. With the mast or derrick stored in a horizontal position, lighter units can move readily along a roadway. The truck can move to location, erect the derrick, activate hydraulic rams to level the rotary table, and begin drilling within a few minutes of reaching the borehole location.

Light truck-mounted rigs are most commonly used for drilling shallow drilled shafts in soils for traffic structures such as light, sign and signal pole foundations.

Types of Rigs
Light Truck-Mounted

H & T 635
48" Dia.; 35 ft.

Truck-mounted rigs are normally mechanically-driven with a fixed rotary, and therefore may have limited capability to reach over tall casing or to handle tall drilling tools. The space below the rotary table can be increased by placing the rig on a ramped platform, but this procedure is obviously slow and expensive and would be used only in unusual circumstances. However, some truck-mounts are now supplied with a hydraulic sliding rotary which can overcome many of the limitations of older truck-mounted rigs.

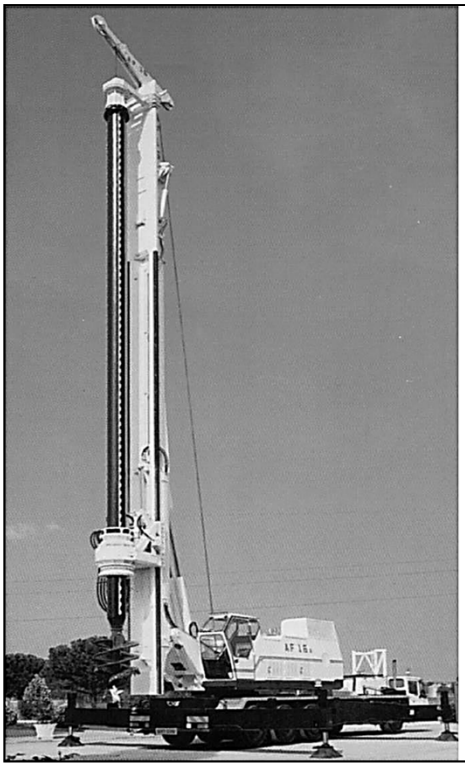
While the truck-mounted unit has a secondary line with some lifting capacity, that capability is necessarily small because of the limited size of the derrick. The drilling tools can be lifted for attachment to and detachment from the kelly, but, if a rebar cage, tremie or casing must be handled, a service crane is usually necessary. Some truck rigs can handle light rebar cages and tremies of limited length

Types of Rigs Carrier-Mounted

Texoma Taurus XL
120 in. Dia; 120 ft.

For large hole diameters and greater depths, equipment weights dictate that crane carriers be used if rubber-tired transport is desired. These larger drills require two front axles to accommodate highway weight limits and to achieve the off-road maneuverability needed.

Characteristic of these drills are three part telescoping kellys capable of drilling 120-inch (12-ft.) diameter holes to depths of 85 feet to 200 feet.



Types of Rigs
Carrier-Mounted

IMT AF16-A
80 in. Dia; 200 ft.

Types of Rigs
Crawler-Mounted

SoilMec R622
100 in. Dia; 245 ft.

Crawler rigs are often used due to their range of capabilities in access, mobility, hole diameters and depths and casing installation. These rigs require less overhead clearance and are very mobile, making them the weapon of choice for restricted work areas.

Crawler or special mounted rigs are also becoming very popular due to the increase in rehabilitation versus new bridge construction.

Types of Rigs
Crawler-Mounted

Bauer
120 in. Dia; 195 ft.

This type of crawler-mounted rig has the capability to twist in casing as it is drilling the hole. This speeds up production.

Types of Rigs
Crawler-Mounted

Casagrande B250

Lightweight crawler mounted drilling machines can be extremely versatile for work on difficult to access sites for applications such as bridge foundations, slope stabilization, sound wall foundations, and foundations for signs, towers, or transmission lines.

Types of Rigs
Excavator-Mounted

LoDril

Another type of crawler mount that has advantages for some special applications is the placement of the drilling machine on the arm of an excavator. These rigs are almost always hydraulic, utilizing the hydraulic system common on an excavator. The advantage of such a mount is that the rig can reach a difficult to access location with low headroom or with limited access immediately adjacent to the hole. Low headroom equipment is often advantageous for applications such as a sound wall where utility lines are overhead or when installing shafts below or very near an existing bridge structure. The use of low headroom equipment has obvious limitations in terms of the depth and size of hole that can be drilled efficiently. Reduced productivity in drilling under low overhead conditions will affect costs.

Types of Rigs Excavator-Mounted

LoDril

Below are rig specifications for LoDrils manufactured by Bay Shore, Inc.

LōDril® Specifications

Specification	Units	DH10	DH18	DH30	DH40	DH60	DH80	DH100
Rotary Torque [1]	ft-lbs	10,000	18,000	30,000	43,000	62,000	84,000	110,000
	kN-m	14	24	40	58	84	114	149
Std. Kelly Winch Line Pull (bare drum)	lbs	5,000	12,000	18,000	18,000	25,000	30,000	30,000
	kN	22	53	80	80	111	133	133
Hole Diameter [2]	in	36	48	60	84	108	132	144
	mm	900	1,200	1,500	2,100	2,700	3,300	3,600
Drill Speed Range [3] low/high/spin off	rpm	25/50/100	30/60/100	30/60/100	30/60/100	20/50/100	20/50/100	20/50/100
Hole Depth [4]	ft	30-50	30-100	30-80	30-80	40-100	40-100	40-80
	m	9-15	9-30	9-24	9-24	12-30	12-30	12-24
Attachment Height [4]	ft	9-14	10-21	16-22	13-24	17-26	22-33	22-33
	m	2.7-4.3	3.0-6.4	4.9-6.7	4.0-7.3	5.2-8.0	6.7-10.0	6.7-10.0
Attachment Weight [4] x 1000	lbs	4-5	7-8	9-10.5	13-16	15-17	22-24	24-26
	kg	1.8-2.3	3.2-3.6	4-4.8	5.9-7.3	6.8-7.7	10-11	11-12
Hydraulic Flow Capacity [5]	gpm	2 x 20	2 x 35	2 x 50	2 x 64	2 x 75	2 x 85	2 x 85
	l/min	2 x 76	2 x 132	2 x 189	2 x 242	2 x 280	2 x 320	2 x 320
Excavator Weight Class [6] x 1000	lbs	16-32	35-50	50-65	70-95	75-100	100-150	100-150
	kg	7-15	15-22	22-29	32-43	34-45	45-68	45-68

Check our website www.bayshoresystems.com for any updated specifications.

1 Running torque at low drill speed

2 Dependent on ground conditions, tooling and operation

3 Dependent on excavator

4 LōDril configuration specific

5 Required to achieve specified drill speed range

6 Excavator modifications may be required

Truck mounted versions available

CE

Types of Rigs
Crane-Mounted

140 in. Dia.;
285 ft.

If there is a need for a larger drill, with greater torque and depth capability, contractors frequently use, what is termed in the industry as “crane attachment” drills. The power of some of these rigs can be truly impressive. Crane attachments come as a unit, including a diesel engine, transmission and torque converter driving a heavy duty rotary table through which a kelly is installed. The entire drill unit is attached to a crane using a “bridge” which allows the rotary table to be rigidly held and sufficiently elevated to accommodate the drilling tools anticipated for the job. Given the power advantages offered by large crane attachments, it is the ability to vary the working room (clearance) under the rotary table which makes this type of drill so attractive for many jobs.

The depth capability of crane attachment drills is dependent on the crane used. These drills are commonly used for hole sizes varying up to 140 inches in diameter and depths of almost 300 feet.

Types of Rigs Crane-Mounted

Hain 754

Diameter and depth dependent upon configuration.

The Hain Model 754 shown can accommodate a maximum outer kelly size of 18 inches (450 mm) square. This unit can reportedly deliver a maximum rotary torque (stall) of 374,631 ft-lbs (500 kNm).

Power units of various sizes can be utilized to supply large torque at slow rotational speeds to the drilling tool. Usually, the downward force on the tool is due to the dead weight of the drill string, but the dead weight can be increased by use of heavy drill pipe (drill collars), "doughnuts," or a heavy cylinder. Special rigging is available for crane machines that will apply a crowd for drilling in hard rock. The cross-sectional area of the kelly can be increased to accommodate high crowds.

The framework or "bridge" that is used to support the power unit and rotary table can vary widely. The rotary table may be positioned 75 ft or more from the base of the boom of a crane by using an extended mount. The ability to reach to access the hole from a distance makes crane mounted machines very attractive in marine construction when working from a barge or work trestle. The bridge for the drilling unit can also be constructed in such a way that a tool of almost any height can fit beneath the rotary table. Therefore, crane-mounted units with high bridges can be used to work casing into the ground while drilling or for accommodating tall drilling tools.

Hammer Grab

Hammer grabs are becoming more prevalent in the industry. They are commonly used to excavate loose to dense unconsolidated soils, including cobbles and small boulders. The hammer grab is lowered to the bottom of the hole inside casing and the jaws are closed when the cables or ropes attached to the spring-driven closing mechanism are retracted.

Rig Information

Contact the Manufacturers for the latest information on the various models and capabilities.

See following detailed information sheets for contact information and rig capabilities.

ODOT MATERIALS & INSPECTION

DRILLED SHAFT AUGER RIGS

AMERICAN MANUFACTURERS

ATLANTIC EQUIPMENT COMPANY

No Contact Information Available

MODEL	MAX. SHAFT DIA.		MAX. SHAFT DEPTH		MAX. TORQUE	
Drill Master TMCD60T	75"	1900 mm	57'	18 m	33,333 ft-lbs	45 kNm
Drill Master DM80T	95"	2400 mm	100'	30 m	51,622 ft-lbs	70 kNm
Williams LDH	88"	2235 mm	100'	30 m	49,410 ft-lbs	67 kNm
Williams LLDH	120"	3048 mm	115	36 m	99,557 ft-lbs	135 kNm

AMERICAN EQUIPMENT & FABRICATING CORP.

100 Water Street
3710 Lee Highway
East Providence, RI 02914
Tel:(401) 438-2626
Fax:(401) 438-0764
www. american-equipment.com

DRILL RIGS	CASING DRIVERS	LOAD TEST EQUIPMENT
Soilmec Models	**H.M. Vibro** **PTC**	**Osterberg Load Cell**

DRILLED SHAFT AUGER RIGS

AMERICAN MANUFACTURERS

CALWELD

No Contact Information Available

MODEL	MAX. SHAFT DIA.		MAX. SHAFT DEPTH		MAX. TORQUE	
ADL	72"	1828 mm	100'	30 m	64,896 ft-lbs	88 kNm
ADM	60"	1524 mm	57'	18 m	64,896 ft-lbs	88 kNm
125 CH (Crane)	186"	4730 mm	*	*	124,631ft-lbs	169 kNm
155 CH (Crane)	186"	4730 mm	*	*	152,654 ft-lbs	207 kNm
400 CH (Crane)	204"	5180 mm	*	*	399,705 ft-lbs	542 kNm

* Dependent upon crane size and capability

STEVEN M. HAIN CO.

713 E. Walnut Street
Garland, Texas 75040
Tel:(972) 272-6461
Fax:(972) 272-9194
www.smhainco.com

MODEL	MAX. SHAFT DIA.	MAX. SHAFT DEPTH	MAX. TORQUE	
4-71//3531-3 (Crane)	*	*	167,404 ft-lbs	227 kNm
8V71/754 (Crane)	*	*	374,631 ft-lbs	508 kNm
3-53T/3331-1 (Crane)	*	*	102,507 ft-lbs	139 kNm

* Dependent upon crane size and capability

DRILLED SHAFT AUGER RIGS

AMERICAN MANUFACTURERS

REEDRILL/TEXOMA

Acquired by Bucyrus who was acquired by Caterpillar.

MODEL	MAX. SHAFT DIA.		MAX. SHAFT DEPTH		MAX. TORQUE	
Texoma 600	72"	1,828 mm	30'	10 m	40,560 ft-lbs	55 kNm
Texoma 700	72"	1,828 mm	57'	18 m	53,834 ft-lbs	75 kNm
Texoma 800	85"	2,438 mm	85'	207 m	57,522 ft-lbs.	78 kNm
Texoma 900	85"	2,438 mm	115'	36 m	104,719 ft-lbs.	142 kNm
Texoma Taurus XL	120"	3,048 mm	115'	36 m	143,805 ft-lbs.	195 kNm
Texoma C-100	85"	2,438 mm	115'	36 m	99,557 ft-lbs.	135 kNm

WATSON

4015 S Freeway
Fort Worth, TX 76110
Tel:(800) 927-8486
Fax:(817) 927-8716
www.watsonusa.com

MODEL	MAX. SHAFT DIA.		MAX. SHAFT DEPTH		MAX. TORQUE	
1500	76"	1,930 mm	86'	27 m	56,047 ft-lbs.	76 kNm
2500	86"	2,440 mm	86'	27 m	80,383 ft-lbs.	109 kNm
3100	86"	2,440 mm	115'	36 m	99,557 ft-lbs.	135 kNm
500CA (Crane)	120"	3,050 mm	138'	43 m	98,820 ft-lbs	134 kNm
EDT-7 (Crane)	54"	1,370 mm	87'	18 m	53,834 ft-lbs	73 kNm

DRILLED SHAFT AUGER RIGS

EUROPEAN MANUFACTURERS

BAUER
91 Greenville Road
Livermore, CA 97551
Tel:(800) 745-3622
Fax:(925) 449-6034
www.bauerpileco.com

MODEL	MAX. SHAFT DIA.		MAX. SHAFT DEPTH		MAX. TORQUE	
BG9	52”	1300 mm	130’	40 m	68,584 ft-lbs	90 kNm
BG14	72”	1800 mm	180’	55 m	103,244 ft-lbs	140 kNm
BG18	72”	1800 mm	130’	40 m	162,241 ft-lbs	220 kNm
BG30	120”	3000 mm	195’	60 m	265,486 ft-lbs	360 kNm
BG50	100”	2500 mm	260’	80 m	265,486 ft-lbs	360 kNm

CASAGRANDE
Via A. Malignani, 1
33074 - Fontanafredda (PN), Italy
Tel: +39 0434 9941
Fax:+39 0434 997009
www.casagrandegroup.com

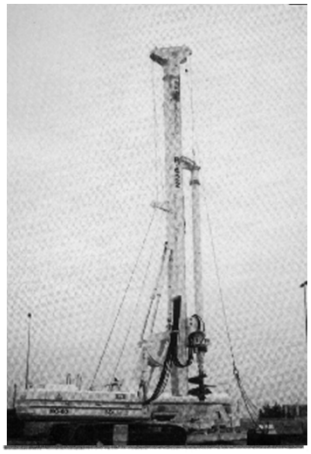
MODEL	MAX. SHAFT DIA.		MAX. SHAFT DEPTH		MAX. TORQUE	
B130E	65”	1,600 mm	155’	48 m	93,657 ft-lbs	127 kNm
B220	100”	2,500 mm	218’	68 m	152,654 ft-lbs	207 kNm
C600	100”	2,500 mm	265’	81 m	401,917 ft-lbs	545 kNm
C800	100”	2,500 mm	265’	81 m	294,985 ft-lbs	400 kNm

DRILLED SHAFT AUGER RIGS

EUROPEAN MANUFACTURERS

IMT International S.p.a.
Via D'ancona
39 60027 Osimo (AN) - Italy
Tel:+39 071 723341
Fax: +39 071 7133352
www.imtspa.com

MODEL	MAX. SHAFT DIA.		MAX. SHAFT DEPTH		MAX. TORQUE	
AF6	48"	1,200 mm	105'	32 m	46,460 ft-lbs	63 kNm
AF10	60"	1,500 mm	135'	42 m	75,221 ft-lbs	102 kNm
AF12	60"	1,800 mm	195'	60 m	84,808 ft-lbs	115 kNm
AF15	72"	1,800 mm	193'	60 m	115,044 ft-lbs	156 kNm
AF18	72"	1,800 mm	190'	59 m	136,430 ft-lbs	185 kNm
AF20	80"	2,000 mm	200'	62 m	147,492 ft-lbs	200 kNm
AF50	120"	3,000 mm	285'	89 m	368,731 ft-lbs	500 kNm



SOILMEC SPA
Via Dismano, 5819
47522 Cesena (Forlì Cesena) Italy
Tel: +39 0547 319111
Fax: +39 0547 318548
www.soilmec.com

MODEL	MAX. SHAFT DIA.		MAX. SHAFT DEPTH		MAX. TORQUE	
R-208	48"	1,200 mm	130'	40 m	77,651 ft-lbs	82 kNm
R-312	60"	1,500 mm	130'	40 m	83,333 ft-lbs	113 kNm
R-412	60"	1,500 mm	150'	46 m	80,383 ft-lbs	109 kNm
R-515	60"	1,500 mm	200'	62 m	105,457 ft-lbs	143 kNm
R-618	80"	2,000 mm	193'	60 m	126,843 ft-lbs	172 kNm
R-622	100"	2,500 mm	245'	76 m	148,230 ft-lbs	201 kNm
RT3-ST (Crane)	100"	2,500 mm	260'	80 m	151,916 ft-lbs	206 kNm

Learning Objective
Identify drill rig components

Table

Kelly: One-piece or telescoping

Rig: Truck, Track, Crane or Crawler

Tool: Bits and Buckets

Learning Objective

Identify different types of drill rigs

- Truck-Mounted Rigs
- Carrier-Mounted Rigs
- Crawler-Mounted Rigs
- Excavator-Mounted Rigs
- Crane-Mounted Rigs

ODOT MATERIALS & INSPECTION

Auger Bits and Tools

It has often been said that an auger drill, no matter how large or powerful, is no better than the tool at the end of the kelly. If you have ever tried to use a small hand drill with a worn bit, you can relate to how it can affect production.

For that reason, tools have been fabricated for virtually every below ground condition imaginable. The most common augers can be classified as either dirt (soil) or rock types, with variations of each as to the number of flights, teeth, and lead bit. Many contractors build their own designs, but there are a number of manufacturers who specialize in drilling tools as well.

Often, small details in the design of a tool can make a huge difference in effectiveness. For example, it is necessary that the lower portion of the tool cut a hole slightly larger than the upper part of the tool to prevent binding and excessive friction. It would not be unusual for one driller to reach refusal with a particular tool while another driller could start making good progress with only a slight adjustment to the same tool.

Augers & Tools

Auger bits are generally classified as either:

- **Earth (soil)** or
- **Rock**

Earth Augers

- Single or double flight
- Double flight has superior soil removal capability

Rock Augers and Tools

- Double or triple flight
- Single core barrels
- "Air barrels" (double wall core barrel)

The tool selected for rotary drilling may be any one of several types, depending on the type of soil or rock to be excavated. Rotary tools described in this section include augers, buckets, coring barrels, full faced rotary rock tools, and other specialized tools for drilling soil and rock The tools for rotary drilling are typically available in sizes that vary in 6 inch increments up to approximately 10 ft in diameter. Larger sizes are available for special cases.

Why is this important?

The Inspector must be able to:

- Compare on site tools and equipment to the approved Drilled Shaft Installation Plan
- Note on daily activity report the equipment on-site
- Recognize and document the tools being used
- Recognize and document the condition of the tools

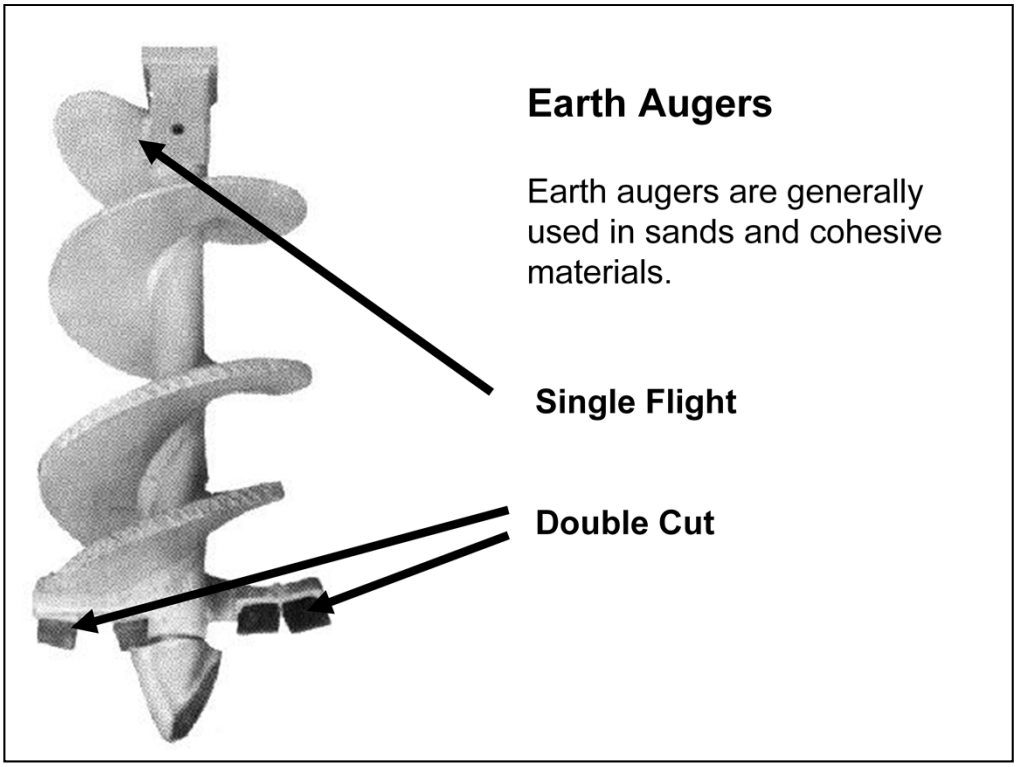
The Inspector must have the knowledge to identify the various drilling tools being used by the Contractor.

Remember – it is not the Inspector's responsibility to direct the Contractor's work or technique.

However, the Inspector must make accurate notes as to the tools and equipment on-site and being used.

If the Contractor only has earth augers on site and rock needs to be penetrated, it is important to have this information noted, as the Contractor may say the material cannot be penetrated and was misrepresented or harder than indicated. May not really be so if they had the right bit.

The Inspector's accurate, unbiased observations and documentation can help alleviate problems or questions that might arise.

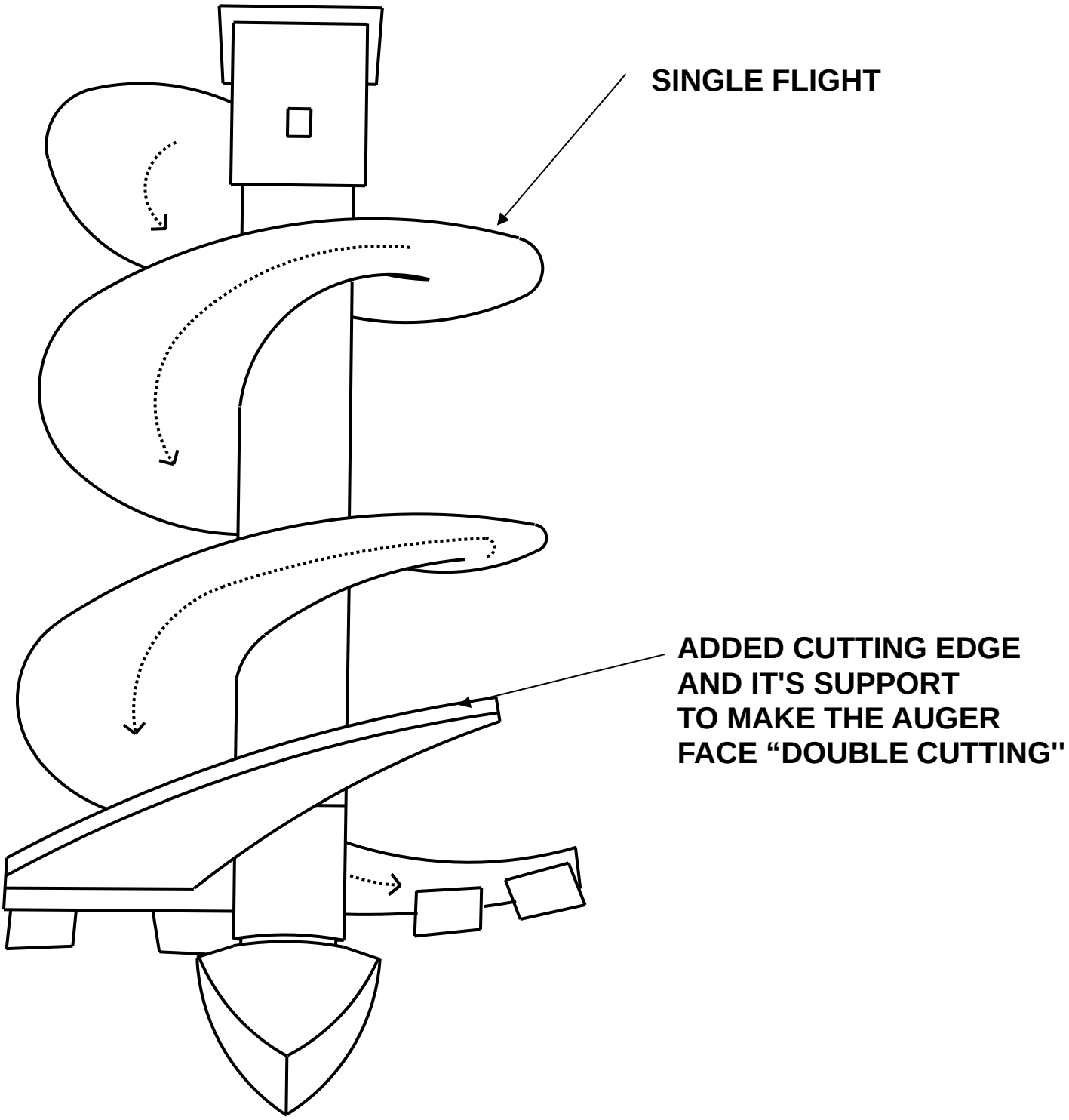


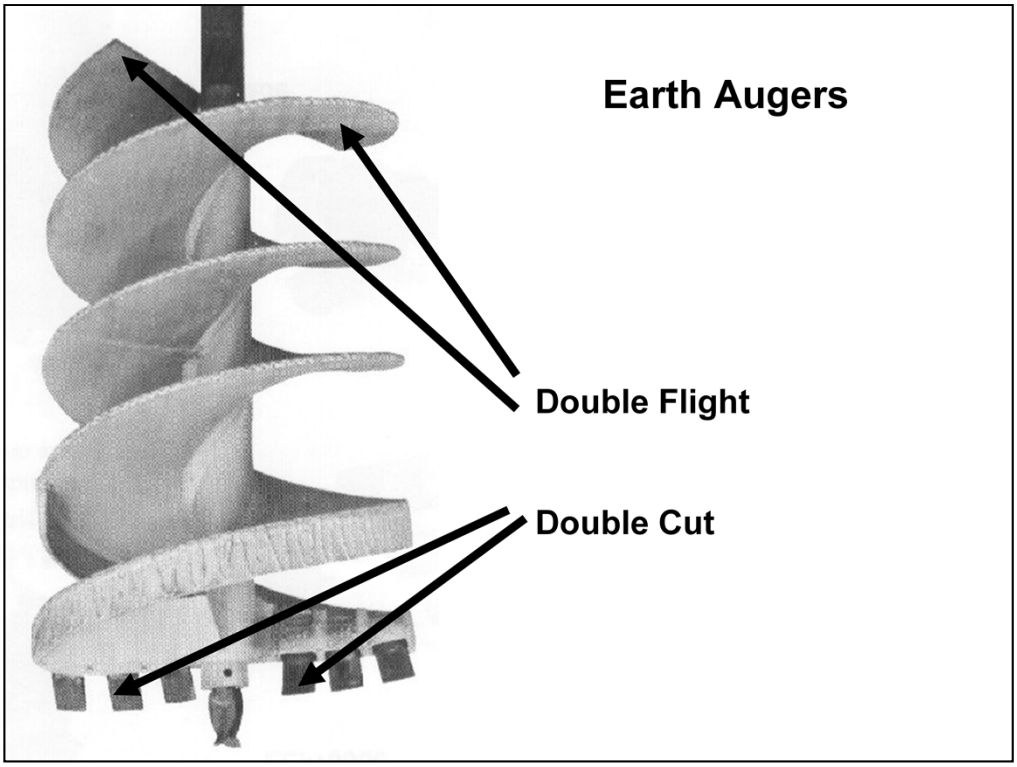
Earth augers are usually made with a single or double cutting surface, or “flights”. Most have a central point or "stinger" at the base that prevents the auger from wobbling. Above is a single flight auger designed so as to cut on both sides of the stem. These are distinguished from rock augers by the use of lighter weight material and flat edge blades as cutting teeth..

When inspecting earth augers, the Inspector should examine them for diameter, condition of the flights, and if on, condition of the teeth. Check teeth for missing from the pockets, and worn down or broken teeth edges.

Full size drawing follows.

SINGLE FLIGHT - DOUBLE CUT EARTH AUGER

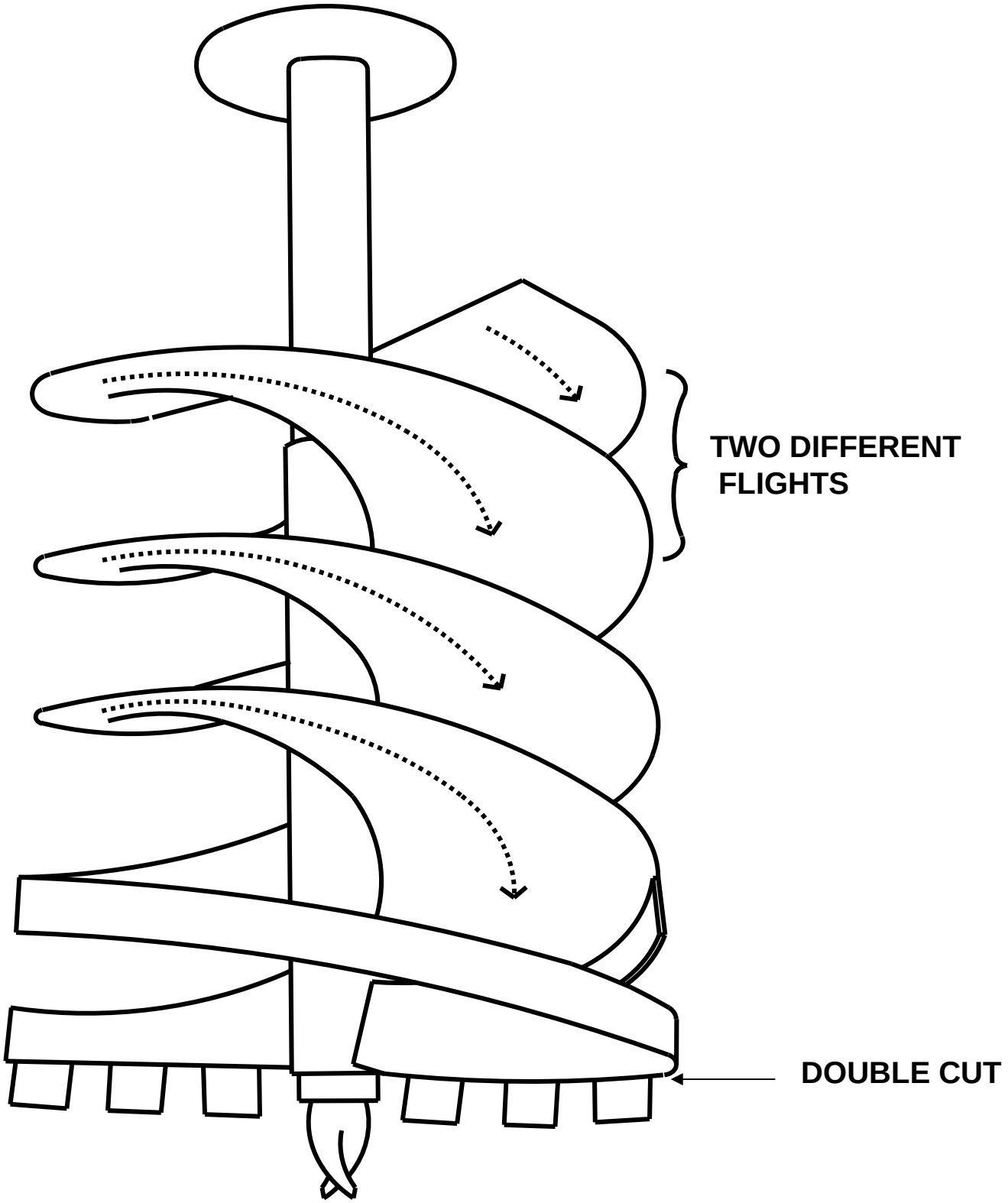


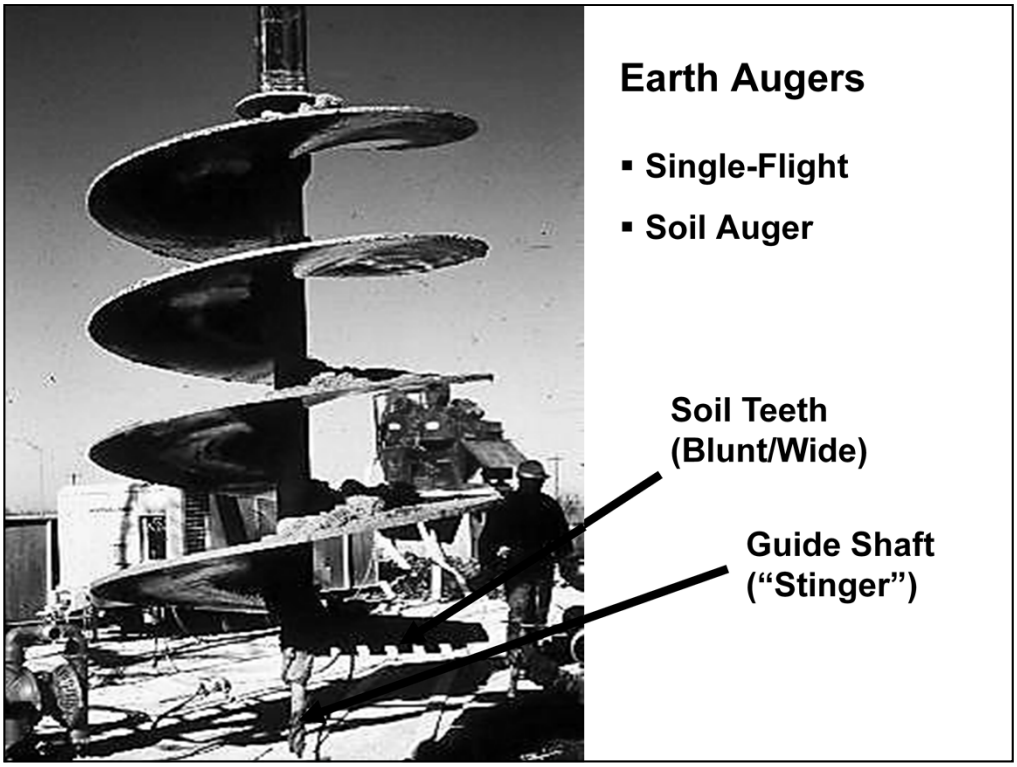


Double cut augers make it easier to keep the hole straight since they are less likely to “walk” to one side. Double flight augers are generally preferred for large diameter holes so that the cutting resistance on the base of the tool is more evenly balanced. Because of their superior removal capacity, double flight designs are also usually best for the fine sandy soils

Full size drawing follows.

DOUBLE FLIGHT - DOUBLE CUT EARTH AUGER



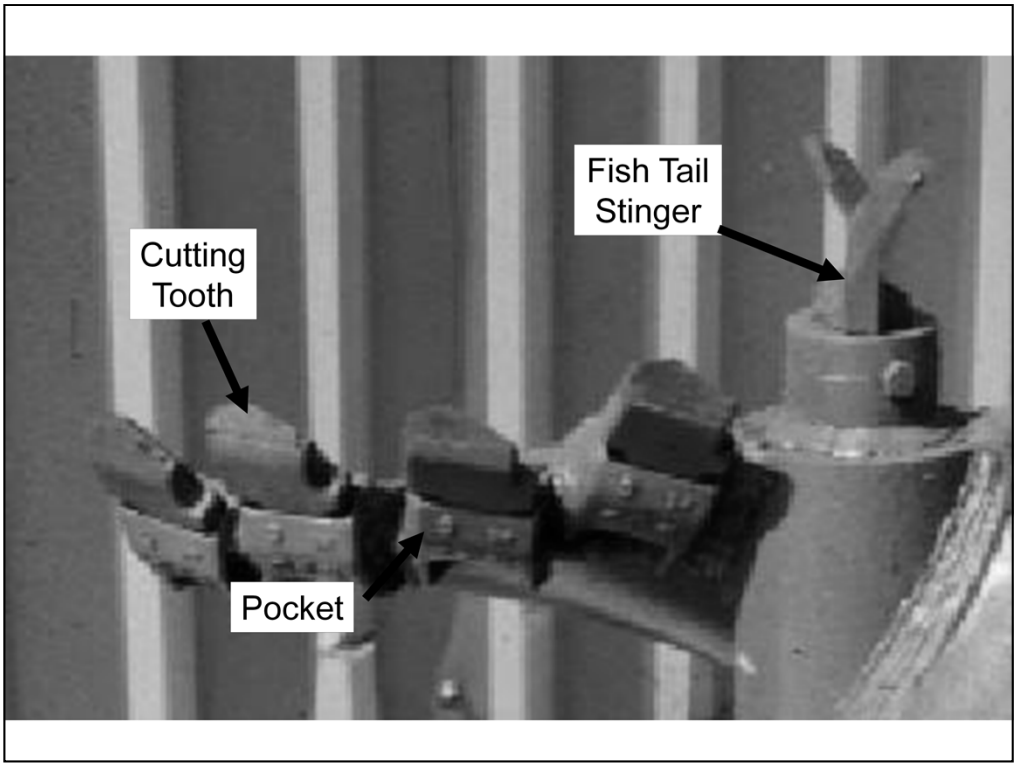


This is a standard single-helix (flight) auger for excavating relatively weak soils that have some cohesion. Sometimes, it can be used to excavate "Intermediate Geo-Materials" (IGM's) or soft rock if the IGM or rock is horizontally bedded and bedding planes are very closely spaced. Note the tooth design for gouging out large volumes of soil and the several turns on the auger, which allows for transport of considerable amounts of soil to the surface at one pass.

This type of bit has a tendency to walk off, meaning getting out of axial alignment. The stinger is needed because there is an unbalanced torque on the cutting face when the auger is excavating. The stinger is needed to ensure that the tool remains aligned.

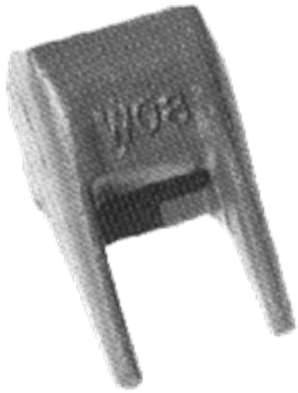
The advantage of this bit is that it can remove large volumes of material. The disadvantage is in its tendency to walk off.

If a stinger bit is being used, the Inspector should examine it for missing or broken teeth and type.



These are typical of the cutting teeth used on earth augers. The pocket, which holds the cutting teeth, is welded onto the auger. This allows for changing out broken or worn teeth. The stinger bit aids in keeping the axial alignment and minimizing “walking off”.

Pocket

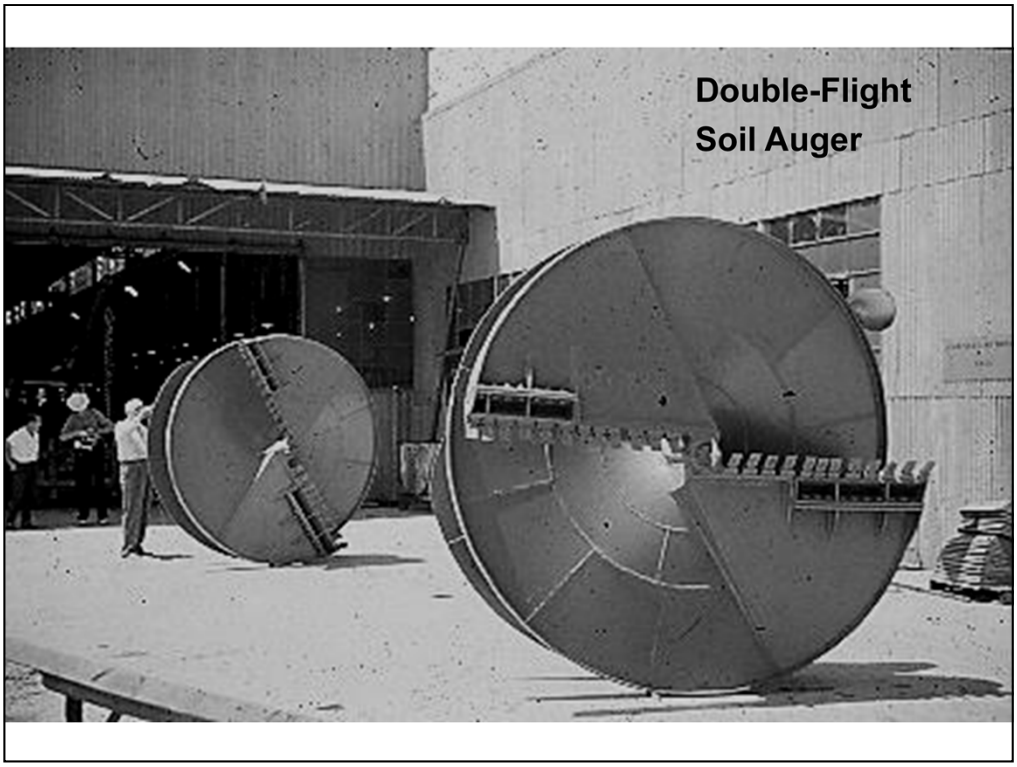


Cutting Tooth

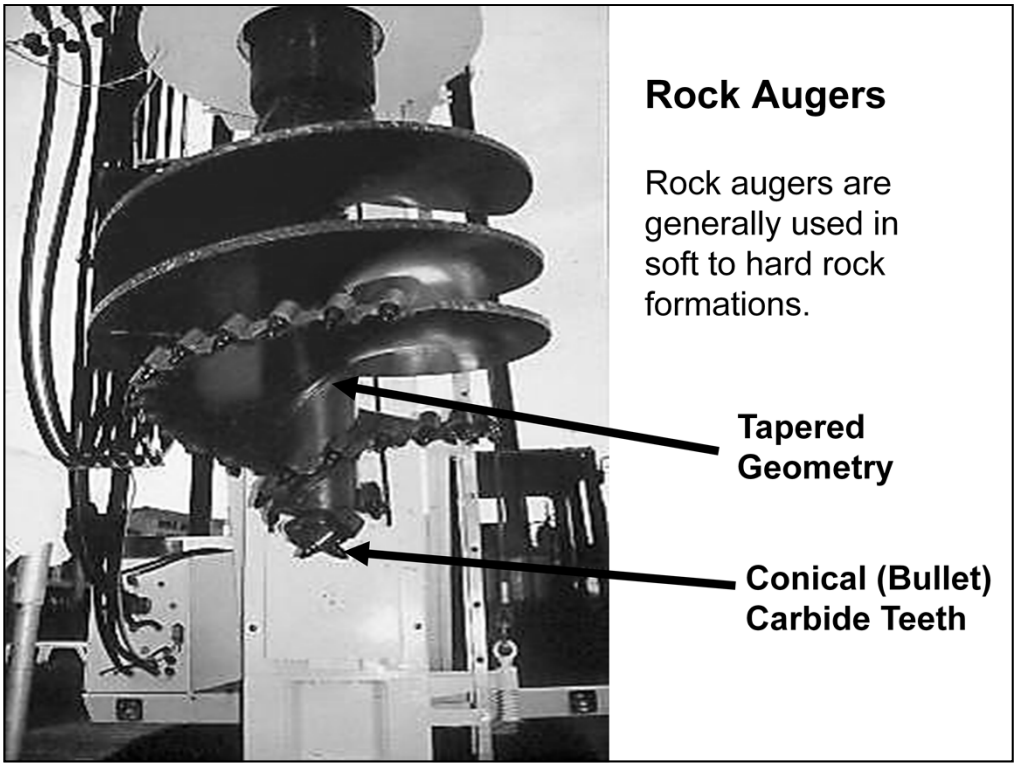
Stinger Bits

Spade

Fish Tail

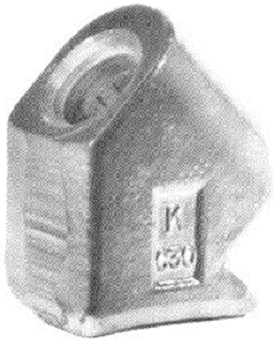


The Contractor may have trouble maintaining hole alignment or jamming the auger in the hole if the hole diameter becomes larger than 5 to 8 feet (1.5 to 2.5 m), depending upon the hardness and regularity of the soil. In such a case, he or she should change to a double helix auger such as this. Note that the opposing rows of teeth will give a balanced torque reaction on the cutting face. The auger has only a little more than one turn to reduce torque reaction from the sidewalls.

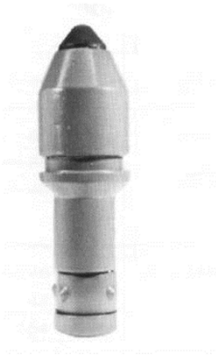


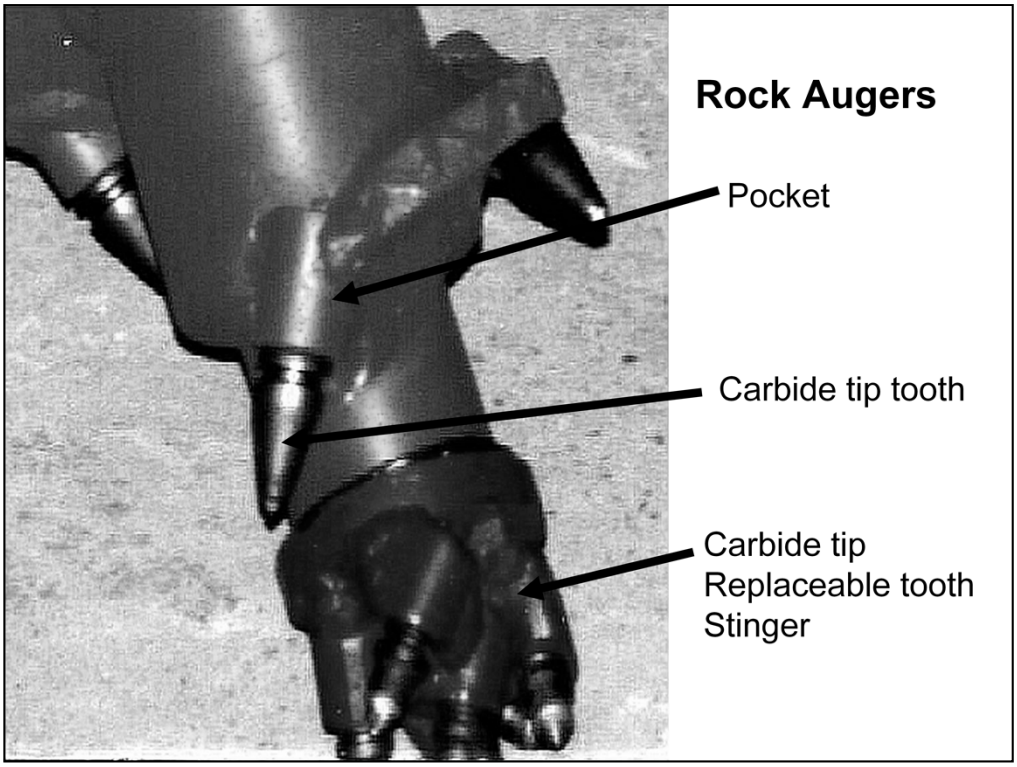
When soil augers and buckets fail to excavate the geomaterial, contractors frequently use rock augers. A typical rock auger is shown here. The rock is broken into small pieces by the ripping (tungsten carbide) teeth and either lifted out on the auger or removed with a clam or other tool. Some rock is so hard, however, that rock augers will not be effective.

Pockets



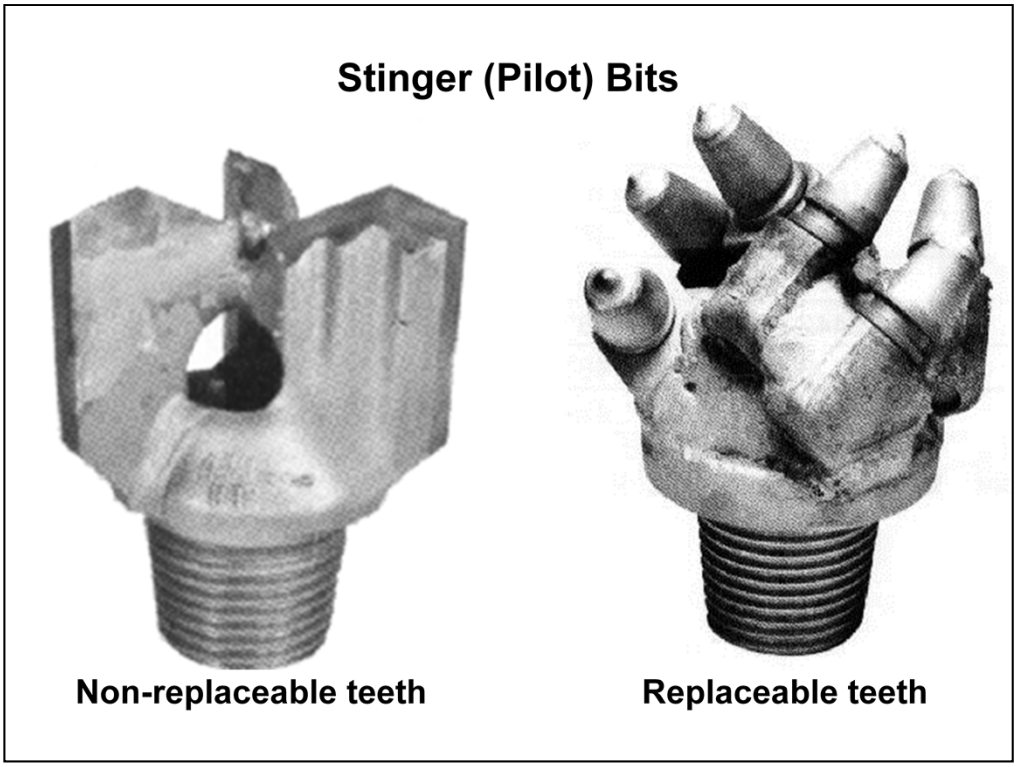
Carbide Bit Teeth





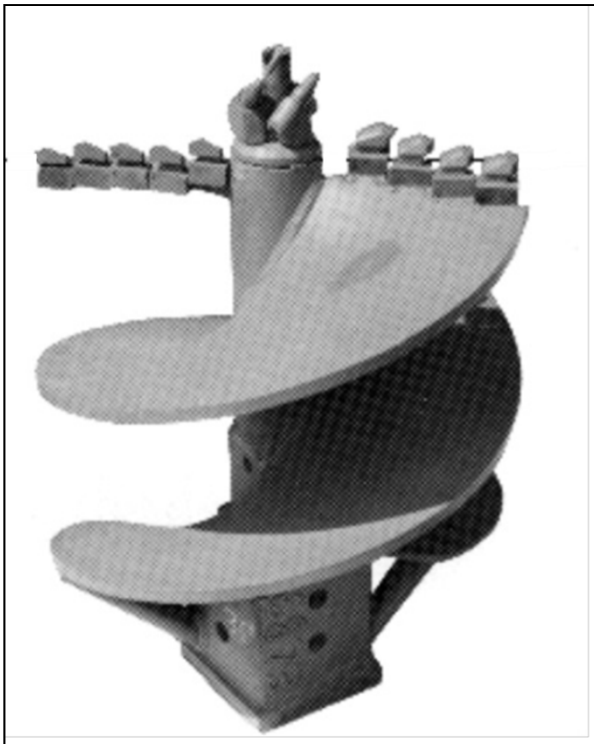
The thickness of the metal used in making the flights is more substantial than that used in making augers for excavating soil. Also, the geometry and pitch of the teeth are important details in the success of the excavation process, and the orientation of the teeth on a rock auger is usually designed to promote chipping of rock fragments. Rock augers can also be tapered.

Some contractors may choose to make pilot holes in rock with a tapered auger of a diameter smaller than (perhaps one-half of) that of the borehole. Then, the hole is excavated to its final, nominal diameter with a larger diameter, flat-bottom rock auger or with a core barrel. The stress relief afforded by pilot-hole drilling often makes the final excavation proceed much more easily than it would had the pilot hole not been made. It should be noted that tapered rock augers will not produce a flat-bottomed borehole, and an unlevel base in the borehole can be more difficult to clean and to produce a sound bearing surface.



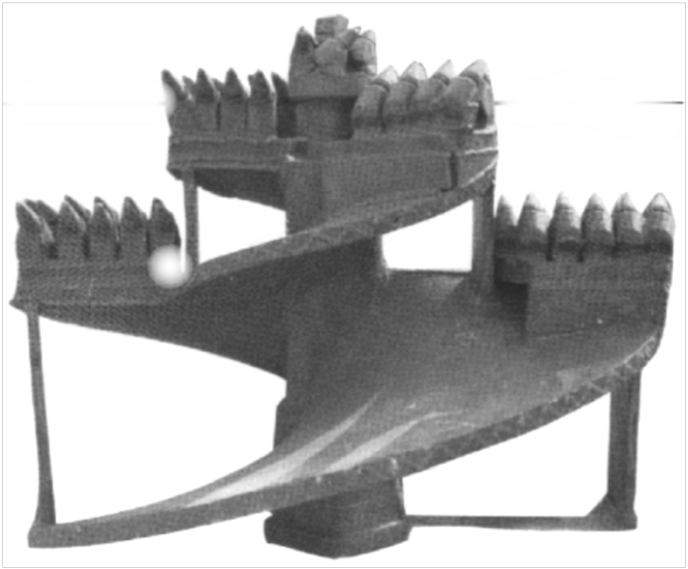
The one on the left does not have replaceable teeth like the one on the right. This is commonly called a “drag bit”.

As with earth auger stingers, these assist in starting the hole and keeping the auger aligned. They may also be called pilot bits.



Rock Augers

This is typical rock auger designed for drilling in soft to medium rock.



Rock auger for soft to medium rock.

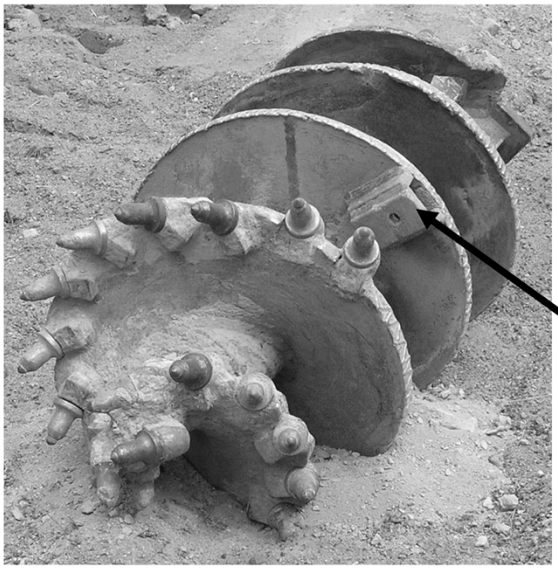
BULLET STEP TYPE
3 Way Rock Auger

Rock Augers

These are typical of rock augers designed for drilling in hard rock.

R-5000
Step Type Rock Auger

Rock Augers



Typical rock auger designed for drilling in hard rock.

Slot for reaming tooth

Reaming teeth may be installed on the sides of the auger flights to either remove “smear” from the sides of the borehole wall (for increased side friction) or they may be specified to increase the roughness of the sidewalls (also for increased side friction).

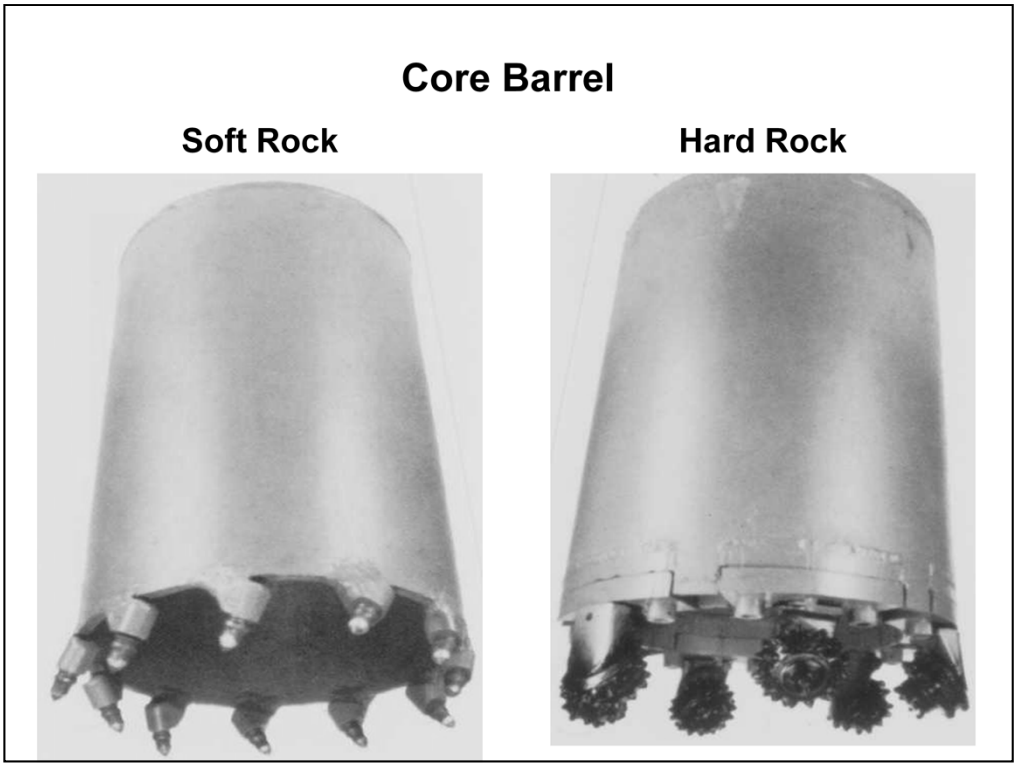
Rock Augers

Cutting teeth
on a rock auger.

Note arrow is pointing to cracked rock pocket. Good to inspect the tools prior to use so you are aware of the condition before and after drilling.

Rock Auger Cutting Teeth

These are some of the types of cutting teeth for rock augers.

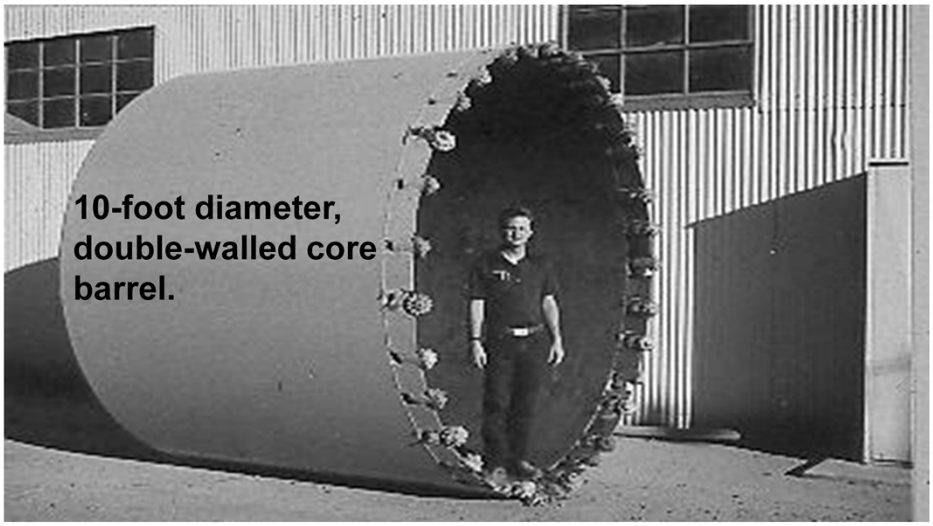


Harder, more dense rock formations may require the use of core barrels to speed advancement of the hole.

The concept of a core barrel is to minimize the amount of rock that has to be “cut” in order to deepen the hole, thereby accelerating the process. By using a single tube design, shown above left, the cutting force (down pressure and torque) can be concentrated along the perimeter of the barrel. This barrel uses replaceable carbide tipped “bullet” teeth. Ideally, the core barrel cores into the rock until a discontinuity is reached and the core breaks off. The section of rock contained in the barrel, or "core," is held in place by friction from the cuttings and is brought to the surface by simply lifting the core barrel. The core is then deposited on the surface by shaking or hammering the core barrel or occasionally by using a chisel to split the core within the core barrel to allow it to drop out.

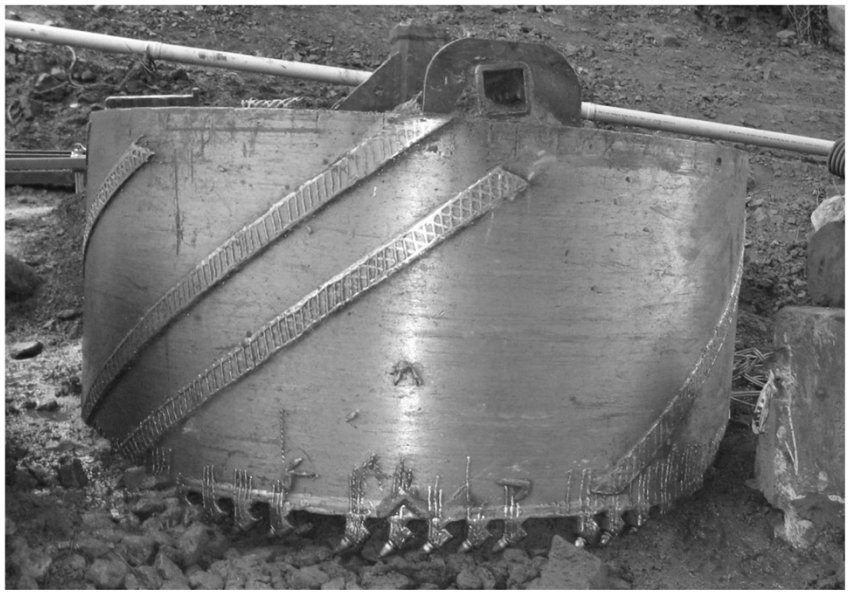
Larger drill units with sufficient down pressure and torque can utilize “air barrels” (on right above) effectively. This system uses large volumes of compressed air in conjunction with a double wall core barrel which can be equipped with a variety of cutting devices. These cutters can be replaced when worn, or exchanged for button-type bits for harder rock formations.

Core Barrel

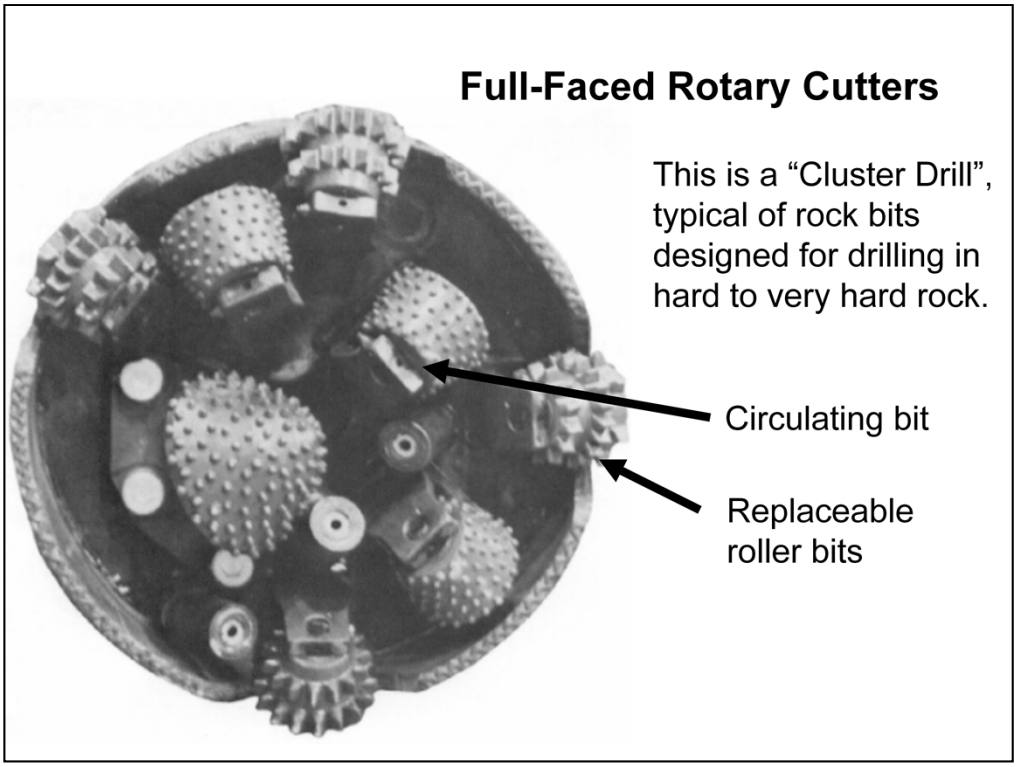


The small roller bits cut a core in the rock. Cuttings are flushed to the surface with drilling fluid that is pumped through orifices in the roller bits and exits between the outer barrel and the inner barrel. The outer barrel provides the energy for cutting the core. The inner barrel remains stationary around the core, and the core is held in place by cuttings that jam between the core and the inner barrel. When joints or discontinuities in the rock are reached, the core breaks off and can be lifted.

Core Barrel



Example of core barrel with replaceable carbide bullet teeth.



When rock augers are not sufficient to excavate rock because it is too hard, these (and other) tools might be considered.

Above is a cluster drill. This tool beats (pulverizes) the rock, and using a process known as “reverse circulation,” sucks the slurry-cuttings suspension off the bottom of the borehole. These devices will work in massive rock even when core barrels will not.

This is a step-faced roller bit, which grinds rock first in a small pilot hole (near the center), which weakens the remaining rock in the borehole, followed by the remainder of the hole (near the outer circumference). Cuttings are forced to the surface with compressed air with this tool.

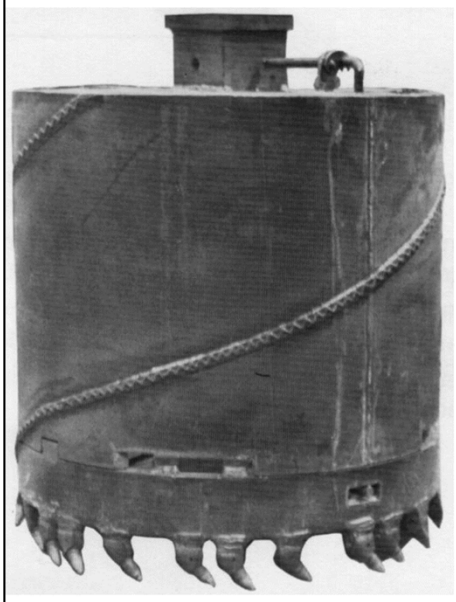
Other Options in Hard Rock

Pneumatic rotary-percussion bit for very hard rock

Why so deep? Drilled shafts may need to be embedded several feet in rock for many reasons including scour resistance and/or earthquake stability.

Does not use circulation to remove cuttings and is designed for small jobs with minimal footage. Uses replaceable roller bits.

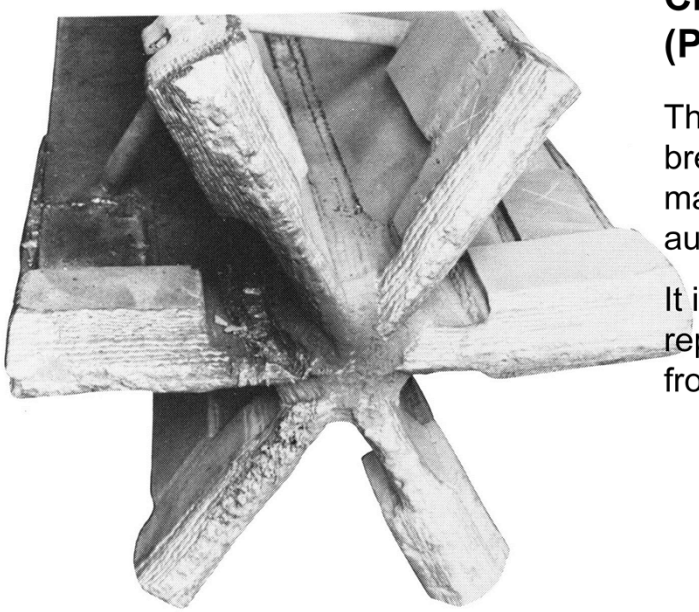
Boulder Bucket and Auger



Drilling Contractors and their suppliers have devised many ingenious tools. The one on the left, by the Stephen Hain Company, is a barrel (open-bottom bucket with tungsten carbide teeth around the perimeter of the bottom edge) that is used to maneuver boulders into the borehole and flaps that then grab the boulder to allow the driller to lift it to the surface for disposal. This tool can be used to augment drilling augers and buckets. Other devices, such as boulder rooters (tapered augers) can also be used for this purpose.

Percussion Drilling

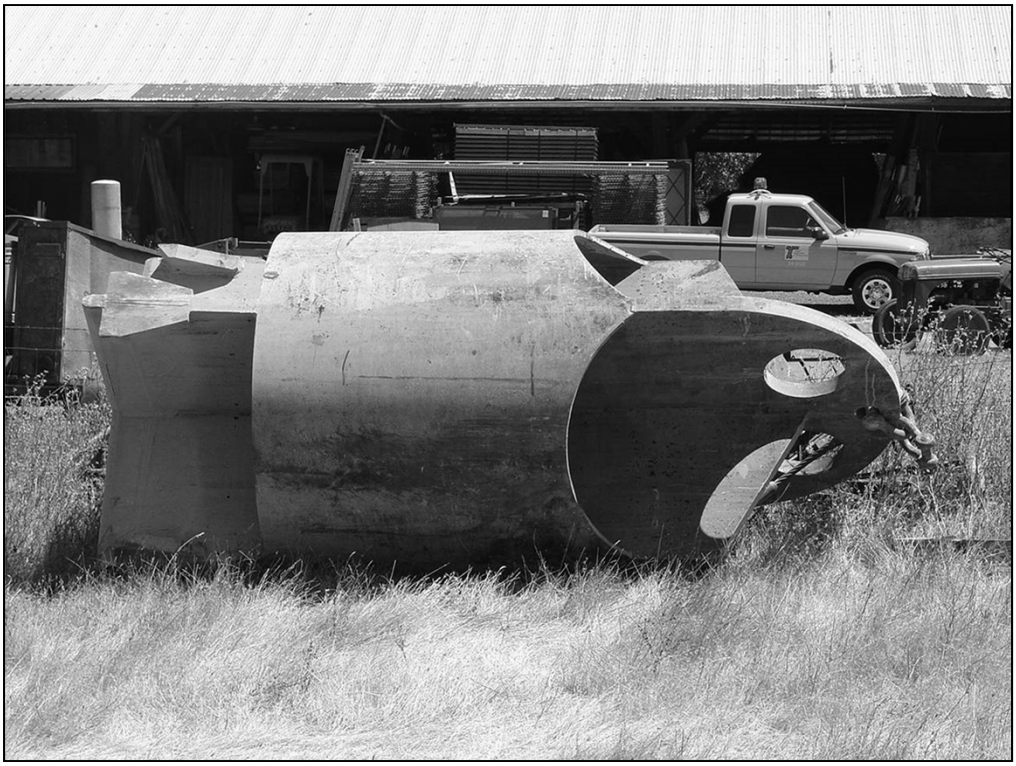
Percussion drilling involves lifting and dropping a heavy tool on rock or boulders to break it up (such as the “chum drill” on the left) and then lifting out the debris (as with the borehole clam on the right). This method can be used in hard rock when core barrels will not work. More frequently it is used in boulder fields or zones of fragmented rock.



Chopping Bit (Punch)

This bit is for breaking up rock that may not be augerable.

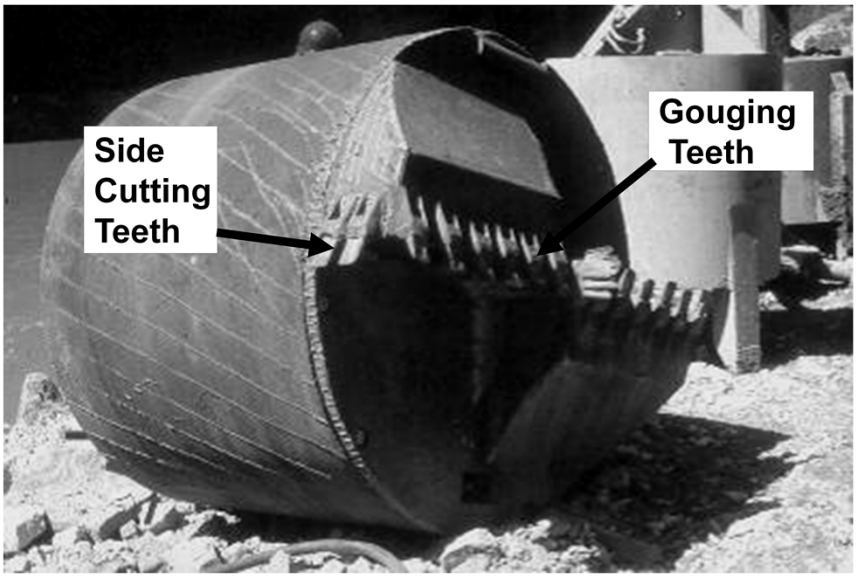
It is dropped repeatedly from a crane.



This is another boulder busting tool that is repeatedly lifted and dropped to break up rock or boulders to sizes that can be removed from the hole by other means.

Drilling Bucket

This is typical of a drilling bucket used in cobbles, gravel and clay.



An auger will not work well in a truly cohesionless soil, like a sand or gravel, especially below the water table, where boreholes are often filled with drilling fluid. In such soil conditions, contractors often use drilling buckets, like this one.

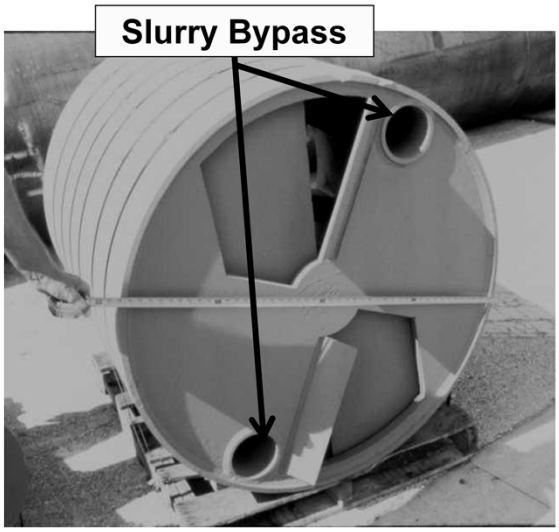
It is a good idea that these tools be vented to allow drilling fluids to bypass them during insertion and extraction of the tool when drilling under a fluid. This circumvents creating a piston effect during insertion or suction during extraction, which may cause the borehole to collapse. A flattened side or simple pipe passing through the tool can often be used for this purpose. Although it is the Contractor’s responsibility to excavate the drilled shafts, when he or she cannot do so, it becomes the Engineer's problem. So, details such as this can be important.

Sand or gravel is scooped up by the teeth and fed through flaps into the bucket on the left side of the picture. The sand or gravel cannot fall back through the flaps and so will be lifted when the bucket is lifted.

Drilling Bucket

This is typical of a drilling bucket used in cobbles, gravel and soft rock.

This bucket auger has a plate on the bottom so when bucket is full the driller reverses the tool in the hole and bottom plates slides closed to hold the material inside for removal..



Cleanout (Muck) Bucket

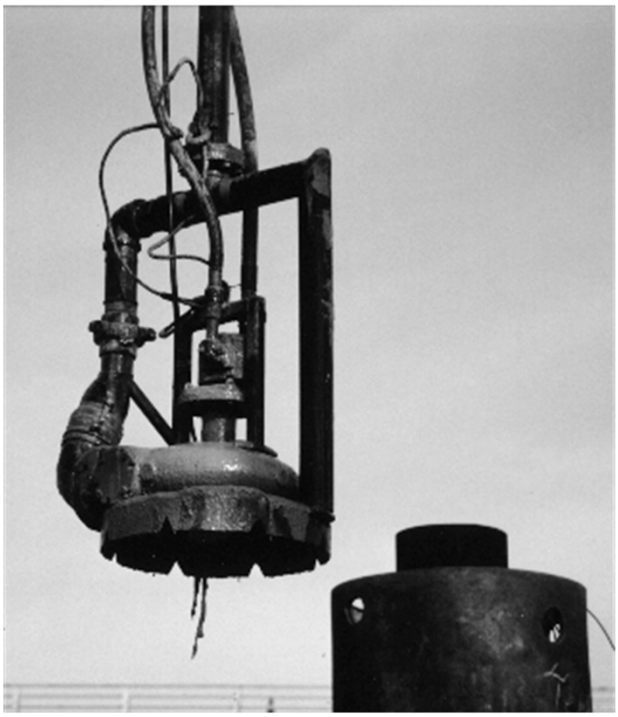
This is typical of a cleanout (muck) bucket used to clean out the cuttings and sediments from the bottom of the shaft.

These rotating bottom muck buckets are used to remove the sediments and cuttings from the bottom of the shaft. Clean-out buckets have cutting blades, rather than teeth, to achieve more effective removal of cuttings.

Normally cleanout buckets are at least 6 inches to 1 foot or more, smaller than the hole diameter, enabling movement around the hole bottom while reducing the danger of putting large negative pressures on the shaft excavation when the tool is withdrawn. Holes incorporated in this design assist in minimizing suction as well. This can be very important where rock formations contain significant amounts of sand.

The kelly is rotated in the normal drilling direction and the bottom stays open and picks up sand, muck and water. Then, while leaving the bucket on the bottom, the kelly is turned in the opposite direction, which closes the bottom of the bucket. The bucket can then be removed from the hole, dumped and the process started again.

The operation of the closure flaps on the clean-out bucket, or steel plates that serve the same purpose as flaps, are critical for proper operation of the clean-out bucket. If such flaps or plates do not close tightly and allow soil to fall out of the bucket, the base cleaning operation will not be successful.



Cleanout Tool

Final cleaning down-the-hole pump

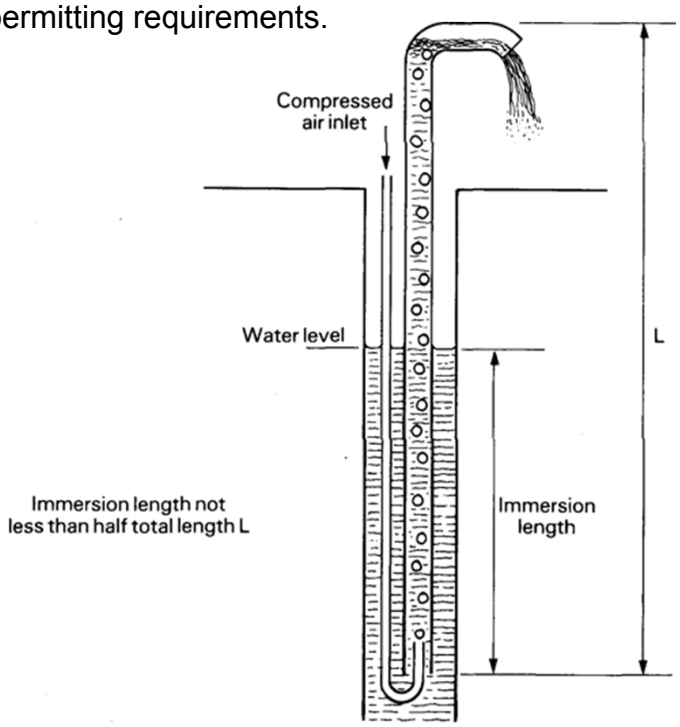
For final cleaning of the shaft, contractors frequently use down-the-hole pumps.

A hydraulically driven version of such a pump is shown here. Normally mineral slurry is pumped from the bottom of the shaft to a desanding unit while fresh slurry is replaced in the top of the shaft. Pumping shafts from the bottom greatly speeds the operation of shaft cleaning and gets better end results as opposed to extended periods of using muck buckets alone.

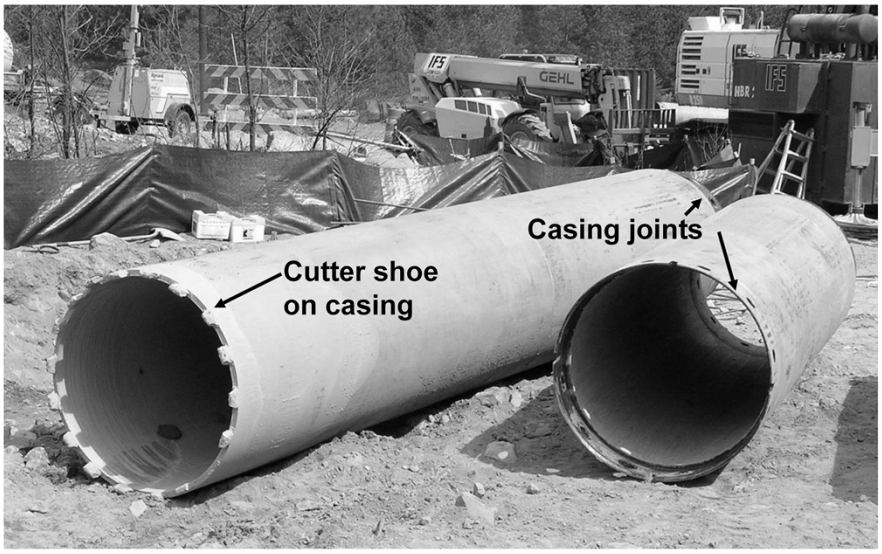
Airlift Cleanout

Final cleaning using an airlift pump

An airlift pump works by pumping compressed air through a hose into the lowest point at the base of a steel pipe that is inserted to the bottom of the hole. As the air rises in the steel pipe up to the surface, water flows into the pipe behind the air bring up loose material in the bottom of the shaft. To be effective, the hole needs to be drilled to a depth more than twice the depth to the static water level. The material is blown out the top of the pipe and so proper containment of the removed spoils must be in accordance with environmental permitting requirements.



Casing

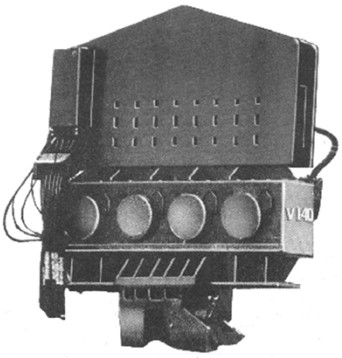


Casing is often used to stabilize the sides of the excavation during shaft construction and to achieve a seal into this bearing formation in order to control seepage or caving around the bottom of the casing. It is also often placed in the upper portion of the hole for safety (OSHA) reasons or to extend shaft excavation through water. Unless the bearing formation into which the casing is sealed is stable and dry, it will not be possible to use the casing method alone without the addition of drilling fluid or water.

Casing may be either temporary or permanent. Most casing is steel and is temporary and removed as the concrete is placed. Permanent casing is always specified in the plans and specifications. Temporary casing is usually the responsibility of the contractor.

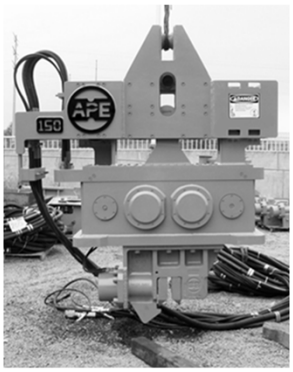
The casing may be either pushed, twisted or vibrated into the ground. The tips of the casing may have shoes welded on with teeth to aid in seating the casing into bedrock or some other hard strata.

Vibratory Hammer Manufacturers



MKT

APE



ICE

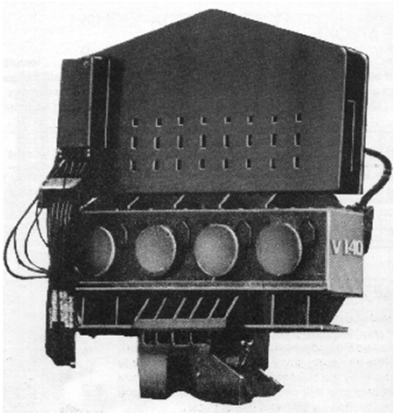
Vibratory hammers can be used to install and remove casing.

Installation of the casing using a vibratory hammer is most effective in sandy soil deposits, and to penetrate through sandy soils into a clay or marl stratum below. The hammer clamps to the top of the casing, which is often reinforced at the end with an extra thickness to aid in resisting the transmitted forces. The vibration of the casing often causes temporary liquefaction of a thin zone of soil immediately adjacent to the casing wall so that penetration is achieved only with the weight of the casing plus the hammer. This technique is particularly effective in sandy soils with shallow groundwater.

To facilitate penetration through particularly dense soils, the casing can be installed by an alternating sequence of driving the casing and drilling to remove the soil plug within the casing. Penetration of harder layers such as rock may be difficult or impossible with a vibrodriven casing.

VIBRATORY HAMMERS

Contact the hammer manufacturer or web site for detailed information about specific vibratory hammer specifications.



MKT Manufacturing Inc.
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Fax: 314-869-6862
MKTpileman.com

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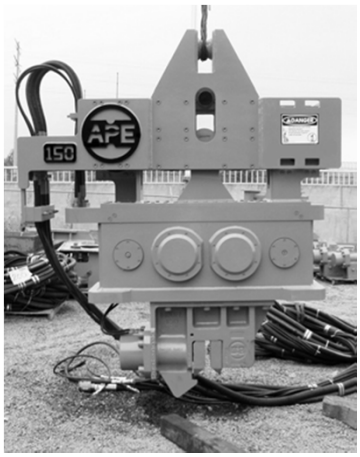
Fax:(704) 821-2781
www.iceusa.com



APE
American Piledriving Equipment, Inc.
Corporate Offices
7032 South 196th St.
Kent, Washington 98032 USA
Tel:(253) 872-0141
Fax:(253) 872-8710
www.apevibro.com

Version 1: 12-02

Vibratory Hammers

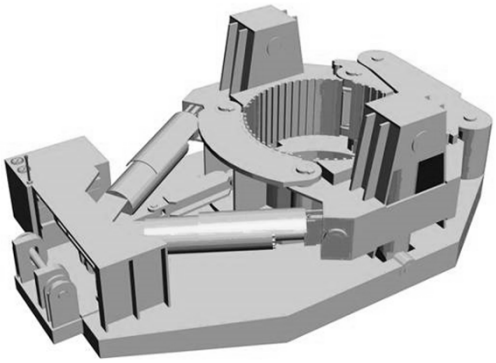
These are photos of a vibratory hammer removing temporary casing.

Removal of the casing with the vibratory hammer must be accomplished while the concrete is still fluid. During extraction, the hammer is attached and powered, and then typically used to drive the casing downward a few inches using the weight of the casing and hammer to break the casing free of the soil. Once the casing is moved, the crane pulls the casing upward to remove it and leave the fluid concrete filled hole behind.

Casing Oscillator

Casing oscillators twist the casing back and forth into the ground using a system of hydraulic jacks.

Downward pressure can be applied during installation and an upward force during removal of temporary casing.



Casing Oscillator

Attached to crawler rig

This rig is preparing to extract the temporary casing using the casing oscillator.

Casing Advancer

Advanced by twisting the casing into the ground while applying down pressure

Casing Rotator

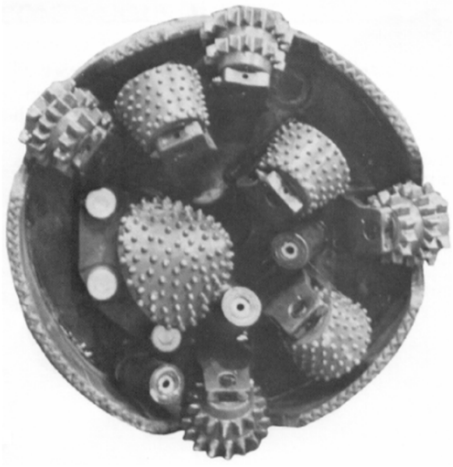
This is a casing twister bar. It is inserted in the notches on the casing, attached to the rig, and then the casing is twisted into the ground.

Overreaming Bucket

This is a Contractor designed tool, using a drilling bucket with holes cut in the sides and steel cable slipped through the holes.

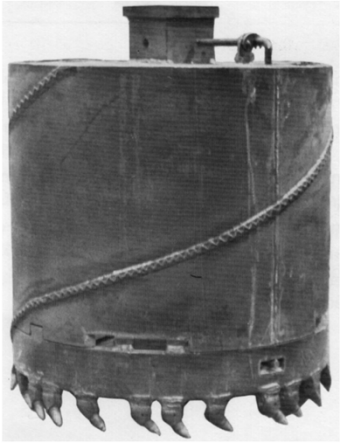
Learning Objective

Identify drilling tools and explain their uses.



Learning Objective

Identify drilling tools and explain their uses.



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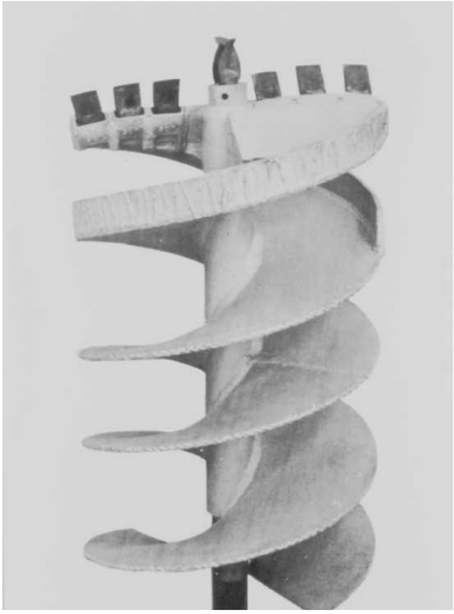

Learning Objective

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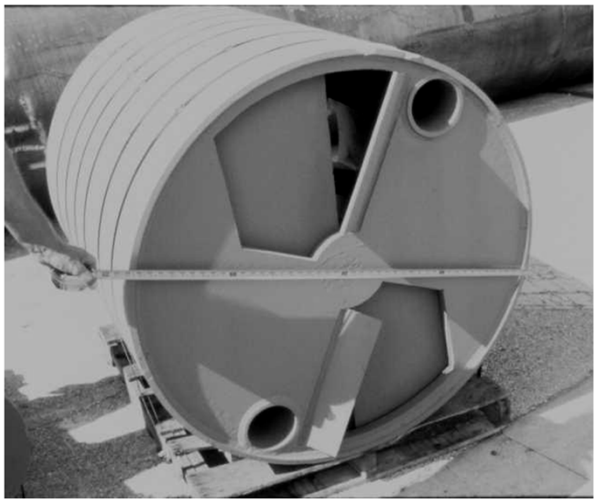

Learning Objective

Identify drilling tools and explain their uses.

Unit Review

- Identify drilled shaft rig components
- Identify different types of drill rigs
- Identify drilling tools and explain their uses