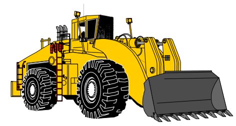
CHAPTER

12b

DRILLING ROCK AND EARTH

A. J. Clark School of Engineering •Department of Civil and Environmental Engineering



By

Dr. Ibrahim Assakkaf

ENCE 420 – Construction Equipment and Methods

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University of Maryland, College Park

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.

DRILLING JOB ANALYSIS

- In analyzing a job for drilling and blasting operations, there are four factors to be considered:
  1. The cubic yards of rock per linear foot of hole.
  2. The number of pounds of explosive per cubic yard of rock.
  3. The number of pounds of explosive per linear foot of hole.
  4. Will the resulting breakage meet the job requirements?

DRILLING JOB ANALYSIS

Note: The value of each of the first three factors may be estimated in advance of drilling and blasting operations, but after experimental drilling operations are conducted, it probably will be desirable to modify the values to give better results.

The fourth factor is more subjective, but the relationship between hole size and spacing gives some indication of expected results.

DRILLING JOB ANALYSIS

- The relationships between the first three factors are illustrated in Table 1.
- The volumes of rock per linear foot of hole are based on the net depth of holes and do not include sub-drilling, which usually will be necessary.
- The pounds of explosive per linear foot of hole are based on filling the holes completely with 60% dynamite.

Table 1 (Table 12-4, Text) Drilling and Blasting Data

Size hole (in.)	Hole pattern (ft)	Area per hole (sq ft)	Volume of rock per lin. ft of hole[‡] (cu yd)	Pounds of explosive per lin. ft of hole[†]	Pounds of explosive per cu yd of rock[†] % of hole filled		
					100	75	50
$1\frac{1}{2}$	4×4	16	0.59	0.9	1.52	1.14	0.76
	5×5	25	0.93	0.9	0.97	0.73	0.48
	6×6	36	1.33	0.9	0.68	0.51	0.34
	7×7	49	1.81	0.9	0.50	0.38	0.25
2	5×5	25	0.93	1.7	1.83	1.37	0.92
	6×6	36	1.33	1.7	1.28	0.96	0.64
	7×7	49	1.81	1.7	0.94	0.71	0.47
	8×8	64	2.37	1.7	0.72	0.54	0.36
3	7×7	49	1.81	3.9	2.15	1.61	1.08
	8×8	64	2.37	3.9	1.65	1.24	0.83
	9×9	81	3.00	3.9	1.30	0.97	0.65
	10×10	100	3.70	3.9	1.05	0.79	0.53
	11×11	121	4.48	3.9	0.87	0.65	0.44
4	8×8	64	2.37	7.5	3.16	2.37	1.58
	10×10	100	3.70	7.5	2.03	1.52	1.02
	12×12	144	5.30	7.5	1.42	1.06	0.71
	14×14	196	7.25	7.5	1.03	0.77	0.52
	16×16	256	9.50	7.5	0.79	0.59	0.40
5	12×12	144	5.30	10.9	2.05	1.54	1.02
	14×14	196	7.25	10.9	1.50	1.13	0.75
	16×16	256	9.50	10.9	1.15	0.86	0.58
	18×18	324	12.00	10.9	0.91	0.68	0.46
	20×20	400	14.85	10.9	0.73	0.55	0.37
6	12×12	144	5.30	15.6	2.94	2.20	1.47
	14×14	196	7.25	15.6	2.05	1.54	1.02
	16×16	256	9.50	15.6	1.64	1.23	0.82
	18×18	324	12.00	15.6	1.30	0.97	0.65
	20×20	400	14.85	15.6	1.05	0.79	0.53
	24×24	576	21.35	15.6	0.73	0.55	0.37
9	20×20	400	14.85	35.0	2.36	1.77	1.18
	24×24	576	21.35	35.0	1.64	1.23	0.82
	28×28	784	29.00	35.0	1.21	0.91	0.61
	30×30	900	33.30	35.0	1.05	0.79	0.53
	32×32	1,024	37.90	35.0	0.92	0.69	0.46

[†] Based on using dynamite weighing 80 lb per cu ft.
[‡] Does not account for subdrilling.

DRILLING JOB ANALYSIS

- The pounds of explosive per cubic yard of rock are based on filling each hole to 100, 75, and 50% of its total capacity with dynamite.
- When a hole is not filled completely with dynamite, the surplus volume is filled with stemming.

RATES OF DRILLING ROCK

- The rates of drilling rock will vary with a number of factors such as:
  - ✓ The type of drill and bit size,
  - ✓ Hardness of the rock,
  - ✓ Depth of holes,
  - ✓ Drilling pattern,
  - ✓ Terrain, and
  - ✓ Time lost waiting for other operations.

RATES OF DRILLING ROCK

- If pneumatic drills are used, the rate of drilling will vary with the pressure of the air.
- The portion of time that a drill is operative is defined as the *availability factor*, which is usually expressed as a percent of the total time that the drill is expected to be working.

RATES OF DRILLING ROCK

- Historical drill penetration rates based on very general rock-type classification is shown in Table 2 (Table 12-5, Text)
- These rates should be used as a guide
- Actual project estimates need to be based on drilling tests of specified rock which will be encountered.

RATES OF DRILLING ROCK

Table 2. Drilling Production Rates (Table 12-5, Text)

Bit size	Drill type Compressed air	Direct penetration rate Granite (ft/hr)	Direct penetration rate Dolomite (ft/hr)	Estimated† production rate good conditions Granite (ft/hr)	Estimated† production rate good conditions Dolomite (ft/hr)
	Rotary-percussion				
$3\frac{1}{2}$	750 cfm @ 100 psi	65	125	35	55
$3\frac{1}{2}$	900 cfm @ 100 psi	85	175	40	65
	Downhole drill				
$4\frac{1}{2}$	600 cfm @ 250 psi	70	110	45	75
$6\frac{1}{2}$	900 cfm @ 350 psi	100	185	65	90
	Rotary				
$6\frac{1}{4}$	30,000 pulldown	NR	100	NR	65
$6\frac{3}{4}$	40,000 pulldown	75	120	30	75
$7\frac{7}{8}$	50,000 pulldown	95	150	45	85

NR-Not recommended.
† Estimated productions are for ideal conditions, but they do account for all delays including blasting.

RATES OF DRILLING ROCK

- Drill bits, rods, and couplings are high wear items, and the time required to replace or change each affects the drilling production.
- Table 3 (Table12-6, Text) gives the average life of these high wear items based on the drill footage and the type of rock.

RATES OF DRILLING ROCK

Table 3 (Table 12-6b, Text)

6b
Metamorphic rock: Average life, in feet, for drill bits and steel

Drill bits (in.)	Type	Metamorphic rock: High silica LA < 35 (Quartzite) (ft)	Medium silica low mica (Schist) (Gneiss) (ft)	Medium silica high mica (Schist) (Gneiss) (ft)	Medium silica LA < 25 (Metala-) (tite) (ft)	Low silica LA > 45 (Marble) (ft)
3	B	200	1,200	1,500	800	1,300
3	STD	NR	800	900	400	850
3½	STD	NR	1,300	1,700	850	1,600
3½	HD	NR	1,800	2,200	1,200	2,100
3½	B	450	3,000	3,500	2,000	3,300
4	B	600	3,300	3,800	2,300	3,700
Rotary bits						
5	ST	NR	NR	NR	NR	NR
5⅞	ST	NR	NR	NR	NR	1,200
6¼	ST	NR	NR	NR	NR	2,000
6¾	ST	NR	NR	750	NR	4,500
6¾	CB	NR	3,700	4,200	1,200	9,000
7⅞	CB	NR	5,500	6,500	2,200	13,000
Down hole bits						
6½	B	500	2,700	3,200	1,500	4,500
Drill steel						
Shanks		5,000	5,700	6,200	5,550	5,800
Couplings		900	1,000	1,200	750	800
Steel	10 ft	1,700	2,100	2,300	1,500	1,600
Steel	12 ft	3,000	3,300	3,800	2,800	3,000
5 in.	20 ft	50,000	90,000	100,000	85,000	175,000

B = button, CB = carbide button, HD = heavy duty, ST = steel tooth, STD = standard, NR = not recommended.

OPTIMUM AIR PRESSURE FOR DRILLING

- Figure 1 (Fig 11-15 Text) shows the relationship between the average rate of penetration and the operating pressure for each group of drills.
- Figure 2 (Fig 11-16, Text) is a nomogram based on the information appearing in Fig. 13-15 which indicates the percent increase in penetration resulting from an increase in air pressure.

Example:

If the pressure is increased from 90 to 100 psi, the increase in penetration will be 38%.

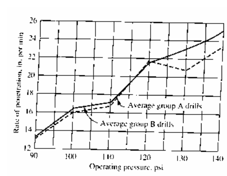


FIGURE 13-15
Variations in the rate of penetration with air pressure.

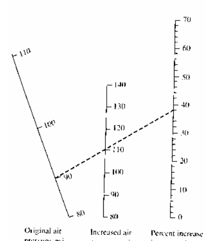


FIGURE 13-16
Variations in the rates of penetration with air pressure.

ECONOMY OF INCREASING AIR PRESSURE

- The decision to increase the air pressure at the drills should not be determined solely on the basis of the anticipated increase in production and the increase in the cost of compressed air and drilling equipment.
- Drilling is only one item in a chain of operations, which includes drilling, blasting, loading, and hauling.
- Figure 3 presents a curve that establishes the lowest total cost of producing the end product of a drilling operation. The curve is plotted to indicate this cost for varying air pressures.

ECONOMY OF INCREASING AIR PRESSURE

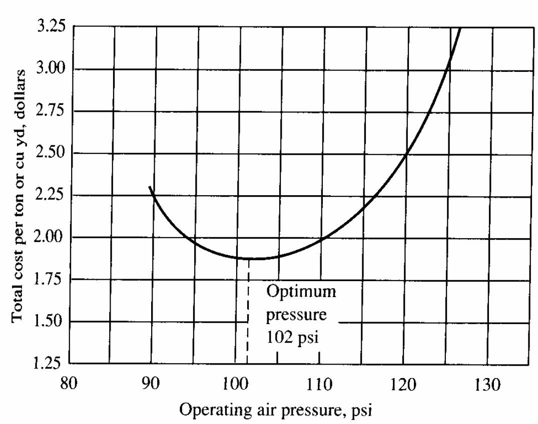


FIGURE 13-17
Variation in the total cost of rock product with air pressure.

DRILLING PRODUCTION ESTIMATE

To begin a drilling production estimate it is first necessary to make an assumption about the type of equipment that will be used. Tables 12-5 & 12-6 provide information to guide that first decision.

PRODUCTION ESTIMATE

The final equipment decision should only be made after test drilling the formation. Test drilling should help to quantify:

- Penetration rate
- Drilling method
- Bit size / Bit type

PENETRATION RATE

Penetration Rate is a function of:

- The rock
- The drilling method
- The size & type of bit

THE ROCK

The rock properties which effect penetration rate are:

- Hardness
- Texture
- Breaking characteristic
- Formation

HARDNESS

Hardness is the resistance of a smooth surface to abrasion.

It is measured by the MOH scale (Friedrich Mohs).

HARDNESS

Hardness is measured by the MOH scale.

The scale is from 1 to 10, with

- **Diamond rated as 10**
- **Talc rated as 1**

HARDNESS

		Scratch Test
Diamond	10.0	
Schist	5.0	Knife
Granite	4.0	Knife
Limestone	3.0	Copper coin
Potash	2.0	Fingernail
Gypsum	1.5	Fingernail

HARDNESS

Hardness affects drilling speed.

HARDNESS	DRILLING SPEED
1-2	FAST
3-4	FAST - MEDIUM
5	MEDIUM
6-7	SLOW - MEDIUM
8-9	SLOW

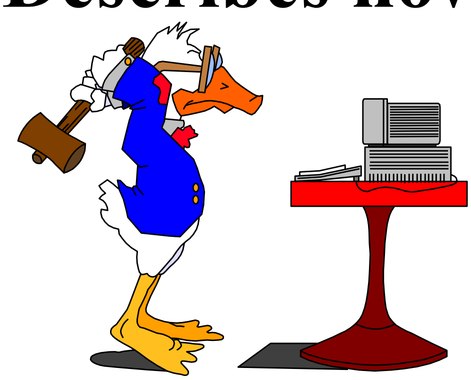
TEXTURE

Texture is the grain structure of the rock.

- A loose grained structure (porous, cavities) drills fast.
- Grains large enough to be seen individually (granite) will drill medium.
- Fine-grained rocks drill slow.

BREAKING CHARACTERISTIC

Describes how the rock



breaks when struck.

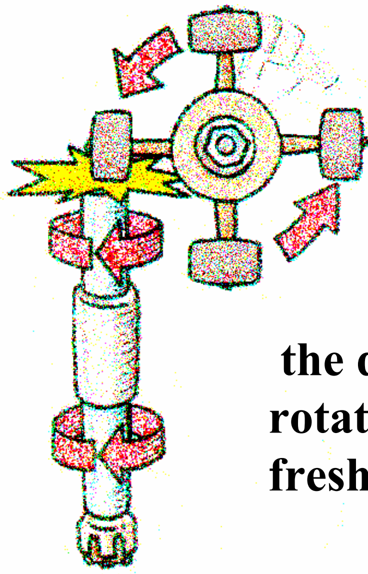
BREAKING CHARACTERISTIC

- Shatters - into small pieces from a light blow
- Brittle - breaks easily with a light blow
- Shaving - when shaved off in pieces they break easily
- Strong - resists breaking when hit hard
- Malleable - flattens instead of breaking

BREAKING CHARACTERISTIC

- Shatters - drills fast
- Brittle - drills fast to medium
- Shaving - drills medium
- Strong - drills slow to medium
- Malleable - drills slow

DRILLING METHOD



ROTARY-PERCUSSION

The piston provides striking energy to the rock through the drill steel. There is rotation so the bit strikes fresh rock with each blow.

PERCUSSION DRILLING

	Hardness
Quartzite	7.0
Trap Rock	6.0
Schist	5.0
Granite	4.0
Dolomite	3.5
Limestone	3.0
Galena	2.5

ESTIMATING DRILLING PRODUCTION

- The first step in estimating drilling production is to make an assumption about the type of equipment which will be used.
- That first assumption will be guided by the type of rock to be drilled.

ESTIMATING DRILLING PRODUCTION

- Both Tables 2 and 3 give information that is useful in making such a decision.
- Once a drill type and bit is selected, the format given in the following figure (Figure 4) can be used to estimate the hourly production.

ESTIMATING DRILLING PRODUCTION

- It must again be emphasized, the final decision on the type of equipment should only be made after test drilling the specific formation.
- The drilling test should yield data on the penetration rate based on bit size and type.

ESTIMATING DRILLING PRODUCTION

Figure 4. Format for Estimating Drilling Production

(1)	Depth of hole:	(a) ______ ft pull, (b) ______ ft drill		
(2)	Penetration rate:	______	ft/min	
(3)	Drilling time:	______	min	(1b)/(2)
(4)	Change steel:	______	min	
(5)	Blow hole:	______	min	
(6)	Move to next hole:	______	min	
(7)	Align steel:	______	min	
(8)	Change bit:	______	min	
(9)	Total time:	______	min	
(10)	Operating Rate:	______	ft/min	(1b)/(9)
(11)	Production efficiency:	______	min/hr	
(12)	Hourly production:	______	ft/hr	(11)×(10)

GUIDELINES FOR ESTIMATING DRILLING PRODUCTION

(1) Depth of Hole:

Usually, when drilling for loading explosives and blasting, it is necessary to subdrill below the desired final bottom or floor elevation. This extra depth is dependent on the blasting design.

Normally, 2 or 3 ft of extra depth is required. Therefore, if the depth to the finish grade is 25 ft (pull depth), it may be necessary to actually drill 28 ft

$$\text{Drill (ft)} = \text{Pull} + 2 \text{ or } 3 \text{ ft}$$

GUIDELINES FOR ESTIMATING DRILLING PRODUCTION

(2) Penetration Rate:

The penetration rate will be an average rate developed from test drilling program based on specific bit size and type

If no information given for a particular drill, Table 2 (Table 13 5)can be used for estimating the penetration rate

Example: If a 41/2 dill is used @ 250 psi to penetrate dolomite, the penetration rate in minutes will be

$$\text{Penetration Rate} = \frac{110}{60} = 1.83\,\frac{\text{ft}}{\text{min}}$$

GUIDELINES FOR ESTIMATING DRILLING PRODUCTION

Table 2. Drilling Production Rates (Table 12-5, Text)

Bit size	Drill type Compressed air	Direct penetration rate Granite (ft/hr)	Direct penetration rate Dolomite (ft/hr)	Estimated† production rate good conditions Granite (ft/hr)	Estimated† production rate good conditions Dolomite (ft/hr)
	Rotary-percussion				
$3\frac{1}{2}$	750 cfm @ 100 psi	65	125	35	55
$3\frac{1}{2}$	900 cfm @ 100 psi	85	175	40	65
	Downhole drill				
$4\frac{1}{2}$	600 cfm @ 250 psi	70	110	45	75
$6\frac{1}{2}$	900 cfm @ 350 psi	100	185	65	90
	Rotary				
$6\frac{1}{4}$	30,000 pulldown	NR	100	NR	65
$6\frac{3}{4}$	40,000 pulldown	75	120	30	75
$7\frac{7}{8}$	50,000 pulldown	95	150	45	85

NR-Not recommended.
† Estimated productions are for ideal conditions, but they do account for all delays including blasting.

GUIDELINES FOR ESTIMATING DRILLING PRODUCTION

(3) Drilling Time:

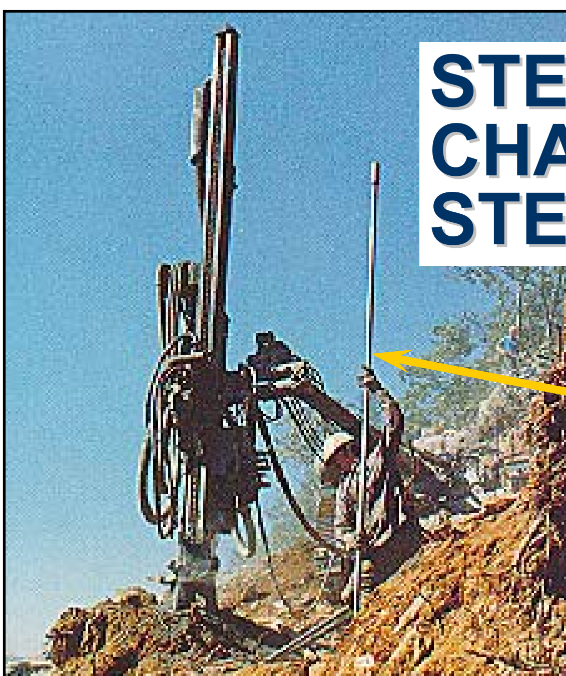
The drilling time shall be calculated from

$$\text{Drilling Time} = \frac{\text{Drill}}{\text{Penetration Rate}}$$

(4) Change Steel:

If drilling depth is greater than the steel length, it will be necessary to add steel during the drilling and to remove steel when coming out of the hole.

For track-mounted rotary-percussion drills, standard steel lengths are 10 or 12 ft. They require about 0.5 min or less to add or remove a length.

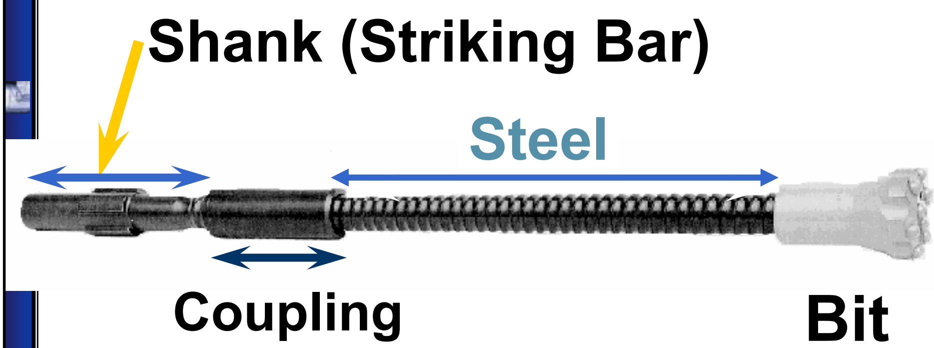


STEP 4 CHANGE STEEL

Steel

Text p. 359

STEP 4
CHANGE STEEL



GUIDELINES FOR ESTIMATING DRILLING PRODUCTION

(4) Change Steel (Cont'd):

It is recommended by the author to use

1.1 min to add 20-ft length of steel, and

1.5 min to remove the same length of steel

NOTE: if the steel length is less than 20 ft, the time required to change steel can be taken as 0 min, unless otherwise specified.

STEP 4 CHANGE STEEL

Steel, approximate weights:

SIZE INCHES	LENGTH FEET	WEIGHT POUNDS
1.5	10	53
1.5	12	64
1.75	10	60
1.75	12	71

STEP 4 CHANGE STEEL

Steel

GUIDELINES FOR ESTIMATING DRILLING PRODUCTION

(5) Blow Hole:

After the actual drilling is completed, it is good practice to blow out the hole to ensure that all cuttings are removed. Some drillers prefer to drill an extra foot and to pull the drill out without blowing the hole clean

NOTE: It is customary to use 0.1 min for the blow hole time, unless otherwise specified for a particular site conditions and drill type.

GUIDELINES FOR ESTIMATING DRILLING PRODUCTION

(6) Move to Next Hole:

The time required to move between drill hole locations is a function of the distance (blasting pattern) and the terrain.

Track-mounted rotary-percussion drills have travel speeds of from 1 to 3 mph. However, because the hole spacing is often less than 20 ft and the operator is maneuvering to place the drill over an exact spot, the travel speed is so low

A speed of 0.25 mph can be used.

May have to lower the mast

STEP 6 MOVE

GUIDELINES FOR ESTIMATING DRILLING PRODUCTION

(6) Move to Next Hole (cont'd):

Example:

If the blasting pattern is a 6 X 8 ft grid, then the time required (in minutes) to the next hole will be

$$\text{Time required (min)} = \frac{\text{distance}}{\text{speed}} = \frac{8}{0.25}\left(\frac{60}{5280}\right) = 0.36 \text{ min}$$

(7) Align Steel:

Once over the drilling location, the mast or steel must be aligned. In the case of rotary drills the entire machine is leveled by the use of hydraulic jacks. This usually takes about **0.5 to 1.0 min**.

STEP 6
MOVE TO NEXT HOLE

If drilling for blasting operations distance will be set by the blasting pattern. An 8 X 10 pattern means 8 ft between rows and a 10 ft spacing between holes. Therefore, the travel distance moving along the row is 10 ft.

STEP 7 ALIGN STEEL

Time to align is discussed on page 360.

Outrigger for leveling

GUIDELINES FOR ESTIMATING DRILLING PRODUCTION

(8) Change Bit:

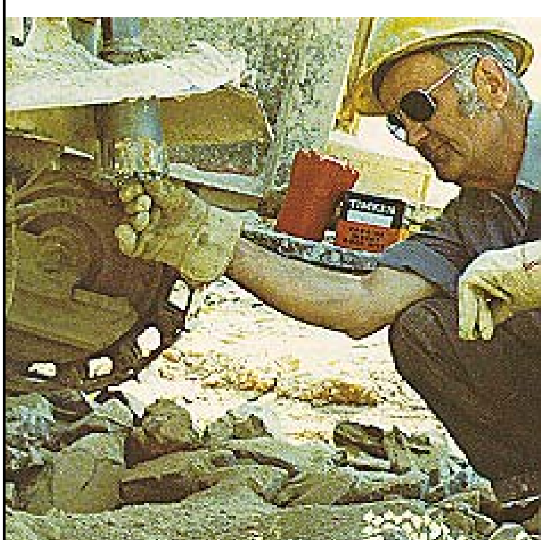
A time allowance must be considered for changing bits, shanks, couplings, and steel. Table 3 (Table 13-6, Text) provides information for determining the frequency of such changes

On the average, the normal time is about **4 min** Unless otherwise specified.

Example: A 6 1/2 Bdownhole drill @ 350 psi to be used for drilling medium silica granite. What is the time required to change bit? Assume 23' drill length.

$$\text{Time (min)} = \text{normal time} \times \frac{\text{drill (ft)}}{\text{life (ft)}} = 4 \times \frac{23}{1800} = 0.05 \text{ min}$$

STEP 8 CHANGE BIT



Bits, shanks, couplings and steel are all high wear items that must be replaced frequently.

STEP 8 CHANGE BIT

The time allowance for replacement is a factor of both the actual *time to remove* and replace, and the *frequency* of such changes. Table 12- 6 provides frequency information.

GUIDELINES FOR ESTIMATING DRILLING PRODUCTION

Table 4 (Table 12-6a, Text)

Igneous rock: Average life, in feet, for drill bits and steel

Drill bits (in.)	Type	Igneous rock: High silica LA < 20 (Rhyolite) (ft)	High silica 20 < LA < 50 (Granite) (ft)	Medium silica LA < 50 (Granite) (ft)	Low silica LA < 20 (Basalt) (ft)	Low silica LA > 20 (Diabase) (ft)
3	B	250	500	750	750	1,000
3	STD	NR	NR	NR	NR	750
$3\frac{1}{2}$	STD	NR	NR	NR	750	1,500
$3\frac{1}{2}$	HD	200	575	1,000	1,400	2,000
$3\frac{1}{2}$	B	550	1,200	2,500	2,700	3,200
4	B	750	1,500	2,800	3,000	3,500
Rotary bits						
5	ST	NR	NR	NR	NR	NR
$5\frac{7}{8}$	ST	NR	NR	NR	NR	NR
$6\frac{1}{4}$	ST	NR	NR	NR	NR	NR
$6\frac{3}{4}$	ST	NR	NR	NR	NR	800
$6\frac{3}{4}$	CB	NR	NR	1,500	2,000	4,000
$7\frac{7}{8}$	CB	NR	1,700	2,400	3,500	6,000
Down hole bits						
$6\frac{1}{2}$	B	500	1,000	1,800	2,200	3,000
Drill steel						
Shanks		2,500	4,500	5,800	5,850	6,000
Couplings		700	700	800	950	1,100
Steel	10 ft	1,450	1,500	1,600	1,650	2,200
Steel	12 ft	2,200	2,600	3,000	3,500	5,000
5 in.	20 ft	25,000	52,000	60,000	75,000	100,000

B = button, CB = carbide button, HD = heavy duty, ST = steel tooth, STD = standard, NR = not recommended.

GUIDELINES FOR ESTIMATING DRILLING PRODUCTION

(9) Total Time:

$$\text{TotalTime} = (3) + (4) + (5) + (6) + (7) + (8)$$

(10) Operating Rate:

$$\text{Operating Rate (ft/min)} = \frac{\text{Drill (ft)}}{\text{Total Time (min)}}$$

GUIDELINES FOR ESTIMATING DRILLING PRODUCTION

(11) Production Efficiency:

With experienced drillers working on a large project, a 50-min production hour should be achievable. Sometimes, a 40-min production hour might be more appropriate.

(12) Hourly Production

$$\text{Hourly Production (ft/hr)} = \text{Production Efficiency} \times \text{Operating Rate}$$

Example 1

A project utilizing experienced drillers will require the drilling and blasting of high silica, fine-grained sandstone rock. From field drilling tests it was determined that a direct drilling rate of 120 ft per hour could be achieved with a 3 1/2 HD bit on a rotary percussion drill @ 100 psi. The drills to be used take 10-ft steel. The blasting pattern will be a 10 X 10-ft grid with 2 ft of sub-drilling required. On the average the specified finish grade is 16 ft below the existing ground surface. Determine the drilling production.

Example 1 (cont'd)

Using the format of Figure 4:

(1) Depth of hole	(a) 16-ft pull	(b) 18-ft drill (16 + 2)
(2) Penetration	2.00 ft/min	(120 ft ÷ 60)
(3) Drilling Time:	9.00 min	(18 ft ÷ 2 ft/min)
(4) Change Steel:	0.00 min	(d<20 ft)
(5) Blow Hole:	0.10 min	
(6) Move to Next Hole	0.45 min	(10 ft ÷ 0.25 mph)
(7) Align Steel:	1.00 min	
(8) Change Bit:	0.08 min	(4 X 18/850)
(9) Total Time	10.63 min	

Note: 850 was obtained from Table 5

Example 1 (cont'd)

Table 5 (Table 12-6c, Text)

Sedimentary rock: Average life, in feet, for drill bits and steel

Drill bits (in.)	Type	Sedimentary: High silica fine grain (Sandstone) (ft)	Medium silica coarse grain (Sandstone) (ft)	Low silica fine grain (Dolomite) (ft)	Low silica fine-med. grain (Shale) (ft)	Low silica coarse grain (Conglomerate) (ft)
3	B	800	1,200	1,300	2,000	1,800
3	STD	NR	850	900	1,500	1,200
$3\frac{1}{2}$	STD	NR	1,500	1,800	3,000	2,500
$3\frac{1}{2}$	HD	850	2,000	2,200	3,500	3,000
$3\frac{1}{2}$	B	2,000	3,100	3,500	4,500	4,000
4	B	2,500	3,500	2,000	5,000	4,800
Rotary bits						
5	ST	NR	1,000	NR	8,000	6,000
$5\frac{7}{8}$	ST	NR	2,500	NR	15,000	13,000
$6\frac{1}{4}$	ST	NR	4,000	4,000	18,000	14,000
$6\frac{3}{4}$	ST	500	6,000	8,000	20,000	15,000
$6\frac{3}{4}$	CB	2,000	8,000	10,000	25,000	20,000
$7\frac{7}{8}$	CB	3,000	10,000	15,000	25,000	20,000
Down hole bits						
$6\frac{1}{2}$	B	2,500	3,500	5,500	7,500	6,000
Drill steel						
Shanks		5,000	5,500	6,000	7,000	6,500
Couplings		1,000	1,200	1,500	2,000	1,750
Steel	10 ft	2,000	2,300	2,500	4,000	3,500
Steel	12 ft	4,500	5,000	6,000	7,500	7,000
5 in.	20 ft	65,000	250,000	200,000	300,000	250,000

B = button, CB = carbide button, HD = heavy duty, ST = steel tooth,
STD = standard, NR = not recommended.

Example 1 (cont'd)

(10) Operating Rate:	1.69 ft/min	(18 ÷ 10.63)
(11) Production Efficiency.:	50 min/hr	
(12) Hourly Production	84.5 ft/hr	(50 × 1.55)

Example 2

The drilling production of Example 1 must match that of hauling and loading for the project, which is 500 cu yd per hour. How many drill units will be required?

$$\text{Hole Production} = \frac{10 \times 10 \times 16}{27} = 59.26 \text{ cu yd/hole}$$

$$\frac{84.5 \text{ ft/hr}}{18 \text{ ft/hole}} = 4.69 \frac{\text{hole}}{\text{hr}} \text{ per drill}$$

$$4.69\left(\frac{\text{hole}}{\text{hr}} \text{ per drill}\right) \times 59.26 \text{ cu yd / hole} = 278 \text{ cu yd}$$

$$2 \times 278 = 556 \text{ cu yd} > 500 \text{ cu yd}$$

$\therefore$ Two drills will be required

DRILLING EARTH

Purposes for drilling holes in earth.

In the construction and mining industries holes are drilled into the earth for many purposes, including, but not limited to:

1. Obtaining samples of soil for test purposes.
2. Locating and evaluating deposits of aggregate suitable for mining.
3. Locating and evaluating deposits of minerals.
4. Permitting the installation of cast-in-place piles or shafts to support structures.

DRILLING EARTH

5. Enabling the driving of load-bearing piles into hard and tough formations.
6. Providing wells for supplies of water or for deep drainage purposes.
7. Providing shafts for ventilating mines, tunnels, and other underground facilities.
8. Providing horizontal holes through embankments, such as those for the installation of utility conduits.