Drilling - Lecture 1

- Rock drilling – mechanical rock penetration
- Purpose of drilling in mining
- Drill hole characteristics
- General classification of drilling
- Trends in drilling
- Factors considered in selection of drilling equipment
- Factors affecting drilling performance

Concepts and principles of mechanical rock penetration

Concepts and principles of mechanical rock penetration

To appreciate the concepts and principles of drilling, one needs to understand:

1. Mechanics of rock penetration
2. Factors influencing penetration rate
3. Strength characteristics of rock
4. Rock type
    - Homogeneous, Anisotropy, Isotropy

5. Drillability factors

- Intrinsic environmental factors
  - Geologic conditions
- State of stress of rock
- Internal structure of rock and resistance to penetration

6. Engineering properties

Some terms related to rock disintegration include:

- Force
- Friction
- Angle of friction
- Torque
- Resistance
- Energy ; kinetic energy,
- Compressive strength
- Tensile strength
- Stress
- Shear stress
- Strain
- Stress/strain curve
- Theories of elasticity
- Thrust

Force is a push or a pull on an object with mass that can cause it to change its velocity (to accelerate). A force is a vector, which means it has both magnitude and direction

Friction is the resistance to motion of one object moving relative to another. It is not a fundamental force. Friction is the force resisting the relative motion of solid surfaces, fluid layers, and material elements sliding against each other.

When a system expels or accelerates mass in one direction, the accelerated mass will cause a force of equal magnitude but opposite direction on that system. The force applied on a surface in a direction perpendicular or normal to the surface is called **Thrust.**

Torque is a twisting (torsion) or turning force that tends to cause rotation around an axis.

Energy is the capacity for doing work. It may exist in potential, kinetic, thermal, electrical, chemical, nuclear, or other various forms.

Stress is the force per unit area applied to the material. Tensile stress

Compressive stress

Young's modulus or modulus of elasticity is a measure of the ability of a material to withstand changes in length when under tension or compression. Young's modulus is equal to the longitudinal stress divided by the strain.

Principles of Rock Disintegration

Rock drilling

- For rock failure, energy is required
- Enough energy to overcome rock strength
  - Compressive strength (resistance)

Basically the energy (ε_1) is required to penetrate or disintegrate the rock. The energy to overcome resistance should equal to the compressive strength per unit area

- Force is applied on the rock by the bit
- Bit-rock interface - under stress

Fundamentals of mechanical rock penetration

Prime mover (drill) converts original form of energy into mechanical energy and the rod transmits the mechanical energy to the bit then to the rock:

- Rotational effect creates torque
- Percussive effect creates thrust

Torque and thrust create compressive stress

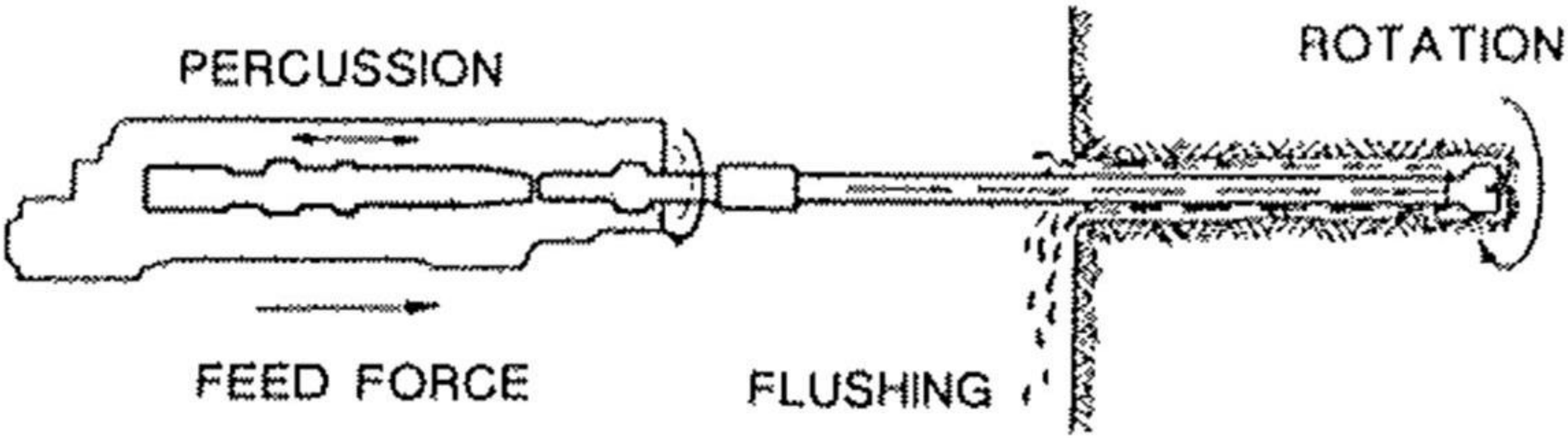
- Bit and rock under compressive stress

The energy to overcome resistance should equal to the compressive strength per unit area

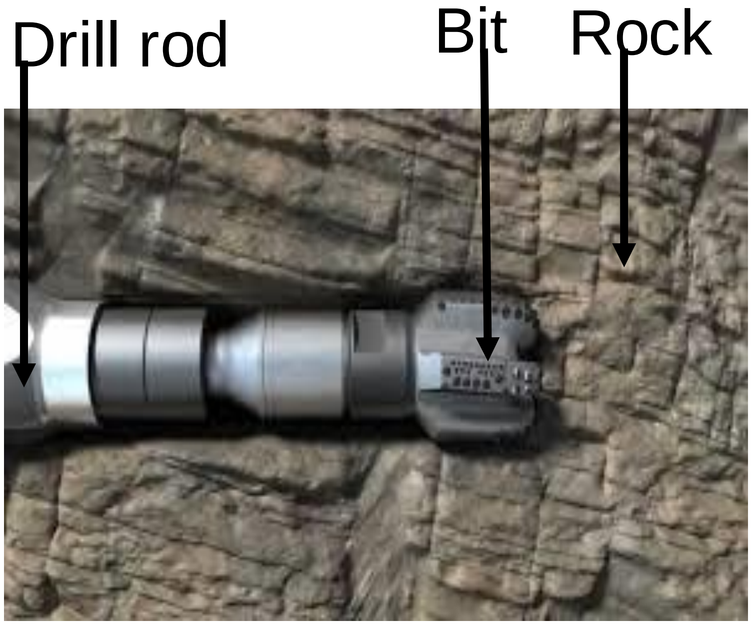
Compressive strength depends on Young's modulus of a particular rock

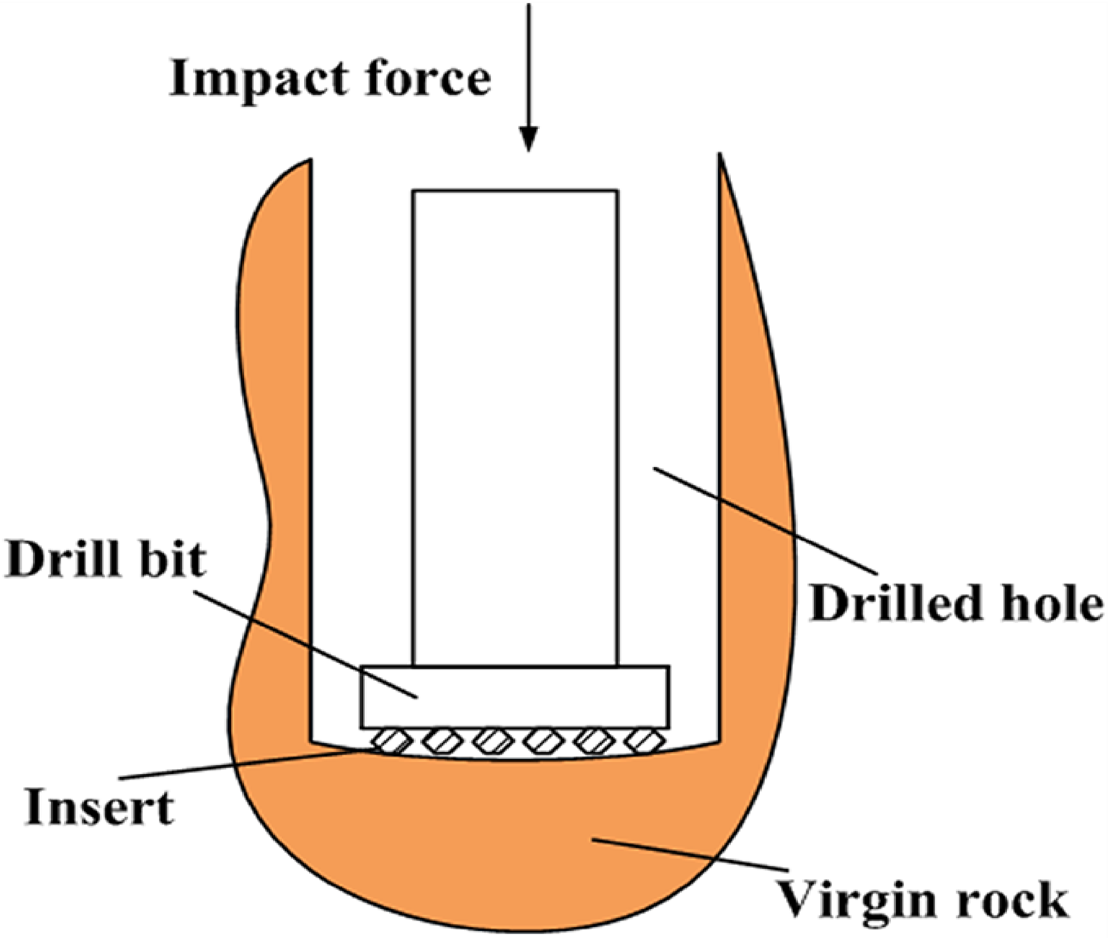
Fundamentals of rotary-percussive drilling

- Percussion
- Rotation
- Feed or thrust load
- Flushing

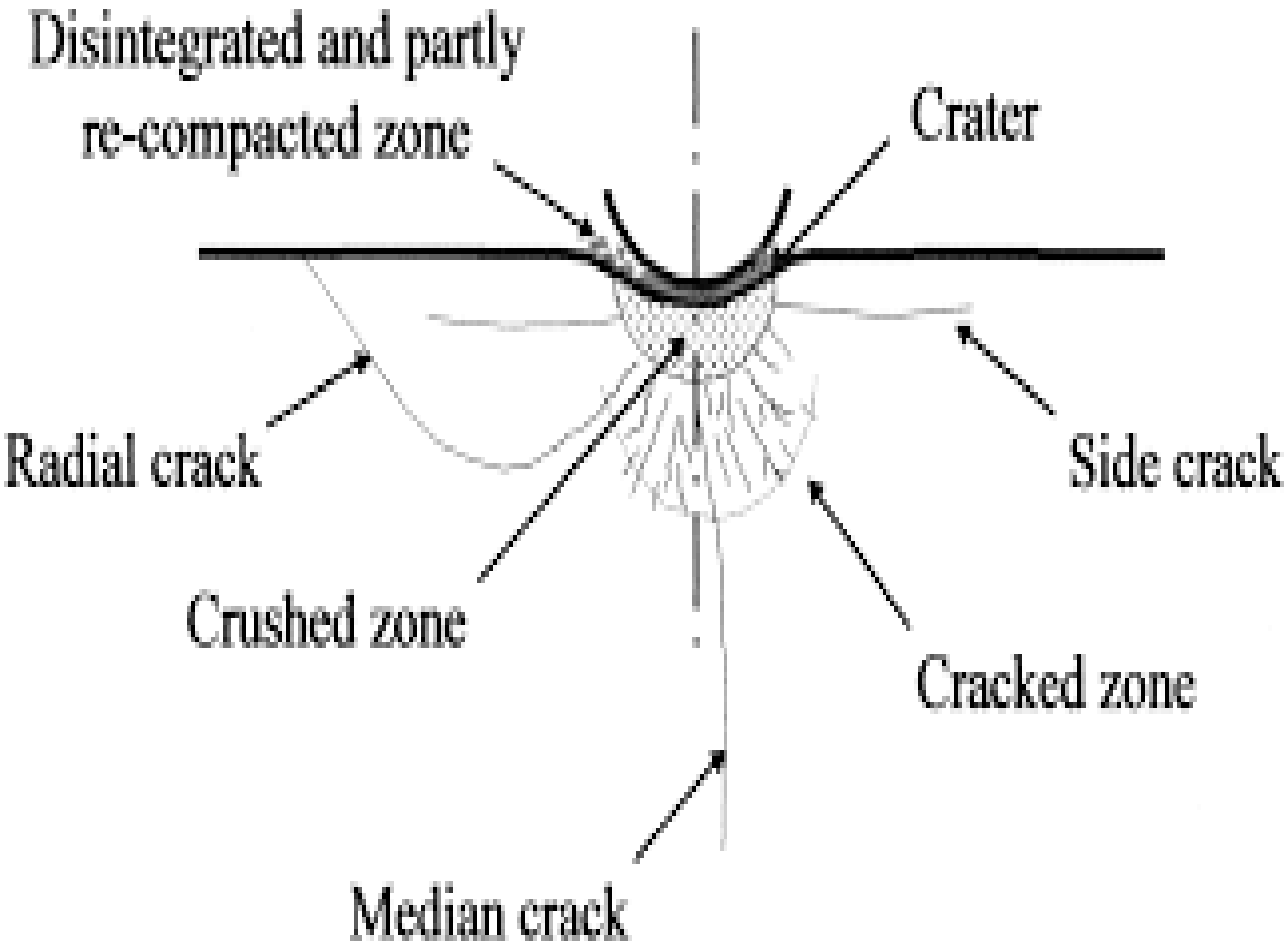


Bit-rock interface

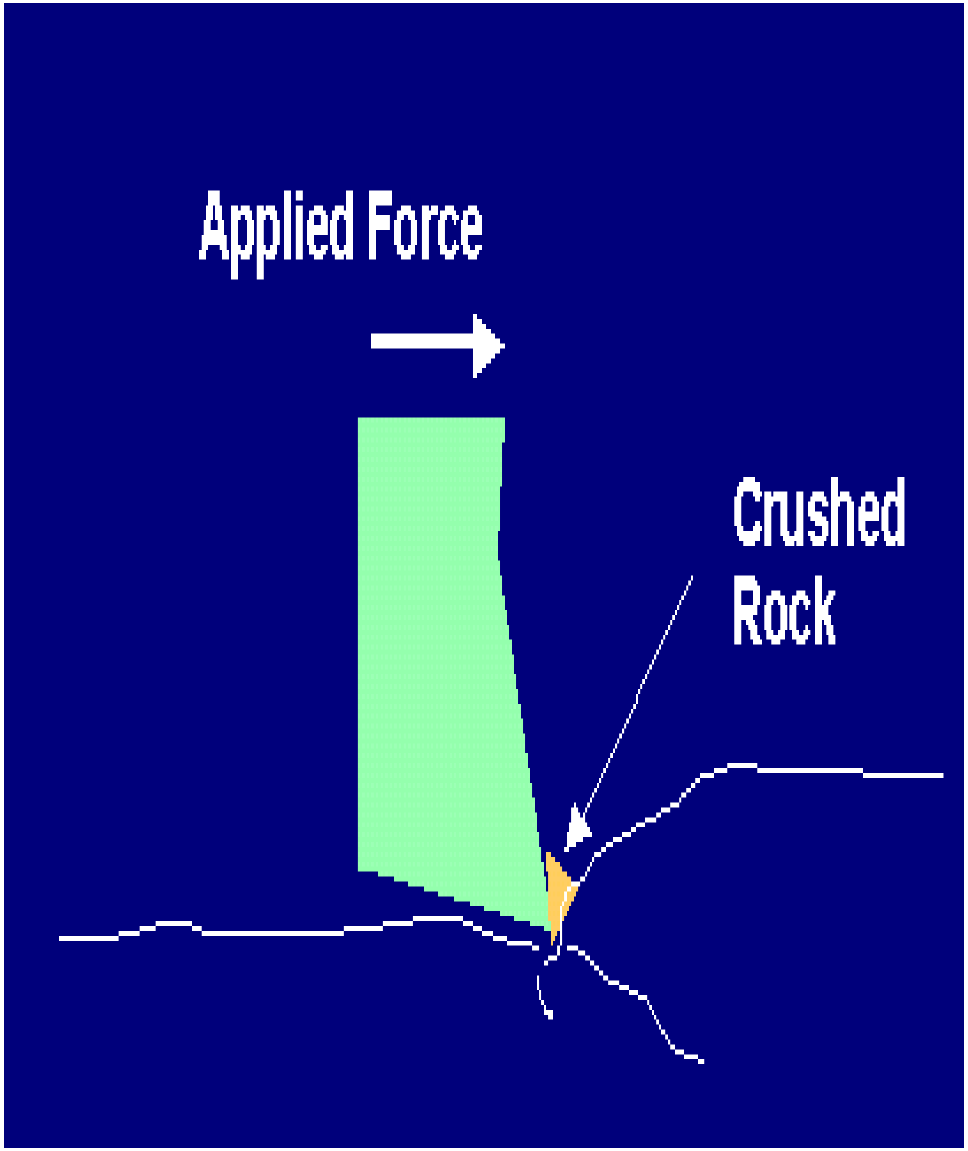


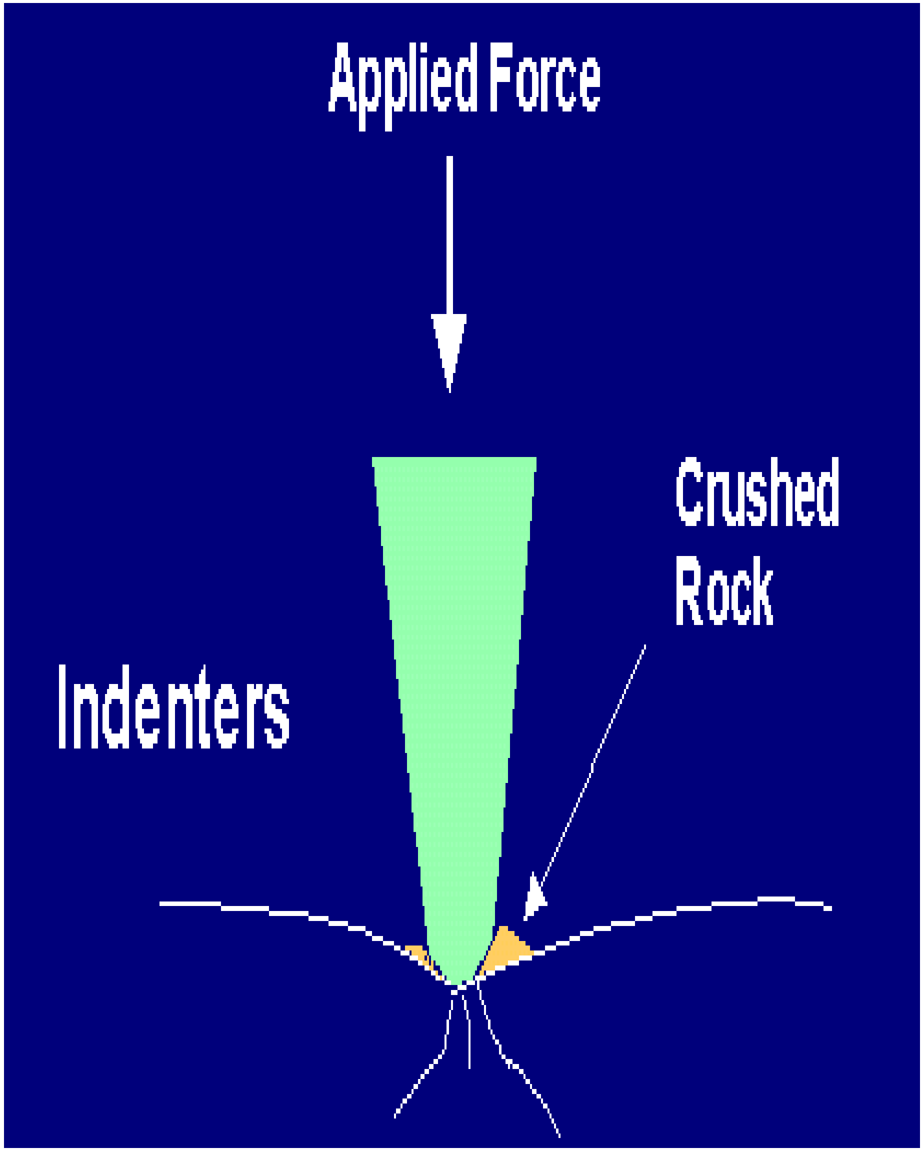


Bit-rock interface

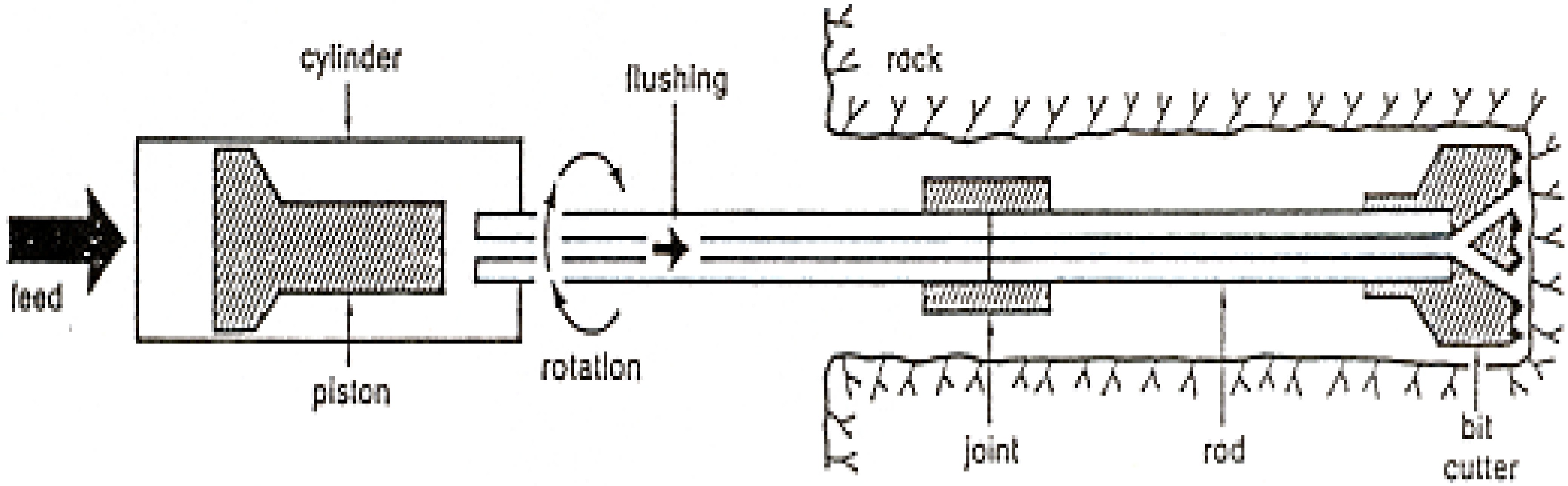


Principles of Rock Disintegration





Functional Components of Drilling System



Principle of percussive drilling

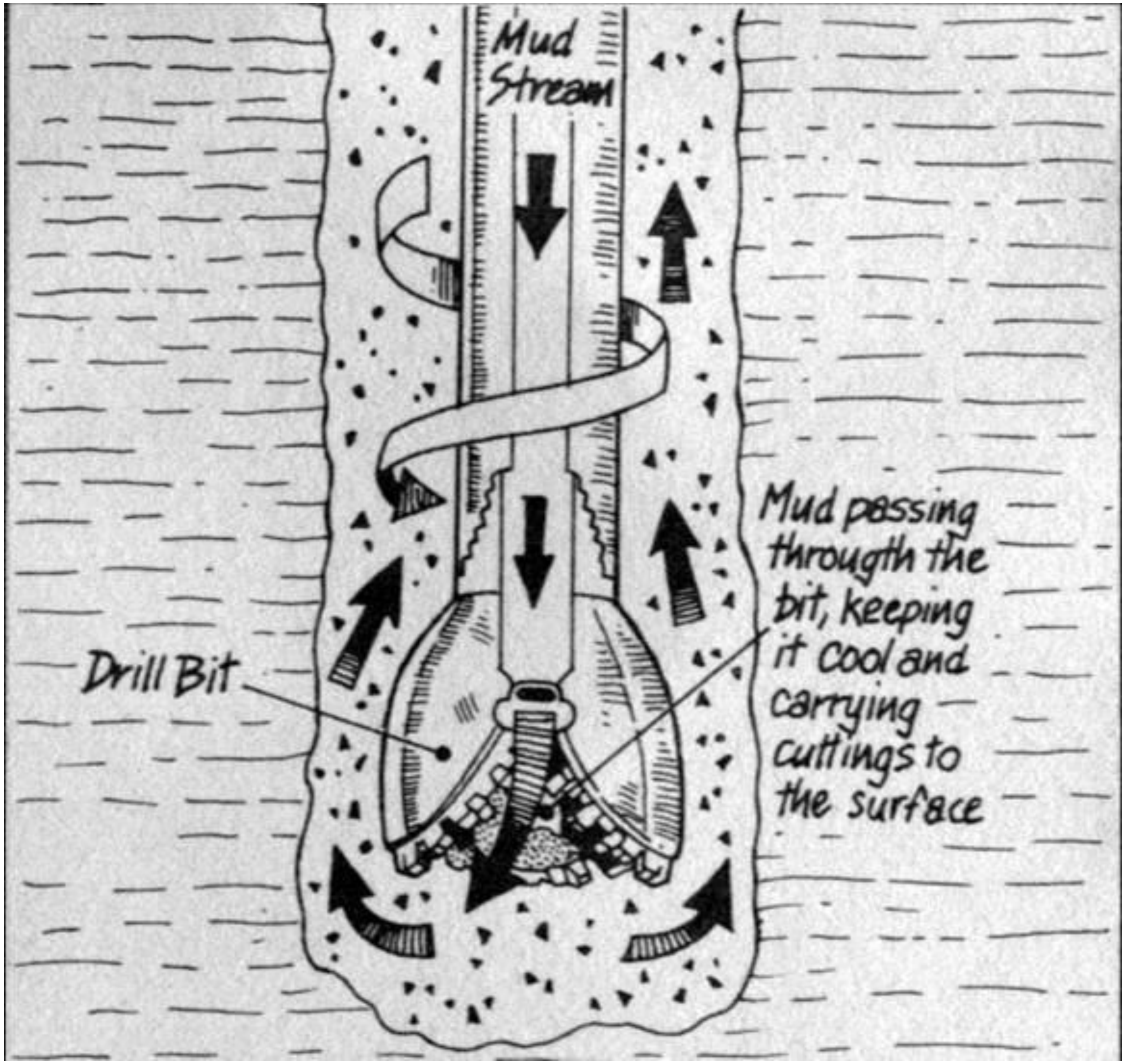
The Flushing Fluid

The circulation fluid is the flushing medium which is supplied through the flushing-holes in the drill steel and distributed through flushing-holes in the bit front.

The front of the bit has space for flushing the cuttings or chips rearwards.

The flushing medium may be air, water or mud.

Principle of Drilling Fluid



The Circulation Fluid

- Cleans the hole
- Cools the bit and
- Stabilises the hole
- Supports the penetration through removal of cuttings

Air, water or sometimes mud is used for this purpose.

Drillability

Drillability means rate of drill bit penetration into rock [Tamrock..1983]. Schmidt R. L. [1972] defines drillability as the resistance of rock to penetration. Paithanker et al [1980] have shown that any stage of bit wear has a complex function of several rock properties, viz compressive strength, modulus of elasticity, density and coefficient of friction between rock and bit.

Factors Affecting Drillability

Factors affecting the rate of penetration (drillability) include:

1. Rock properties
2. Drilling parameters
   - Thrust
   - Torque
   - Flushing

Rock properties influence on drillability

Among the important rock material properties having an over-all effect on the drilling techniques and drillability include:

- Hardness
- Abrasiveness
- Texture
- Structure

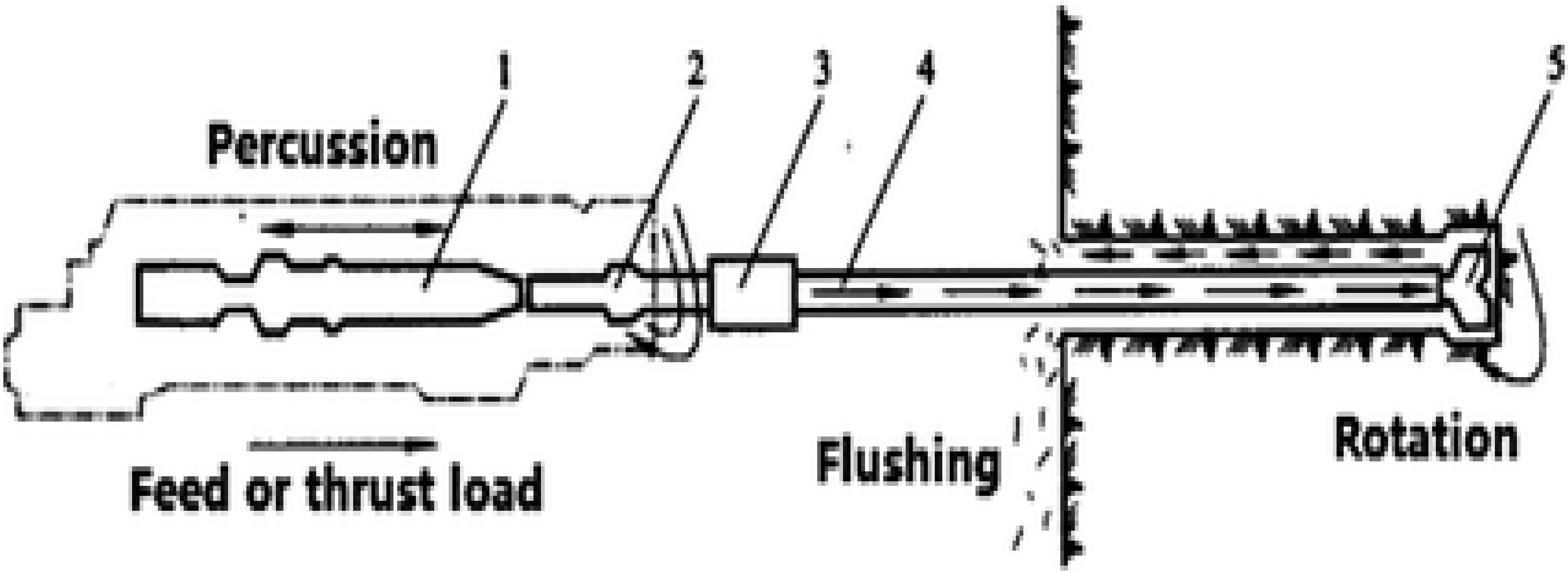
Degree of rock hardness related to compressive strength of rock		
Hardness	**Mohs Level**	**MPa**
Extremely hard	7 and above	200 and above
Hard	6 - 7	120 - 200
Medium hard	4 - 6	60 - 120
Somewhat soft	3 - 5	30 - 60
Soft	2 - 3	10 - 30
Extremely soft	1 - 2	10 and below

Consumption of drilling components

Drilling components including bits, rods, coupling sleeves, shank adapters wear out and become obsolete. The life-span of drilling components depends on:

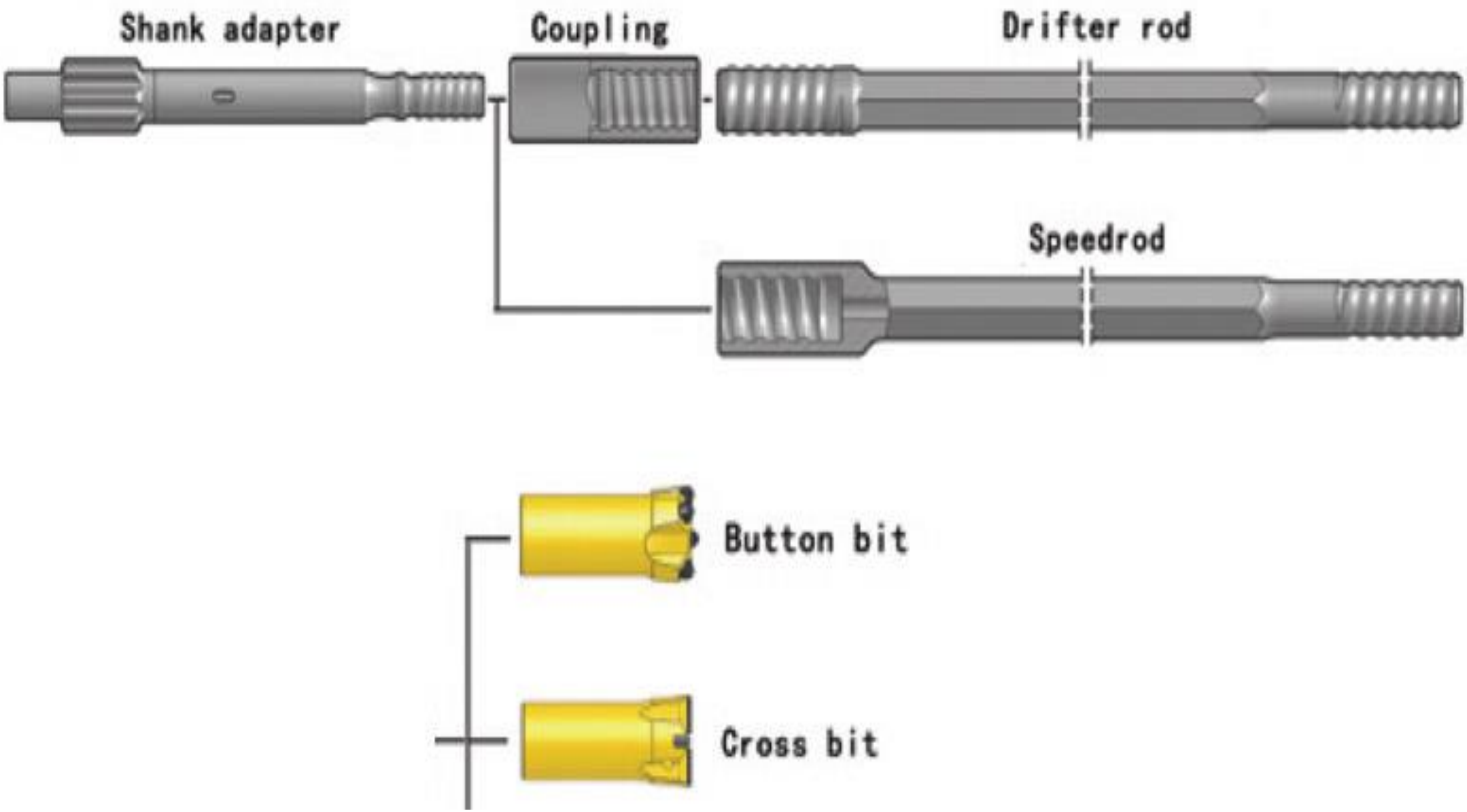
- Rock hardness
- Abrasiveness
- Texture
- Structure
- Hole diameter and length

Drilling components



1 - Piston 2 - Shank adapter 3 - Coupling 4 - Drilling rod 5 - Bit

Drilling components



Q1. List five intrinsic environmental factors which affect the rate of rock penetration

Q2. In rock drilling, force of 15kN is applied on two circular bits with diameters 0.15m and 0.3m, calculate:

a) The stresses produced by each bit on the rock

b) Make comments on stresses produced

c) Which bit has high penetration rate

Q3. With reference to stress/strain curve, explain the behavior of rock under drilling forces and why the rock behavour is different from steel under the same forces.

Example: Consumption of drilling components

Calculate the required bits, rods, coupling sleeves, shank adapters and production in cubic metres given:

Tunnel length	=	300m
Tunnel area	=	40m^3
Depth of round	=	4.6m (with 95% advance)
Number of holes	=	55 holes per round

Average service life:

45mm button bit	=	300m
Coupling sleeves	=	1,600m
R38 rods	=	1,600m
Shank adapters	=	2,500m

Solution

Total drilled metres = Tunnel length x holes per round + 5% overdrill = (300 x 55) + (300 x 55 x 0.5) = 16,500 + 825 = 17,325m

Required bits = Total drilled metres/Average service life = 17,325/300 = 57.75 therefore 58 bits required

Required sleeves = 17,325/1,600 = 10.83; therefore 11 sleeves required

Required rods = 17,325/1,600 = 10.83; therefore 11 rods required

Required adapters = 17,325/2,500 = 6.93; therefore 7 adapters

Production = Area x Length = 40 x 300 = 12,000m^3

Q1: Calculate the required:

a) Bits;
b) Shank adapters
c) Sleeves; and
d) Rods

Given:

Production	=	1,000,000 tonnes
Density	=	4 tonnes/m^3
Specific drilling	=	0.5

Average service life (life span) of:

51mm button bit	=	450m
Shank adapters	=	3,500m
Sleeves	=	250m
R32 rods	=	150 holes
R32 rod length	=	1.8m

Solution 2

Production = Tonnes/Density = 1,000,000/4 = 250,000m^3

Drilled metres = Production x specific drilling = 250,000 x 0.5 = 125,000m

Required components = Drilled metres/Service life

Required bit = 125,000/450 = 277.78

Therefore 278 bits are required to drill125,000m

Required shank adapters = 125,000/3,500 = 35.7

Therefore 36 adapters required to drill 125,000m

Required sleeves = 125,000/250 = 500 sleeves

Required R32 rods = Drilled metres/no. of holes x rod length = 125,000/(150 x 1.8) = 462.96

Therefore 463 rods required to drill 125,000m