ROCK BLASTING

CONTENT

11.1 Introduction

11.2 Blasting process and explosives
   11.2.1 Detonation of low and high explosives
   11.2.2 Blasting process

11.3 Optimized and control blasting
   11.3.1 Powder factor
   11.3.2 Bench blasting
   11.3.3 Blast Damage & Vibration Criteria
Module 11: Rock Blasting

LECTURE 36

11.1 INTRODUCTION

Rock blasting is done to break rocks so that it may be quarried or to excavate ground for construction purposes. It is the controlled use of explosives mostly in mining, quarrying and civil engineering such as tunnel, dam or road construction. Blasting is one of the major and greatest inventions in the history possibly after discovery of fire and metals which changed the pace of civilization. Dr. Alfred Nobel famous for the Nobel trust and Nobel prizes is known for inventing dynamite. Blasting, explosives and dynamite became synonymous since then with dynamite being the first safest high explosives.

Impact of rock blasting is enormous and currently utilizes many different type of explosives with different compositions and performance properties. Higher velocity explosives are used for relatively hard rock in order to shatter and break the rock, while low velocity explosives are used in soft rocks to generate more gas pressure and a greater heaving effect. The most commonly used explosives in large scale blasting today are ANFO (ammonium nitrates and fuel oil) based blends due to lower cost than dynamite. Worldwide, huge quantity of explosives is being consumed every day for various Mining and Civil engineering needs. This consumption is also related with the breakage mechanism of rocks and a optimised blast design may in-turn lead to huge savings. Understanding the rock mechanics of blasting would help in safe, efficient and economic blast design and rock breakage.
11.2 EXPLOSIVES

Explosives are mixture of chemical compounds which rapidly decompose, instantly releasing large quantity of energy in the form of heated gas at a high pressure. Its basic ingredients are oxydiser, fuel and a sensitizer. Some of the important properties of explosives are, strength, velocity of detonation (how long it takes for the chemical reaction to happen and energy released), density, water resistance, sensitivity, fume characteristic and legal permission.

The strength of an explosive is a measure of the work done by a certain weight or volume of explosive. This strength can be expressed in absolute units, or as a ratio relative to a standard explosive. Usually the bulk strength of explosives is related to the strength of ANFO (ammonium nitrate and fuel oil) that is assigned an arbitrary bulk strength of 100. One measure of the strength of an explosive is its velocity of detonation (VOD); the higher the velocity the greater the shattering effect. However, explosive strength, density and degree of confinement are also factors that should be considered in selecting an explosive for a specific purpose.
Examples of high explosives are Nytraglycerine/dynamite, TNT, water gels, special gelatine, slurry, emulsion, ANFO etc. whereas examples for low explosives, gun/ black powder.

**Explosives types**

**High explosives**
- High velocity of detonation (VOD), detonated with shock wave propagation with gas expansion.

**Low explosives**
- Low velocity of detonation, deflagrated with gas expansion only.

**Figure 11.2: Type of explosives- High and Low explosives**

**EXPLOSIVES**

- **LOW EXPLOSIVES**
  - BLACK POWDER
  - SMOKELESS POWDER
  - FLASH POWDER

- **HIGH EXPLOSIVES**
  - PRIMARY HIGH EXPLOSIVES
    - LEAD AZIDE
    - LEAD STYPHNATE
    - MERCURY FUMINATE
    - DNP
    - TETRAZENE
  - BOOSTERS
    - PETN
    - RDX
  - MAIN CHARGE
    - DYNAMITE
    - BINARY EXPLOSIVES
    - WATER GELS
    - EMULSIONS
    - TNT
    - ANFO

**Figure 11.3: Different type of explosives used in rock blasting**
11.2.1 Detonation of low and high explosives
When low explosive is blasted the process of constituent substances is propagated by rapid combustion of particle to particle through the mass of explosive and the effect of explosion is relatively low. A low explosive is fired by ignition or a flame. High explosive always contains an ingredient which is explosive in itself, at least when sensitized by proper means. A high explosive explodes when a violent shock is applied to it with the help of detonator. Here, the process of oxidation doesn’t proceed from particle to particle, but is instantaneous and the constituents react with high velocity and produce a shattering effect.

![Figure 11.4: Detonation of low and high explosives](image)

11.2.2 Blasting Process
When explosive detonates, hole pressure may exceed 20,000-100,000 times than the atmospheric pressure. This also generates stress waves that travel with a velocity of 5000 m/s. The loading front of the stress wave is compressive but is closely followed by a tensile stress responsible for rock fragmentation. A compressive wave reflects when it reaches a exposed rock surface and on reflection becomes a tensile strain pulse. Rocks break much more easily in tension than in compression and fracture progresses backward from the free surface.

A simple bench blasting representation is shown in figure 11.5 with vertical holes in an inclined face. There are three basic zones formed during the blasting process, first the pulverized zone, compressive stress zones and followed by radial cracking zone. Schematic illustration of processes occurring in the rock around a blast hole, showing formation of

308
crushing zone, fracture zone and fragment formation zone is shown in figure 11.6. Figure 11.7 shows the reflection of stress wave in the blasting process showing the reflected pulse returning from the free face. A detailed mechanism of rock breakage with explosives with spalling of rock surfaces with returning tensile wave pulse and the expansion of explosive gases with high pressure is shown is figure 11.8 a-c.

Figure 11.5: A simple bench blasting representation- Vertical holes in an inclined face
Figure 11.6: Illustration of processes occurring in the rock around a blast hole, showing formation of crushing zone, fracture zone and fragment formation zone.

Figure 11.7: Reflection of stress wave in the blasting process.
Figure 11.8: Mechanism of rock breakage with explosives