Unlocking Possibility of Blasting Near Residential Structure
Using Electronic Detonators

ARVIND K. MISHRA
Department of Mining Engineering, Indian School of Mines, Dhanbad – 826 004

Abstract: Ever since development of human civilization, mining and agriculture has been the backbone of growth. Today the most developed countries of the world are the ones focused on core economical development, be it power generation, steel making, oil and gas production, or agriculture. Mining has been gaining importance over the years both from the economic perspective and as an area of sustained research. With the advent of globalization, things have changed very fast and today it is an industry that is driving the economies of several nations. Global competition has propelled countries to reach higher production levels through better techniques of drilling and blasting, excavation and mineral processing. We now have bigger and faster drill machines and excavators. In Explosives technology too significant progress has been made towards having safer explosives and accurate initiating systems that have increased overall control over blasting in terms of vibration, fragmentation, throw, fly rock and overall blast economics.

Explosives and Rock Blasting Technology has advanced so much in the last few decades that blasting can now be precisely performed, controlled and predicted. Development of new tools like electronic blasting systems and advanced simulation software has made it possible to customize blasting results as per requirement. These developments have helped mining engineer worldwide in reaping huge productivity benefits besides making it possible to meet the environmental norms even in most demanding conditions.

Inability to blast large size shots on account of proximity of mines to human habitation have always constrained mine management in fully leveraging the strength of large size production equipments. Mine managers have been forced to conduct small blasts on increased frequency to provide feed to large capacity shovels while compromising on Shovel productivity on account of undesirable movement of shovels during blasting. This paper deals with a case study at SEB quarry of Tata Steel wherein it was difficult to fire a big blast due to existing nearby structures. A critical scientific study was conducted before successfully firing of one of the biggest shot of 83 tonnes in the history of quarry. The paper discusses the issues being faced, alternate solutions opted and the final outcome.

Keywords: Blasting technology, Innovative blasting, Digital blasting system, Modelling.

INTRODUCTION

Ever growing demand for coal and mineral has compelled the mining industry for increase in size of open pit mines. The buzzword today in opencast technology is bigger and bigger sizes of mines with high capacity earth moving equipment. This trend has called for usage of large amount of explosives coupled with sprawl of urbanisation and increased public environmental consciousness. This has called for much greater control over blast induced ground vibrations, noise and fly-rocks. With extensive demand of coal, majority of opencast mining projects are becoming closer to habitation, which has called for identification of a system of blasting which can give desired results in the most economical way without damaging nearby structures and raising public litigation cases. To control ground vibration, fly rocks, noise and fragmentation due to blasting, the basic mechanism for the rock breakage should be clearly understood.

Explosives and Rock Blasting engineering has advanced so much in the last few decades that Rock Blasting can safely be called as Science now. Development of new tools like electronic blasting systems and advanced simulation software has made it possible to customize blasting results as per our requirement. These developments have helped mining engineer worldwide in reaping productivity benefits besides making it possible to meet the stringent environmental norms even in most demanding conditions.

Inability to blast large size shots on account of proximity of mines to human habitation have always constrained mines management in fully leveraging the strength of large size
production equipments. Mine managers have been forced to conduct small blasts on increased frequency to provide feed to large capacity shovels while compromising on shovel productivity on account of undesirable movement of shovels during the time of blasting.

This paper deals with the problem being faced by the mine management and methodology adopted for resolving the same without compromising the productivity.

AREAS OF CONCERN WITH BLASTING

Ground Vibrations

Ground vibration is an integral part of the process of rock blasting. Dynamic stresses in surrounding rock mass around blast hole is set due to sudden acceleration of rock mass by detonating gas pressures on the hole walls. This sets up a wave motion in the ground. The wave motion spreads concentrically from the blast site in all direction and gets attenuated due to spreading of fixed energy over a greater mass of material and away from its origin. Even though the ground vibration attenuates exponentially with distance but due to large quantity of explosives per delay it can still be high enough to cause damage to building and other man-made structures by causing dynamic stresses that exceed building materials strength.

Damage caused by ground vibration is dependent on the amplitude of ground velocity and on the frequency of ground motion. All the vibration standards till date are based on the resultant peak particle velocity of ground vibration because this is accepted as the best criterion for assessing levels of damage due to vibration. The recent trend is to refer to frequency of the ground motion. Low frequency waves (below 6 Hz) causes more damage to structure particularly in case of multi-storeyed buildings (Atlas Powder Company, 1987; Broadbent, 1974; Birch and Chafffer, 1983; Hinzen, 1988; Singh et al. 1997; Siskind et al. 1980)

Air Blast/Noise

When blasting is done, a loud noise is heard which is known as air blast. Air blast, however, is not simply the sound that is heard. Air blast is an atmospheric pressure wave consisting of high frequency sound that is audible (from 20 Hz to 20 k Hz) and low frequency sound or concussion (less than 20Hz) that is sub-audible and cannot be heard. Although air blast seldom causes structural damage but sudden great noise causes psychological fear in the nearby inhabitants and in some severe case even breakage of window panes have been reported (Persson et al. 1994). Air blast is influenced by type and amount of explosive, adequacy and type of material for stemming, direction of blast and meteorological conditions. Main cause of noise is the energy released in open air by the initiation system and inadequate stemming column, burden etc.

Air overpressure is measured in decibel (dB) or in Pascal (Pa), which is given as:

$$L_p = 20 \log \left( \frac{P}{P_o} \right)$$

where, $L_p$ = sound level in decibel (dB), $P_o$ = reference sound level, which is defined to be zero dB = $20 \times 10^{-6}$ Pa and $P$ = sound level in Pa.

Fly Rock

When blasting operations are carried out, the rock gets fragmented and the fragmented material is moved forward to make mucking of the fragmented mass easier and less costly. In addition to this desirable displacement of broken fragments in case of surface mine blasting, some stone pieces can get torn and travel to very large distance, this unexpected projection of stone is termed as “Fly rock”. Fly rocks eject with a terrific speed and it can cover a distance of 400 m or even, more which can damage buildings, equipments and may kill men and cattle (Lundborg et al. 1975; Mishra and Gupta, 2002). The cause of fly rock is basically liberation of blast energy through a narrow path of least resistance in rock mass. Factors which are responsible for fly rocks are inadequate burden and spacing, over charged holes, geological characteristics of site, inaccurate drilling and stemming, faulty delay time and overlapping of delays, improper initiation sequence, sometimes loose rock lumps lying on the top of bench or along slope become potential hazard of fly rock as well as due to secondary blasting.

Fragmentation

Fragmentation is considered as an average size of the broken rock. Fragmentation is generally used as a comparative word like good fragmentation or poor fragmentation. A good fragmentation can be defined as the desired size of fragments produced after blasting to match with the loading machine bucket size, dumper and opening