Chapter 14
Investigations on Impact of Blasting in Tunnels

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ABSTRACT
Blasting with longer advance per round leaves an impact both visible (in the form of overbreak) and invisible (cracks) in the surrounding rockmass, however, a number of controlled-blasting techniques, that is line drilling, pre-splitting, and smooth blasting, have been developed to minimise this problem. These techniques require additional drilling, controlled charging, and detonation, and thus, are not preferred in regular development activities. Investigations have been carried out in five different horizontal development drivages of metal mines to assess the blasting impact using burn cut and arrive at the blast-induced rock damage (BIRD) model. Vibration monitoring close to the blast was carried out using accelerometers for the first time in India to develop vibration predictors and overbreak threshold levels for individual sites. This paper reports the development of the overbreak predictive model (BIRD) for burn cut blasting in hard rock drivages by combining the relevant rock, blast design, and explosive parameters. A multivariate statistical model has been developed and validated and the same can find ready application in tunnels and mines for exercising suitable engineering controls both in blast design and explosive selection for reduced basting impacts.

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1. INTRODUCTION

Blasting is the most popular means of excavation for tunnels despite the rapid developments in the mechanical excavators, namely, tunnel boring machines, road headers, continuous miners. Faster drivage rates are possible with the recent developments in explosives (emulsion), initiating systems (NONEL, electronic detonator) and drilling (automation) systems. However, longer pulls, associated with high concentration of explosives, often lead to overbreak due to excess ground vibrations. Overbreak can become an expensive phenomenon in terms of extra concrete backfilling and may also give rise to additional mucking time. Most of the existing controlled blasting techniques, to reduce the blast-induced overbreak, need extra drilling, in turn, adding to drilling and blasting cost and time. Blasting in tunnels aims at the following objectives:

(i) Longer pulls
(ii) Reduced overbreak and rock damage
(iii) Optimized drilling and blasting cost.
(iv) Low cycle time

Thus, it is rational to assess blast-induced overbreak in production blasting and control the same by modifying the blast design.

2. PREVIOUS WORK

Overbreak is largely affected by a host of rock, blast design and explosive parameters. Several researchers have attempted to study overbreak/blast-induced rock damage either based on experimental studies or relating some of the above influencing parameters. A brief discussion on the previous works is provided in the following section.

(i) McKnown (1984) and Singh (1992) used half cast factor as a measure of blast-induced overbreak. Half cast factor is the ratio of total visible drill mark length in the wall and roof after blast and the total drilling length and is given by,

\[ HCF = \frac{\sum_{i=1}^{n} L_i}{\sum_{i=1}^{n} L_r} \]  

Where,

- \( HCF \) = Half cast factor
- \( L_i \) = Post-blast drill mark length visible (m)
- \( L_r \) = Pre-blast drilled length (m)

(ii) Graddy and Kipp (1987) used a scalar, \( D \), to describe the rock damage. The value \( D \) lies between 0 (intact rock) and 1 (complete failure). This can also be used to estimate the rock modulus \( E_d \), of the damaged rock, so that

\[ E_d = E (1 - D) \]  

Where,

- \( E, E_d \) = Modulus of the intact rock and damaged rock respectively

(iii) A method proposed by JKMRC (Australia, 1990) included the frequency, surface condition and density of discontinuities as a descriptor of damage.

(iv) Forsyth and Moss (1990) devised a method of quantifying blast-induced damage. Their proposed Drift Condition Rating (DCR) comprised two components: firstly, the drift back condition (related to the rockmass integrity and the percentage of half cast visible); and secondly, the amount of overbreak. This empirical rating varied from 0 to 9.
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