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Experimental study the effect of time delay interval on blast-induced weakness

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Abstract

This paper reports results of a series of experiments to investigate the effect of time delay interval on blast-induced weakness. Three concrete blocks with the same characteristics were made that had size of 50 ×30×14 cm in which nine 6-mm blasholes in three rows were drilled. The spacing and burden were designed 75 and 50 mm, respectively, giving an S/B ratio of 1.5. Twelve points were arranged on the blocks in four lines and three rows to measure ultrasonic wave velocity before and after delay blasting. Blocks was blasted by detonating cord of 12 g/m in three different delay time intervals between rows including 25, 50, and 75 millisecond. Weakness index was defined by incorporating difference of ultrasonic wave velocity in intact and blasted blocks. The results were analysed and discussed for different measuring directions and contour plot of weakness in blocks was plotted. This study concludes that increasing of time delay interval has different effect on the magnitude and distribution of weakness.

Keywords: *Time delay interval, blast-induced weakness, concrete block, ultrasonic wave velocity*

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Extended Abstract:

1. Introduction

The delay times between blastholes and the initiation sequences plays an important role in blasting because they reduce the charge weight per hole and, as a consequence, the levels of vibrations produced along with a more effective breakage and control over rock displacement, subdrilling, and flyrock. Therefore, selection of optimum time delay interval leads to optimize fragmentation and minimize negative outcomes.

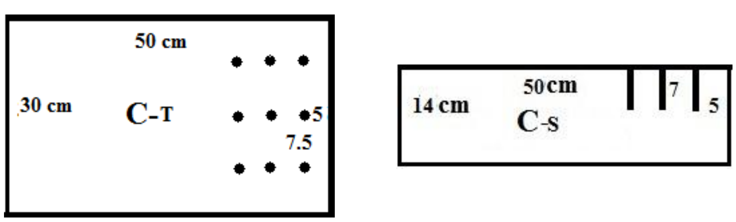
Up to now, the effect of time delay interval on blasting results have been studied. Critical review of literature reveals that most researchers focused on time delay effect on fragmentation (Katsabanis et al., 2006; Blair, 2009; Kim, 2010; Johansson and Ouchterlony, 2012; Katsabanis and Omidi, 2015; Omidi, 2015; Gkikizas Lampropoulos, 2016; Sasaoka et al., 2019; Saadatmand Hashemi and Katsabanis., 2020). However, there are few studied concern to investigate the effect of delay on the negative consequences of blasting while reducing such outcomes are the main aim of a delay blasting operation. Among blasting consequences, weakness of remaining sourending rock mass, as the most important induced-damage, is a critical because it is an in-situ alteration in the rock mass characteristics. Therefore, this paper was aimed to study induced damage in term of weakness due to delay blasting.

2. Materials and methods

Three concrete blocks (C1, C2, and C3) were prepared with the same dimension, concrete mixture, production process and storing conditions including density of 2150 Kg/m^3, tensile strength of 2.8 MPa, UCS of 26 MPa and ultrasonic wave velocity of 30 m/s. A same blasting pattern in three rows was designed for all blocks. Blocks geometry and designed blasting pattern are illustrated in Table 1 and Figure 1.

Table 1. Blocks geometry and designed blasting pattern

Dimension (cm)	Burden (cm)	Spacing (cm)	Hole length (cm)	Hole diameter (cm)
50 ×30×14	5	7.5	7	0.6



a. plan view b. Side view

Figure 1. Schematic representation of blocks geometry and blasting pattern

comparison of ultrasonic wave velocity before and after blasting is selected to quantify blast-induced weakness in concrete blocks. Weakness index was defined according to the equation (1):

$$W = \left(\frac{t_{post} - t_{pre}}{t_{post}}\right) \times 100 \quad (1)$$

where W is surrounding rock weakness (%), t_{pre} is passing time of ultrasonic wave through intact specimen (μsec), and t_{post} is passing time of ultrasonic wave through blasted specimen (μs).

In order to measure ultrasonic wave velocity, a same measurement grid was designed beyond the last row of blastholes in all blocks as is depicted in Figure 2.

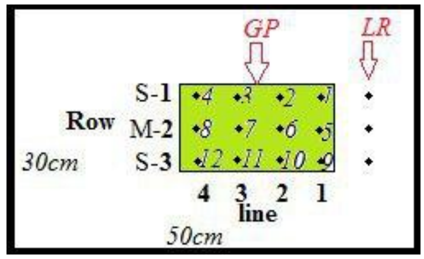


Figure 2. Measuring points of wave velocity on concrete model

In order to blast the blocks, full length of blastholes was charged by detonating cord of 12 g/m and diameter of 5.8 mm. In each block, blastholes placed in a row were blasted simultaneously while, time delay interval between rows was 25, 50 and 75 millisecond in blocks C1, C2 and C3, respectively.

3. Results

Table 2 gives calculated weakness index for all blocks. Figure 2 illustrates contour plot of resulted weakness in concrete blocks.

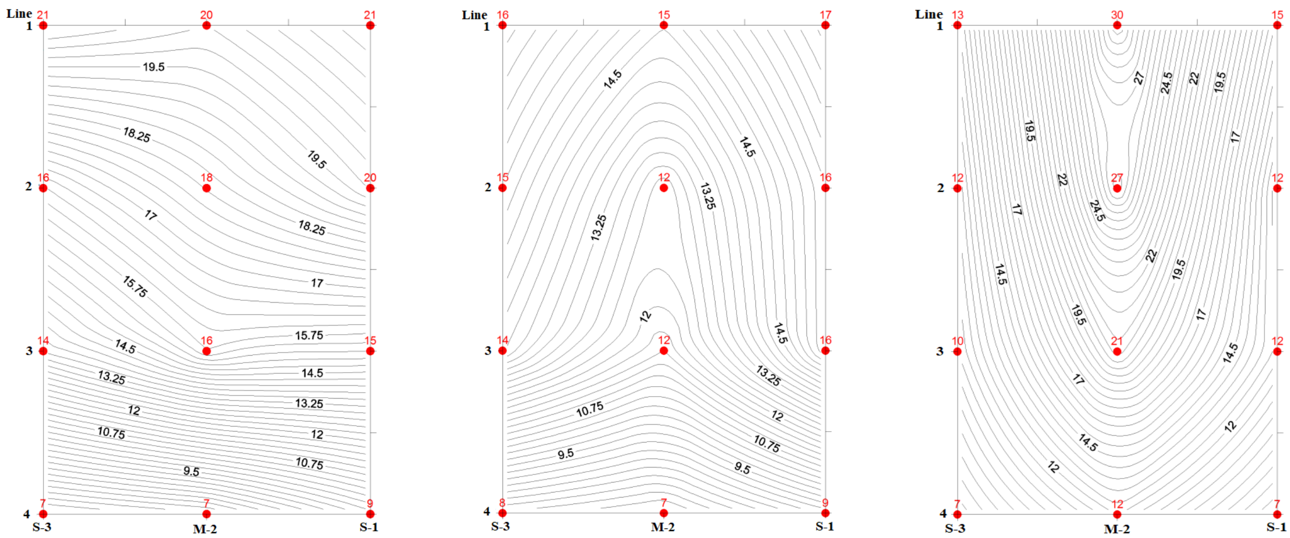
Table 2. Calculated weakness index in the measurement points for all blocks

Block	Line	Row		
		S-1	M-2	S-3
C1	1	21.26	20	20.63
	2	19.79	18.03	16.20
	3	15.25	15.73	16.54
	4	9.37	7.41	6.83
C2	1	16.90	14.53	16.43
	2	15.73	12.28	15.25
	3	15.73	11.50	14.04
	4	8.81	7.12	7.69
C3	1	15.25	30.07	13.29
	2	12.02	27.36	11.50
	3	12.28	20.84	10.45
	4	7.41	12.02	7.21

4. Conclusion

Based on results, the following conclusions could be drawn:

1. In all concrete blocks, the peak values of blast-induced weakness appear in the 1st line which is the nearest line to the fireline, while, the lowest values are in the 4th line, the furthest measurement line from blasting holes. An almost similar decreasing trend was observed in the weakness with respect to the line of measurement in all blocks.
2. Maximum and minimum calculated weakness of 30.07% and 7.12% was calculated in the middle row of measurement grid in block C3 and C2, respectively.
3. In all blocks difference between blast-induced weakness in side rows was approximately equal. However, weakness of S-1 row was higher than S-1 ones.



a. block C1 b. block C2 c. block C3

Figure 2. Weakness contour plot in concrete blocks

4. It was observed that increasing of time delay interval has different effect on the weakness of middle row. In this regard, weakness of middle row in the block C1 was the mean value of side rows weakness, in the block C2 was lower than side rows and in the block C3 was considerably more than side rows.
5. Generally, increasing of time delay interval has different effect on the magnitude and distribution of weakness. Accordingly, it can be concluded that principles of blasting shock wave superposing should be incorporated to interpret blast-induced weakness.

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