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ORIGINAL PAPER

Investigation into Rock Breakage with Expansive Cement Under Biaxial Confinement

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Abstract

While drilling and blasting with explosives is widely used for rock fragmentation in mining and civil engineering, its use is associated with rigorous safety and environmental constraints as blasting creates toxic fumes, vibrations and dust. In recent years, there has been a growing interest in transitioning from blasting with explosives to rock fragmentation without explosives. In this study, the potential of expansive cement (EC), aka soundless chemical demolition agent (SCDA), as an alternative to explosives to break hard rock under confinement is explored through a comprehensive experimental and numerical modelling study. To do so, two large-scale tests have been designed and carried out on 1 m × 1 m × 0.25 m panels made from high-strength concrete and subjected to planar, biaxial loading conditions. Such test configuration is designed to mimic a mining front subjected to biaxial stresses. Different EC drill hole patterns were tested and compared. The fragmentation behaviour due to EC was first examined with five particle flow code (PFC2D) models simulating different EC drill hole patterns. Two panel designs were retained for the large-scale experiment. It is found that rock breakage with EC under confinement is feasible and promising, especially when the optimized drill pattern from numerical modelling is adopted. It is demonstrated that discrete element modeling with PFC2D can be used effectively to design and optimize the EC drill hole pattern under biaxial confinement. The findings of this study could set the stage for numerous future applications of EC for rock fragmentation of subsurface hard rock excavations such as shafts, tunnels, and mine openings.

Highlights

- PFC2D models are developed to examine the efficiency of expansive cement to fragment a panel under biaxial loading.
- Both modelling and large-scale test results indicate that panel breaks more effectively when relief holes are employed in both loading directions.
- Concrete panel #2 is successfully fractured using expansive cement while both in-plane and bulging failure mechanisms are observed during the test.

Keywords Expansive cement · Hard rock fragmentation · PFC model · Large-scale biaxial tests

1 Introduction

Drilling and blasting with explosives is widely used for rock fragmentation in mining and civil engineering projects. However, the use of explosives is associated with rigorous safety and environmental constraints as blasting creates toxic fumes, ground vibrations and dust. Moreover, underground mining blasts are often accompanied by damage of the wall rocks causing overbreak and requiring additional ground supports. Due to these factors, there has been a growing interest in transitioning from blasting with explosive energy to rock fragmentation without explosives. In this study, the potential of expansive cement (EC), aka soundless chemical demolition agent (SCDA), as an alternative to explosives to

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