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ORIGINAL PAPER

Biaxially Confined Rock Breakage with SCDA: Large-Scale Tests and Numerical Modelling

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Abstract
Soundless chemical demolition agents (SCDA), also known as expansive cement, represent a potentially viable method for fracturing rock without explosives. Traditionally, expansive cement is used for surface applications, such as block splitting in dimension stone quarries and demolition of concrete foundations. For deep underground applications, the major challenge with the use of expansive cement in an excavation face has been the presence of high biaxial stress field that would hinder the development of fractures in a mining face. This study aims to explore how expansive cement can be potentially used for rock fragmentation in deep underground environments. To do so, large-scale tests on 1 m × 1 m × 0.25 m concrete and granite panels with a novel drilling pattern are prepared, instrumented, and tested under biaxial confinement conditions. Test results show that the proposed drill pattern for expansive cement boreholes is capable of fracturing both panels under biaxial stresses. A 3D finite-difference modelling code FLAC3D 7.0 was developed and validated with observed panel breakage process and failure mechanisms. Both large-scale tests and numerical modelling show that expansive cement induces significant fracturing parallel to the loading plane. These findings should lay the groundwork and provide guidelines for the future application of expansive cement to underground hard rock excavations.

Keywords Expansive cements · SCDA drill pattern · Rock fracturing · Large-scale tests · FLAC3D modelling

1 Introduction

Soundless chemical demolition agents (SCDA), also known as expansive cement, or static cracking agents, are powdery materials that harden and expand once mixed with water. When an SCDA is poured in a confined borehole, it generates expansive pressure and fractures the surrounding materials during the cement curing process. Since its introduction in the early 1970s, SCDA were mainly used for surface applications in civil engineering field, such as rock quarrying and concrete demolition (Cho et al. 2018; Kim et al. 2021). By pouring SCDA slurry into boreholes in boulder or concrete block, the SCDA will expand and produce fracture networks in a controlled manner under no load. SCDA products are environmentally friendly, producing no toxic fumes, which reduces ventilation requirements in underground mines and tunnels. Another important advantage of SCDA is that the rock cracking process is well-controlled, eliminating overbreak and decreasing the demand for primary rock supports (Habib et al. 2022a).

Despite the advantages of SCDA, the properties and application guidelines of SCDA have not been widely studied and understood. Some studies have been conducted to examine SCDA physical properties and behaviours in laboratory conditions. SCDA expansion pressure was mostly quantified using thick-walled cylinder method, where the SCDA mixture is poured into a thick-walled metal cylinder with strain gauges installed on the cylinder outer surface. The SCDA pressure is calculated analytically based on the measured tangential strain of the cylinder surface (Hinze & Brown 1994; Habib et al 2023; Li et al. 2021; Xu et al. 2021a, 2022). De Silva et al. (2017) investigated the variation of mechanical properties and microstructures of SCDA during the hydration process. Their results showed that SCDA could be more effective to produce higher pressures in fracturing rockmass with high confinement. De Silva et al. (2019) studied the impact of saturation conditions in fracturing performance of SCDA in geological

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