Strain distributions for shotcrete failure in hard rock tunnels

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Abstract

Shotcrete linings are a commonly used support system in hard rock tunnel construction, providing flexibility and minimizing construction time. Understanding the strain behaviour of shotcrete under different loading scenarios and interface conditions is vital for optimizing tunnel support design and ensuring long-term structural integrity. In this study, distributed optical fibre sensors were installed in laboratory prepared specimens, in which the lining was subjected to two distinct loading scenarios: a rock load and a distributed load. The specimens in the study consisted of two concrete layers where the substrate slab was either hydro-demolished or ground prior to casting a top fiber reinforce concrete layer. Key findings from the experiments reveal that specimens with rougher substrate surfaces exhibit higher post-failure ductility compared to those with ground surfaces, suggesting superior performance after peak loading.

Keywords: Shotcrete; Distributed optical fibre sensors; Structural health monitoring; Experiments.

1 Introduction

In hard rock tunnels, sprayed fibre reinforced concrete, or shotcrete, in combination with rock bolts, is the most commonly used lining system. The rock bolts anchor large loose blocks to underlaying rock, whereas the shotcrete carries smaller blocks and loose rock material between the rock bolts. As the shotcrete is sprayed directly on the rock, a bond is formed between the materials and loads on the lining are carried in composite action.

Experiments on shotcrete linings have been carried out previously [1, 2], however, the focus was put on the interaction between lining and rock bolts and characterization of load carrying capacities. Furthermore, previous test setups only considered loads in one direction, not enabling redistribution of forces.

In analytical design of shotcrete linings, as proposed by Barret and McCreath [3], two cases are considered where the bond is either intact or not. If the bond is intact, the load is considered as rigid and transferred as shear forces in the lining to the rock bolts. In the other case, without bond between lining and rock, the load is considered as distributed and the lining acts as a slab in bending, supported by the rock bolts. By considering the interface as unbonded between the materials, the model is conservative, and the probability of overdesigning is high. By investigating the failure process of a shotcrete lining subjected to block loads and distributed loads from rock mass, a

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