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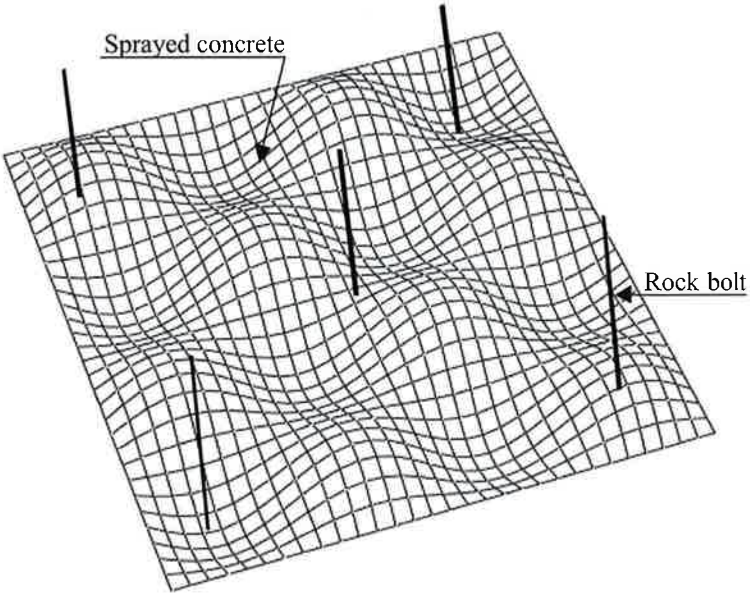

Structural behaviour of fibre reinforced sprayed concrete anchored in rock

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Abstract

The main objective of this investigation was to create a better foundation for design of a bolt-anchored tunnel lining. Mechanisms that influence the load bearing capacity such as compressive arch action and the irregular shape of the lining have been especially studied. A thorough investigation of the punching capacity has also been performed.

It has been shown that compressive arch action has a considerable positive effect on the load bearing capacity of fibre reinforced concrete. Punching tests were performed on circular symmetrically loaded slabs that symbolised a full-scale model of sprayed concrete around a rock bolt. A thick steel ring was placed around some of the slabs in order to incorporate the effect of compressive arch action on the failure. This ring simulates to a certain degree the restraint against lateral movements that the corresponding surrounding parts in a real lining would provide on a local failure zone. All slabs that were tested without a surrounding steel ring and could freely rotate along the support failed in bending without any signs of punching. The slabs that were tested with a lateral confinement received a considerably higher load bearing capacity and a changed failure behaviour that in many cases may be regarded as pure punching. The increase of load bearing capacity due to the surrounding steel ring was caused by compressive arch action, which also transformed the failure into punching. Increasing the fibre content from 30 kg/m^3 to 60 kg/m^3 gave no observable effect on the structural response of the slabs. A comparison between existing calculation/design methods for punching and test results showed that these methods are not fully valid for a bolt-anchored tunnel lining. Finite element simulations indicated that the failure is almost inverse to the traditional mechanism of punching.

The influence of the irregularity of the tunnel surface on the structural behaviour of the sprayed concrete was studied with numerical calculations using non-linear finite element analysis. A portion of a tunnel lining with a bolt placed at its centre showed that the stiffness is more affected by the irregularity than the load bearing capacity. If the bolts were consistently placed at the peaks or at the depressions in the lining, a completely different structural behaviour was observed. The load bearing capacity became considerably higher if the bolts were located at the peaks. This can be explained by the fact that the lining acted as compressed domes between the bolts and hence the high load bearing capacity.

Key words: *sprayed concrete, steel fibre, rock bolt, flexure, compressive arch action, non-linear finite element analysis, punching failure, irregular shape*

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