APPLICATION OF NOVEL BI-COMPONENT FIBERS IN SPRAYED CONCRETE

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Abstract

In tunnel and mining applications spraying of concrete is a well-established and economical alternative to conventional casting techniques. Further time and cost savings are achieved when fiber reinforced concrete is applied. Often steel fibers are used for such purpose. Corrosion risk, damage of water drainage foils through the stiff fibers and a relatively high fiber rebound, fibers falling off the wall upon spraying, are some of the drawbacks. A polymer fiber would not suffer from such, but so far other problems like creep or insufficient mechanical properties prevented from a wide application of such fiber types.

Recently developed structured bi-component polymer fibers were tested for spray applications as well. In field tests fiber-concrete was sprayed on well-defined artificial stone walls with a rock-type relief. The fiber content of the sprayed concrete and the rebound was measured. Low rebound and fast wall thickness increase, both decisive economic factors were observed.

Creep of fiber reinforced concrete under bending was studied in permanent load tests. Square plates and beams were used as specimens. In these laboratory tests it could be demonstrated that for this type of structured plastic fibers creep seems not to be a limiting factor.

Keywords: Sprayed concrete, bi-component fiber, rebound, fiber orientation, creep

Introduction

Steel fiber reinforced shotcrete is widely applied in mining operations, for forming linings in various railway, road and water tunnels. Other applications include rock slope stabilization work, canal linings or post-strengthening of deteriorated concrete structures. The material is more economical and technically equal to conventional shotcrete using wire mesh and allows modern excavating equipment to advance with fewer interruptions.

During the spray process the fibers and the material may not adhere completely on the wall, so that a certain rebound is observed. The relative losses for coarse aggregates and fibers have been found to be higher than for the rest and the properties of the sprayed concrete may be different when sprayed.

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Modern fiber technologies nowadays allow the production of bi-component fibers which possess a sheath and a core which may consist of different polyolefin polymers [1]. The sheath is optimizes regarding adhesion and bonding, while the core delivers high adequate mechanical properties. The rebound behaviour of such fiber type was studied here in detail.

Experimental and Results

The fiber and material rebound of sprayed fiber reinforced concrete was studied in field application tests on well-defined artificial stone reliefs. The rebound on the floor was collected and the material uptake onto the artificial rock wall was determined by weighing the artificial walls before and after the spray concrete application. The fiber content of the sprayed concrete was determined. Mechanical testing of sprayed fiber reinforced concrete was performed on square panels.

The rebound of larger grains and especially of fibers was significantly more important than the concrete rebound.

Macro-synthetic (plastic) fibers were found to have less rebound than steel fibers. A higher fiber dosage did not lead to a higher rebound. Fibers were observed by computer tomography to be oriented along the rock wall. Furthermore, the fiber type seems to influence the thickness growth on the wall. Macro-synthetic bi-component (Concrix) fibers were found to lead to a significantly faster concrete deposit on the walls than steel fibers.

Plastic fibers may bear the risk of creep under tension. However, novel fiber technologies allowing the production of polyolefin based fibers with higher elastic modulus, the application of special fiber additives and structuring of the surface can significantly reduce bending creep in fiber reinforced concrete. Long-term bending creep behavior of bi-component fibers in the post-peak state (pre-cracked) was studied on square panels.

Creep seems not to be a limiting application factor for these macro-synthetic fibers. In square panel bending creep tests, for bi-component fiber reinforced concrete stable deformation was observed for load levels up to more than 62 % (40 kN).

References

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