Simulation-based Robust Design of Steel Fiber Reinforced Concrete Structures – Application to Segmented Tunnel Linings

G. Meschke*, G.E. Neu and V.E. Gall

* Institute for Structural Mechanics
Ruhr-Universität Bochum
Universitätsstraße 150, 44801 Bochum, Germany
e-mail: guenther.meschke@rub.de, web page: http://www.sd.ruhr-uni-bochum.de/

ABSTRACT

Steel fiber reinforced concrete (SFRC) has a large potential of increasing the durability of concrete structures by adding steel fibers to enhance the ductility of concrete. In the last decades, FRC composite materials characterized by various fiber materials, sizes, shapes, and fiber content in association with different concrete compositions, exhibiting multiple cracking phenomena at small crack widths, either with or without the presence of conventional steel bar reinforcement, have been developed [1].

The beneficial properties of SFRC can be exploited to reduce the vulnerability of concrete structures when affected to construction induced loads, which often lead to local damage in case of conventional reinforced concrete design. One example considered in this presentation are segmented tunnel linings. The cracking of segmental tunnel lining segments in response to construction induced loadings rarely compromises the structural stability of the tunnel lining structure but significantly impacts the serviceability state of the finished construction. These local damages are mostly caused by improper segment handling, but are also results of the limited performance of conventional reinforcement (RC) in this areas due to concrete cover restrictions.

In this contribution, a segmental lining design which is less is less susceptible to damages is derived by applying a robust optimization methodology [2]. In contrast to conventional optimization, the variance of the structural response is included in the evaluation of the objective function caused by the uncertainty of the steel fiber distribution and construction tolerances. In order to capture the cracking behaviour of SFRC, a finite element model in which non-zero-thickness interface-solid elements (ISE) are placed between element boundaries to represent the opening of cracks including the crack bridging effect of the fibres in a discrete manner is developed. The fibre response across the ISE is defined using traction-separation laws, which are obtained from sub-models for individual fibres [3]. They take the amount of the specific fibre type and the distribution of fibres into account. For evaluating the structural response of conventional reinforced segments, the rebars are modeled as trusses and are coupled with the concrete matrix using a constraint condition between control points located on the rebar elements and their respective projection points within the elements in which they are embedded [4].

REFERENCES

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