

Damage simulation of concrete on the mesoscale

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Abstract. Concrete is a heterogeneous material with a highly non-linear behaviour, which is mainly caused by the initiation and propagation of micro-cracks within the several components of the material. The damage behaviour of concrete is usually simulated on the macroscale using complex constitutive models. The direct determination of the homogenized material parameters is often difficult and sometimes impossible. Furthermore these material models do not explicitly represent effects such as micro-cracking or the non-linear bond behaviour of the interfaces between the several components. On the mesoscale the numerical model considers the aggregates, the mortar matrix and the interfacial transition zone explicitly. As a result specific material descriptions can be used for each component. In this paper it will be shown that the complex macroscopic non-linear behaviour of concrete can be simulated using a material model for tensile failure on the mesoscale.

A finite element model, which explicitly represents the aggregate boundaries, is used for the non-linear simulations. In a first approach only the evolution of micro-cracks within the mortar matrix is considered. A linear elastic material behaviour of the aggregates and rigid bond between aggregates and mortar matrix is assumed. Different continuum damage models, e.g. scalar damage, anisotropic damage or rotating cracks, which can be used for the simulation of micro-cracks within the mortar matrix are discussed in this paper. The performance of the different models will be illustrated in several examples. The main problem during the non-linear simulation is the bad convergence behaviour of the standard solution strategies, such as Newton-Raphson-Iteration or Arc-Length. As an alternative approach the so-called saw-tooth softening method [1] is also presented, which transforms the iterative non-linear problem into a number of linear solution steps without the need to iterate for a convergent solution.

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References

- 1 Rots, JG. and Invernizzi, S. (2003): Regularized saw-tooth softening. In: Bićanić, N. et al. (Eds.): *Computational modelling of concrete structures*, EURO-C 2003, 599-617.