Phase-field modeling of shrinkage-induced cracking in cement mortar

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ABSTRACT

Due to the multiphase nature of porous media, pore fluid redistribution induces a variation of strains in the solid matrix according to the theory of effective stress [1, 2]. In cement-based materials, this phenomenon is related to the change of volume at early states because of thermal shrinkage, autogenous and drying shrinkage. In the presence of restraints (self-, internal or external), cracks may develop [3, 4]. Such early-age cracks can affect the durability of the material as they facilitate the transport of harmful chemical substances into the medium. Objective of this work is to describe drying shrinkage in cementitious materials with the theory of porous media and the phase-field approach to fracture. The phenomenon of drying is modeled within the poromechanical theory of [5], where the average properties of the solid and the fluid water phases are taken into account. Crack initiation, propagation and branching can be numerically modeled by the phase-field approach, which describes cracks as diffusive interfaces and offers an unprecedented flexibility in describing crack patterns with arbitrarily complex topology. The poromechanical-phase-field framework in the context of variable saturation [6] is calibrated with original experimental data. We present the calibration procedure and validation of the framework with some examples of shrinkage-induced cracks observed experimentally.

Keywords: phase-field modeling of fracture, shrinkage, drying, cement, mortar.

REFERENCES

[1] K. Terzaghi. *Erdbaumechanik auf Bodenphysikalischer Grundlage*. Franz Deuticke, Liepzig-Vienna, 1925.

[2] A.W. Bishop and G.E. Blight. Some aspects of effective stress in saturated and partly saturated soils. *Geotechnique*, 13(3):177–197, 1963.

[3] J. Bisschop. *Drying shrinkage microcracking in cement-based materials*. TU Delft, Delft University of Technology, 2002.

[4] P. Lura. *Autogenous deformation and internal curing of concrete*. PhD thesis, TU Delft, Delft University of Technology, 2003.

[5] O.C. Zienkiewicz, A.H.C. Chan, M. Pastor, B.A. Schrefler, and T. Shiomi. *Computational geomechanics - with special reference to earthquake engineering*. John Wiley & Sons, 1999.

[6] T. Cajuhi, L. Sanavia, and L. De Lorenzis. Phase-field modeling of fracture in variably saturated porous media. *Computational Mechanics*, 61(3):299–318, 2018.