Calibration and evaluation of creep formulations within fully coupled multiphase models

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ABSTRACT

Multiphase models are a promising approach for in-depth numerical simulations of the placement of concrete overlays, which is one of the most common measures for restoring and improving the load carrying capacity of reinforced concrete bridges. To allow an efficient design and dimensioning for this strengthening technique, it is necessary to appropriately consider the evolution of stiffness and strength as well as the shrinkage behavior of concrete overlays in interaction with an existing substrate. Thereby restraint effects in the form of tensile stresses in the overlay as well as compressive stresses in the existing bridge deck are induced, which are reduced over time by creep effects in compression and tension. Multiphase models, such as the one given in [1, 2], are based on the theory of partially saturated porous media and describe the underlying coupled hygral, thermal, chemical and mechanical processes in detail. The governing equations represent balances of mass, momentum and enthalpy together with kinematic relations and constitutive laws for the individual phases. The early age properties are thereby formulated in terms of the hydration degree. Shrinkage is described by means of the effective stress concept and creep on the basis of the microprestress solidification theory. An enhanced desorption isotherm with a hydration dependent air entry value is used to improve predictions of the early-age autogenous shrinkage strain. Furthermore, alternatives to the commonly used effective stress driven shrinkage and creep formulations are studied, which overcome previous limitations in predicting the long-term behavior.

The application of multiphase models for numerical simulations requires the knowledge of a variety of parameters to realistically represent the respective mechanisms. Several comprehensive studies on a particular type of overlay concrete have been conducted by the authors including tests on calorimetry, age-dependent mechanical properties, mass water content and corresponding measurements of shrinkage and creep on sealed and unsealed specimens loaded at different ages. The present contribution focuses on the thorough calibration of the different creep and shrinkage formulations and their application to numerical investigations for evaluation and comparison. The profound calibration of complete parameter sets thereby allows the appropriate representation of the aforementioned coupled processes.

REFERENCES

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