Modeling of coupled chemical and mechanical processes in concrete structures with respect to aging

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ABSTRACT

An accurate prediction of aging of concrete structures requires a detailed description of the continuously running processes taking into account the complete load history affecting aging of mechanical, physical and chemical properties. Neglecting these effects leads to unrealistic results.

A numerical model is introduced, which allows the description of the most important aging processes in concrete life cycle like hydration, loss of passivation of the steel due to chloride and carbon dioxide attack or dehydration via a monolithic algorithm. A detailed overview is given in [1]. On the one hand coupling of processes, which proceed at the same time scale is possible. On the other hand processes may be coupled consecutively in time. The coupling allows the predictive analysis of concrete structures over their whole life cycle.

The model bases on the theory of porous media. Therefore, the linear momentum, the conservation of energy and the balance equations of mass for the solid, liquid and the gas phase are formulated as well as for additional substances. Constitutive model equations describing the mechanical and transport behaviour as well as the chemical reactions for the different phenomena complete the governing equations. The transport and reaction processes and the mechanical processes are coupled on the one hand by formulating the model parameters depending on the grade of the chemical reactions, on the other hand by using the effective stress concept comprising Cauchy stresses and the pressure of the solid skeleton, see [2]. The material behavior is described in the context of non-local continuum damage theory including the mechanical and the thermo-chemical damage of concrete.

Applications of the model to durability analysis of concrete under chloride and carbonate attack indicate, that the consideration of the load history and therefore of changes in material structure and model parameters influences strongly the depth of the chloride penetration and of the carbonation. Excluding these aging effects leads to an overestimation of material capabilities. Thus the presented numerical model allows a more detailed and realistic description of aging processes in concrete structures during their life cycle.

REFERENCES

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