Modelling Coupled Chemo-Hygro-Thermo-Mechanical Phenomena in Porous Building Materials

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ABSTRACT

A general approach [1] to modelling various degradation processes in porous building materials, due to combined action of variable chemical, hygro-thermal and mechanical loads, is presented. Mechanics of multiphase porous media and damage mechanics are applied for this purpose. Kinetics of physico-chemical processes, like for example: salt crystallization/dissolution [2], calcium leaching [3], Alkali Silica Reaction (ASR) [4], and water freezing/thawing [5], is described with evolution equations based on thermodynamics of chemical reactions. The mass-, energy- and momentum balances, the evolution equations describing chemical reactions, as well as the constitutive and physical relations are briefly summarized. The mutual couplings between the chemical, hygral, thermal and mechanical processes are presented and discussed, both from the viewpoint of physicochemical mechanisms and mathematical modelling. Numerical methods used for solution of the model governing equations are presented. For this purpose the finite element method is applied for space discretization and the finite difference method for integration in the time domain.

Four examples of the model application for analysing transient chemo-hygro-thermo-mechanical processes in porous building materials are presented and discussed. The first example concerns the salt crystallization during drying of a wall made of concrete or ceramic brick, causing degradation of surface layer due to development of crystallization pressure. The second one deals with calcium leaching from a concrete wall due to chemical attack of pure water, exposed to gradients of temperature and pressure. The third one describes cracking of concrete element, caused by development of expanding products of ASR. The fourth example concerns freezing and thawing of a wet concrete wall in variable temperature and relative humidity.

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