# CEMENTITIOUS COMPOSITES: MATERIAL MODELING ACROSS MULTIPLE SCALES

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The effective properties of cementitious materials such as concrete, mortar or grout are characterized by their heterogeneous microstructure. The influence of the microstructure on the effective properties of the cementitious material as well as the physical processes occurring on the microscale can be investigated using analytical and computational models. In this thesis, such an investigation is performed in order to characterize two different phenomena.

The first phenomenon is the Alkali-Silica Reaction (ASR), which is a deleterious reaction taking place in concretes containing reactive aggregates. This reaction leads to the formation of a hygroscopic gel which swells in the presence of moisture causing microcracking and an expansion of concrete. A semi-analytical model is developed in order to describe these ASR related processes on the microscale and predict their effect on the macroscale. The proposed approach couples reaction kinetics and the framework of linear elastic fracture mechanics for modeling the microcrack growth in time. A mean-field homogenization method is used to obtain the overall concrete degradation and expansion. Data from the experimental program presented in this work is used to calibrate and validate the model.

A different modeling approach is proposed for the description of the second phenomenon - the compaction of compressible cementitious composite materials. Compressible cementitious materials can be used in tunnel constructions subject to geological conditions characterized by excessive rock expansion. These materials can be incorporated in the form of a compressible layer around the tunnel which protects the tunnel lining from damage due to large deformations of the ground. The deformation capacity of the compressible layer can be enhanced by the introduction of different compressible components into the mix (e.g., air voids), which govern the constitutive properties of the compressible composite material. The computational model developed by combining a voxel based approach with continuum micromechanics accounts for the composite microstructure and its influence on the composite behavior. In addition to the developed voxel based model, a computational strategy using a Discrete Element Method (DEM), where not only the microstructure but also the pore collapse mechanism is explicitly represented, is applied to simulate the compaction of cementitious composite materials. Both the voxel based model and the DEM approach are able to replicate the main compaction mechanisms of compressible cementitious materials as confirmed by comparisons with experimental data.

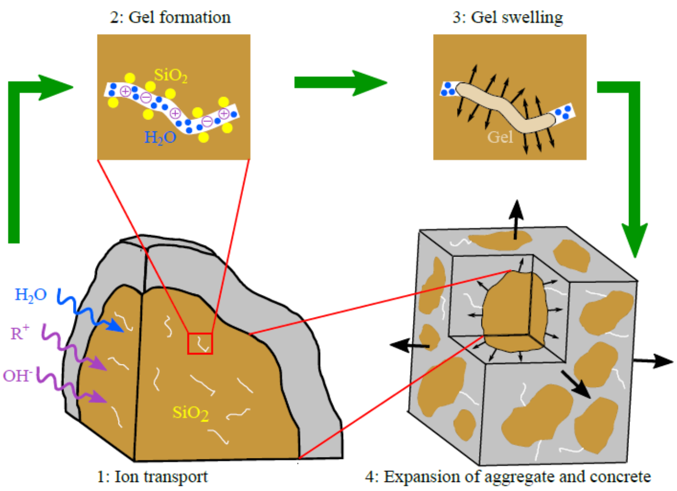


Fig: Graphical illustration of ASR reaction and ASR induced microcracking in concrete

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