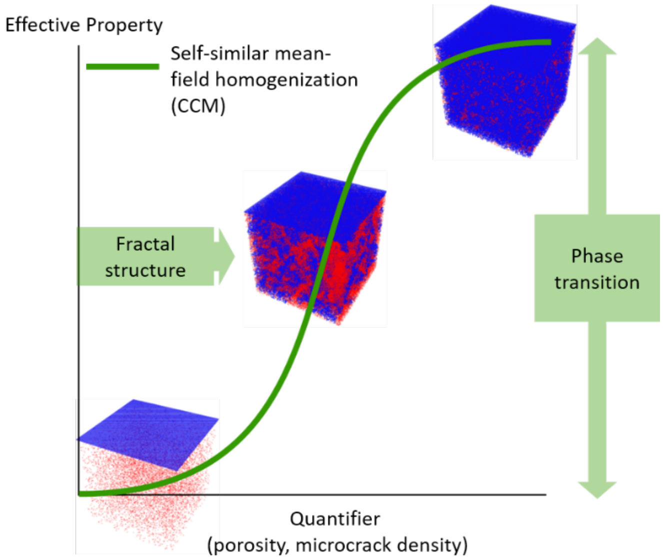
Doctoral Defense
Nov. 25. (Friday) 2016, 10:00 – 10:30, IC 6/156

Analytical and Computational Models for the Effective Properties of Disordered Microcracked Porous Materials - Jithender J. Timothy

The effective mechanical and transport properties of cementitious materials, rocks and ceramics strongly depend on the complexity of the microstructure of the material. The influence of the material microstructure on the effective material properties is investigated using a combination of analytical, semi-analytical and computational models. Within the framework of the mean-field homogenization method, a novel recursive homogenization model is proposed (CCM). The model provides a link between fractality, geometrical phase transition and mean-field homogenization. The model predicts a threshold value for the porosity or the microcrack density beyond which the material shows radically different behaviour. Three different computational models have been developed to confirm the predictions of the analytical model and provide additional insight into the characteristics of the microstructure that influence the effective property. A novel high-resolution pixel finite element method and a microcrack pore network model have been developed to run computational simulations for molecular diffusion and fluid flow in highly heterogeneous microstructures. The classical lattice Boltzmann method is extended to simulate fluid flow in a porous media with a microcrack, effectively simulating Stokes, Brinkman and Darcy flow in a single domain. Finally, an image based percolation model is used to study the structure and connectivity of the microcrack network in highly disordered microcracked materials. The model predictions are confirmed by experimental data. The analytical models can be easily incorporated into existing multiphysics simulation platforms while the computational models can be used to study the overall properties of specific microstructure topologies. The models find applications in the prognosis of the durability of concrete structures, characterization of geothermal reservoirs for hydraulic fracturing and energy extraction and design of porous composites.



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