Stochastic up-scaling of random heterogeneous materials

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ABSTRACT

Many materials of practical interest e.g concrete exhibit randomness in their response due to uncertain heterogeneous micro-structure. To get a realistic macro-scale response representative of the material micro-scale, one has to take into account the inherent stochastic nature of the micro-scale. We propose a probabilistic strategy to up-scale the material randomness from micro to macro-scale. To implement this idea in a computational framework, one requires suitable macro-structure models and an up-scaling tool conveying information from micro to macro-scale.

The macro-scale models are defined in the framework of generalized standard materials which require only the Helmholtz free energy and the dissipation functions to characterize material response e.g. ductile or quasi-brittle etc. In particular we consider phenomenological coupled plasticity-damage model in which the material parameters e.g. yield stress for plasticity and elastic limit for damage criteria are modelled a priori as random variables/fields according to maximum entropy law and expert's knowledge. The micro-scale is modelled using both continuum and discrete (composed of beams and trusses with embedded discontinuities) models, the associated material properties are specified as realization of a random field or randomly distributed inclusions.

With the forward response of macro-scale and micro-scale measurements computed as stored energy and dissipation, the macro-scale parameters are estimated in a probabilistic setting using tools from Bayesian inference. In particular, here will be presented the novel Bayesian strategy based on the polynomial chaos approximations, which is able to provide posterior estimates of inherently random parameters.

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