INELASTIC HOMOGENIZATION OF SIMPLE HETEROGENEOUS MEDIA: CASE STUDIES FOR PROBABILISTIC ANALYSIS

LORI L. GRAHAM-BRADY*

* Department of Civil Engineering
Johns Hopkins University
Baltimore, MD 21218, USA
lori@jhu.edu

One of the most effective tools for bridging microstructural information and macro-scale response is the application of constitutive relationships that are calculated using homogenization. Homogenization of elastic media shows that small-scale random fluctuations in the microstructure have little effect on the global macro-scale stiffness of the material. In other words, the effective constitutive properties of a random elastic medium with small scales of fluctuation are close to deterministic. Of course, the local elastic response of such media (such as local stresses or strains) is significantly more variable. When considering inelastic media, however, even the global homogenized constitutive properties can become significantly more variable.

This work provides motivation for stochastic homogenization of random inelastic media through the analysis of very simple elasto-plastic spring models. Such springs in series show that global yield stress is dictated by the minimum yield stress in the series; therefore in a random medium the global yield stress varies with the minimum. In parallel the spring model shows that global yield stress is dictated by the average yield stress and is therefore not highly variable. Based on the expressions derived for the homogenized behavior, probability density functions of the stress-strain relationships can be estimated.

In true two- and three-dimensional models the homogenized behavior is expected to be somewhere between the two spring models. Finite element models are used as a tool to show these cases. Results show that small-scale variations in inelastic properties can have a significant on large-scale response of these materials. This motivates the need for stochastic homogenization of such media, and the development of such tools is currently underway.