Homogenization Techniques for Multiscale Modeling of Composite Structures Exhibiting Strain Localization

Dr. Evan J. Pineda
Multiscale and Multiphyscis Modeling Branch
Structures and Materials Division
NASA Glenn Research Center, Cleveland, OH, U.S.A. 44135

It has been widely published that numerical solutions to problems in solid mechanics when the material undergoes strain localization due to softening damage (i.e., local failure) exhibit a pathological dependence on the refinement of the grid, or mesh, used to discretize the structure, unless the energy dissipated due to the failure process is properly regularized. Pathological dependence of the numerical solution on the discretization of the structure eliminates any predictive capabilities of the numerical model. Thus, various solutions have been developed to assuage this problem. Within a continuum damage framework, several techniques have been proposed which regularize the dissipated failure energy via introduction of a characteristic length. These methods include non-local damage and smeared crack/crack band theories. For composite structures, often it is appropriate to consider the effects of the microstructure on the global response of the structure. One popular approach for achieving this is multiscale modeling. Energy regularization schemes can be effectively utilized to obtain objective solutions at the microscale. However, the question still remains on how to properly traverse the length scales in the multiscale problem, and still ensure that energy is preserved at all levels. This question holds true regardless if the multiscale modeling framework is purely hierarchical (one-way coupling), or concurrent/synergistic (two-way coupling). In this seminar, the high-fidelity generalized method of cells (HFGMC) micromechanics theory is utilized, in conjunction with the crack band theory, to model local softening damage within composite representative volume elements (RVEs). Two techniques for homogenization of these RVEs exhibiting softening damage for use within a multiscale framework are investigated [1, 2]. The focus of these studies is to demonstrate objectivity of the global response of the RVE with respect to local refinements in the HFGMC grid, size of the RVE, and number of inclusions in the RVE.

1. Nguyen, V.P., Llobera-Valls, O., Stroeven, M. Sluys, L. J. (2011). Homogenization-based multiscale crack modelling: From micro-diffusive damage to macro-cracks. *Comput. Methods Appl. Mech. Engrg.*, 200, 1220-1236.

2. Pineda, E.J., Bednarcyk, B.A., Waas, A. M., Arnold, S.M. (2013). On multiscale modeling using the generalized method of cells: preserving energy dissipation across disparate length scales. *CMC: Computers, Materials & Continua*, 35(2), 119-154.