8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

Multiscale micromorphic theory for material failure

*** Franck J. Vernerey[1], Wing K. Liu[2] and Brian Moran[3]**

[1] University of Colorado, Boulder, Department of Civil Engineering
1111 Engineering Drive, 428 UCB, ECOT 422
franck.vernerey@colorado.edu

[1] Northwestern University, Department of Mechanical Engineering
2145 Sheridan Rd. Evanston, IL 60208-3111
w-liu@northwestern.edu

[1] Northwestern University, Department of Civil Engineering
2145 Sheridan Rd. Evanston, IL 60208-3111
b-moran@northwestern.edu

Key Words: *Multiscale methods, heterogeneous materials, damage, localization, higher-order continua.*

ABSTRACT

In order to design new materials and predict their reliability and life cycle, it is important to understand and quantify their behavior across several lengthscales. While brute-force modeling of all the details of a material's microstructure is too costly, current homogenized continuum models suffer from their inability to capture the certain key elements of the response -especially where localization and failure are concerned. To overcome this, a multi-scale continuum theory is proposed so that kinematic variables representing the deformation at various scales are incorporated. The method of virtual power is then used to derive a system of coupled governing equations; each equation represents a particular scale and its interactions with the macro-scale through the presence of stress couples. A constitutive relation is then introduced to preserve the underlying physics associated with each scale. The inelastic behavior is represented by multiple yield functions, each representing a particular scale of microstructure, but collectively coupled through the same set of internal variables. The proposed theory is illustrated with the example of high strength steel for which the microstructure of interest consists of an alloy matrix with two populations of inclusions, each with distinct length-scale. The model is capable of predicting size effects at various scales and important transitions during failure that regular continuum models cannot predict. The new multiscale model allows the prediction and exploration of the material's resistance to crack propagation in terms of the microstructure's key components, leading to new research directions in materials design and prediction.

E-mail: *franck.vernerey@colorado.edu*

REFERENCES

[1] F. J. Vernerey, W.K. Liu and B. Moran. "Multi-Scale Micromorphic Theory for Hierarchical Materials". *Journal of the Mechanics and Physics of solids*, Vol. **55**, 2603–2651, 2007.

[2] F. J. Vernerey, W.K. Liu, B. Moran and G.B. Olson "A Micromorphic Model for the Multiple Scale Failure of Heterogeneous Materials", doi:10.1016/j.jmps.2007.09.008, 2007.