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MESO-SCALE MODELLING OF PLASTICITY IN TWO PHASE COMPOSITE MATERIALS

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ABSTRACT

Composite materials exhibit localization of stresses caused by the inhomogeneous configuration of the microstructure. This behavior makes even simple loading configurations complex to analyze. One strategy for modeling the behavior of composite materials is to use homogenization methods, which assign effective properties to stand in as an approximation for the actual heterogeneous material property fields. Homogenization methods are useful in many applications; however, they cannot capture the localization of stresses in the composite microstructure, only the overall macroscopic effects. Local stress concentrations play an important role in the analysis of nonlinear behavior such as plasticity. In this case, mesoscale homogenization can be used to provide some of the advantages of homogenization while at the same time retaining some degree of local descriptiveness. Many different mesoscale homogenization techniques are available. In this work we will consider the Generalized Method of Cells homogenization scheme, which is brought to the mesoscale using a moving-window averaging technique.

Several parameters are manipulated to optimize the performance of the locally homogenized model in comparison with a benchmark analytical model for the case of a single inclusion. The benchmark model was developed by Mendelson[1] for the case of a single inclusion in an infinite matrix under constant radial loading at the infinite boundary. The four main parameters under consideration in this study are the resolution of the sample, the contrast ratio between the inclusion and the matrix, the effect of including strain hardening in comparison to a perfectly plastic model, and finally the window size, or degree of local smoothing, used in the moving window averaging process. Based on the results of this benchmark comparison analysis, a well-behaved material with appropriate levels of resolution and smoothing is chosen for continuation of the analysis. The second phase of the analysis is focused on examining a cross section of a matrix material with random fibrous inclusions. The goal of this analysis is to determine how well the windowed model approximates inclusion interaction. The windowed model will be compared with a highly refined finite element version of the same microstructure in order to determine the loss of accuracy which can be expected due to approximation error. Ultimately, once the sources of error are minimized, the

results of the meso-scale analysis may be used to generate sample statistics which can then be used to generate simulations of the sample microstructure.

REFERENCES

[1] Alexander Mendelson, "Elastoplastic analysis of circular cylindrical inclusion in uniformly stressed infinite homogeneous matrix", *NASA Technical Note*, TN D-4350, (1968).