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Multiscale Analysis of Failure

T. Belytschko[1], J. Song[1], R. Gracie[1], J. Oswald[1]

Summary

Several methods for the hierarchical and concurrent multiscale modeling of failure are described. The range of scales considered spans from the quantum scale to the macroscale. Particular emphasis will be placed on the situation where the coarse scale model loses ellipticity, which is always the case with failure. A new method for treating that situation is described. Its notable feature is the decomposition of the unit cell response into a discontinuity and a smooth response. Two key concepts are fundamental to the development of this method: the notion of a perforated unit cell that excludes all unstable material and a method for extracting the discontinuity at the macroscale from the microscale response. The methods are combined with the extended finite element method for coarser scale model, so that arbitrary discontinuities at the macroscale can be treated. The adherence of this method to the energetic theorems of Hill are explored. It is also shown that when the material in the perforated unit cell is strictly elliptic, then the bulk material at the coarser scale is ellitptic. Examples include a composite with circular inclusions, a microcracking solid with an emerging macrocrack and applications to dislocations. For the latter, a new method for dislocation modeling is described. In this method, .the dislocation is modeled as a discontinuity in the displacement field. The core can either be treated by regularization procedures or by locally enriching the field with functions based on closed form solutions for dislocations. This method for dislocations, in contrast t most existing methds, is applicable to problems with complicated geometries, such as grain boundaries and interfaces.

References

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[1]Department of Mechanical Engineering, Northwestern University 2145 Sheridan Road, Evanston, IL, 60208, U.S.A. E-mail: tedbelytschko@northwestern.edu, j-song2@northwestern.edu, rgracie@northwestern.edu, j-oswald@northwestern.edu