

AUTOMATIC GENERATION OF MICROSTRUCTURE MODELS WITH INCLUSIONS FOR COMPOSITE MATERIAL MODELLING

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Abstract

This work presents a computational framework for the generation of Representative Volume Elements (RVEs) of composite materials, with emphasis on the development of efficient separation algorithms for non-overlapping inclusions, providing a system for the analysis of composite materials. The methodology ensures geometric admissibility and preserves periodic boundary conditions, allowing the direct use in Finite Element Analysis (FEA). An optimization-based separation algorithm is first formulated for spherical inclusions and subsequently extended to more general convex geometries using convex hull representations and Gilbert, Johnson and Keerthi (GJK) collision detection. A multi-stage refinement strategy is adopted to balance computational efficiency and geometric accuracy.

The framework is coupled with homogenization techniques and structural analysis methodologies to construct matrix failure envelopes under multiaxial loading, serving as a proof of concept. The results highlight the influence of inclusion number, spatial distribution and volume fraction on matrix-dominated failure.

The main contribution of this work is the development of a flexible microstructure generation framework, enabling the systematic micromechanical analyses of composite materials, and thus facilitating the development of microstructure optimization frameworks.