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A GFEM-based reduced-order homogenization model for heterogeneous materials under volumetric and interfacial damage. (English) Zbl 07340386

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Summary: This manuscript presents a multiscale reduced-order modeling framework for heterogeneous materials that accounts for both cohesive interface failure and continuum damage. The model builds on the eigendeformation-based reduced-order homogenization model (EHM), which relies on the pre-calculation of a set of coefficient tensors that account for the effects of linear and nonlinear material behavior between regions of the domain known as parts. A k-means clustering algorithm is used to optimally construct these parts and a new formulation for the partitioning of interfaces using this method is proposed. The extraction of the volumetric and interfacial influence functions is performed using the Interface-enriched Generalized Finite Element Method (IGFEM), which relies on a finite element discretization that does not conform to the material phase boundaries. A Lagrange multiplier method is used in this preprocessing phase, allowing for the reuse of the matrix factorization for different influence function problems and hence leading to efficiency improvement. A newly proposed traction calculation for the interface partition is also adopted to alleviate the instability caused by traction calculations along interfaces. The accuracy and efficiency of the IGFEM-EHM method is assessed through comparison with reference IGFEM simulations. The method is then used to extract the nonlinear multiscale response of particulate, unidirectional fiber-reinforced, and woven composites.

MSC:

74 Mechanics of deformable solids
78 Optics, electromagnetic theory

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eigendeformation-based reduced-order homogenization model; generalized FEM; composite materials; cohesive model; continuum damage

Software:

VCFEM-HOMO

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