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An Efficient Peridynamics Based Statistical Multiscale Method for Fracture in Composite Structure with Randomly Distributed Particles

Zihao Yang[1], Shaoqi Zheng[1] and Fei Han[2,*]

[1]School of Mathematics and Statistics, Northwestern Polytechnical University, Xi'an 710072, China

[2]Department of Engineering Mechanics, Dalian University of Technology, Dalian 116023, China

[*]Corresponding Author: Fei Han. Email: hanfei@dlut.edu.cn

ABSTRACT

This paper proposes a peridynamics-based statistical multiscale (PSM) framework to simulate the macroscopic structure fracture with high efficiency. The heterogeneities of composites, including the shape, spatial distribution and volume fraction of particles, are characterized within the representative volume elements (RVEs), and their impact on structure failure are extracted as two types of peridynamic parameters, namely, statistical critical stretch and equivalent micromodulus. At the microscale level, a bond-based peridynamic (BPD) model with energy-based micromodulus correction technique is introduced to simulate the fracture in RVEs, and then the computational model of statistical critical stretch is established through micromechanical analysis. Moreover, based on the statistical homogenization approach, the computational model of effective elastic tensor is also established. Then, the equivalent micromodulus can be derived from the effective elastic tensor, according to the energy density equivalence between classical continuum mechanics (CCM) and BPD models. At the macroscale level, a macroscale BPD model with the statistical critical stretch and the equivalent micromodulus is constructed to simulate the fracture in the macroscopic homogenized structures. The algorithm framework of the PSM method is also described. Two- and three-dimensional numerical examples illustrate the validity, accuracy and efficiency of the proposed method.

KEYWORDS

Peridynamics; statistical multiscale method; particle reinforced composites; fracture simulation; representative volume elements

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