Strength estimation of composite material by peridynamics considering random field modelling of inclusions

Yuki Arai[1] and Sei-ichiro Sakata[2]

[1] Graduate school of Kindai University, 3-4-1 Kowakae-Higashiosaka Osaka Japan, yuki.arai.jpan@gmail.com
[2] Kindai University, 3-4-1 Kowakae Higashiosaka Osaka Japan, sakata@mech.kindai.ac.jp

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In this presentation, stress analysis of a unidirectional fiber reinforced composite material by peridynamics considering random field modelling of microstructure is discussed for apparent strength estimation of the material. One of the reasons on dispersion of apparent strength of composite materials is randomness / uncertainty in microstructure. In particular, random variation of location of inclusions will have a large influence on its microscopic stress distribution. The finite element method is generally used to analyze stress distribution in composite materials, but microscopic damage propagation analysis of composites having many inclusions by the finite element method is difficult due to the modelling of complex microstructures and complex damage propagation caused by multiple cracks originating from the interface between the reinforcement material and the base material. For this analysis, for example, XFEM based approach or analysis using the cohesive element has been attempted, but further effort for more efficient analysis is needed. From this background, we attempted to employ the peridynamics method [1] to the probabilistic stress analysis of composites having many inclusions. In this method, the formulation is based on integral equations and the target object is spatially discretized by particles, and it will be more effective for modelling and solving problems involving many inclusions and discontinuities such as cracks than conventionally used analytical methods such as finite element method. For the probabilistic stress analysis, the random field modelling with a set of images of actual composite specimens is employed for generating a set of realizations of the fiber arrangement [2].

Firstly, outline of the problem setting, peridynamics and the random field modelling method are explained. Some numerical results on the stress analysis of the fiber reinforced composite plate under a tensile load are shown and application of random field modelling to analytical models. Validity and effectiveness of the peridynamics-based analysis with random filed modelling for composite material are investigated, and applicability of the method to the analysis of a fiber reinforced composite material is discussed.

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