Hybrid multiscale model for nonlinear analysis of arbitrarily stiffened composite structures

*Jie cong¹, Kuo Tian¹, Tong Li², Bo Wang¹ and †Mingfa Ren¹

¹Department of Engineering Mechanics, Dalian University of Technology, China ²Mechanical Engineering, University of Delaware, USA

> *Presenting author: congj@mail.dlut.edu.cn †Corresponding author: renmf@dlut.edu.cn

Abstract

In order to conduct geometric nonlinear analysis for arbitrarily stiffened composite structures, a novel framework of hybrid multiscale models is proposed based on the extended multiscale finite element method. This hybrid multiscale model of composite stiffened structures consists of a macroscopic model of the unstiffened composite plate and several microscopic models with various configurations of stiffeners. The macroscopic model is discretized into rectangular elements, while the microscopic models are all discretized into triangle elements to represent the complicated stiffener configurations. This hybrid multiscale model can improve the computational efficiency while ensuring the fidelity from physical viewpoints. The coupling relationships between sub-models in the hybrid multiscale model are developed by constructing the multiscale base functions. Based on Total-Lagrange description and incremental theory, the incremental finite element formulations of the hybrid multiscale model are derived. In addition, the perturbed microscopic displacements are calculated under the incremental displacement boundary conditions to consider the effect of microscopic unbalanced nodal force on the computing accuracy. According to a few numerical examples, this proposed modeling framework shows higher computational efficiency than conventional finite element method and higher accuracy and improved applicability than the numerical implementation of asymptotic homogenization method, which is a commonly used multiscale method.

Keywords: Hybrid multiscale model; Extended multiscale finite element method; Nonlinear analysis; Arbitrarily stiffened composite structures