Accepted Manuscript

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PII: S0045-7825(18)30343-8
DOI: https://doi.org/10.1016/j.cma.2018.07.012
Reference: CMA 11984

To appear in: *Comput. Methods Appl. Mech. Engrg.*

Received date : 29 March 2018
Revised date : 22 June 2018
Accepted date : 9 July 2018

Please cite this article as: E. Artioli, S. Marfia, E. Sacco, High-order virtual element method for the homogenization of long fiber nonlinear composites, *Comput. Methods Appl. Mech. Engrg.* (2018), https://doi.org/10.1016/j.cma.2018.07.012

High-order virtual element method for the homogenization of long fiber nonlinear composites

E. Artioli*, S. Marfia†, E. Sacco‡

Abstract

A high-order virtual element method (VEM) for homogenization of long fiber reinforced composites is presented. In particular, periodic composites are considered studying square or rectangular unit cell arrays and circular inclusions. A suitable displacement representation form is adopted reducing the three-dimensional problem to an equivalent two-dimensional one. Material nonlinearity is taken into account for the matrix which can be plastic or visco-plastic. The formulation is proposed for linear and high-order virtual elements. Numerical applications are performed to assess the accuracy of the VEM formulation in comparison with the classical finite element approach. In particular, convergence investigations on the overall elastic moduli and on the Mises equivalent stress are performed. Elasto-plastic and visco-plastic analyses are carried out exploiting the local mesh refinement features typical of VEM showing efficiency of polygonal discretizations.

Keywords Virtual Element Method, High-order method, Polygon, Computational Homogenization, Fiber reinforced composite, Material nonlinearity.

1 Introduction

The use of composite materials is becoming more and more attractive and successful in many engineering fields. The modeling of composite materials presents peculiar aspects as they are heterogeneous materials, made of different constituents that can present nonlinear behavior. Thus, the overall response of the composite is significantly influenced by the mechanical properties of the constituents, by its specific nonlinear response and, of course, by the geometrical distribution of the heterogeneities.

The need of developing efficient material models and computational tools for the structural analysis of elements made of composite materials is increasing in the scientific

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