Accepted Manuscript

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PII: S0263-8223(16)32416-3
DOI: http://dx.doi.org/10.1016/j.compstruct.2017.02.022
Reference: COST 8241

To appear in: *Composite Structures*

Please cite this article as: Azoti, W.L., Elmarakbi, A., Multiscale modelling of graphene platelets-based nanocomposite materials, *Composite Structures* (2017), doi: http://dx.doi.org/10.1016/j.compstruct.2017.02.022

Multiscale modelling of graphene platelets-based nanocomposite materials

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Abstract

This work presents a multiscale framework for the elasto-plastic response of platelets-like inclusions reinforced nanocomposite materials. The solution of the heterogeneous material problem is solved by a kinematic integral equation. An imperfect interface is introduced between the particles and the matrix through a linear spring model LSM, leading to a modified Eshelby's tensor. The interfacial contribution, related to the strain concentration tensor within each material phase and inside the average strain field, is described by a modified Mori-Tanaka scheme. The non-linear response is established in the framework of the J_2 flow rule. An expression of the algorithmic tangent operator for each phase is obtained and used as an uniform modulus for homogenisation purpose. Numerical results are conducted on graphene platelets GPL-reinforced polymer PA6 composite for several design parameters such as GPL volume fraction, aspect ratio and the interfacial compliance. These results clearly highlight the impact of the aspect ratio as well as the volume fraction by a softening in the overall response when imperfection is considered at the interface. Finally, a multiscale simulation is performed on a three bending specimen showing the capability of the developed constitutive equations to be implemented in a finite element FE code.

Keywords: Interfacial imperfection, Graphene platelets, Micromechanics, Modified Eshelby's tensor, Modified Mori-Tanaka scheme, FE simulation

1. Introduction

Nanocomposites have gained worthy significance with use of multifunctional nano fillers like the graphene. This latter finds direct applications in composites. Kuilla et al [1] reported graphene-based polymer composites in which substantial property enhancements have been noticed at much lower volume fraction with respect to polymer composites containing conventional micron-scale

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