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Abstract

This paper presents an efficient method to automatically generate and mesh random non–periodic three dimensional (3D) microstructures for three classes of complex heterogeneous media having a wide range of important engineering applications, porous media, composites with interfacial debonding and composites with high density particles. The resulting 3D microstructure is intentionally constructed to be easily and efficiently implemented in standard finite element computational codes. Several examples of 3D representative volume elements are shown. The performance of the proposal in finite element analysis is demonstrated in numerical implementation to predict the effective non–linear elastic–plastic response of two–phase particulate composites reinforced with spherical particles. The main result achieved is the estimation of the effective plastic tangent modulus by a simple linear regression equation for different volume fractions.

Keywords

Homogenization ; Heterogeneous materials ; Spherical particles ; Elastic–plastic behavior ; Composites

1. Introduction

To improve the mechanical properties of particle–reinforced composites, several studies have focused on the geometry and properties of dispersed particles in matrix. Therefore, quantitative modeling methods have been proposed. The effective mechanical properties have been characterized by many analytical approaches. Innovative contributions on analytical and computational modeling of composite structures were appeared in several fields, for instance, when the required conditions for the homogenization validity cannot be applied, see e.g. [4], to calculate the non–local constitutive behavior of an infinite composite laminate [31], to modify the constitutive stress–strain relationships by employing the nonlocal theory [2], also in functionally graded nanobeams [3], and multi–span masonry arch structures[7], or Saint–Venant beams under torsion [1]. Nevertheless, with some simplified assumptions in geometry and stress–strain distributions [34], the accuracy of analytical methods in complex geometry and loading conditions is limited. Moreover, the results obtained by these approaches are not sufficiently accurate [38]. It can be shown to be upper or lower bounds in most cases, e.g. Voigt–Reuss ; Hashin–Shtrikman bounds [35, 37].