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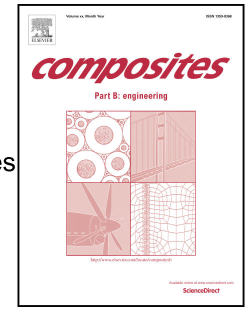

Two-step hierarchical micromechanics model of partially saturated porous composites doped with ellipsoidal particles with interface effects

Enrique García-Macías, Rafael Castro-Triguero, Filippo Ubertini

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Two-step hierarchical micromechanics model of partially saturated porous composites doped with ellipsoidal particles with interface effects

Enrique García-Macías[a,*], Rafael Castro-Triguero[c], Filippo Ubertini[b]

[a]*Department of Continuum Mechanics and Structural Analysis, School of Engineering, Universidad de Sevilla , Camino de los Descubrimientos s/n, E-41092-Seville, Spain*
[b]*Department of Civil and Environmental Engineering, University of Perugia, Via G Duranti 93, Perugia 06125, Italy*
[c]*Department of Mechanics, University of Cordoba, Campus de Rabanales, Cordoba, CP 14071, Spain*

Highlights

- A consistent homogenization model is proposed for particle-loaded porous composites
- Soft and hard particle interphases are considered
- The effect of partially saturated pores is investigated
- Different geometries of voids are studied

Abstract

Recent advances in the manufacture of micro- and nano-composites have made it possible to produce new multifunctional materials. However, the development of theoretical models that assist their design still remains an open research issue. This paper presents a two-step hierarchical micromechanics approach for the mechanical homogenization of particle-reinforced porous composites, including particle/matrix interfacial bonding and porosity saturation effects. Firstly, the particle-reinforced matrix is homogenized by means of a double-inclusion approach. The interfacial bonding effect is accounted for by both compliant and hard interphases surrounding the particles. Secondly, another homogenization step is conducted by considering the particle-reinforced composite as a homogeneous matrix and voids as embedded inclusions. Pores saturation is also taken into account by means of homogeneous equivalent pores. Comparative analyses against experimental data are presented to demonstrate the effectiveness of the present approach, followed by detailed parametric analyses to illustrate the influence of the major micromechanical variables, including interphase thickness and stiffness, filler aspect ratio, porosity and saturation degree.

Keywords: Double-inclusion, Eshelby's tensor, Homogenization, Interphase, Porous composite

1. Introduction

Recent advances in the manufacture of micro- and nano-composites have made great strides forward in the development of new multifunctional materials with a broad spectrum of applications in many fields such as building engineering, aerospace, automotive, construction, or industry. There is no shortage of research works that report on innovative composite materials with high-performance properties such as metals [1], ceramics [2], strain sensing bricks [3], phase changing materials [4], polymers [5], or cementitious composites [6]. In particular, the increasing demand for lightweight structures with superior mechanical properties has promoted an increasing attention on porous composites. Examples such as composite ceramics, foam-like materials, or spray deposits, not only exhibit excellent mechanical properties, but also multifunctional capabilities including low thermal conductivity, piezoresistive properties, low apparent density, and low moisture absorption [7–9]. In this context, the development of accurate homogenization schemes to assist the design is of pivotal importance. Despite great efforts have been put into the modeling of micro- and nano-composites, features such as the interfacial bonding condition between constituent phases, as well as complex microstructures with unsaturated porosity, still remain open research issues.

*Corresponding author.
Email address: `egarcia28@us.es` (Enrique García-Macías)