PREFACE: MULTISCALE MECHANICAL MODELING OF "COMPLEX" MATERIALS AND ENGINEERING APPLICATIONS. DEDICATED TO THE 60TH BIRTHDAY OF PATRIZIA TROVALUSCI

1. INTRODUCTION

The present volume is a special issue of selected papers collected in honor of the 60th Birthday of Patrizia Trovalusci. Patrizia Trovalusci is a highly independent, profound, and serious scholar. She has made outstanding contributions within the field of Mechanics of Solids and Structures related with fundamental and applied research, teaching, and an ever-increasing, worldwide recognized, leadership.

Patrizia’s fundamental research encompasses a variety of topics concerned with computational methods for non-classical continua, masonry materials and structures, composites, multiscale modeling, theory of plasticity and non-standard limit analysis, nonlinear finite-element analysis, and structural architecture.

Contributors to the special issue are all recognized experts in the field of Mechanics of Solids and Structures with the topic “Multiscale Mechanical Modeling of ‘Complex’ Materials and Engineering Applications,” which has been the title of a series of symposia (18th at the present year) organized yearly at renowned international events about solids and structural mechanics and computational methods. The early focus of the symposium was to bridge the gap between solid mechanics and materials science, providing a forum for the presentation of fundamental, theoretical, experimental, and practical aspects of mechanical modeling of materials with complex microstructures and complex behavior.

Each contribution has undergone a standard review process, and only papers that received positive recommendations from at least two international referees are included. These contributions provide a survey of the multiscale approaches proposed to describe materials with various internal structures at different scales (nano/micro, meso, macro), from composite, to shape memory, to masonry-like materials, and with complex behaviors such as plasticity, damage, fracture, and phase transformation. Most of the papers aim at detecting the structural performances of advanced materials in various engineering applications ranging from microelectronics to civil engineering. The articles are briefly introduced in the paragraphs below.

Ibrahimbegovic et al. (2022) develop a 3D strongly coupled multiscale computational procedure for failure analysis of heterogeneous materials capable of representing full set of different failure modes under various stress states. The proposed approach targets structural failure modeling by a multiscale method with no need for scale separation where homogenized structural response is described on macroscale, while microscale is utilized for representing the full set of 3D damage mechanisms inside the domain.

Funari et al. (2022) propose a two-step strategy for the mechanical analysis of unreinforced masonry (URM) structures, either subjected to in- or out-of-plane loading. A micromodeling description of the masonry is allocated to regions within the failure mechanism. Conversely, the other domain regions are modeled via a macro approach, whose constitutive response is elastic and orthotropic and formulated through closed-form homogenized-based solutions.

Konstantinidis and Aifantis (2022) provide a particular methodology based on a generalization of classical theories of elasticity, plasticity, and failure through the introduction of higher-order gradients of the pertinent variables and corresponding internal lengths. The contribution begins with a simple paradigm on how to extend standard thermoelasticity theory to its gradient counterpart. Examples are provided in the paper in order to demonstrate the validity of the present procedure.

An innovative study on electrosurgery is presented by Ran et al. (2022) aimed at the removal of tumors resulting in highly transient heat conduction. Simulations of temperature fields, under the assumption that heat in soft tissue
organs is governed by a telegraph (damped hyperbolic) equation, are conducted in a two-dimensional setting with finite differences in space and time.

An analysis on infiltrated phase composites widely applied in aviation, aerospace, and energy industries is presented by Postek et al. (2022). Such composites are investigated under impact loads using a peridynamics method and the effects on the skeleton (SiC) and the matrix (Al–Si12) are presented.

Fantuzzi et al. (2022) propose a multiscale analysis of nanocomposites made of hexagonal assemblies. In particular, the present internal material pattern is made of irregular concave hexagonal-shaped assemblies interacting with elastic interfaces. The homogenization of such irregular units causes anisotropic constitutive properties which are implemented into a finite-element computer code for Cosserat 2D solids analyzed in the dynamic regime.

Eremeyev and Reccia (2022) consider nonlinear micropolar elasticity in the dynamic regime within the framework of elastic networks with rigid joints. The present micropolar model considers two constitutive relations by introducing a strain energy density and a kinetic energy density, respectively. 3D elastic networks are presented and effective elastic properties are provided and analyzed by the authors.

Curved masonry structural elements with a periodic texture are investigated by Addessi et al. (2022). Such structures are investigated with a multiscale approach based on a 3D elastic Cauchy continuum. Efficiency and reliability of the model are demonstrated and validated within the paper with applications and comparisons with respect to reference solutions.

Pau et al. (2022) study the dynamic nonlinear problem of wave propagation in infinitely long hysteretic beams under bending. Such a problem is tackled by proposing an asymptotic treatment based on the method of multiple scales. The equations of motion are obtained reducing the 3D-continuum model to the one-dimensional plane beam problem via the cross-section rigidity constraint and describing the hysteresis via a nonlinear viscoelastic material model, which can be easily tuned to obtain either hardening or softening characteristic responses.

Cutolo et al. (2022), based on their previous studies, presented a nonlinear finite-element analysis of masonry spiral staircase in Nisida (Naples). The comparison is made against the same problem considered with limit analysis to check advantages and disadvantages of both approaches for analyzing complex masonry structures.

Wojciechowski et al. (2022) explore the possibility of using machine-learning techniques to identify the characteristics of the initial components of a composite, starting from the knowledge of the macro behavior of the heterogeneous material or structure. The authors show, for a periodic medium, that the inverse relation can be approximated as easily as the direct one. The paper focuses on the use of artificial neural networks, which are trained with the macroscale properties at the input layer and with the microstructural parameters at the output layer.

Finally, tensegrity structures have recently shown great potential as bracing devices for seismic control due to their unique ability to passively dissipate energy in structures subjected to severe deformations. Santos et al. (2022) analyzed such structures in a 3D framework with the aim of proposing an advantageous design of D-bar–based bracing systems with optimized masses.

We hope that the readers will find this special issue informative and especially reflective of some of Professor Trovalusci’s vision for the field.

Guest Editors:
Nicholas Fantuzzi
Department of Civil, Chemical, Environmental and Materials Engineering
Alma Mater Studiorum, University of Bologna
Viale del Risorgimento 2, 40136, Bologna, Italy

Somnath Ghosh
Department of Civil and Systems Engineering
Johns Hopkins Whiting School of Engineering, United States
3400 North Charles Street Baltimore, Maryland 21218, USA

Tomasz Sadowski
Department of Solid Mechanics

International Journal for Multiscale Computational Engineering
REFERENCES