20th European Mechanics of Materials Conference - EMMC20
Florence, Italy | May 27th-29th, 2026
www.emmc20.unifi.it

Deformation behavior of bioinspired metamaterials with random microstructure

Vivek Singh[1], Elina Gilbert[2], Thibaud Derieux[3], Valérie Geertsen[4], Patrick Guenoun[5], Thuy Nguyen[6], Daniel Bonamy[7]

[1] Université Paris-Saclay, CEA, CNRS, SPEC, SPHYNX, 91191, Gif-Sur-Yvette, France, France. vivek.singh@cea.fr
[2] Université Paris-Saclay, CEA, CNRS, SPEC, SPHYNX, 91191, Gif-Sur-Yvette, France, France. elina.gilbert@cea.fr
[3] Université Paris-Saclay, CEA, CNRS, SPEC, SPHYNX, 91191, Gif-Sur-Yvette, France, France. thibaud.derieux@cea.fr
[4] Université Paris-Saclay, CEA, CNRS, NIMBE, LIONS, 91191, Gif-Sur-Yvette, France, France. valerie.geertsen@cea.fr
[5] Université Paris-Saclay, CEA, CNRS, NIMBE, LIONS, 91191, Gif-Sur-Yvette, France, France. patrick.guenoun@cea.fr
[6] De Vinci Research Center, Paris, France;Université Paris-Saclay, CEA, CNRS, SPEC, SPHYNX, 91191, Gif-Sur-Yvette, France, France. thuy.nguyen@devinci.fr
[7] Université Paris-Saclay, CEA, CNRS, SPEC, SPHYNX, 91191, Gif-Sur-Yvette, France, France. daniel.bonamy@cea.fr

Paper ID: 577
Symposium S4: Mechanics of architected materials: Experiments and modelling

Abstract

With recent advances in additive manufacturing technologies, mechanical metamaterials have attracted significant attention in the past decade. Unlike conventional materials, mechanical metamaterials derive their effective properties primarily from their engineered microstructure rather than their constituent material, enabling the realization of unique, non-naturally occurring, and highly tailorable mechanical responses. Owing to their tunable properties, high strength-to-weight ratios, and multifunctionality, mechanical metamaterials have found applications in aerospace structures, biomedical implants, thermal management systems, and vibration isolation and damping devices. Most existing studies have focused on periodic metamaterials composed of a single repeating unit cell, which simplifies design and analysis but limits the range of achievable behaviors. In contrast, biological materials often exhibit spatially heterogeneous and non-periodic microstructures that contribute to their exceptional mechanical performance. Motivated by this observation, the present work proposes a bioinspired mechanical metamaterial with a random microstructure and investigates its mechanical behavior. The influence of microstructural randomness on the effective mechanical response is systematically examined through numerical simulations, highlighting its potential advantages over conventional periodic designs.

Keywords:

Metamaterials Random microstructure Mechanical behavior