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

Constitutive Modeling and Experimental Characterization of Flexible 80A for 3D-Printed Lattice Structures

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Paper ID: 212
Symposium S4: Mechanics of architected materials: Experiments and modelling

Abstract

3D-printed lattice structures are increasingly used in mechanical metamaterials and energy-absorbing components, requiring accurate yet computationally efficient material models for reliable simulation-based design. This work investigates Flexible 80A, a soft elastomer commonly used for additive manufacturing, to determine the necessary complexity of constitutive models for lattice simulations. Two lattice architectures - an octet truss and a modified Kelvin cell - were manufactured and tested under quasi-static compression and dynamic loading. Although numerical simulations rely on idealized lattice geometries, the printed structures contained defects arising from layer-by-layer fabrication and from support removal. The influence of these defects on the structural response was investigated. The material showed a rate-dependent and hyperelastic behavior, which was explored through a test campaign combining compression, tensile, and Split Hopkinson Pressure Bar (SHPB) experiments. Strain rates from 0.001 s^{-1} up to 1000 s^{-1} were investigated to capture both quasi-static and dynamic loadings. Several constitutive models were calibrated with the objective of identifying the trade-off between predictive accuracy and computational cost in the simulations of the lattice structures. In the numerical simulations, we first disregarded rate effects associated with the viscoelastic response by using a linear elastic model before advancing to the Arruda-Boyce hyperelastic model. Then, we studied the dynamic effects by introducing a linear viscoelastic model based on

Prony series, and finally the Bergström-Boyce model, combining both hyper- and viscoelasticity. The findings from this study provide guidelines for selecting constitutive models in elastomer-based metamaterial design, enabling more robust and cost-effective simulations of lattice-based structures.

Keywords:

Quasi-static loading Dynamic loading Hyperelasticity Viscoelasticity Lattice structures