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Multiscale computational framework for simulation of cellular solids

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ABSTRACT

Natural and man-made cellular solids have been used in a variety of engineering applications. Despite their widespread use, the behavior of such materials is not well understood because of their high heterogeneity and complex microstructure. A multiscale computational framework is formulated to study the behavior of structures and components made from cellular solids over a wide range of spatial and temporal scales. The framework consists of two levels of models, a continuum level and a microstructural level. The continuum-level models utilize finite element (FE) and mesh-free (MF) methods in conjunction with spatial domain decomposition and temporal multitime-stepping to capture different local- and global-scale behavior. At the microstructural level, the framework relies on a realistic representation of the foam microstructure and homogenization techniques to couple it with the continuum-level models. This study focuses on addressing the issues related to the formulation and implementation of this multiscale framework. These issues include formulating a variationally consistent coupling of FE and MF methods in space and time at the continuum level, and formulating an efficient micromechanical constitutive model for cellular solids to simulate a wide range of material behavior. Numerical characteristics of the computational framework are studied using several benchmark problems.