A FINITE ELEMENT REPRESENTATIVE VOLUME ELEMENT-BASED APPROACH TO DETERMINE LATTICE RESPONSE AND STABILITY IN SOLID AND SHELL-LIKE STRUCTURES

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ABSTRACT

Recent advances in additive manufacturing technology make possible the use of lattice structures to optimally tailor structural responses by spatially varying lattice infill density in engineering components that would historically be fabricated using bulk materials. In many cases, it may not be convenient or tractable to explicitly analyze the detailed lattice geometry on the scale of whole engineering components. In such cases, multi-scale homogenization methods provide a means of approximating the lattice's effective response, permitting the lattice to be modeled as a continuum at the scale of engineering components.

Using a homogenized lattice response means that it is not possible to explicitly predict the occurrence of failure mechanisms that are driven by local stresses arising at the smaller scale of the lattice, such as yielding or buckling of the lattice members. The current work presents a multi-scale approach for predicting such failures in engineering structures that use lattices as a bulk material or as a sandwich core in a shell-like system. At the structural component scale, bulk lattice material is modeled as a continuum and lattice-core panels are modeled as shells with elastic or section properties determined through a finite element Representative Volume Element (RVE)-based homogenization approach based on strain energy equivalence. In addition to calculating the effective response for the lattice or lattice core panel, static and buckling analyses are performed using unit cell RVE models of the lattice to determine the effective far-field loadings (either macro stresses or shell section

forces and moments) required to cause buckling or yielding in various lattice designs. By performing these studies under a variety of multiaxial loads, a simple multiaxial failure model is developed to predict the occurrence of lattice failure for general multiaxial far-field loadings obtained from large-scale analyses of engineering components in which the lattice is modeled either as a continuum or shell. In this manner, the ability of the lattice component to sustain a given loading can be quickly ascertained based on an a priori multiscale study of the lattice.