Domain wall propagation in assembled structures of rotating squares

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Abstract

Metamaterials have been of increasing interest in various application fields, such as absorbing shocks or vibrations, ensuring a deformation regime that preserves the indenting object and prevents damages. Until now, investigations have focused mainly on varying the geometry of structures rather than considering the mechanical properties of the material itself. More precisely, plasticity has been carefully avoided while it may constitute a key point in designing new metamaterials, that could be produced industrially. In this work, we treat plasticity as a new design tool for metamaterials. Indeed, we observe that plasticity triggers the emergence of a transition wave in buckling, that propagates through the whole structure. Moreover, we observe that the transition wave may emerge at different places of the structure, depending on the loading history. Here, we exploit first a 2d-structure made of a chain of rotating squares and second a 3d-structure made of rotating octahedrons, to show regimes of inhomogeneous rotation upon compression, defining domains in the structure and propagating through it. We exhibit compression tests performed on 3d-printed structures that are compared to Finite Element Method (FEM) simulation results, based on an elasto-plastic description of the hinges. Additionally, we propose modelling ingredients describing the domain wall propagation in 2d structures, in accordance with observations made in FEM simulations. Finally, such concepts of system show resistance to a mechanical load while dissipating energy, which constitutes a key point to design efficient load absorbers.

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