Crack propagation in 2-dimensional architected material: the effects of inertia on fracture

Raquel Dantas Batista*[1], Alessandra Lingua[1], Jan Van Dokkum[1], Mohit Pundir[1], and David Kammer[1]

[1]Institute for Building Materials, ETH Zurich – Switzerland

Abstract

Architected materials have properties not common in homogeneous solid materials while being lightweight. These materials are engineered to achieve a target mechanical behavior by designing the geometry, which consists of connected struts. Despite the advances in additive manufacturing techniques, the engineering use of architected materials is limited as their fracture behavior is not well understood. We identify the complexity of fracture in discrete media as one reason why. The quasi-static approach to fracture is usually adopted in the study of metamaterial fracture. This approach shows that the fracture toughness scales with the relative density, and this scaling law changes with the topology (1,2), highlighting the geometry dependence on the fracture behavior of architected materials. Also, unlike a continuum, the crack advances by sequential breakage of struts, and the crack path is not necessarily continuous. However, the quasi-static approach neglects the effects of inertia on crack propagation, which plays an important role in brittle materials. To consider these effects, an analysis under the context of dynamic fracture mechanics is needed (3). It is known that inertial effects control the crack propagation in continua. Whether the inertial effects can or cannot be neglected in the fracture of architected materials remains an open question. The influence of different topologies and relative density in the fracture under dynamic conditions is unclear. In this presentation, we explore the fracture of architected materials in the context of dynamic fracture mechanics. We compare the crack propagation of two-dimensional architected materials by performing numerical analysis of pre-cracked triangular lattices modeled as beam networks in the quasi-static and dynamic load regimes. We assess the effect of inertia on crack path and fracture properties in architected materials and its influence on different relative densities. (1) N. A. Fleck and X. Qiu. The damage tolerance of elastic–brittle, two-dimensional isotropic lattices. 2007.
(2) M. Omidi and L. St-Pierre. Fracture toughness of semi-regular lattices. 2023.
(3) L. B. Freund. Dynamic fracture mechanics. Cambridge University Press. 1990.

*Speaker