Failure of stretching dominated architected interfaces with rotation imperfections introduced by the confining structure

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Abstract

Confined interfaces such as thick bond lines appear in many structural situations. Athanasiadis et al (2021) have proposed to replace such bulk interface materials with architected materials utilizing their superior material properties. This type of interface is referred to as an architected interface. Architected interfaces introduce additional parameters in the form of topology, relative density, and unit cell size of the architected materials. It has been indicated such architected interfaces have the potential to significantly change the failure process, introducing toughening effects (Hedvard, 2014), and altering the plastic fracture process zone (Fulco et al. 2022).
In recent years, multiple works have studied the fracture mechanics of architected materials and their fracture toughness by using concepts of fracture mechanics of continuous materials. Omidi & St-Pierre (2023) evaluated the fracture toughness of architected lattice materials considering compact tension tests while Shenhav & Sherman (2019) evaluated the fracture toughness of brittle open-cell structures under compression loading, showing a failure process controlled by local buckling. For some topologies tension and compression-loaded lattices are both present, leading to two potential failure modes. As shown by Shaikeea et al. 2022, for an octet truss lattice structure with an introduced crack the failure mode can be changed by altering the relative density, biaxial loading ratio, or the unit cell size to crack length ratio. Material properties of interface materials are often evaluated using the double cantilever beam introducing a localized tension and compression zone resulting in multiple failure modes for even simple architected interfaces such as the pillar interface.

In this work, we evaluate the failure of architected interfaces considering a double cantilever beam setup with a stretching-dominated lattice interface. Stretching-dominated lattice materials are known for their high strength-to-weight and stiffness-to-weight ratios making them a suitable material for lightweight structures. In tension, the failure load is determined by the material strength, while buckling determines the failure in compression under the assumption of slender structures. The introduction of small imperfections changes the buckling problem to a deformation problem leading to a reduction of the load-bearing capacity of the structure (Timoshenko & Gere, 1961). Considering the bending of the confining adherend under loading a rotation imperfection is introduced to the elements within the architected interface. An analytical method of evaluating buckling failure with rotation imperfections is derived and implemented in an analysis framework for architected interfaces. The critical failure load and fracture toughness of such architected interfaces are evaluated for various

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interface properties for both tension and compression failure.

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