Size scale dependence of compressive instabilities in layered composites in the presence of stress gradients

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The compressive strength of unidirectionally or layer-wise reinforced composite materials in direction parallel to their reinforcement is limited by micro-buckling instabilities. Although the inherent compressive strength of a given material micro-structure can easily be determined by assessing its stability under a uniform compressive load, this is often not sufficient for predicting failure initiation within a larger structure. In cases, where the composite material micro-structure is locally subjected to strongly non-uniform loadings, compressive instabilities depend not only on the maximum compressive stress but also on spatial stress or strain gradients, rendering failure initiation size scale dependent. The present work demonstrates and investigates the aforementioned effect through numerical simulations of periodically layered structures with notches and holes under bending and compressive loads, respectively. The presented results emphasize the importance of the reinforcing layer thickness on the load carrying capacity of the investigated structures, at a constant volumetric fraction of the reinforcement. The observed strengthening at higher values of the relative layer thickness is attributed to the bending stiffness of the reinforcing layers.

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