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Computational Investigation of Energy Dissipation through Progressive Failure in Tailored Composite Structures via Explicit Finite Element Analysis

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Abstract

The progressive failure and energy dissipation characteristics of a previously developed, analytically modeled, and experimentally validated composite failure tailoring concept are computationally investigated in this study using an explicit finite element approach. The tailoring concept relies upon a sequential failure process induced in a structure of series connection of parallel redundant load path elements of tailored length and strength. The resulting yield-type response under tensile loading is characterized by an increased energy dissipation compared to a reference conventional structural element of nominally identical length and cross-sectional area, and of the same composite material.

The tailored composite structure is modeled for IM7-8552 composite material using a dynamic, explicit finite element analysis in Abaqus. The approach offers the advantage of capturing the stress wave propagation within the model throughout the dynamic failure sequence. Progressive failure of the tailored composite structure is modeled and analyzed for several configurations of length, width, and strain rates.

An original contribution of the present computational investigation beyond analytical modeling and experimental results for this composite tailoring concept available in the literature provides for the stress wave propagation to be captured in the simulated model for each case, thereby providing a better understanding of the failure progression and of the energy dissipation mechanisms at work. Model predictions are illustrated for and compared with selected tailoring configurations from the literature.
Developing an explicit finite element approach for analyzing the tailoring concept opens the door to characterizing a wide variety of related, more complex configurations for which analytical solutions do not yet exist or may not even be feasible, and/or for which experimental results may be difficult or overly expensive to obtain.