FINITE ELEMENT ANALYSIS OF IMPACT ENERGY ABSORPTION PERFORMANCE OF BIO-INSPIRED HONEYCOMB CORED SANDWICH STRUCTURES

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Abstract
This study investigates the performance of bio-inspired honeycomb core geometries to develop structurally efficient, lightweight, and durable designs against impact loads. Within the scope of the research, various bio-inspired designs—specifically Snail, Wavy, Pomelo Peel, Spider Web, and Hierarchical structures—were analyzed comparatively as alternatives to traditional hexagonal geometries to evaluate their energy absorption capacities. As a methodology, high-fidelity finite element models were developed using LS-DYNA software. The numerical model was validated against experimental data for an impact scenario at 41.8 m/s, achieving high accuracy with a 9% deviation in total energy absorption (622 J experimental vs. 678 J numerical). In the analyses, the structural integrity between Carbon Fiber Reinforced Polymer (CFRP) layers and aluminum alloy (AA2024-T3) face sheets was simulated using realistic contact definitions, including "Tiebreak" and "Automatic Surface-to-Surface" algorithms. Parametric analysis results demonstrate the critical influence of geometric form on mechanical efficiency. The data indicates that the Pomelo Peel geometry emerged as the most successful design, exhibiting a Specific Energy Absorption (SEA) value of 1.27 J/g, which represents an 18.90% increase in efficiency compared to the benchmark structure. This was followed by the hierarchical structure (14.29%) and the spider web design (13.09%). The results confirm that complex bio-inspired geometries offer superior mechanical performance over traditional sandwich structures, particularly for aerospace and automotive applications where lightweighting and impact resistance are prioritized.
Keywords: Bio-inspired Design, Honeycomb Sandwich Structures, Energy Absorption Capacity, High-velocity Impact, LS-DYNA, Specific Energy Absorption (SEA).