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# Shell-Based Adhesive-Core Equivalent Modelling for Aluminum Honeycomb Sandwich Panels Under Compression-After-Impact Loading

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## ABSTRACT

Honeycomb sandwich panels are extensively used in the design and construction of lightweight aerospace industries, offering an optimal balance between high stiffness and low weight. Adhesive fillets at the interface between the face sheets and the honeycomb core play a crucial role in load transfer and structural integrity. Experimental studies have demonstrated that adhesive fillets significantly influence buckling initiation in honeycomb cell walls subjected to low-velocity impact. This study extends this understanding by combining numerical simulations and experimental validation to investigate the adhesive-core interaction during Compression-After-Impact (CAI) loading. While 3D solid modelling of adhesive fillets accurately captures local buckling initiation and energy absorption, its high computational cost can limit industrial-scale simulations. To address this challenge, a calibrated shell-based equivalent adhesive-core representation is introduced, employing simplified geometry and material properties to replicate the fillets' stiffening effect.

Three simulation strategies—full 3D adhesive fillets adhered to cell walls, equivalent adhesive-core shell with calibrated thickness and material properties, and a baseline model with no fillet—are compared against experimental observations of core crush depth and residual load-bearing capacity. A two-level finite element (FE) verification is conducted to validate the calibrated constitutive relationship between the equivalent-fillet shell and a high-fidelity FE model of unit cell representation. The second level includes a sub-scale sandwich panel, consisting of 10 by 10 unit cells, which is analyzed under CAI loading to evaluate the overall structural performance and compare the effectiveness of the equivalent-fillet representation against explicit adhesive modelling. Experimental CAI tests are conducted on ASTM standard-size coupons, providing direct comparisons between physical test results and the equivalent shell-based FE model. The equivalent shell approach offers a significant reduction in element count and CPU time while maintaining close agreement with both solid-element simulations and CAI test data. Validation against sub-scale models and experiments confirms that this approach captures critical damage mechanisms and deflection patterns, providing an efficient means of incorporating realistic adhesive effects in full-scale impact simulations.

In summary, the proposed equivalent adhesive-core methodology offers a balanced solution that reduces computational costs without sacrificing essential predictive capabilities, aiding in the practical design and evaluation of honeycomb sandwich structures for aerospace applications.