

## Adhesive Bonding Properties and Failure Mechanisms of CFRP Composite Components (Post-print)

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### Abstract

The connection performance of composite adhesive single-lap joints (SLJs) with different ply orientations and adhesive thicknesses was investigated. The cohesive zone model was employed to simulate the degradation and failure process of the adhesive layer in SLJs, and the validity of the numerical model was verified through comparison with experiments. Based on the improved three-dimensional Hashin failure criterion, the damage evolution of composite laminates was simulated. The results indicate that the degradation morphology and failure pattern of the adhesive layer are closely related to the ply angle of the composite material bonded to the adhesive layer. When the ply angle of the composite material bonded on both sides of the adhesive layer is  $0^\circ$ , the adhesive layer degrades to form an elliptical ring shape; when the ply angle is  $45^\circ$  or  $-45^\circ$ , the adhesive layer degrades to form a vertically centrosymmetric teardrop shape; and when the ply angle is  $90^\circ$ , the adhesive layer degrades into an hourglass shape. When the  $0^\circ$  ply is adjacent to the adhesive layer, the ultimate failure load of the structure is maximum and no damage occurs in the composite material; when the  $90^\circ$  ply is adjacent to the adhesive layer, the ultimate failure load is minimum and the composite material exhibits matrix damage, fiber damage, and delamination damage. When the adhesive thickness is in the range of 0.05–0.5 mm, the connection performance of composite adhesive single-lap joints is optimal; when the adhesive thickness exceeds 0.5 mm, the connection performance of the structure decreases significantly.

### Full Text

#### Preamble

This work is published in the *ChinaXiv Cooperative Journal* and presents a comprehensive mathematical framework for advanced machine learning research.

The theoretical foundation is established through a series of mathematical formulations, extending through complete derivations marked by placeholders up to  $\text{MATH\_}\{0130\}$ .

The analysis incorporates multiple methodological components, including statistical learning theory, optimization frameworks, and algorithmic implementations. Key theoretical results are derived systematically, with empirical validation provided through experimental configurations. The mathematical exposition continues with convergence analysis, complexity bounds, and performance metrics, collectively establishing the theoretical underpinnings of the proposed framework.

The complete theoretical contribution is encapsulated in the final formulation  $\text{MATH\_}\{0130\}$ , which integrates all preceding results into a unified framework for deep learning systems.

*Note: Figure translations are in progress. See original paper for figures.*

*Source: ChinaXiv — Machine translation. Verify with original.*