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Fatigue behavior of adhesive joints:
Material, design and application perspectives

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1. Introduction

Adhesive bonding has become an essential joining technology for lightweight multi-material structures. However, accurately predicting fatigue durability remains challenging because joint performance is influenced by complex interactions between material properties, joint geometry, loading conditions, and environmental effects.

2. Why Is Fatigue Prediction Difficult?

Material & Stress State
Multi-material bonding generates complex multiaxial stress fields

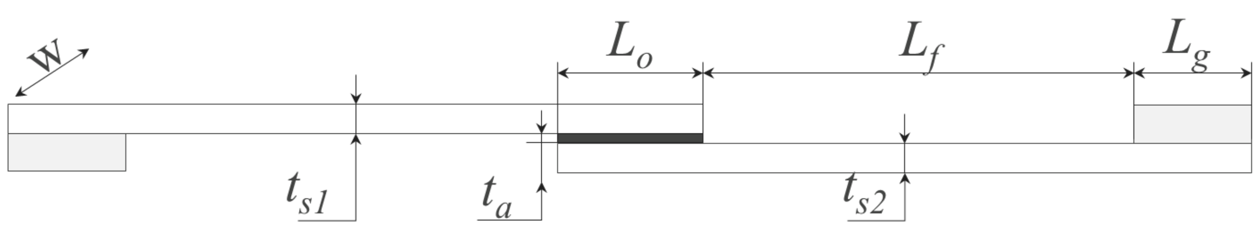
Joint Geometry
Local geometry strongly influences stress concentration and failure initiation

The Durability Gap

Polymeric Nature
Adhesives are highly sensitive to temperature and moisture

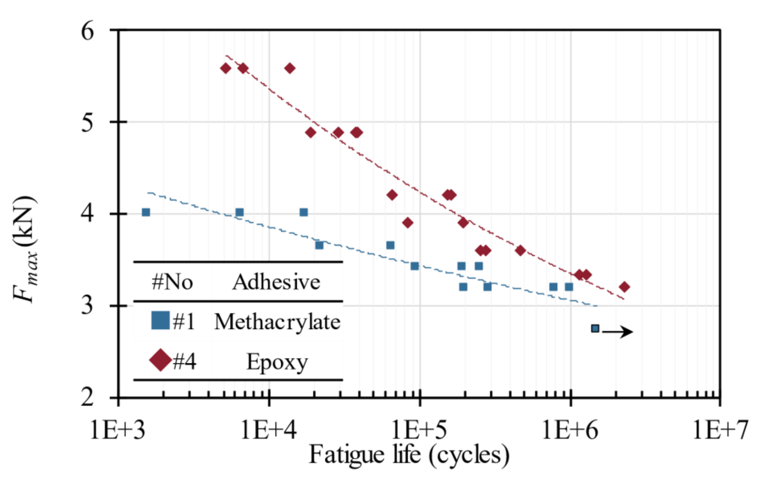
Loading Histories
Variable-amplitude loading significantly affects fatigue durability

3. Experimental and Parametric Investigation

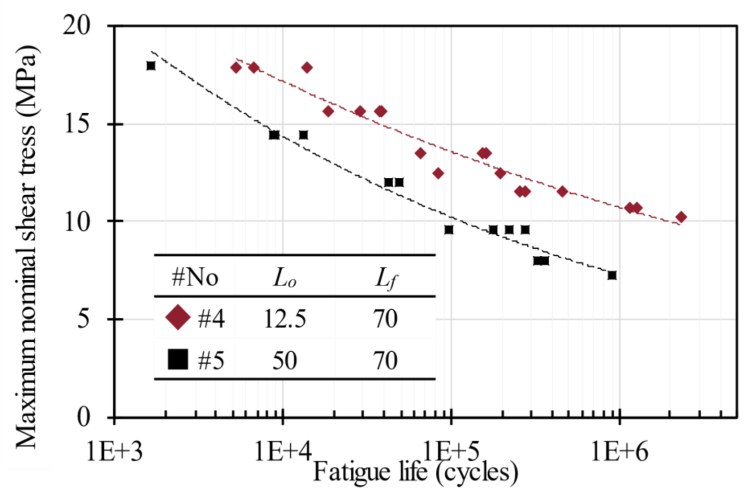


Schematic representation of the tested SLJs

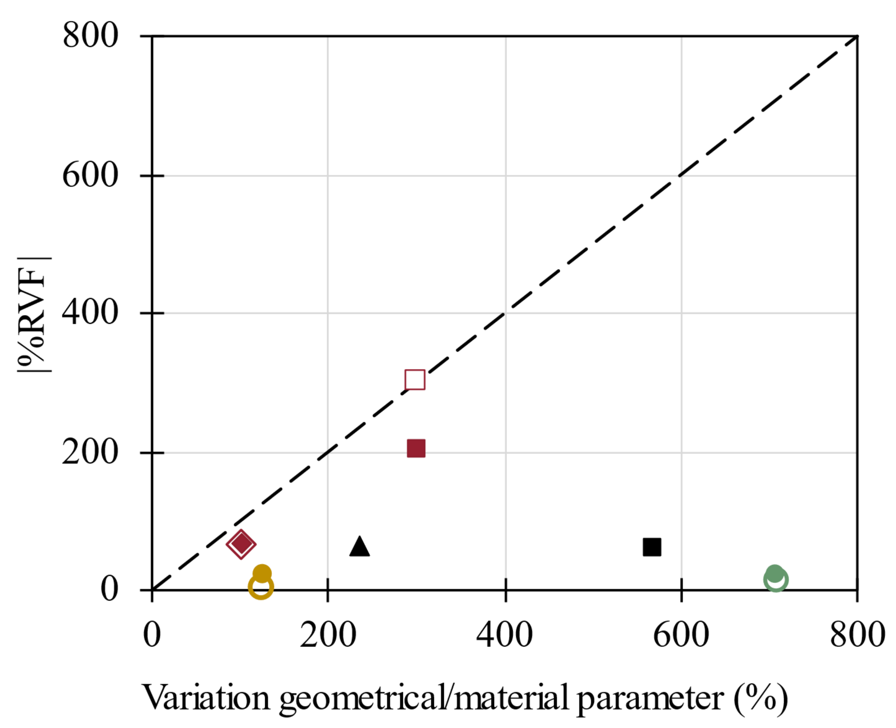
The effects of adherent material (metallic, composite, and hybrid) and joint geometry (overlap length and adhesive thickness) on fatigue life and crack growth were systematically investigated using two structural adhesives under load- and displacement-controlled conditions.



Fatigue results for configurations with different adhesives



Fatigue results for configurations with different overlap length



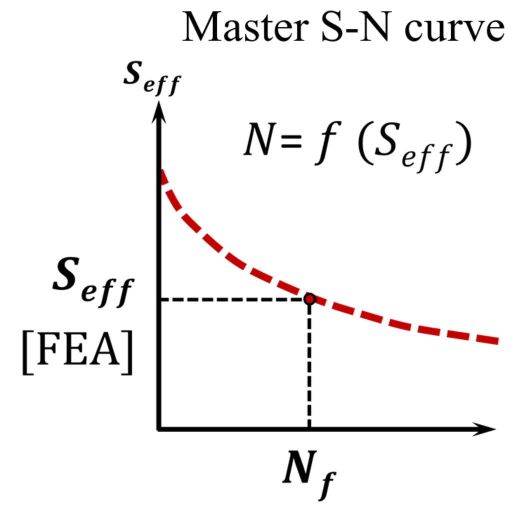
Parameter		%RVF Fatigue	%RVF Static
L_o (mm)	12.5 → 50 (#4 & #5)	+201%	+300%
L_o (mm)	12.5 → 25 (#6 & #7)	+67%	+67%
t_a (mm)	0.3 → 1 (#7 & #8)	-62%	-
t_a (mm)	0.3 → 2 (#13 & #15)	-59%	-
t_s (mm)	2 → 4.5 [19]	+20%	+2%
E_s (GPa)	26 → 210 (#1 & #3)	+21%	+13%

Relative variation in load (|%RVF|) as a function of the percentage variation of each geometrical or material parameter (Fatigue life =10^5cycles)

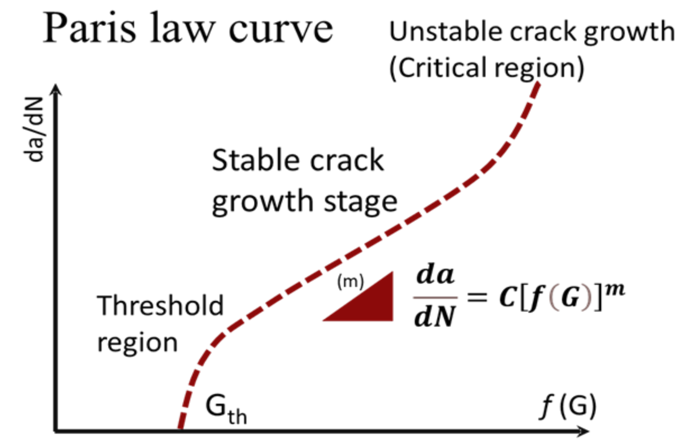
4. Fatigue Assessment Framework

FATIGUE LIFE ANALYSIS

BondLife — S-N APPROACH

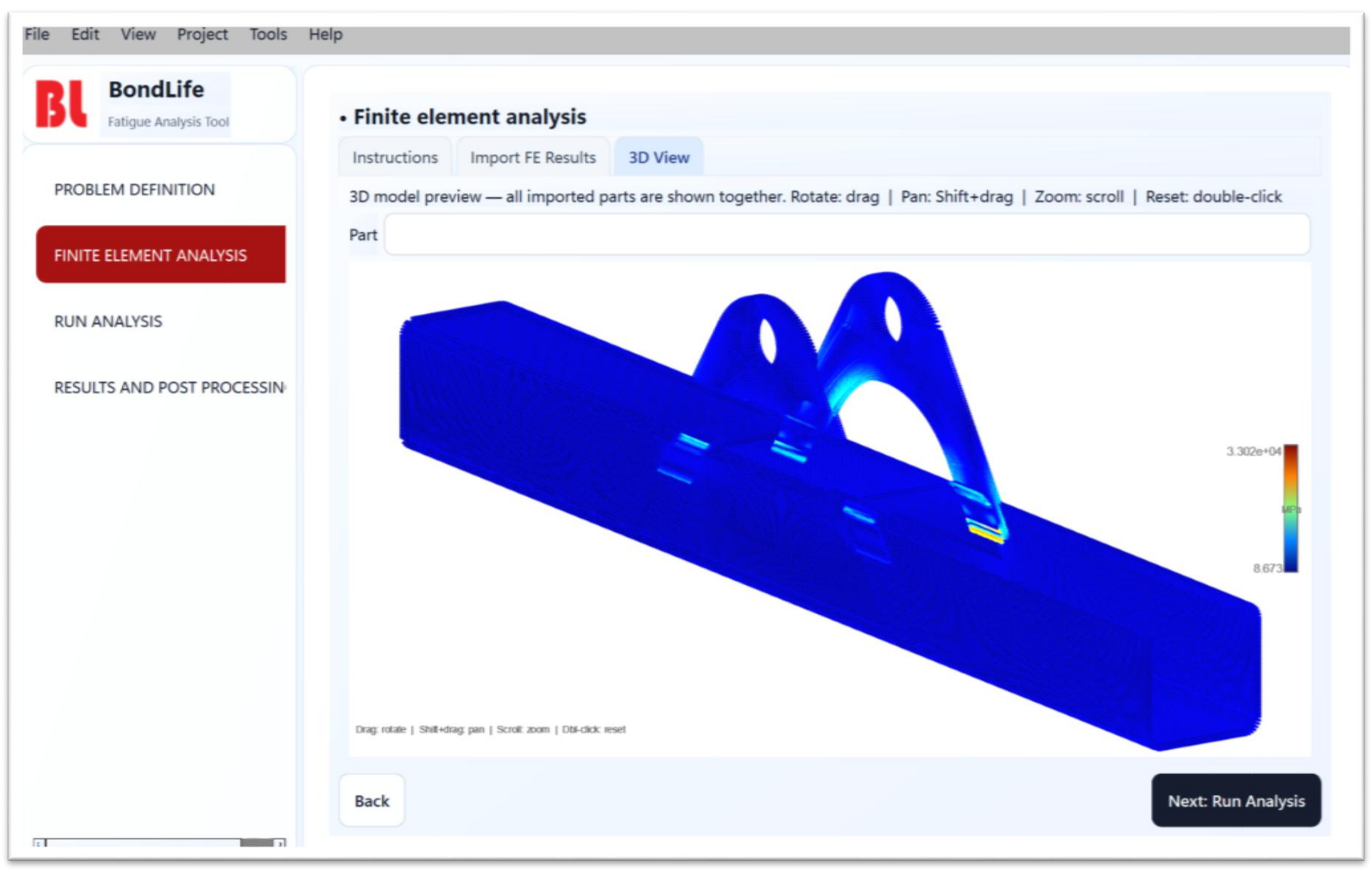


BondCrack — FCG APPROACH



BondCrack predicts fatigue crack growth using Cohesive Zone Modelling (CZM), enabling detailed simulation of crack initiation and propagation in bonded joints.

BondLife is a computational platform for S–N fatigue life prediction. It combines material characterization with advanced numerical analysis to improve prediction accuracy while maintaining computational efficiency.



BondLife GUI – Analyze Read Joint

5. Conclusion

Material selection, joint geometry, and loading conditions govern the fatigue behavior of adhesive joints. Parametric analysis identified overlap length as the most influential design parameter, while static results provided a useful first-order indicator of fatigue performance. BondLife and BondCrack provide complementary tools for fatigue life prediction and crack growth assessment.

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