

Evaluating peel testing behaviour of acrylic pressure-sensitive adhesives: implications for advanced joining and long-term durability

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Introduction

Pressure-sensitive adhesives (PSAs) enable lightweight, damage-free joining across industries. Their performance depends critically on how cracks propagate under mixed loading conditions. This work compares stiff vs. soft PSA formulations to understand how peel angle controls energy dissipation—key knowledge for optimizing adhesive joint design.

Materials & Methods

- Adhesive A: thinner, stiffer, more elastic;
- Adhesive B: thicker, softer, more viscoelastic;
- Peel tests conducted at 30°, 60°, 90°, 120°, 150°, 180°;
- FEM simulations with CZM for validation.

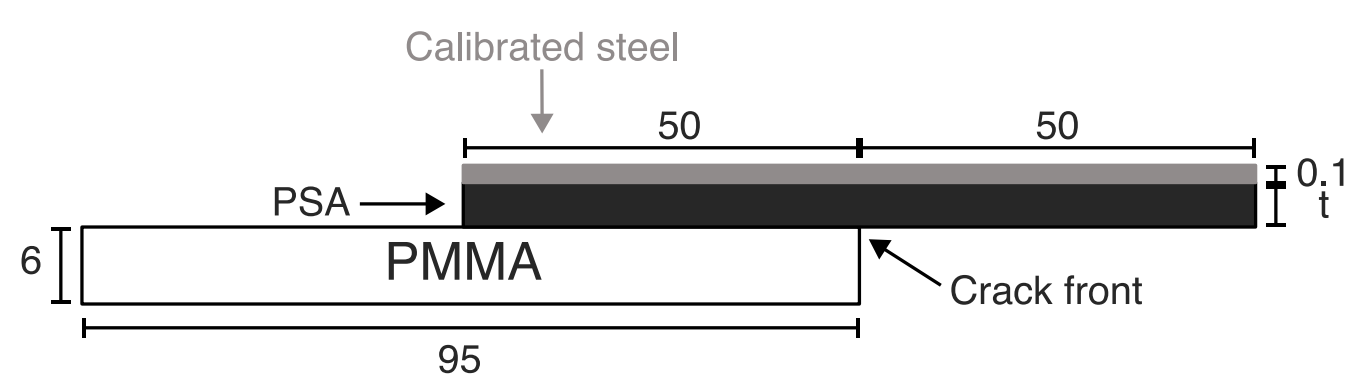


Figure 1 – Peel specimen materials and geometry, in mm.

Experimental Results

Peel vs. angle

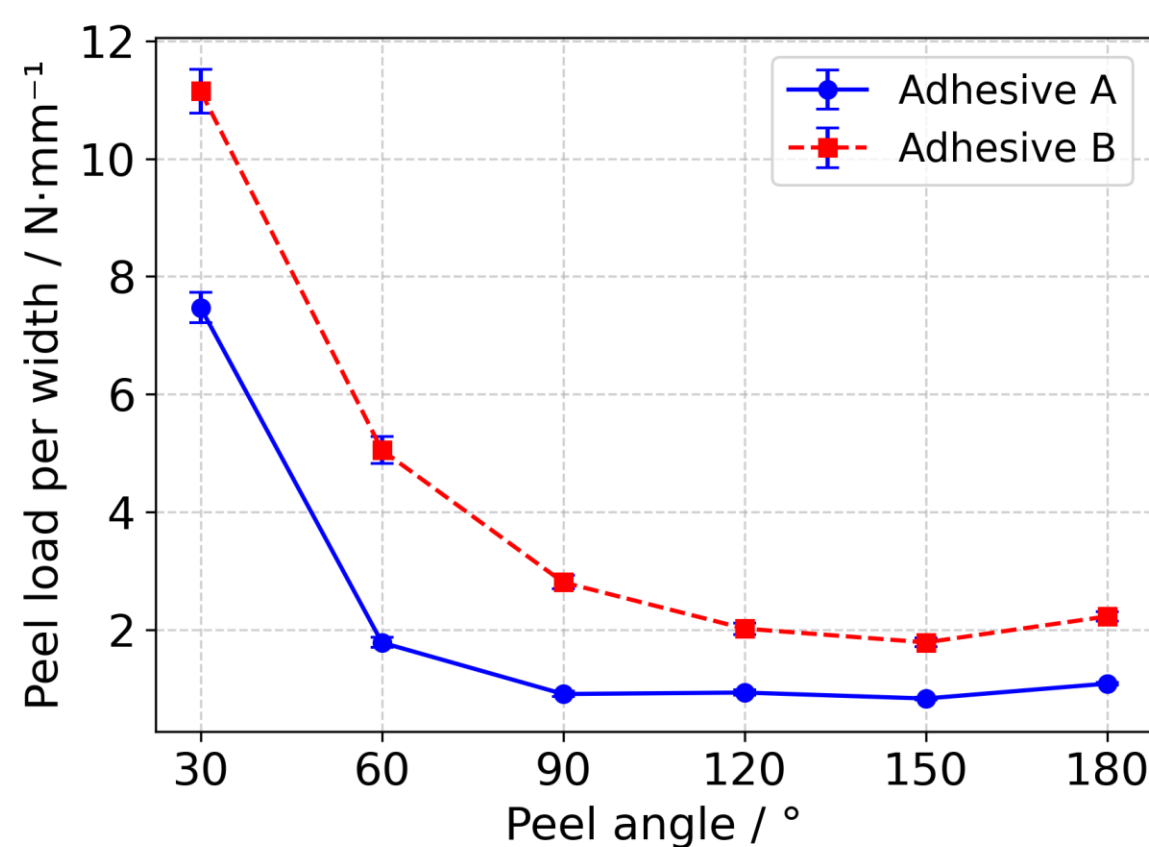


Figure 2 – Peel load per width (Nmm⁻¹) as a function of the peel angle.

Energy decomposition analysis

Fig. 3 shows the energy contributions quantified: elastic bending (G_{eb}), plastic bending (G_{db}), true fracture energy (G_a).

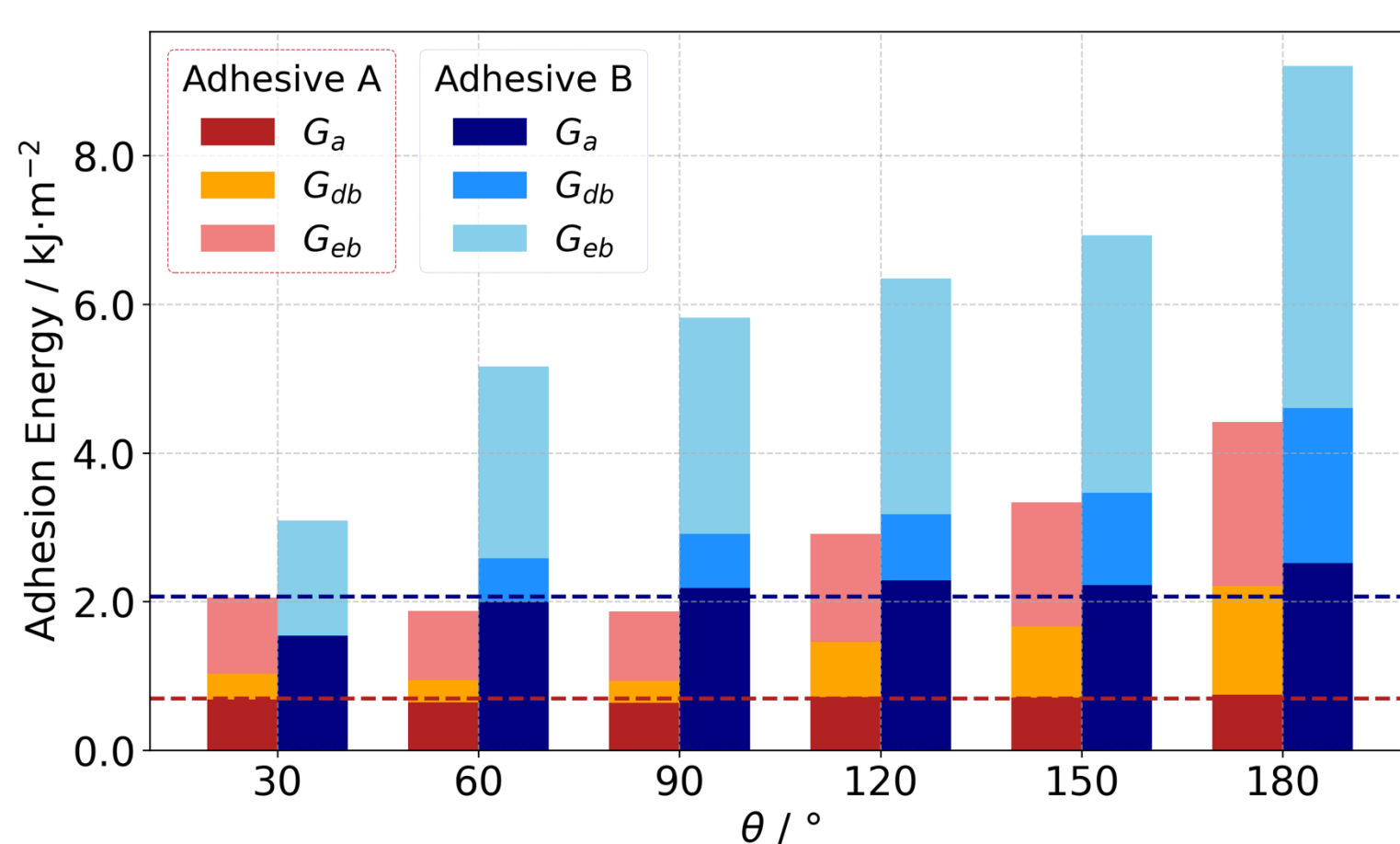


Figure 3 – Energy contribution quantified: elastic bending (G_{eb}), plastic bending (G_{db}), true fracture energy (G_a), for Adhesive A, in red, and Adhesive B, in blue.

- Adhesive A:** Average $G_a = 0.70 \text{ kJ/m}^2$;
- Adhesive B:** Average $G_a = 2.07 \text{ kJ/m}^2$ (3× higher intrinsic toughness);
- Higher thickness does not proportionally increase plastic bending contribution.

Numerical Results

Numerical validation

The CZM model reproduced experimental trends with good agreement in overall geometry and deformation patterns (Fig. 4).

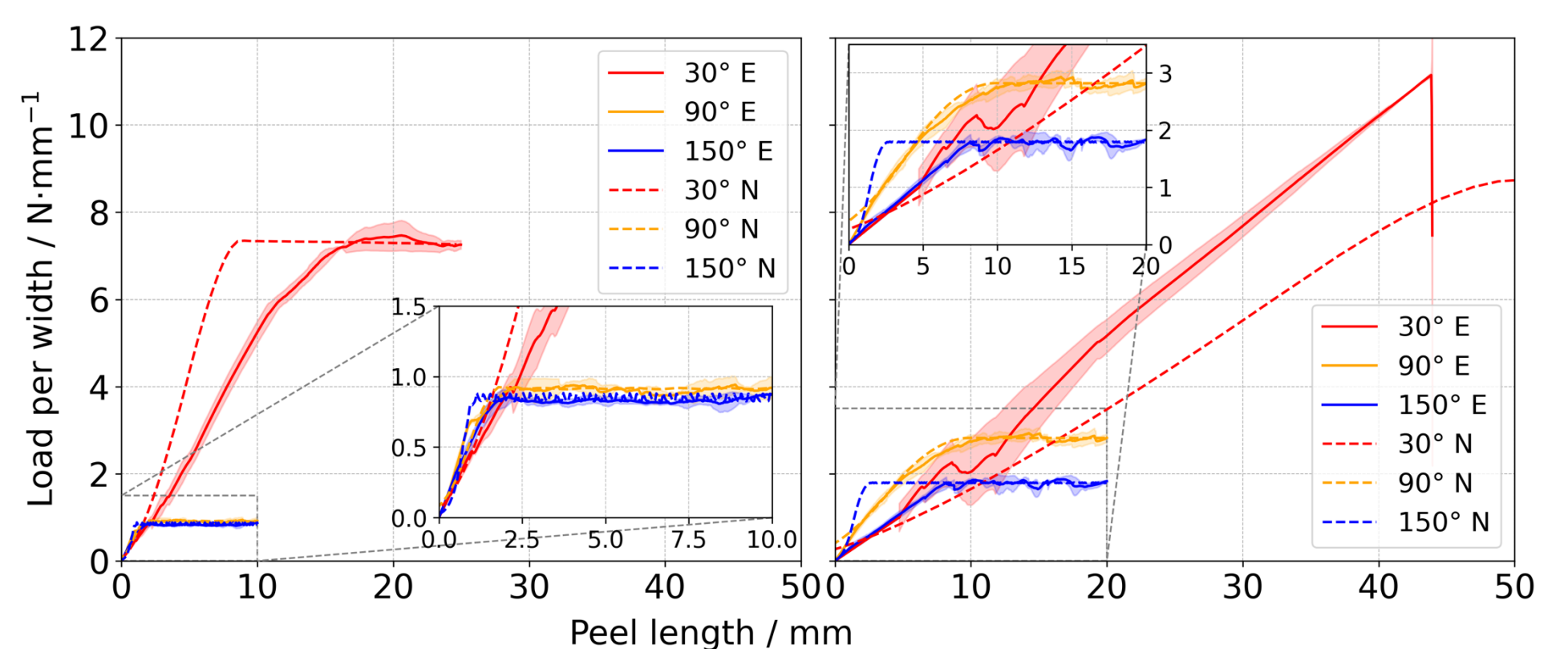


Figure 4 – Numerical vs. experimental load-displacement curves.

Stress field analysis

Fig. 5 shows the stress field analysis near the crack tip, when comparing the lower and the higher angles.

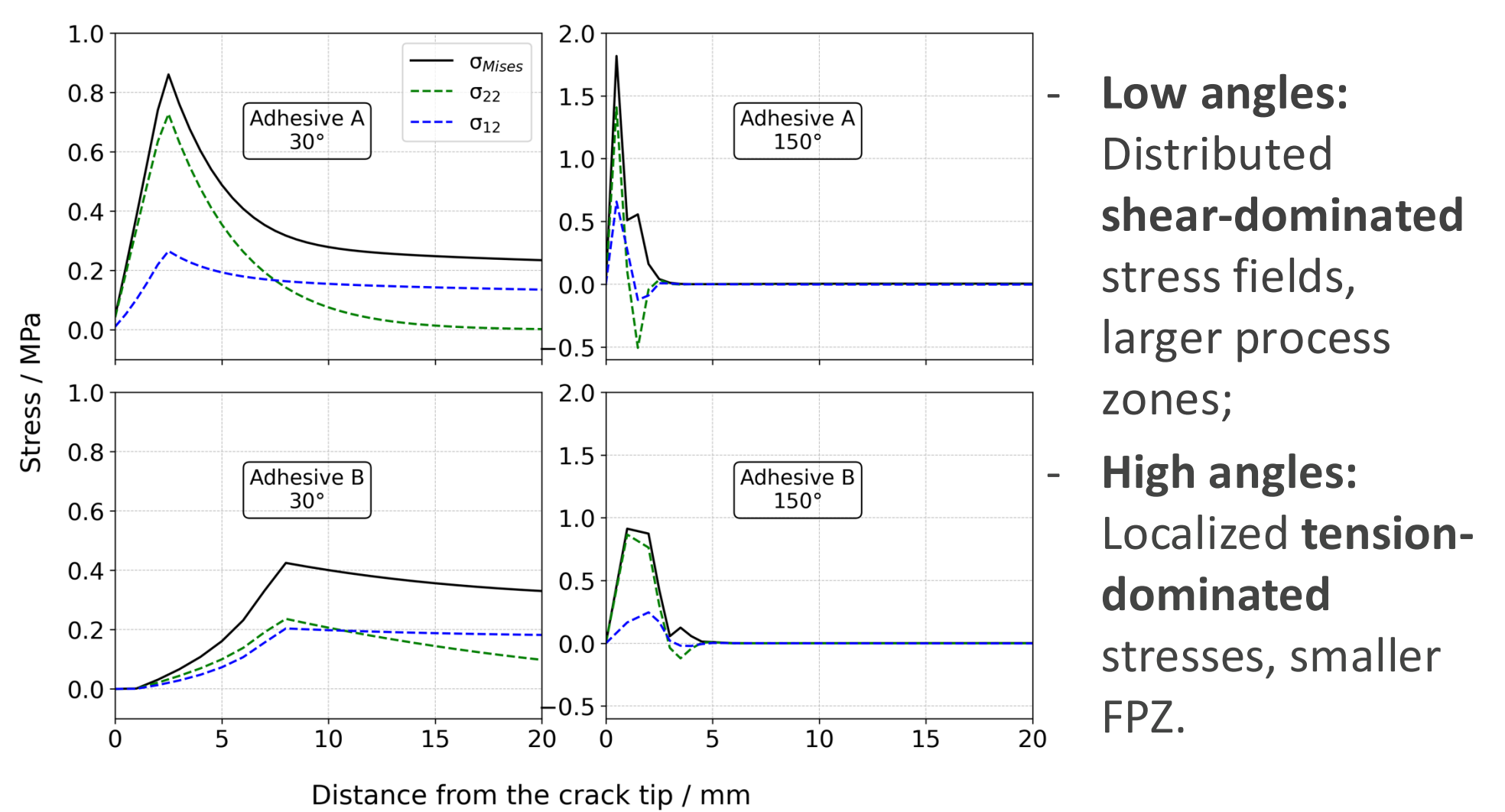


Figure 5 – Stress field analysis near the crack tip for Adhesive A (top) and Adhesive B (bottom) at 30° (left) and 150° (right).



Figure 6 – Simulation vs. experimental deformation comparison image.

Key findings & Conclusions

- ✓ Peel angle significantly influences energy dissipation mechanisms.
- ✓ Material architecture governs fracture behaviour.
- ✓ Practical implications for joining applications.