

A hybrid strategy for strengthening wood joints using bio-adhesive surface infusion

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1. Introduction

The increasing focus on sustainability is driving the use of eco-friendly materials in modern engineering. Wood joints bonded with bio-adhesives are gaining attention for their environmental advantages and good mechanical performance. Unlike traditional fastening methods, adhesive joints offer better load distribution, lower stress concentrations, and cleaner aesthetics. This study investigates both standard and hybrid single-lap wood joints under quasi-static loading.

The main approach involves reinforcing the wood surface by infusing it with a bio-adhesive, aiming to improve the bond between the adhesive and the substrate. This method combines the natural strength of wood with the bonding capabilities of bio-adhesives to create a tougher and more reliable joint. Tests showed that this technique greatly improves joint strength compared to reference pine joints. In addition to higher strength, the hybrid joints also showed increased delamination thickness, which helps absorb more energy during loading. These results suggest that surface-infused bio-adhesives can significantly improve the mechanical performance of wood joints, offering a promising solution for sustainable, high-performance applications.

2. Experimental details

Two wood types—pine and oak—were used to evaluate a bio-based polyurethane adhesive. The specimens were assembled into single-lap joints (25 mm overlap) and cured at 100°C under 30 bar. A zero-thickness bondline was used, and toughness was enhanced through a two-step adhesive penetration method. Four configurations were tested: untreated pine and oak, and two hybrid joints with reinforced outer layers.



Figure 1 – SLJ configurations.

Substrate toughening involves pre-treating wood surfaces to allow adhesive to deeply penetrate the fibers, creating a reinforced interphase. This improves the joint's resistance to cracking and delamination.

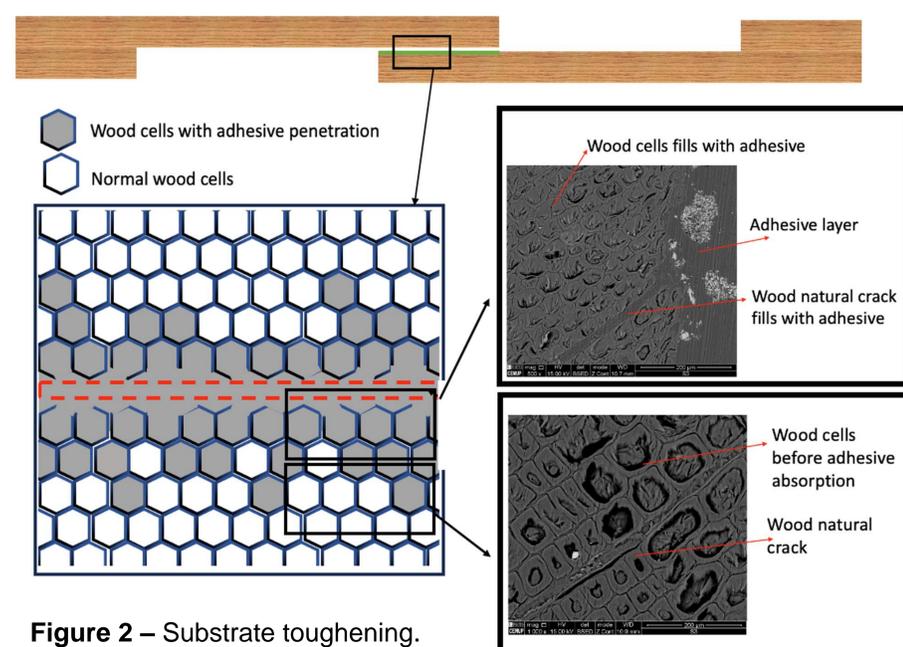


Figure 2 – Substrate toughening.

3. Experimental results

Mechanical tests showed hybrid joints—especially those with oak layers—had the highest strength (6.0 kN) and best energy absorption under impact. They outperformed reference joints, with pine being the weakest. Improved performance is linked to stiff oak layers and stronger adhesive bonding, which enhance stress distribution and reduce cracking.

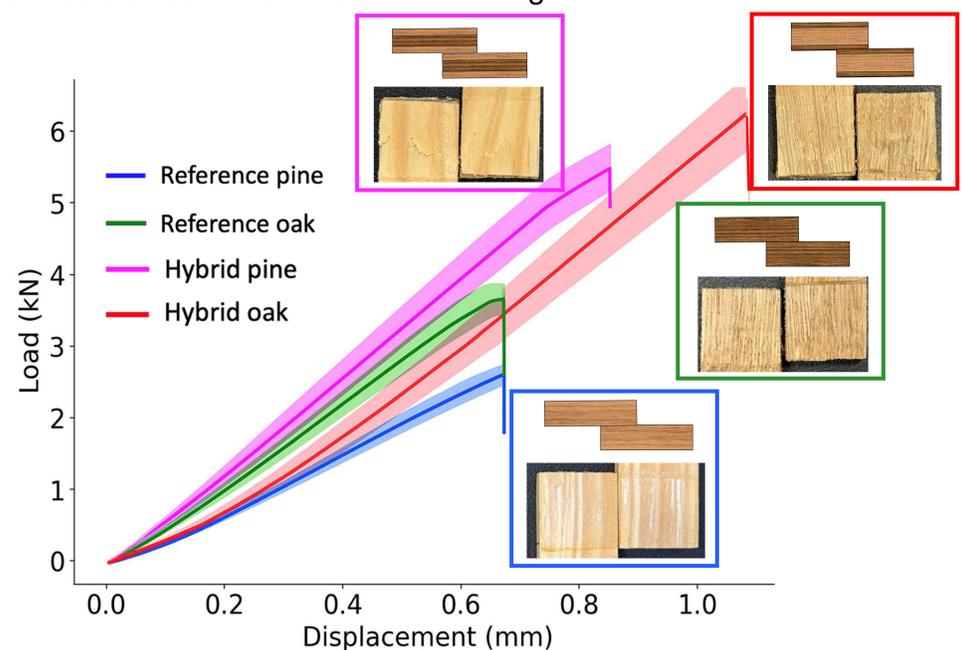


Figure 3. Load displacement behavior of the single lab joints and fracture surfaces.

4. Conclusion

The main findings can be summarized:

- The hybrid joints increased the joint strength more than 100% compared to regular pine substrates;
- The hybrid joints allowed to obtain a joint with highest energy absorption;
- Hybrid joints, particularly those with oak outer layers, showed the best performance.

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