

Low Temperature Adhesive Bonding for Structural Wood Materials



Universität für Bodenkultur Wien
University of Natural Resources
and Life Sciences, Vienna

Anita Tran^{a,b}, Melanie Mayr^a, Johannes Konnerth^a, Wolfgang Gindl-Altmutter^a

^aBOKU - Institute of Wood Technology and Renewable Materials

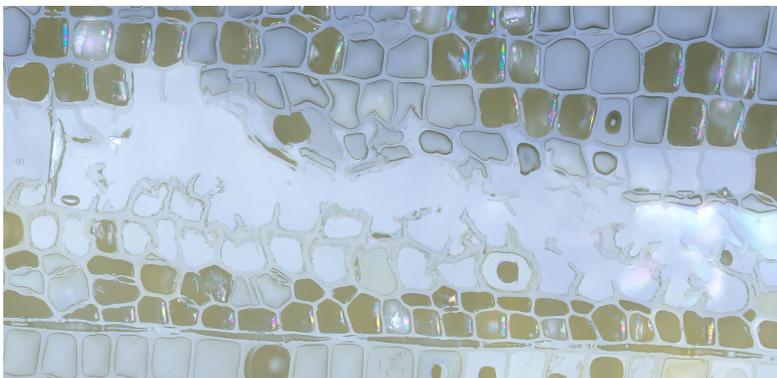
Konrad Lorenz-Straße 24, 3430 Tulln an der Donau, Austria

^banita.tran@boku.ac.at

INTRODUCTION

Strong and reliable bonds are mandatory for load-bearing timber products, therefore manufacturing processes are strictly regulated.

Substrate temperature specification for adhesive application is at minimum 18 °C for structural finger joints¹. This requires in-line pre-heating prior to adhesive bonding, when lamellas are stored outside in winter.



RESEARCH QUESTION

Can adhesive bonds with **identical bond performance** also be achieved with significantly **lower substrate temperature** by simply providing more time for adhesive cure?

METHODOLOGY

Scarf joint samples from spruce imitating finger joint angles of 7.5° were adhesively bonded in three temperature test series (A-C). The melamine-urea-formaldehyde (MUF) adhesive was applied on separate sides. The samples were cut lengthwise for different testing methods.

The following parameters were examined to further understand the influence of substrate temperature on the adhesive bond:

- tensile shear strength parallel to the grain via tensile testing
- adhesive penetration via microscopic analysis
- cell wall penetration and micro-mechanics via of nanoindentation.

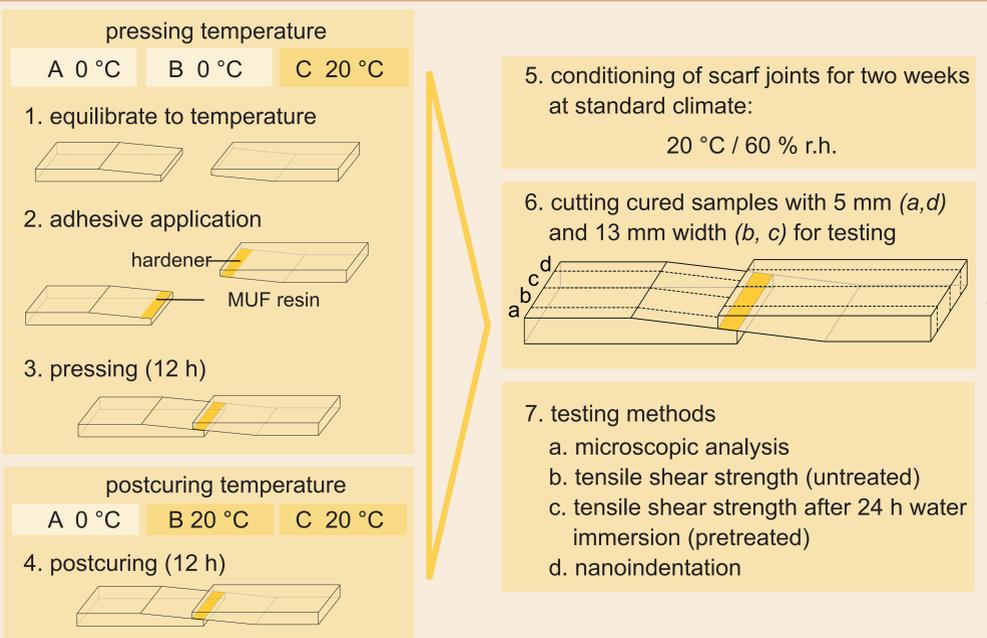


Fig. 1. Overview scheme showing manufacture of scarf joints and subsequent testing methods²

RESULTS

Tensile testing

Resulting tensile shear strength varied marginally for different temperatures. Even after exposure to water, the adhesive bond remained durable.

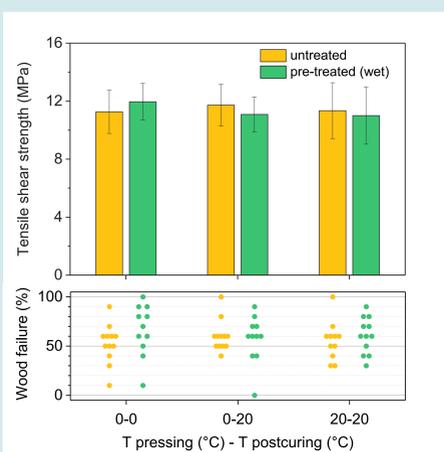


Fig. 2. Tensile shear strength and corresponding wood failure percentage in dependence of test temperature²

Microscopic analysis

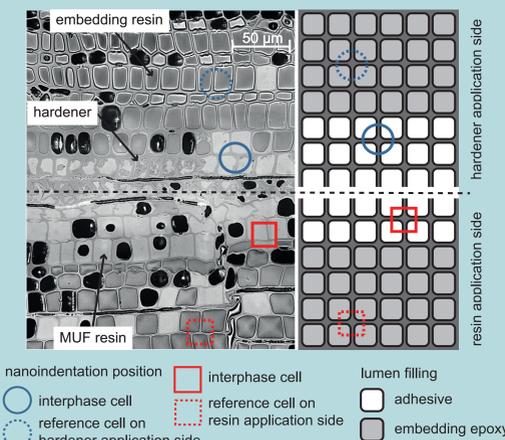


Fig. 3. Microscopic image of bond line (dotted line) with highlighted nanoindentation positions²

The adhesive penetrated on both application sides with no dependency on temperature. The pure hardener was only visible on its application side and clearly distinguishable from the MUF resin. Fig. 3 also depicts preselected positions for nanoindentation in interphase and reference cells on both application sides.

Nanoindentation

Nanoindentation visualized the penetration of the adhesive into the cell wall with increased hardness and reduced modulus of elasticity from unfilled cells to adhesive filled cells independent of temperature.

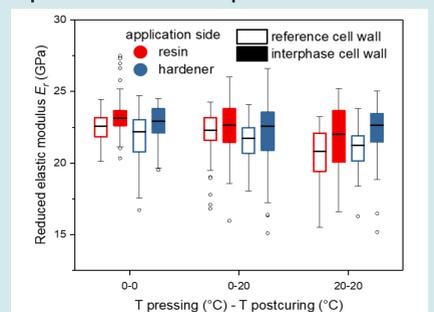


Fig. 4. Reduced elastic modulus of cell walls²

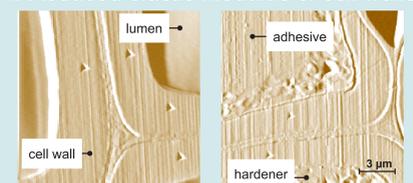


Fig. 5. Topography images after nanoindentation: reference cell (a) and cell filled with adhesive and hardener (b)²

CONCLUSION

The substrate temperature at the time of adhesive application has least influence on the macro- and microscopic level and therefore permits bonding at low temperatures providing enough time for cure at sufficient temperature is allowed. This applies to the examined specimen geometry and is possibly transferable to finger joints.

ACKNOWLEDGEMENT

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References

- ¹ EN 15497, Structural finger jointed solid timber - Performance requirements and minimum production requirements, 2014.
- ² Tran et al., Adhesive strength and micromechanics of wood bonded at low temperature, submitted to Int J Adhes Adhes.

