Towards Durable Wood-Strand Composite Mass Timber Panels

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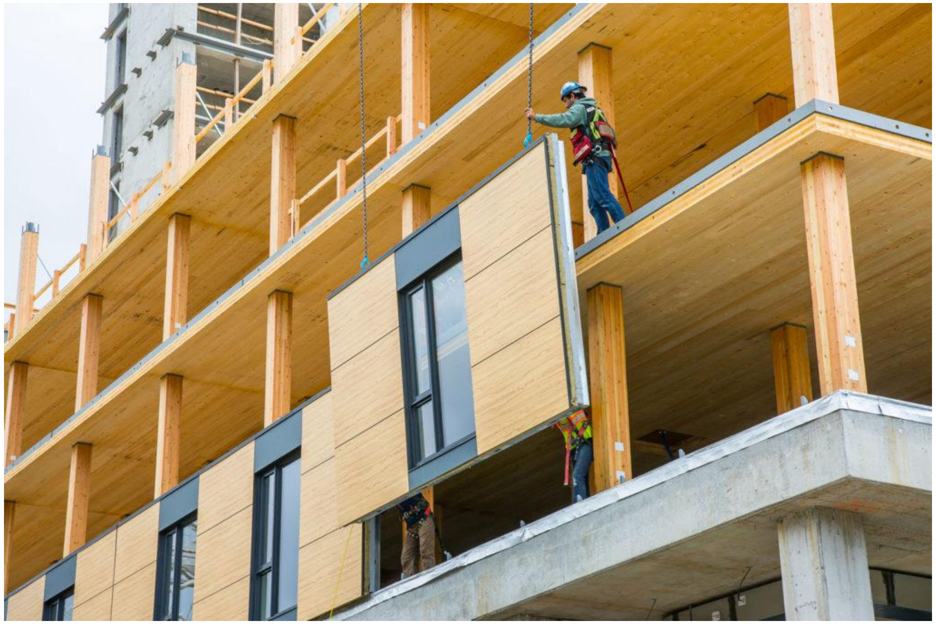
1. Background

Mass timber construction rapidly growing in North America



Brock Commons Tallwood House
18-story-tall wood hybrid building at UBC
Source: Think Wood

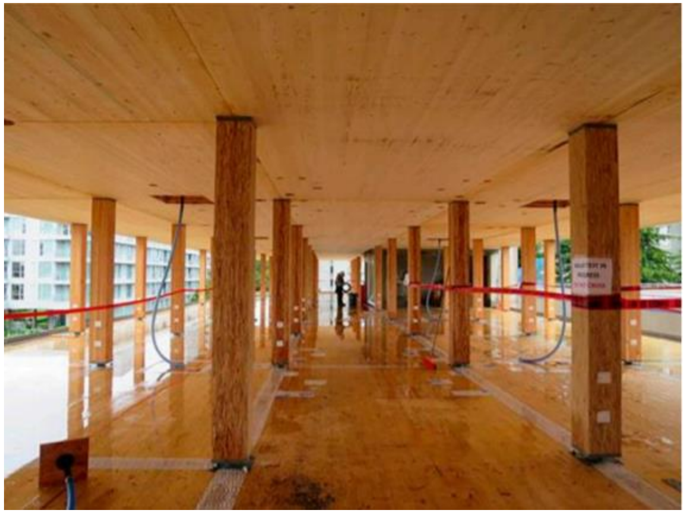
Platte Fifteen
Five-story workspace in Denver, CO
Source: Think Wood

Particularly CLT, the most popular mass timber product, is expected to grow over 13% year over year into mid-2020s

1. Background – Problem statement

Ross & USDA Forest Service, 2010

Schmidt, 2019



Wang et al., 2018

Wang, Gong, & Chui, 2015

Solution?

1. Background – Value proposition

Wood strands thermally modified:

Thermal modification of **wood strands** in a controlled temperature/pressure inert environments to manufacture wood composites (LSVL, CLSVL):

→ Valorizes small-diameter timber (SDT) & supports forest health restoration activities minimizing wild-fires ($$$)

2. Objectives

Schematic diagram of the process

Small diameter timber

Wood strands ready for thermal modification

Lab-scale thermal modification

Thin strand-veneer

Laminated strand veneer lumber (LSVL)

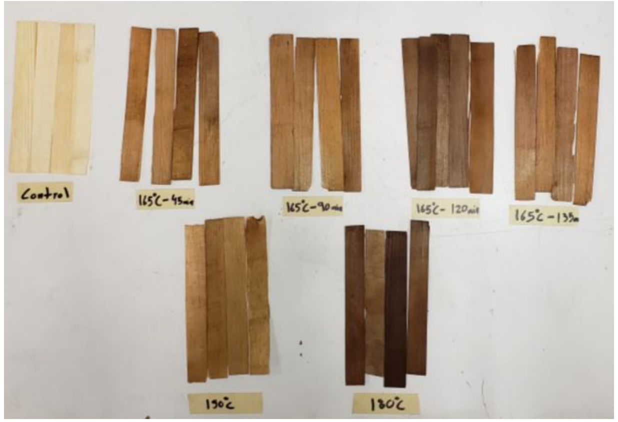
Cross laminated strand veneer lumber (CLSVL) – mass timber product

3. Thermal modification effects

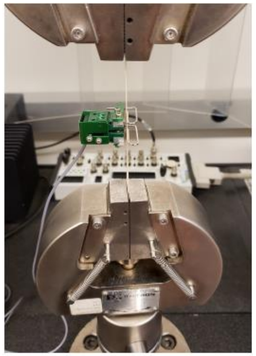
Wood specie: Small Diameter Timber Engelmann Spruce & Lodgepole Pine

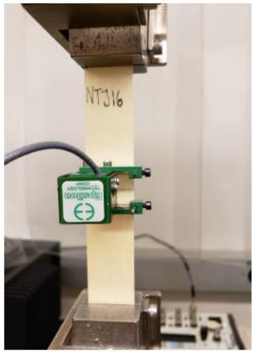
Peak temperature	Dwell time	Initial wood MC
150 °C	180 min	8%
165 °C	45 min	
	90 min	
	135 min	
	180 min	
180 °C	180 min	

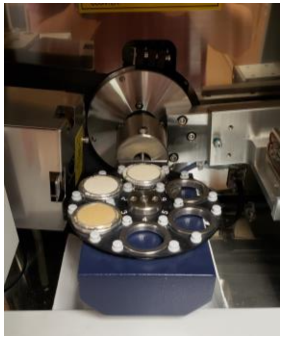
Thermally modified wood-strands



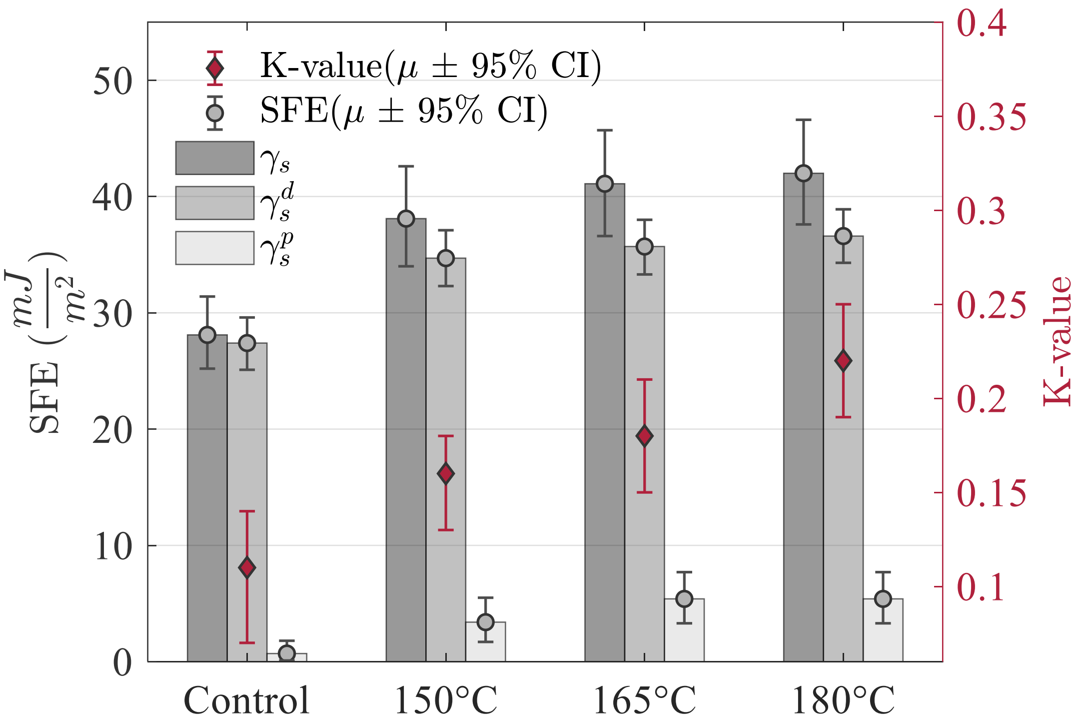
Mechanical properties, wettability and surface free energy, degree of crystallinity, water sorption, chemical composition, resistance to decay

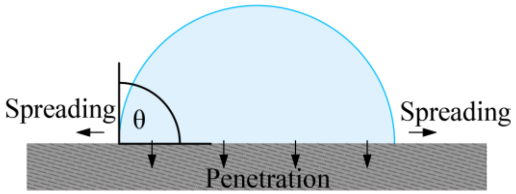






3. Strand's Characterization (wettability)





$$\frac{d\theta}{dt} = -K\theta\left(\frac{\theta_e - \theta}{\theta_e - \theta_i}\right)$$

(Shi & Gardner, 2001)

3. Strand's Characterization

Tensile E: relatively unaffected by TM
UTS: decreased with higher temperature (up to 60%)

Increase in degree of crystallinity (~15%)

Increase in SFE (up to 50%), and wettability of **pMDI** resin

Flattening of sorption isotherm (i.e., from ~20 to ~9 EMC at 90% rh and 22°C)

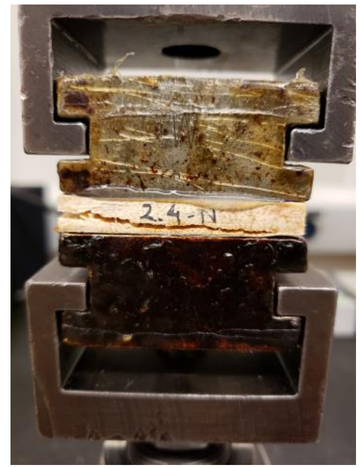
Increase of relative lignin content and decrease of some sugars (galactose)

Gained resistance to brown rot decay (mass loss after testing, from ~65% to ~20%)

4. Performance of thin-veneers

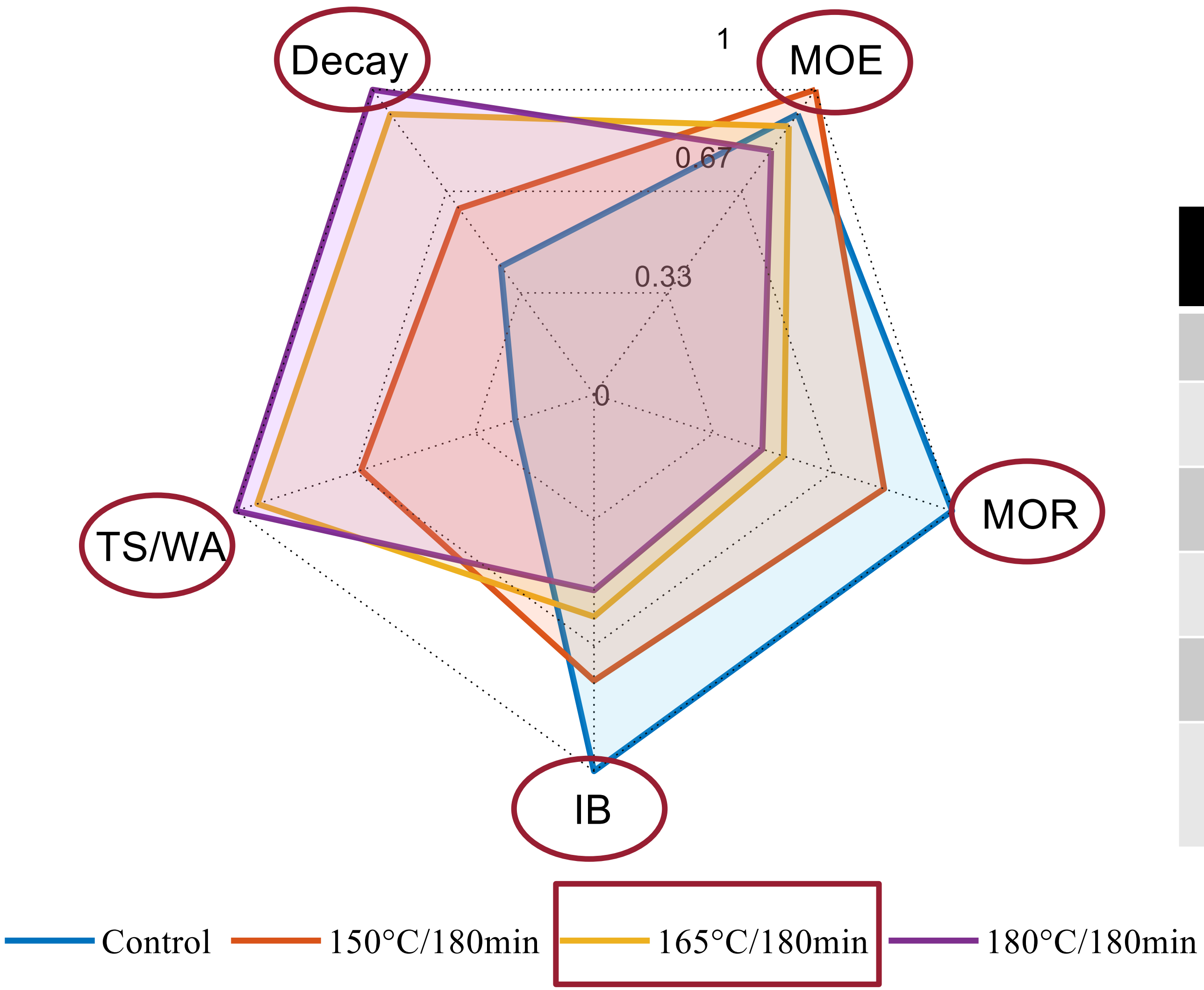
Manufacture & performance evaluation of thin-veneers

Mechanical properties, bonding performance, dimensional stability, resistance to decay



4. Performance of thin-veneers

Radar graph – TM temperature influence (panels)



Type	Value
Control panel prop.	
MOE	13.2 Gpa
MOR	94 MPa
IB	0.9 MPa
TS/WA	0.8
Decay mass loss	63%

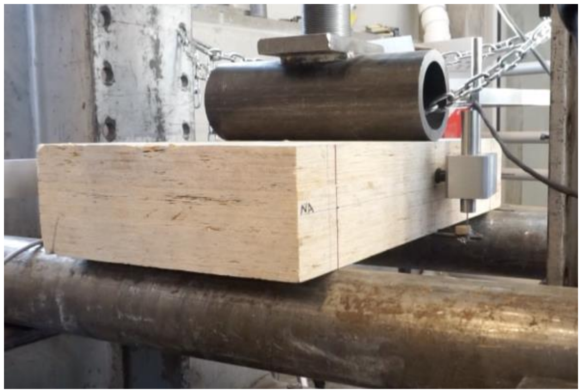
5. CLSVL for out-of-plane loads

Manufacture & testing of CLSVL under out-of-plane bending

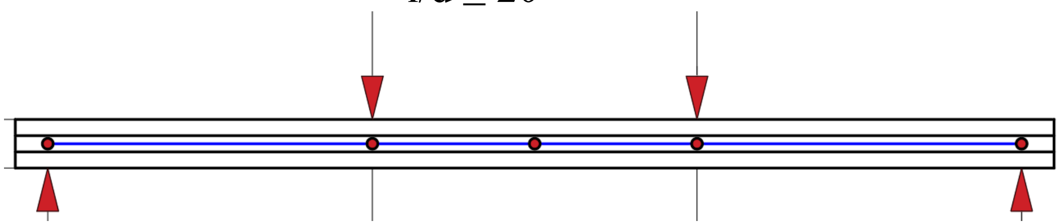
Manufacture, testing and modeling of CLSVL under uniaxial out-of-plane bending

5. CLSVL for out-of-plane loads

CLSVL out-of-plane bending test



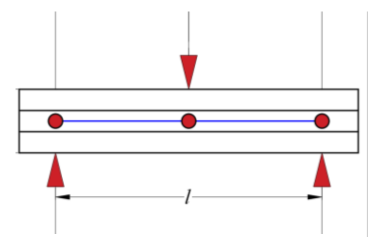
Four-point-bending
l/d ≥ 20



$$l < \frac{3h}{4}\left(\frac{\sigma_{allowable}}{\tau_{allowable}}\right)$$

Shear failure criteria

Three-point-bending
l/d ≤ 5



$$l < \frac{h}{2}\left(\frac{\sigma_{allowable}}{\tau_{allowable}}\right)$$

Laminated beam theory: Shear analogy method accurately predicted bending behavior
Shear performance comparable to CLT*, but system gives flexibility

CLSVL out-of-plane bending (no rolling shear)

5. Concluding remarks

The used TM improves durability by increasing decay and moisture resistance, and dimensional stability of wood-strands

The **controlled TM** ensures adequate bond performance

IB strength may be recouped with moisture addition

Technology very suitable for wood-strands which can later be used in wood composites

Value added to “low quality SDT”

Product offers flexibility to meet different structural performance and with predictable behavior

Acknowledgements

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Questions?