A4 PRESENTATION

WELDED WOOD

Assessing Hot Pressure Welding as a Viable Alternative to Synthetic Adhesives in Engineered Wood Products

HELENA STEVENS - 5523109

Lund Humpfries, 2022

Wooden storehouse, Sweden, n.d.
by Unknown

Source: Rakauskaite, 2026

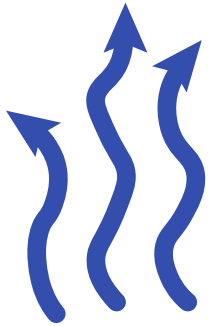
SAWA, Rotterdam, 2025
by Mei architects and planners

This **renaissance** of wood contruction was only possible thanks to the addition of **synthethic adhesives**, creating **Engineered Wood Products** (EWPs)

DISADVANTAGES OF SYNTHETIC ADHESIVES

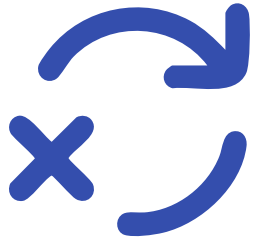
PEOPLE

SICK BUILDING SYNDROME



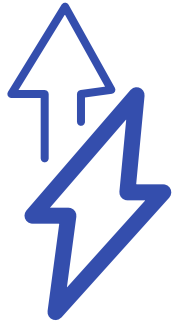
VOCs EMISSIONS

PLANET



NON-RENEWABLE SOURCES

GREENHOUSE GAS EMISSIONS



HIGH ENERGY CONSUMPTIONS

Welded wood as a potential **solution.**

A4 PRESENTATION

WELDED WOOD

Assessing Hot Pressure Welding as a Viable Alternative to Synthetic Adhesives in Engineered Wood Products

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DEFINITION

"**Welding** is a process where two or more surfaces are fused together, either with **time and heat, pressure** or all three."

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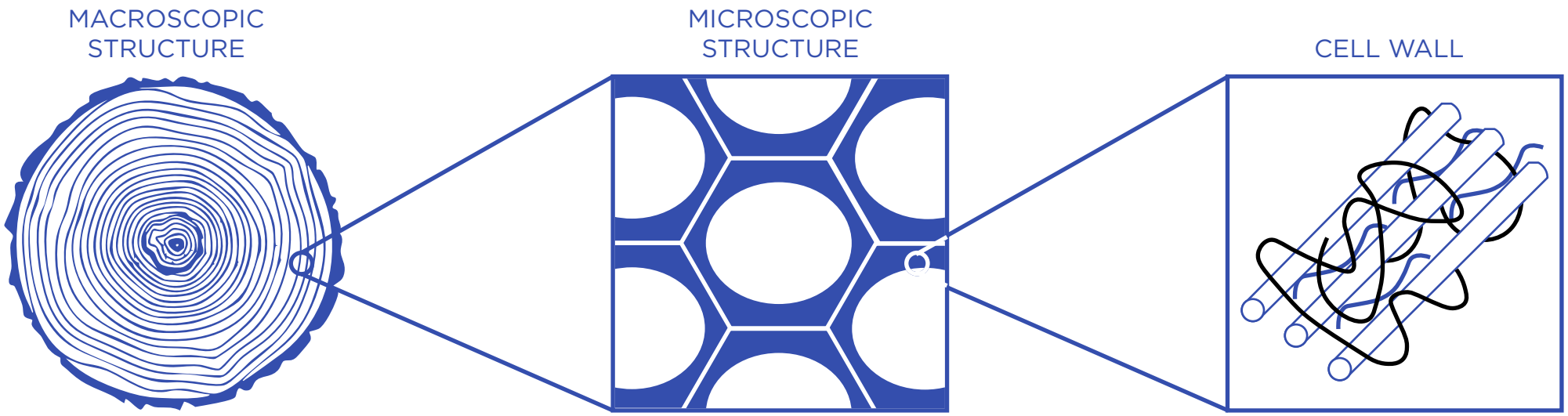
"**Welding** is a process where two or more surfaces are fused together, either with **time and heat, pressure** or all three."

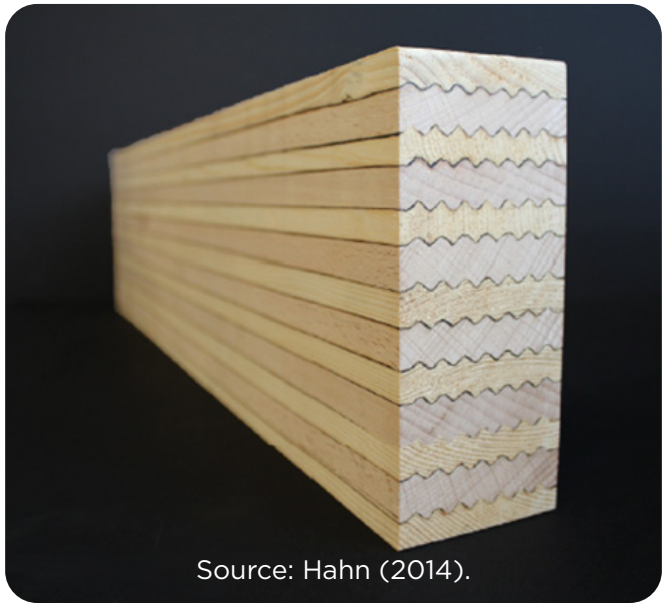
⟶ Mostly done on metals and thermoplastics, however **also possible on wood**

Possible thanks to the **glass transition temperature** of **lignin and hemicellulose.**

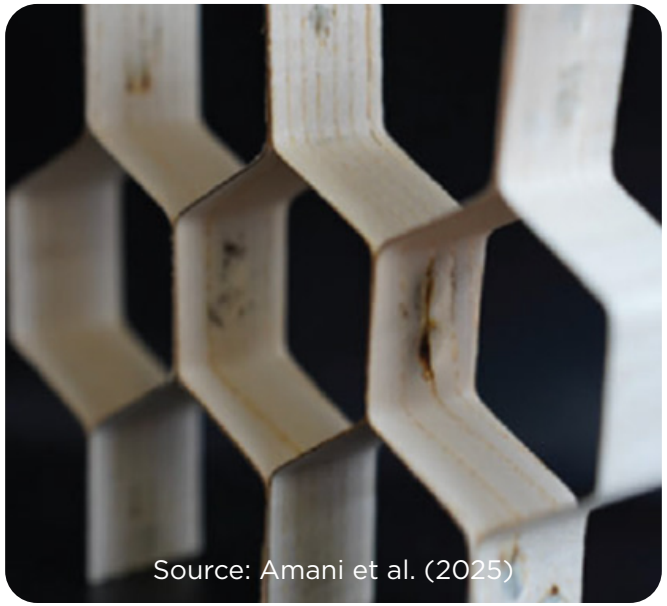


Based on Yuan, Z., Dai, W., Zhang, S., Wang, F., Jian, J., Zeng, J., & Zhou, H. (2022).

DIFFERENT WOOD WELDING TECHNIQUES



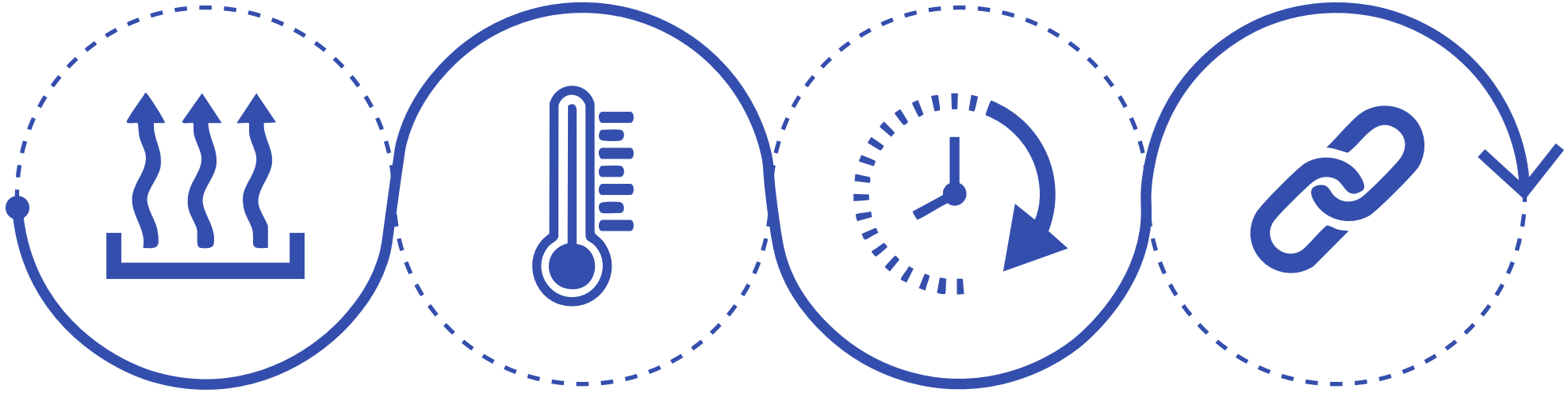
FRICTION WELDING



ULTRA-SONIC WELDING

HOT-PRESSURE WELDING

HOT-PRESSURE WELDING PROCESS



Adding pressure and heat

Melting lignin and hemicellulose

Keeping pressure

Succesfull weld

MAIN RESEARCH QUESTION:

"Can **hot pressure welded wood** be an **alternative** to synthetic adhesives in **EWPs** that are used in the built envirnoment?"

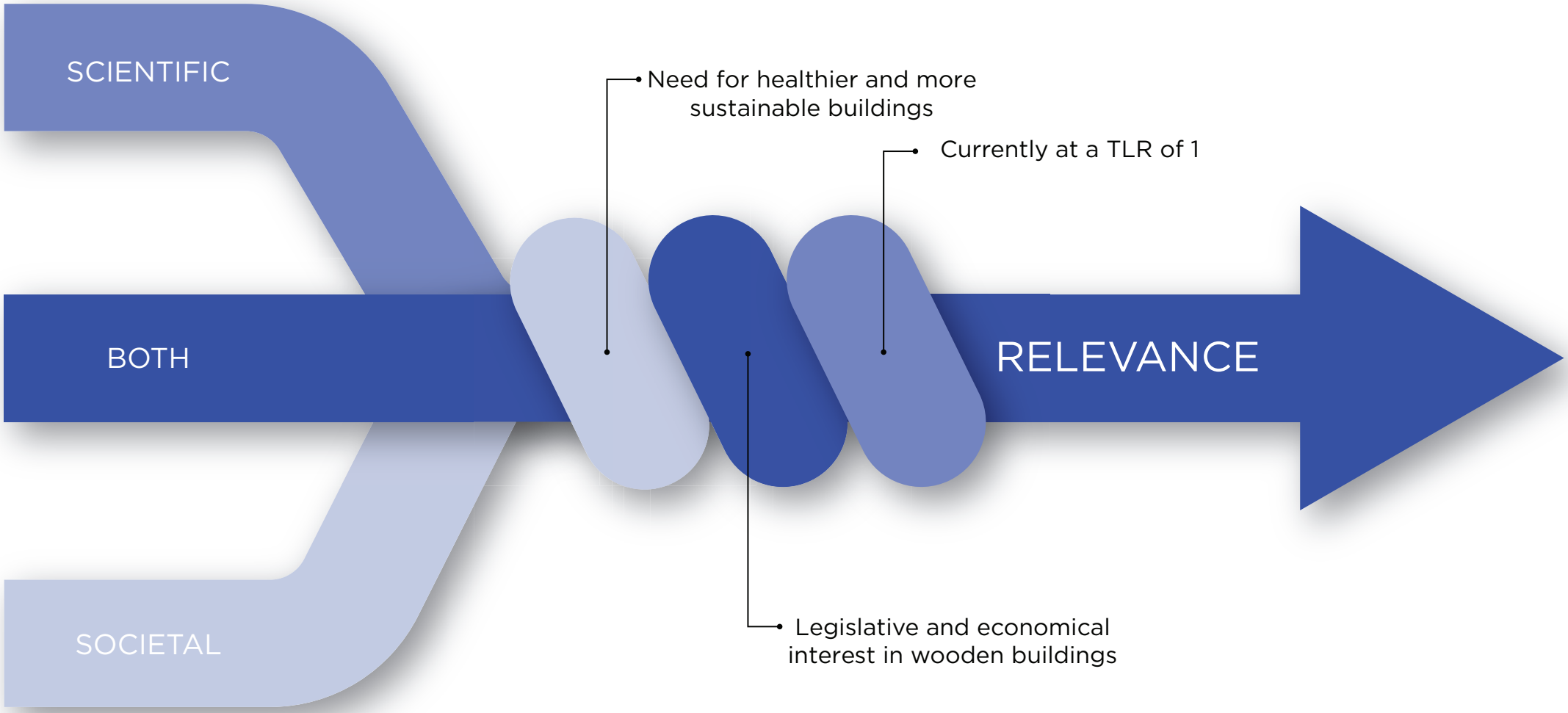
Sub-question 1:
“What is hot pressure welded wood?”

Sub-question 2:
“What are the performance requirements for EWPs in the built environment?”

Sub-question 3:
“Under which parameters can hot-pressure welded wood be manfactured?”

Sub-question 4:
“What is the performance of hot pressure welded wood?”

Sub-question 5:
“Is the performance sufficient for use in the built environment and what applications are feasible?”


SCIENTIFIC
BOTH
SOCIETAL
Need for healthier and more sustainable buildings
Currently at a TLR of 1
Legislative and economical interest in wooden buildings
RELEVANCE

METHODOLOGY

Due to the **underdevelopment** of hot pressure welded wood, the research is **explorative** by nature.

EXPERIMENTS

MANUFACTURING
TESTS

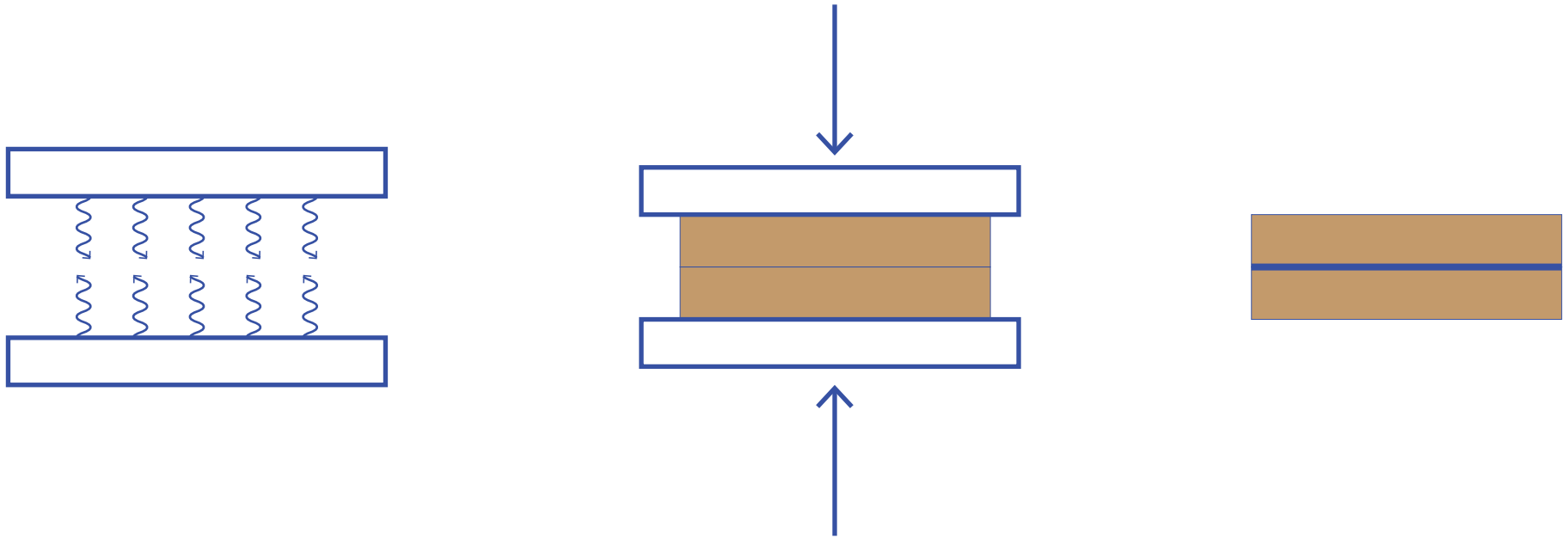
MOISTURE PERFORMANCE
TESTS

MANUFACTURING EXPERIMENTS

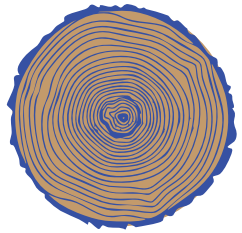
What are the parameters under which complete welds can be manufactured?

MANUFACTURING EXPERIMENTS

SET-UP

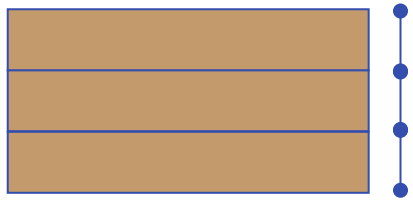


MANUFACTURING EXPERIMENTS
PARAMETERS

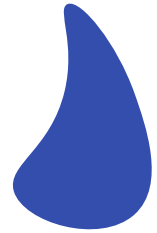


WOOD SPECIES

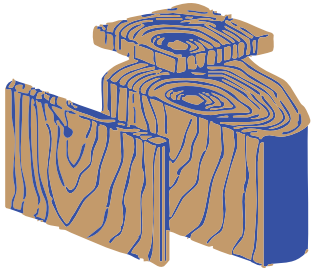
DIMENSIONS OF WOOD



NUMBER OF LAYERS

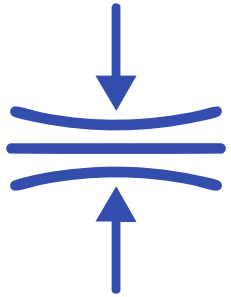


SURFACE TREATEMENT



WOOD GRAIN ORIENTATION

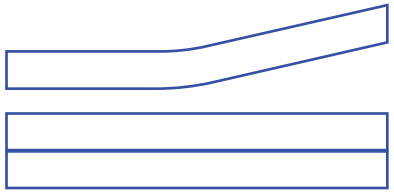
TEMPERATURE MACHINERY



PRESSURE MACHINERY

TIME

MANUFACTURING EXPERIMENTS
ASSESSMENT



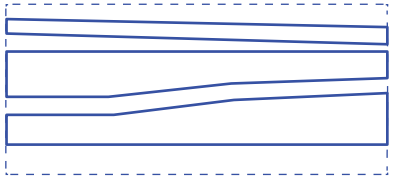
1: COMPLETE DELAMINATION

1: NO SPLINTERING OR EXPANSION

2: PARTIAL DELAMINATION

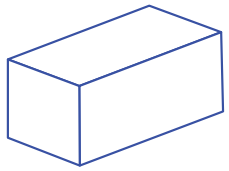
2: LITTLE SPLINTERING OR EXPANSION

3: NO DELAMINATION



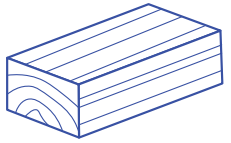
3: COMPLETELY DETERIORATED SURFACE

MANUFACTURING EXPERIMENTS
PROCESS

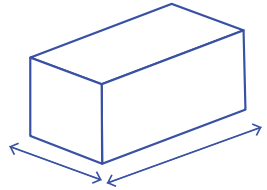


MATERIAL PROPERTIES

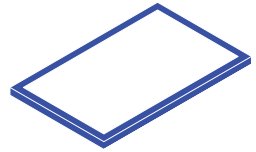
MACHINERY SETTINGS



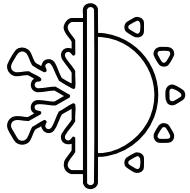
CROSS-GRAIN



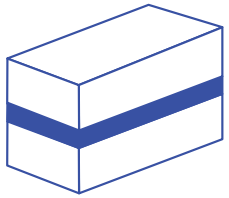
UPSCALING



MOULD PRESSING

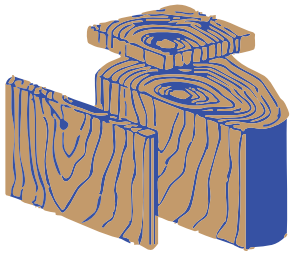


CONTROLLED COOLING/HEATING

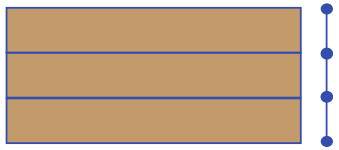


SANDWICH PANELS

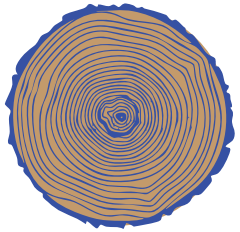
MANUFACTURING EXPERIMENTS
MATERIAL PROPERTIES



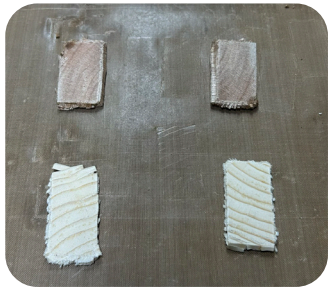
The **end grain** samples yielded more **complete** welds than cross-grain samples.



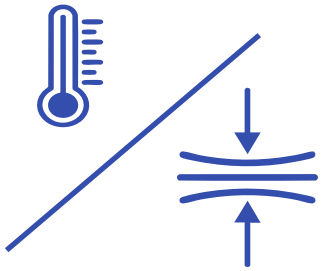
The **thicker samples** had **more deterioration** at the edges.



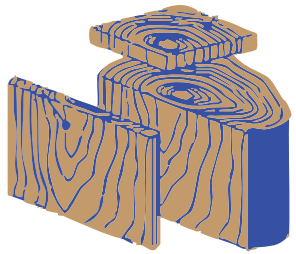
The **meranti** wood samples showed **more deterioration** than the pine wood.



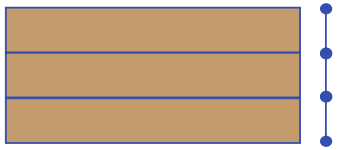
MANUFACTURING EXPERIMENTS
MACHINERY SETTINGS



The **balance** between **temperature and pressure**, otherwise deterioration or decoloration.

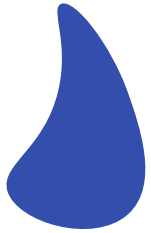


Cross-grain samples benefit from **higher temperature.**



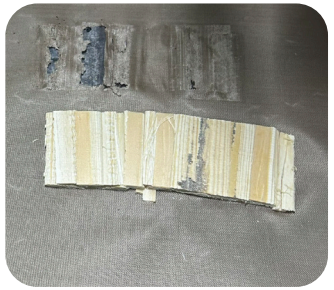
The **middle layer** appears to soften and to be partially **absorbed**.

MANUFACTURING EXPERIMENTS
CROSS-GRAIN SAMPLES

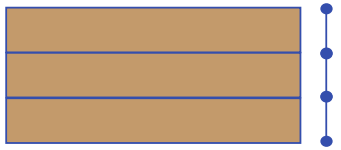


The **addition of lignin** appeared to visually **improve** weld quality.

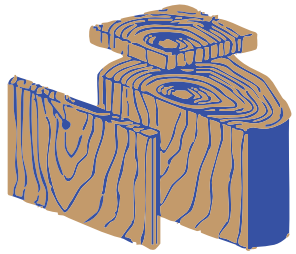
The incorporation of **ridges** in thicker sections **did not** contribute to stronger **weld** formation.



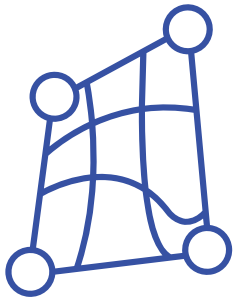
MANUFACTURING EXPERIMENTS
UPSCALED SAMPLES



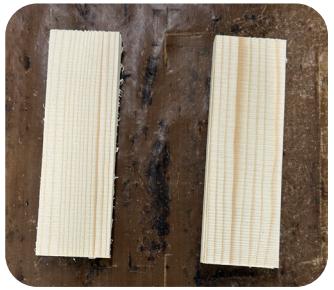
There is **little deterioration** at the edges of the bigger samples.



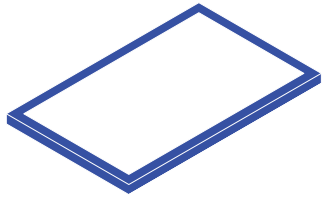
End-grain samples showed **complete** welds.



All samples got **warped** when taken out of the heat press.



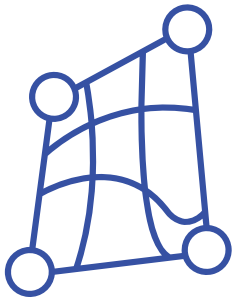
MANUFACTURING EXPERIMENTS
MOULD PRESSING



The **mould** did **mitigate** the splintering at the edges.

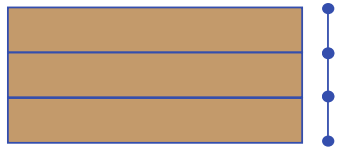
MANUFACTURING EXPERIMENTS
CONTROLLED HEATING AND COOLING

No complete welds occured.

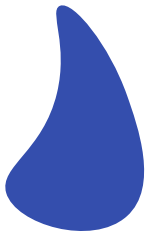


No warping was observed across all samples.

MANUFACTURING EXPERIMENTS
SANDWICH



No complete welds were achieved, even when thickness varied.

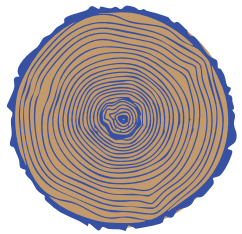


Additional lignin contributed to **better welds** between layers.

MANUFACTURING EXPERIMENTS

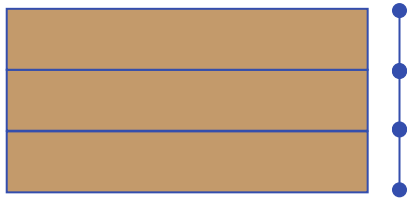
What are the parameters under which complete welds can be manufactured?

MANUFACTURING EXPERIMENTS
RESULTS

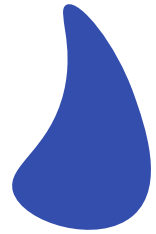


WOOD SPECIES
PINE

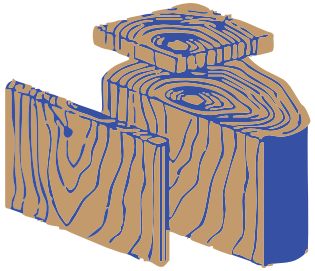
DIMENSIONS OF WOOD
THIN VENEERS



NUMBER OF LAYERS
3-5 LAYERS

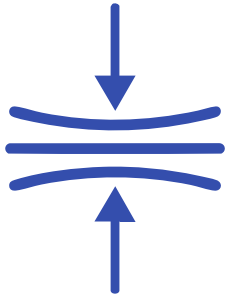


SURFACE TREATEMENT
ADDITIONAL LIGNIN



WOOD GRAIN ORIENTATION
CROSS/END

TEMPERATURE MACHINERY
125 °C



PRESSURE MACHINERY
50 bar

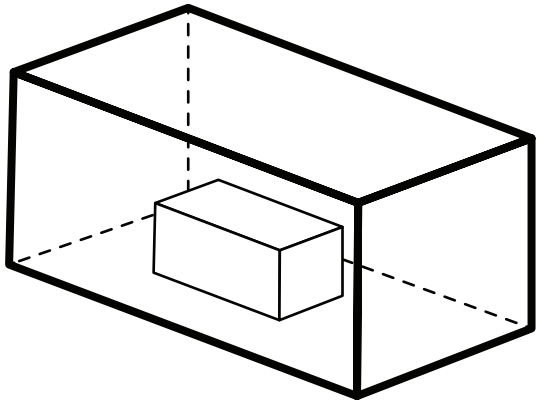
TIME

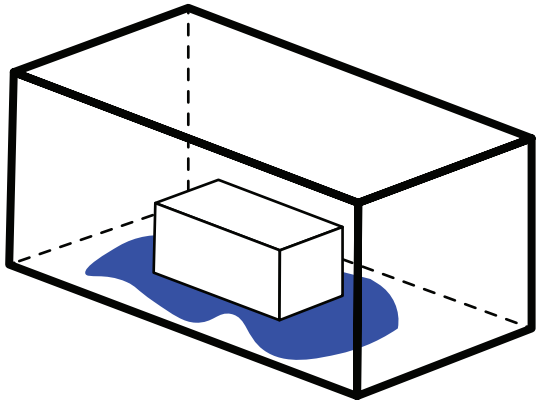
15 MINUTES, CONTROLLED COOLING

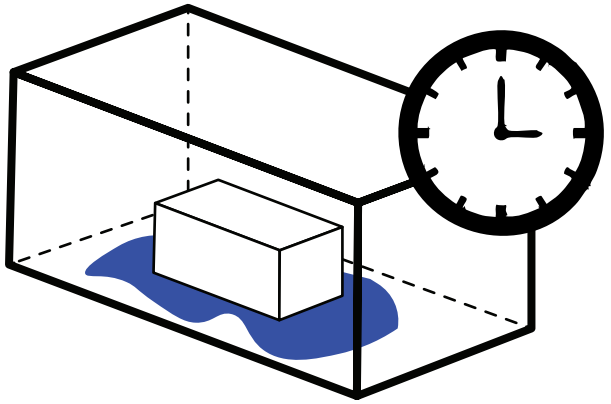
PERFORMANCE TESTS

What is the performance of hot-pressure welded wood?

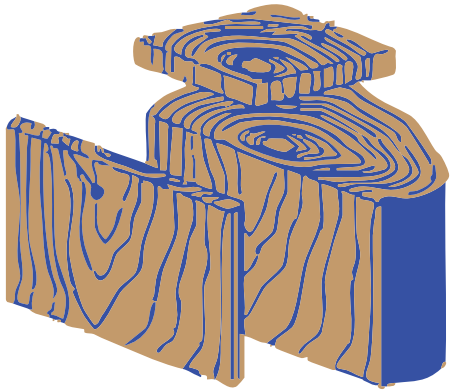
MOISTURE PERFORMANCE
SET-UP







MOISTURE PERFORMANCE
PARAMETERS

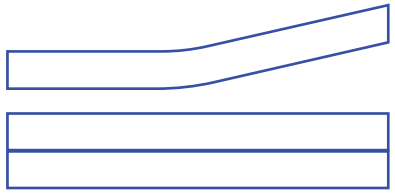


WOOD GRAIN ORIENTATION

CONNECTION METHOD (GLUE OR WELD)

TIME

MOISTURE PERFORMANCE ASSESSMENT



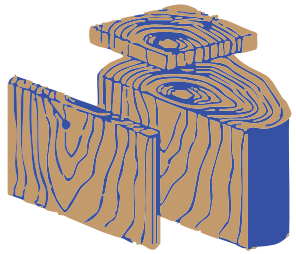
1: COMPLETE DELAMINATION

2: PARTIAL DELAMINATION

3: NO DELAMINATION

MOISTURE PERFORMANCE

After 0 hours

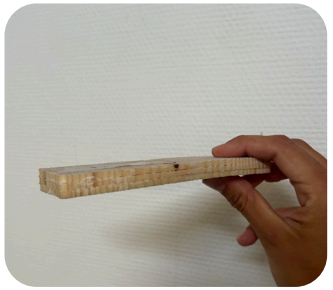


End-grain samples showed **immediate delamination** after being exposed.

MOISTURE PERFORMANCE

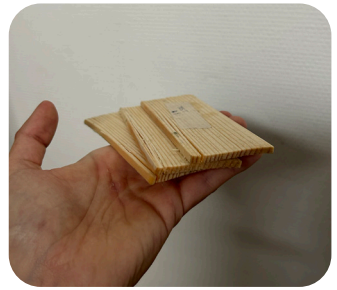
After 24 hours, 72 hours and 10 days

Glued samples showed **no delamination** or deterioration.



Sample with **addtional lignin** showed less delamination.

Welded samples **delaminated** completely and **deteriorated**.



VALIDATION

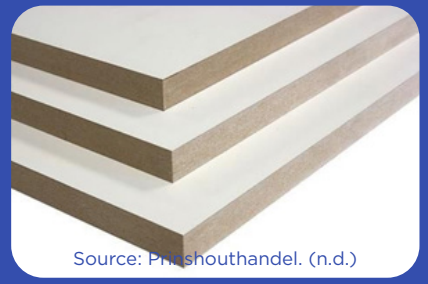
Is the performance sufficient for use in the built environment and what applications are feasible?

POSSIBLE EWP APPLICATION

PARTICLEBOARD

Source: Bord Australia (n.d.)

MDF/HDF



Source: Prijshouthandel. (n.d.)

OSB

Source: Eco-logisch (n.d.)

LVL

Source: Pollmeier (n.d.)

PLYWOOD

Source: PlyDirect (n.d.)

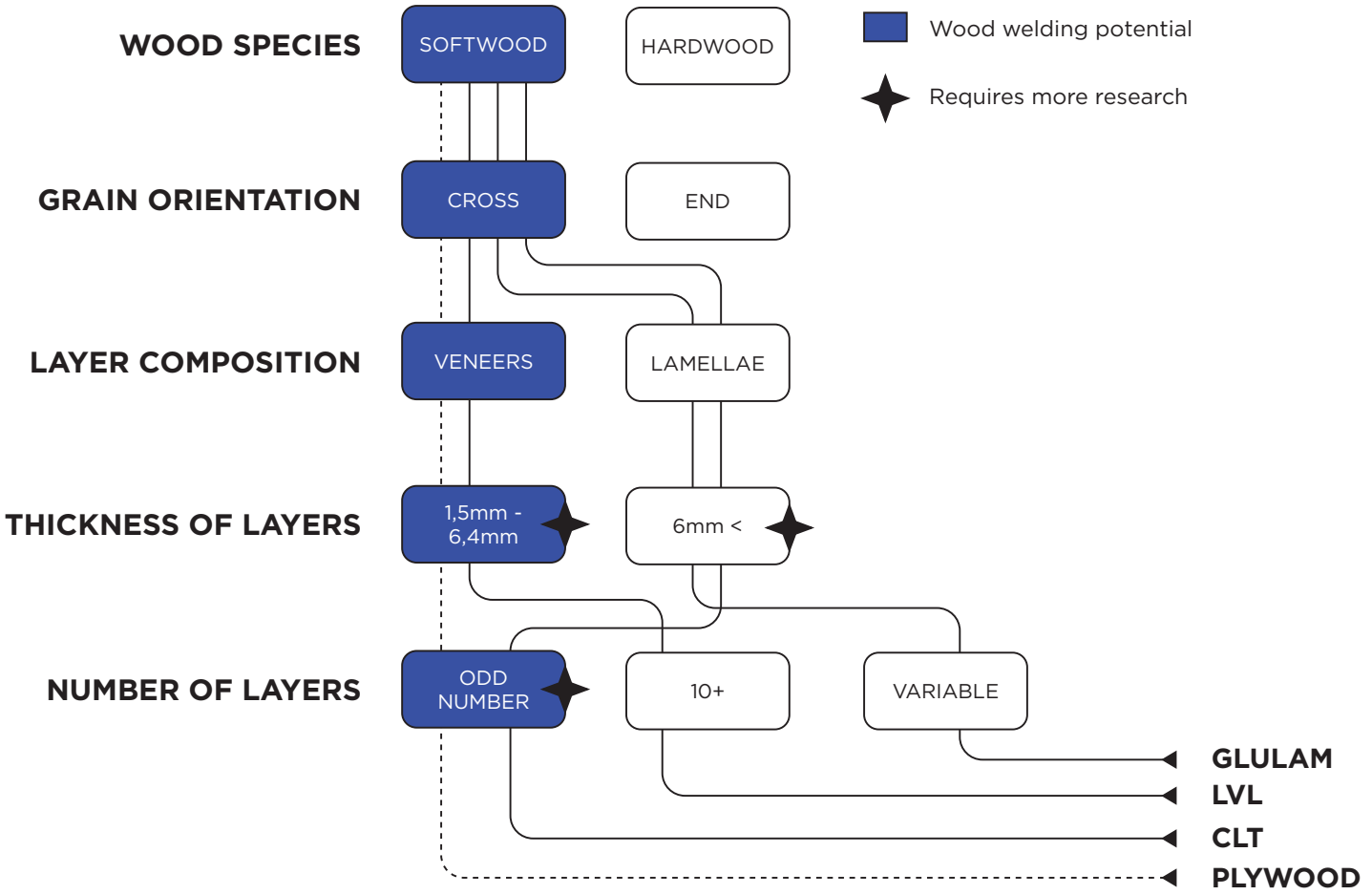
GLULAM

Source: Timber Building Specialist (n.d.)

CLT

Source: Woodtec (n.d.)

POSSIBLE EWP APPLICATION

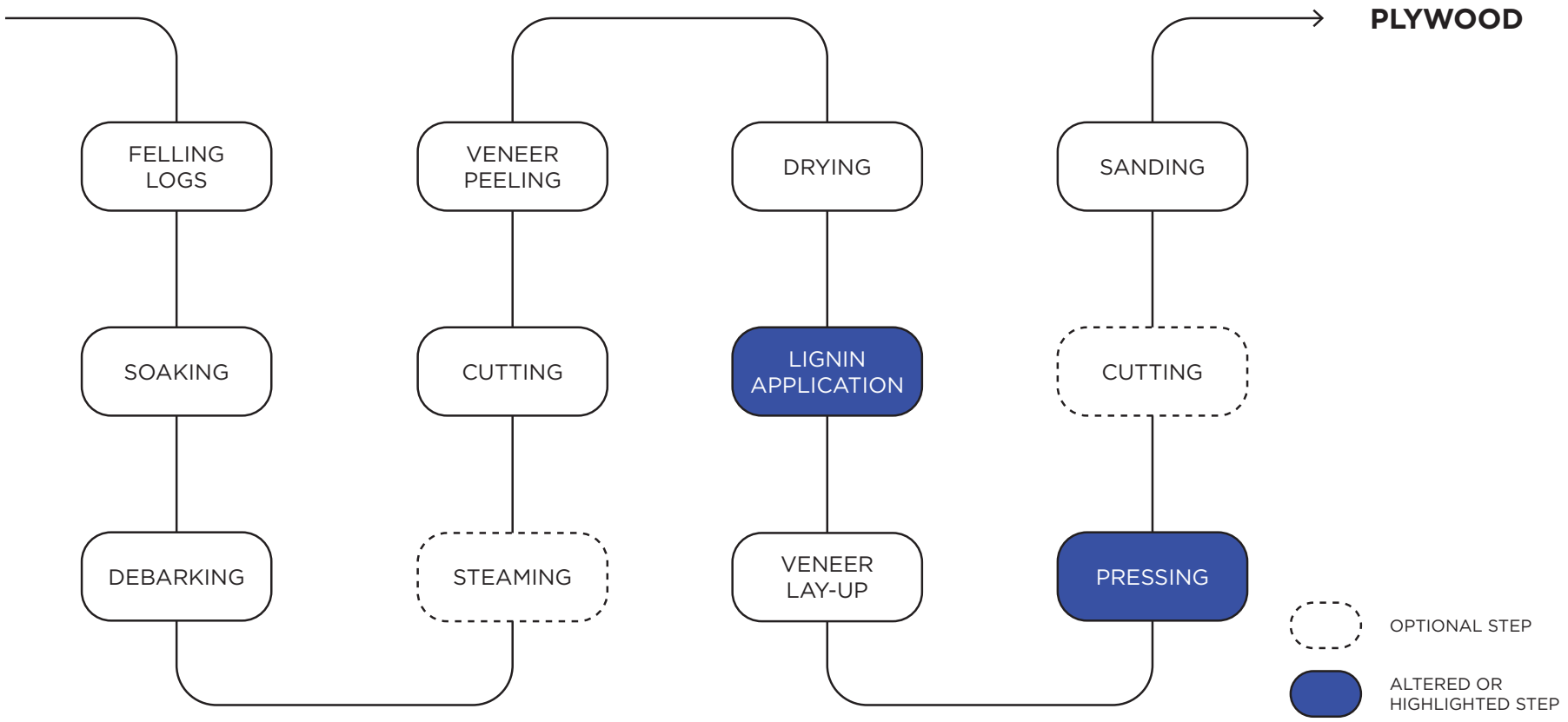


POSSIBLE EWP APPLICATION
MINIMUM VIABLE PRODUCT

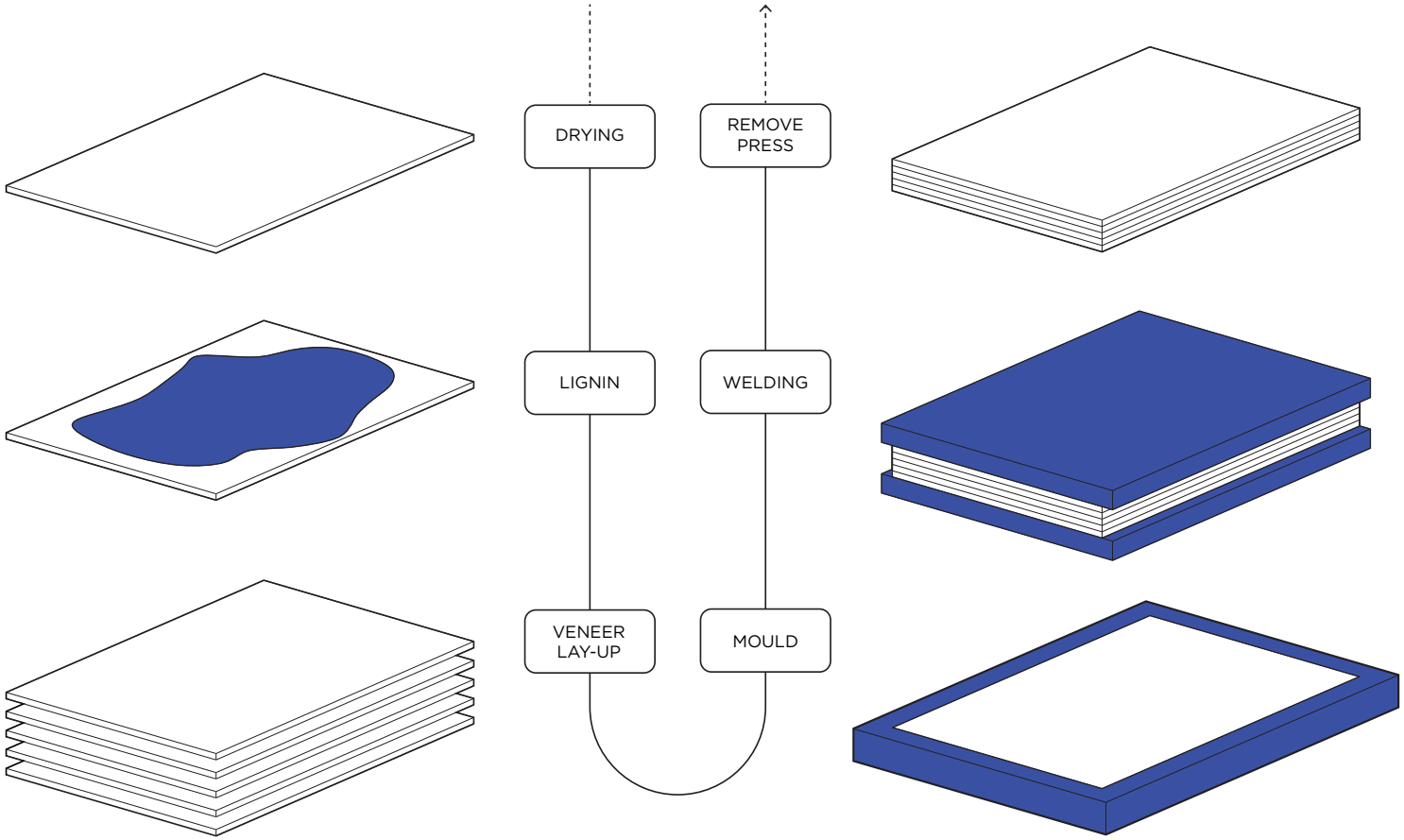
PLYWOOD

Source: PlyDirect (n.d.)

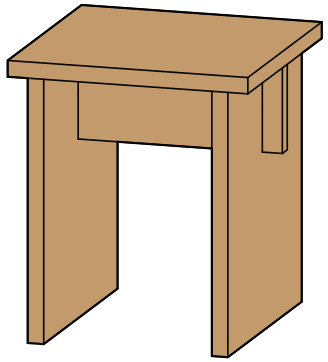
POSSIBLE EWP APPLICATION
MANUFACTURING



POSSIBLE EWP APPLICATION
MANUFACTURING

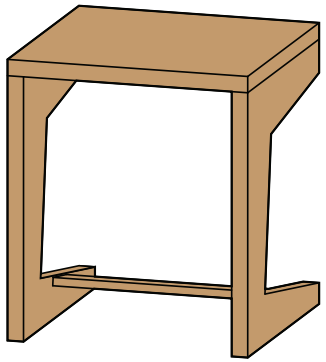


PROOF-OF-CONCEPT
CHAIR



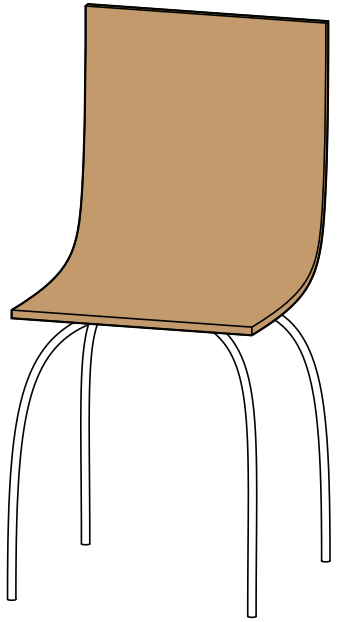
PLATED CHAIR

WELDED WOOD AS AN EWP



CANTILEVER CHAIR

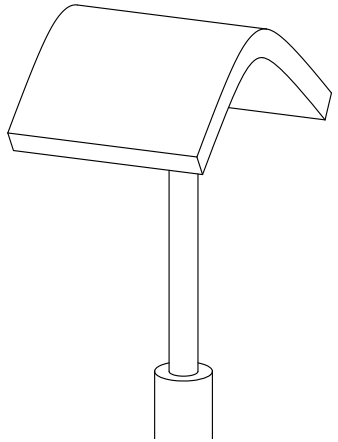
WELDED WOOD WITH HIGH PERFORMANCE



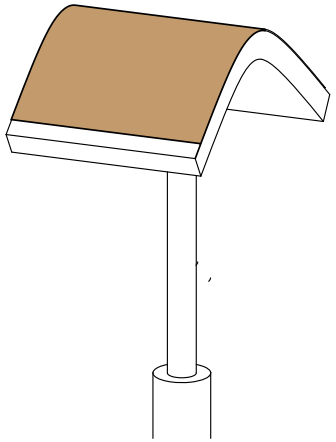
CURVED CHAIR

WELDED WOOD WITH UNIQUE MANUFACTURING PROCESS

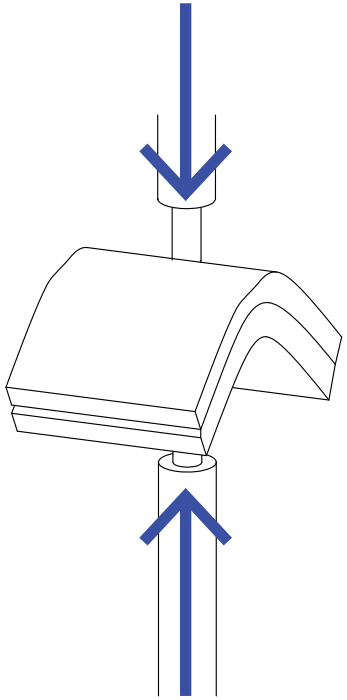
PROOF-OF-CONCEPT
MANUFACTURING



HEATED MOULD



ADD VENEERS



PRESS WITH HEATED TOP MOULD

PROOF-OF-CONCEPT
MANUFACTURING

MOULD MANUFACTURING

DETAIL MANUFACTURING

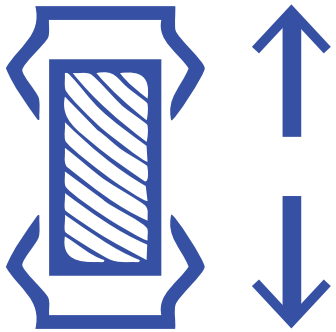
MAIN RESEARCH QUESTION:

"Can **hot pressure welded wood** be an **alternative** to synthetic adhesives in **EWPs** that are used in the built envirnoment?"

CONCLUSIONS

At the **current TRL**, **hot-pressure welding** is **not a viable alternative** to replace synthetic adhesives in EWPs. More development and research is needed.

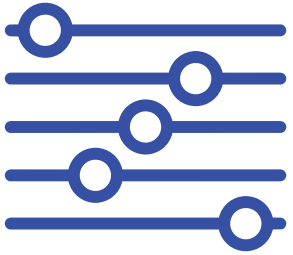
CONCLUSIONS
LIMITATIONS



NO MECHANICAL TESTING

TOO FEW SAMPLES

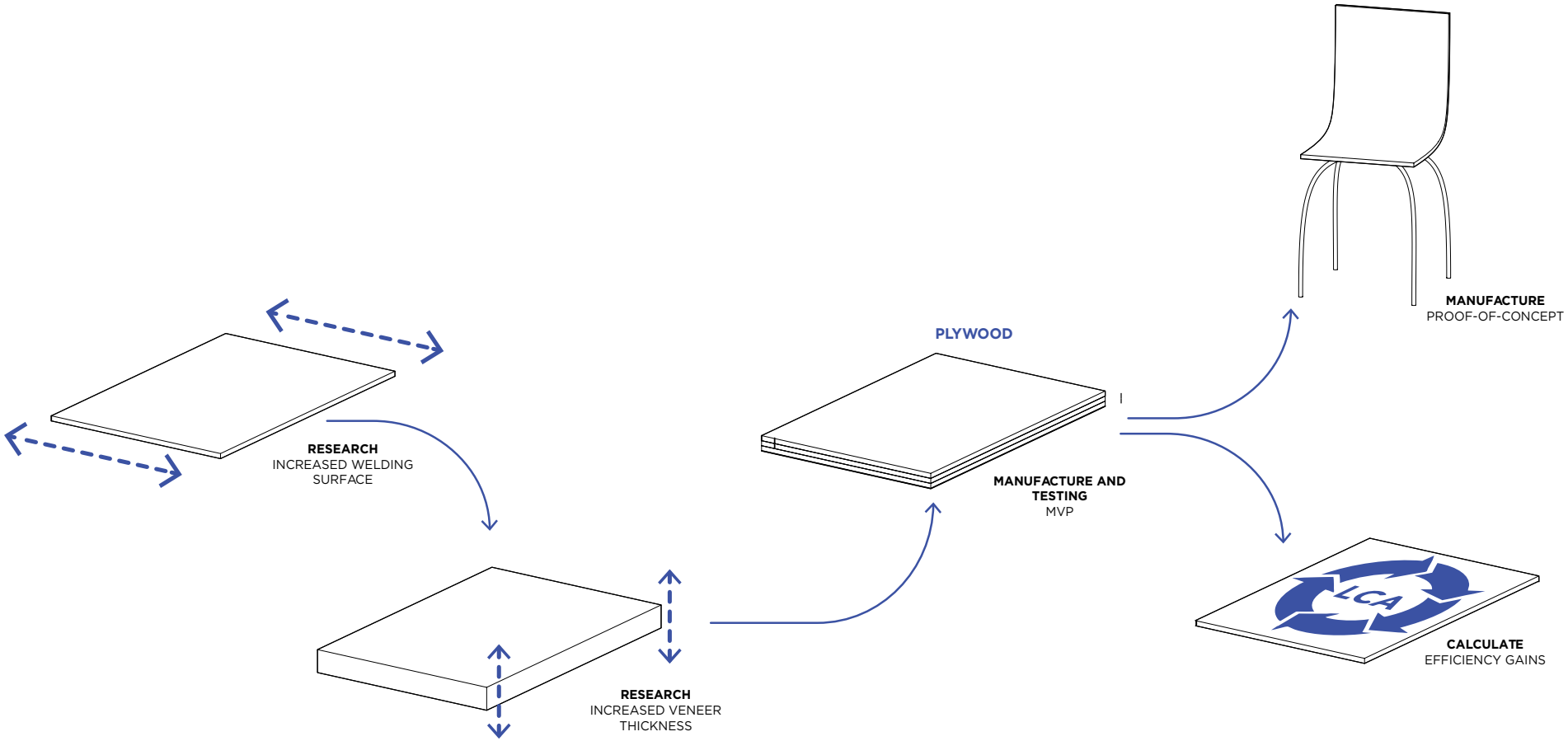
UNPROVEN EXPLANATIONS



UNDEFINED PARAMETERS

UNCLEAR ENVIRNOMENTAL
AND HEALTH IMPACTS

CONCLUSIONS
RECOMMENDATIONS



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SLIDE 10:
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