

HARDWOOD MASS TIMBER

OVERVIEW ON THE PROCESSES, THE PRODUCTS, THE PEOPLE, AND THE POTENTIAL

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**Natural Resources
Research Institute**
UNIVERSITY OF MINNESOTA DULUTH
Driven to Discover



Thanks for the help!

- Omar Espinoza – University of Minnesota – Twin Cities
- Ben Herzog – University of Maine
- David DeVallance – University of West Virginia
- Patricia Layton – Clemson University
- Peggi Clouston – University of Massachusetts, Amherst
- Xinfeng Xie – Michigan Tech University
- Brian Brashaw – USDA Forest Products Laboratory
- Robert Ross – USDA Forest Products Laboratory
- Al Steele – USDA Forest Service
- Mark Milne – Construction Scotland Innovation Center
- Yogun Kim – I-K Design
- Stafan Siemers – the Beck Fastener Group

Agenda

- Mass Timber (more than CLT)
- CLT Overview
- Hardwood Mass Timber Overview
- Machine Tool Vendor Overview
- Hardwood CLT Research
- U of MN, Maine, WVU, Clemson, & UMass
- How the Softwood Sector Funds the CLT Growth
- Next Steps
- Q & A – discussion over the next two days

Mass Timber

- These products are at the intersection of construction and woodworking!
- Who is better at woodworking – the softwood sector or the hardwood sector?



Image by Thoma



Image provided by Construction Scotland

Glulam



Image by StructureCraft



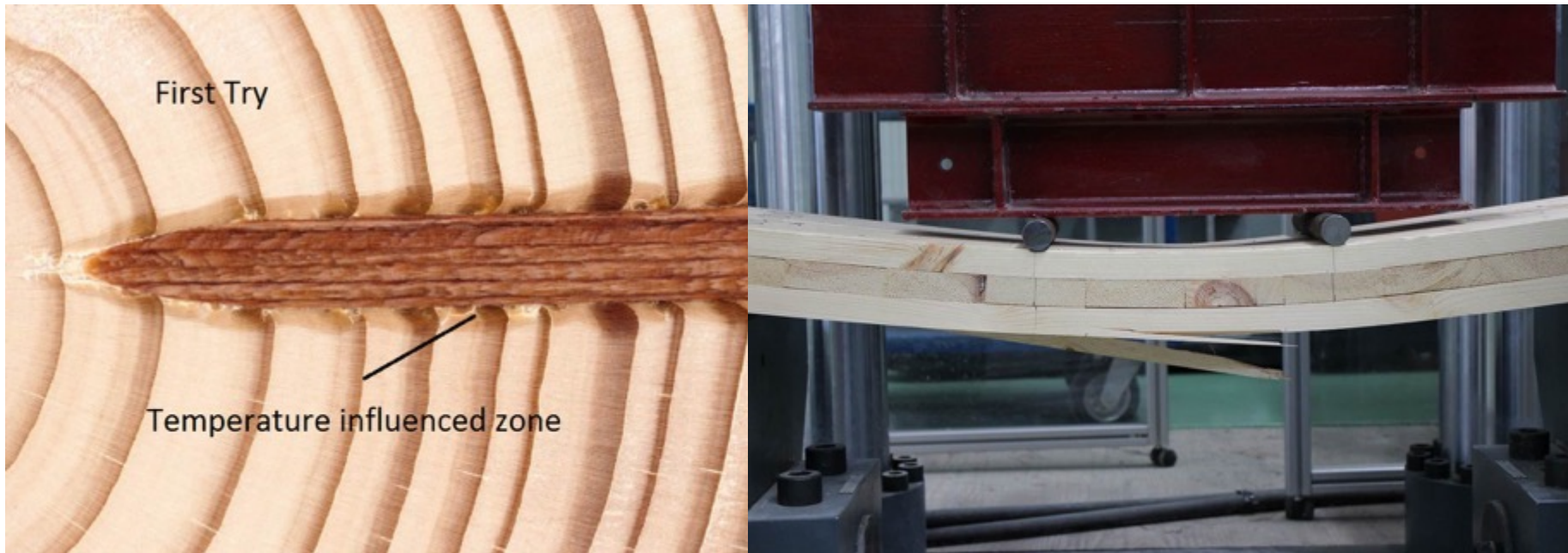
Image by American Wood Council

NAIL LAMINATED



Image by StructureCraft

LIGNOLOC



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Woodwelding

CLT PLYWOOD



Dowel Laminated Timber



Image by Techno Wood



Image by StructureCraft



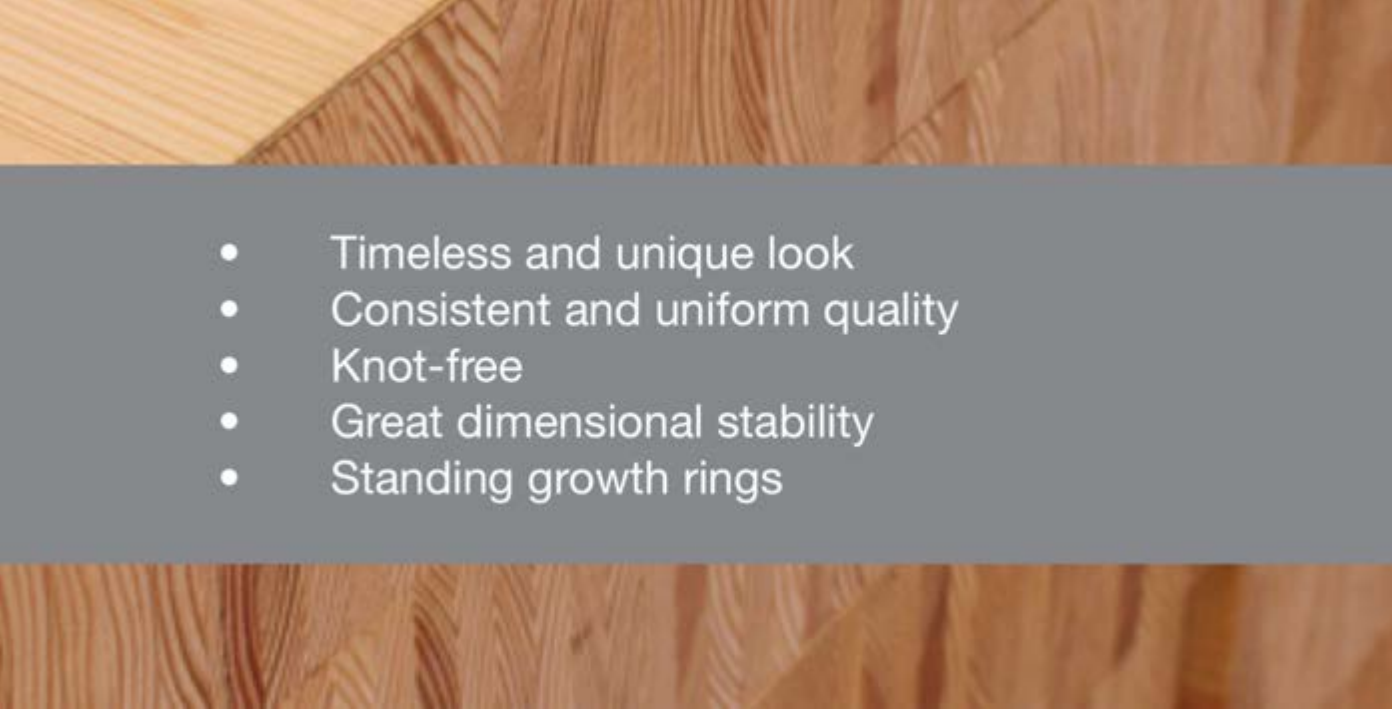
Image by Techno Wood



Image by Techno Wood

Effex Industrial

Modern and sustainable design at its best

- 
- The background of the slide features a close-up, high-resolution image of a wood grain, likely plywood or a similar engineered wood product. The grain is composed of several distinct, slightly wavy lines running diagonally from the top-left towards the bottom-right. The color of the wood is a warm, light brown or tan. Overlaid on the center of this background is a semi-transparent grey rectangular box. Inside this box, there is a bulleted list of five items, each preceded by a small white circular bullet point. The text in the list is white, providing a strong contrast against the grey background of the box.
- Timeless and unique look
 - Consistent and uniform quality
 - Knot-free
 - Great dimensional stability
 - Standing growth rings

CLT Timeline

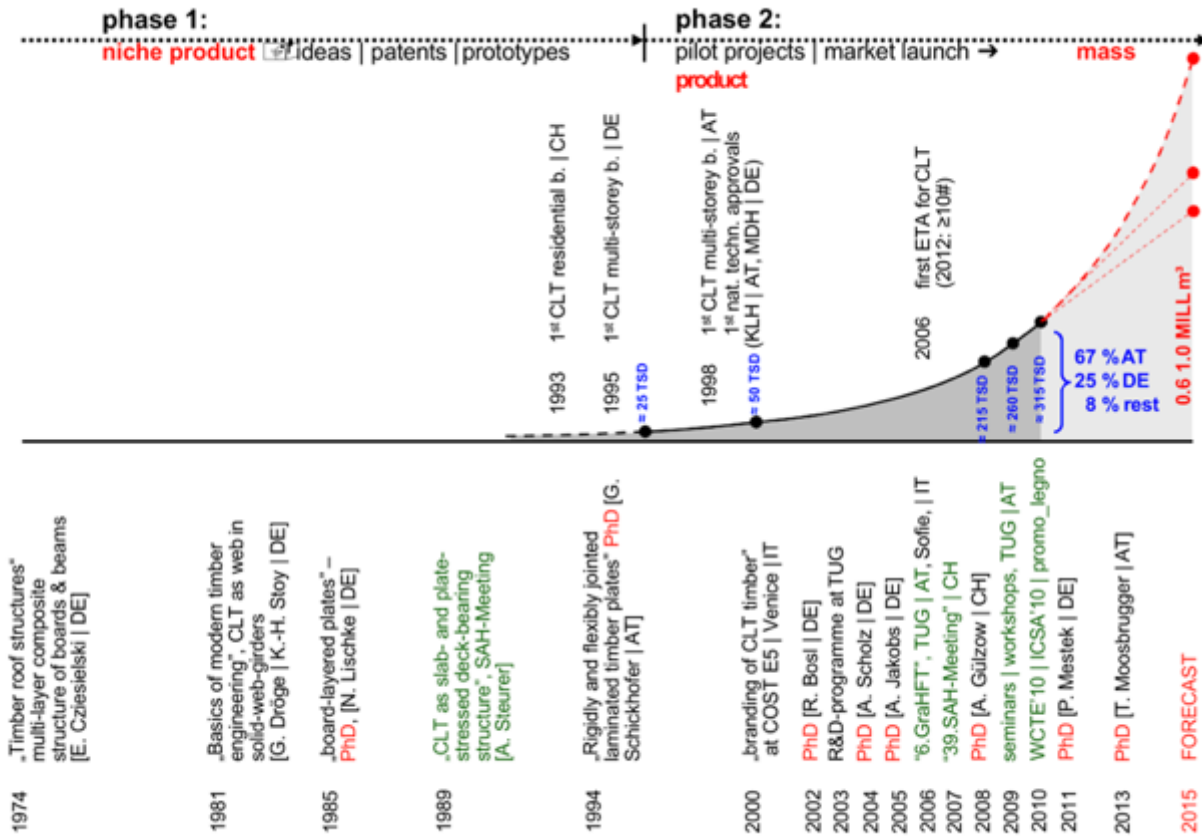


Image by Reinhard Brandner

CLT Process Overview

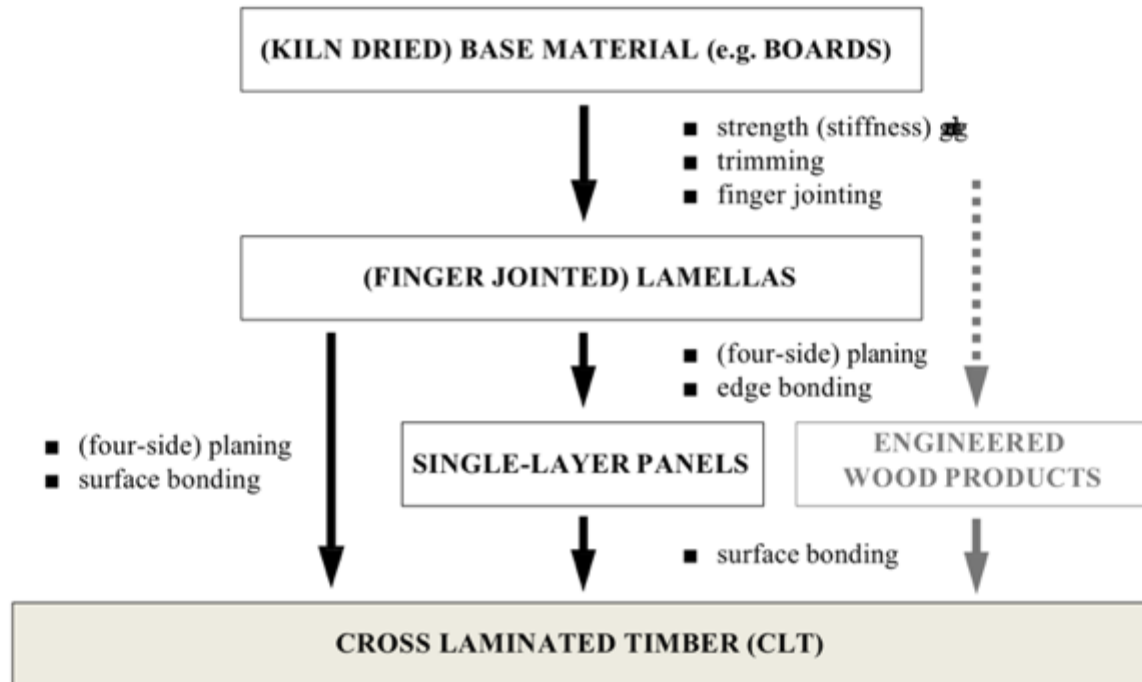


Image by Reinhard Brandner

CLT Benefits

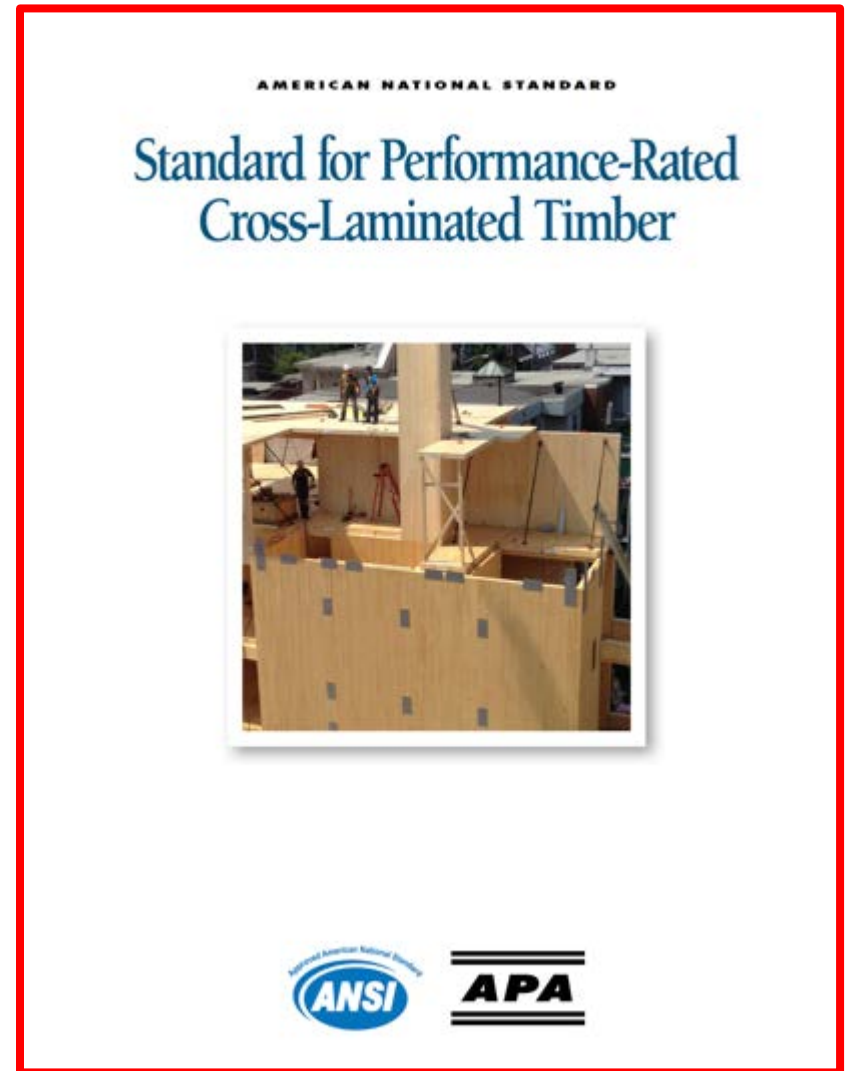
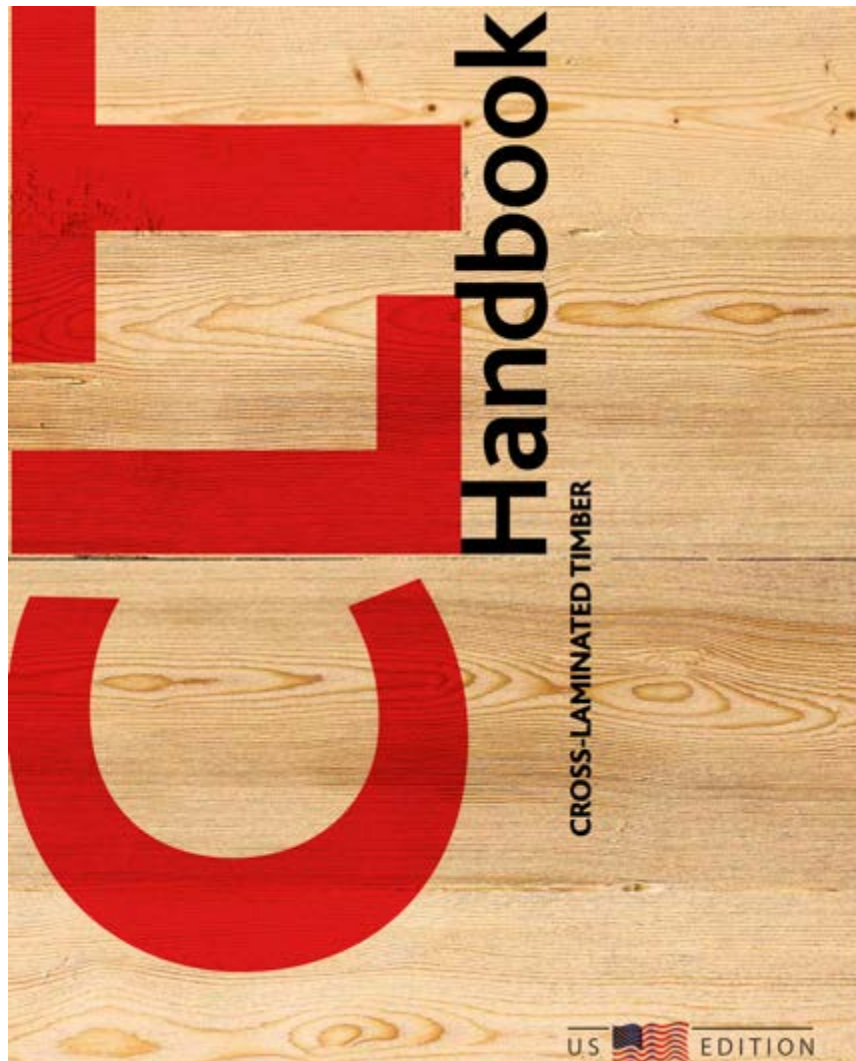
- Generate economic opportunities
- Reduce CO₂ emissions, fossil fuel consumption, increase energy efficiency
- Increase the use of renewable materials
- Create high value-added uses for wood.
- Increase the economic value of forestlands
- Architectural freedom
- Faster, cleaner construction
- Potential incremental volume 5BBF



Credit: MGA

<http://mg-architecture.ca/>

Slide by Omar Espinoza



Adhesives Consideration

- Melamine Urea Formaldehyde (MUF)
 - Hexion
- Polyurethane – Liquid at room temperature (PUR)
 - Henkel
- Emulsion polymer isocyanate (EPI)
 - Franklin

CNC Technology for Connections



- **Computer Numerically Controlled (CNC) connections**
- **Ability to fabricate joints with precision**

CLT Production Line (MUF/EPI)



Images by Reinhard Brandner

CLT Process Line (PUR)

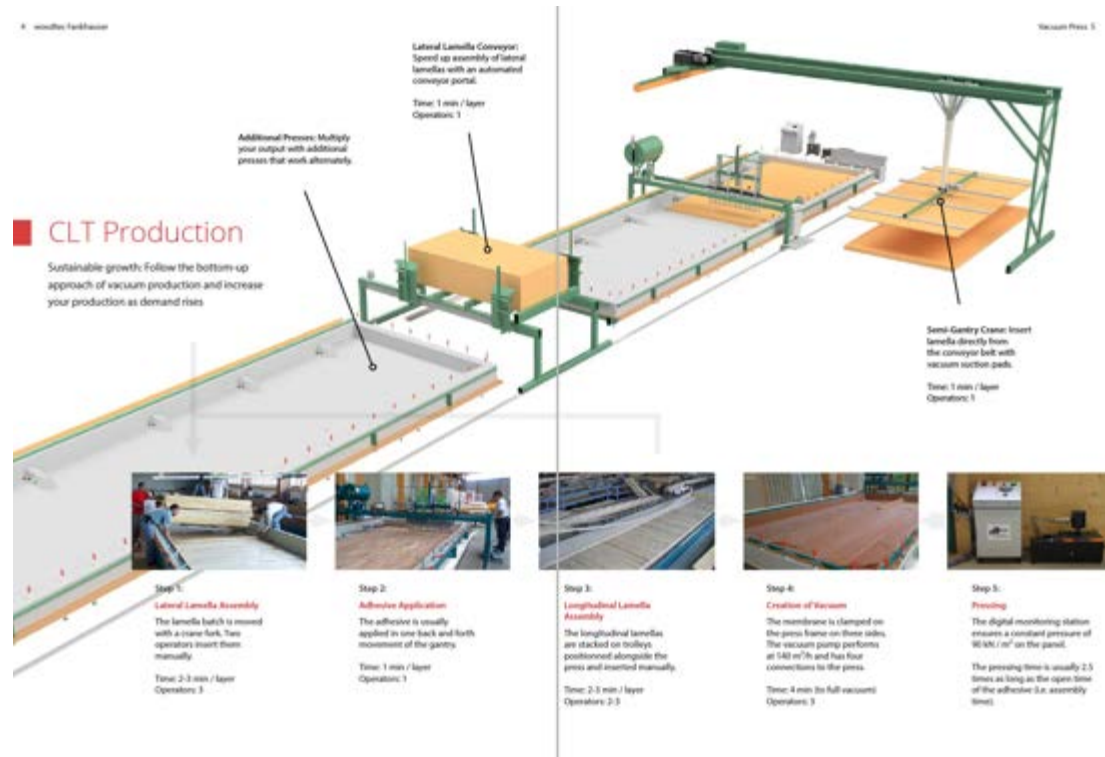


Image by Joulin



Image by WoodTec





HOLZ-HANDWERK

HOLZ-HANDWERK
21-24.03.2018
Nuremberg, Germany

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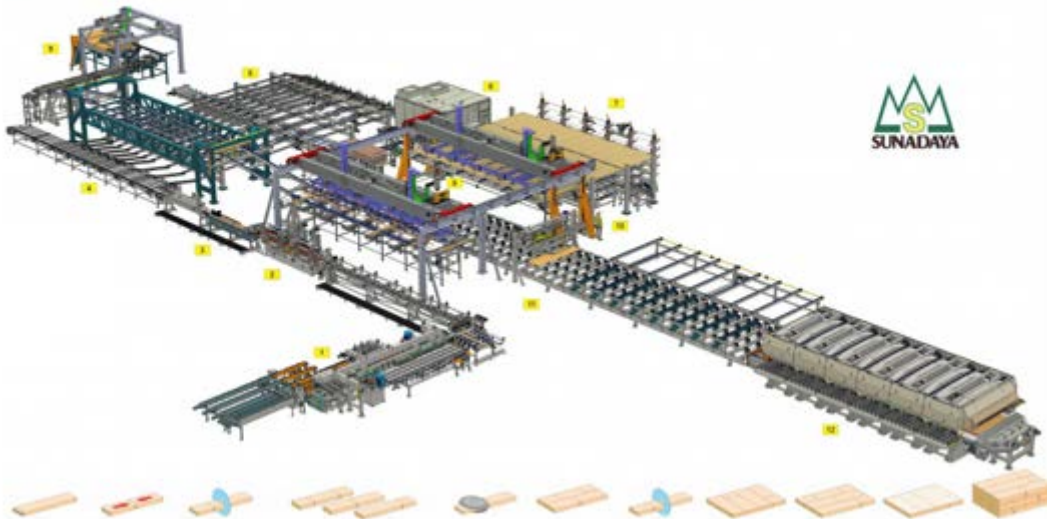
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LEDINEK

PLANING PROFILING FINGER JOINTING ENGINEERED TIMBER SPECIAL AUTOMATION

First complete CLT production from one supplier in Japan at Cypress Sunadaya Co., Ltd. We got the opportunity to supply a CLT production Turnkey solution. The line just recently went into the production stage and will shortly start to supply the domestic market with CLT panels.



Wood

Laminated wood products

Plants and machines

CLT press lines

Glulam press lines

Board press lines

Scantling and small-size
glulam press linesHandling equipment and
stand-alone machines

System solutions

Energy

Industry

Plants and machines

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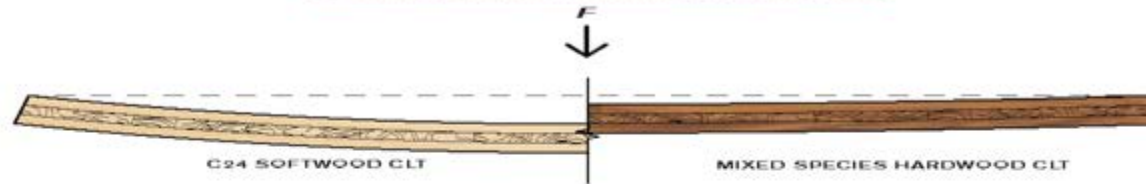
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- Solutions prepared for the future, with the possibility for online optimization of an installation
- Reliable and uniform flow
- Energy saving plants and flexible solutions tailored to your needs.

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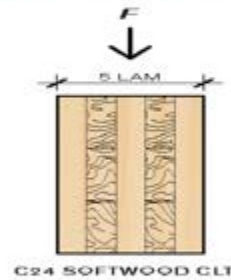


WHY HARDWOOD CLT?

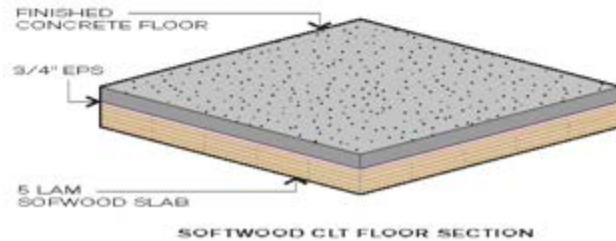
SUPERIOR MECHANICAL PROPERTIES



SAME STRUCTURAL CAPACITY WITH LESS MATERIAL VOLUME



IMPROVED APPEARANCE, DURABILITY AND FIRE RESISTANCE



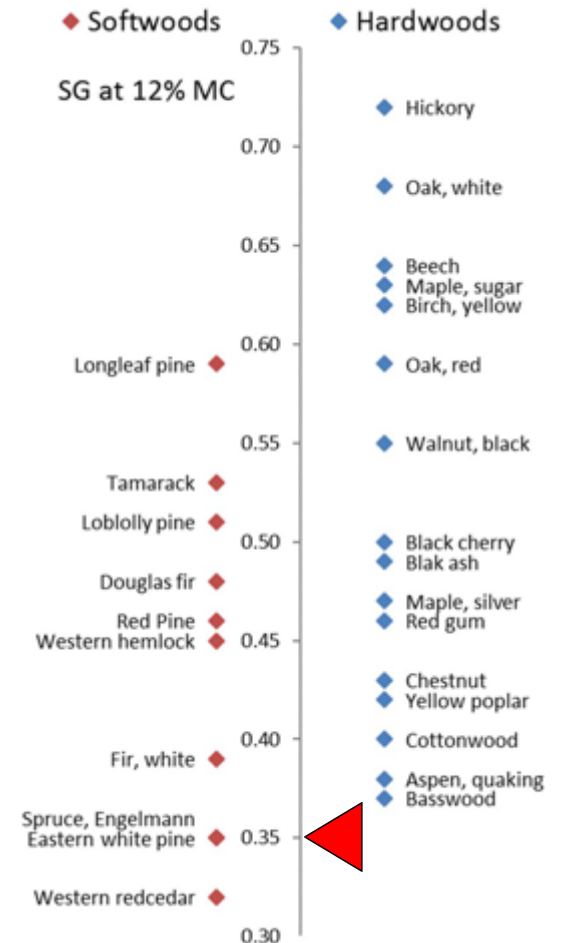
6.1.2 Lumber grades

The minimum grade of lumber in the parallel layers of CLT shall be 1200f-1.2E MSR or visual grade No. 2. The minimum grade of lumber in the perpendicular layers of CLT shall be visual grade No. 3. Remanufactured lumber shall be considered as equivalent to solid-sawn lumber when qualified in accordance with Section 5.4 of ANSI A190.1 in the U.S. or SPS 1, 2, 4, or 6 in Canada. Proprietary lumber grades meeting or exceeding the mechanical properties of the lumber grades specified above shall be permitted for use provided that they are qualified in accordance with the requirements of an *approved agency*.

Note 4. ASTM D5055 provides guidance for proprietary lumber grades used specifically in I-joist applications.

PRG320 - Material Considerations

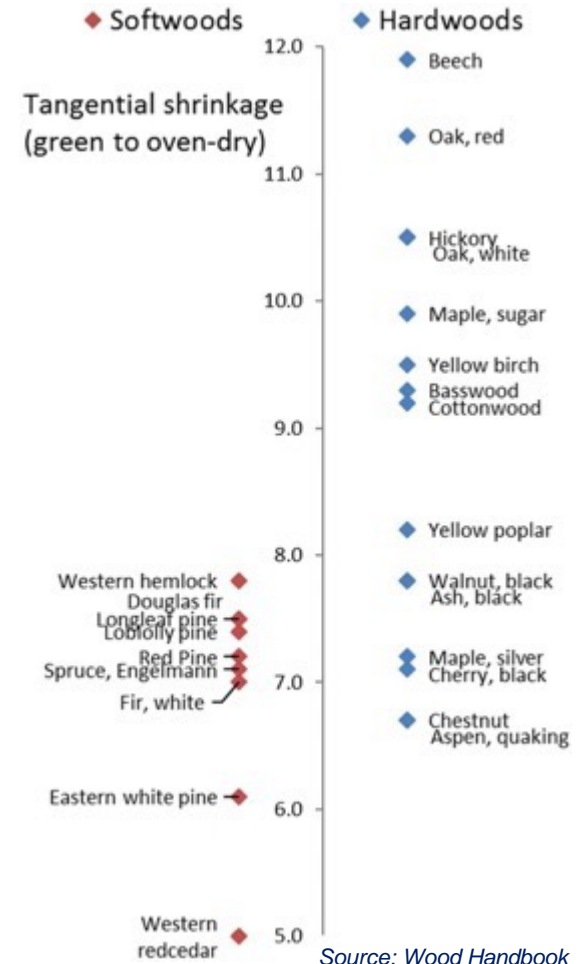
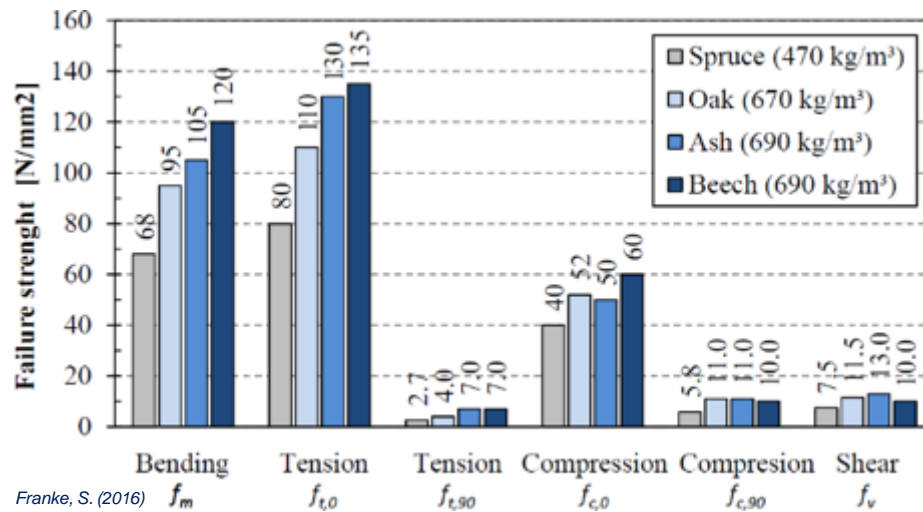
- Any **softwood** recognized by ALSC
- Species: $SG \geq 0.35$
1 per layer
- Grades: #2&btr (//) , #3&btr (□)
- MC: 12 □ 3%
- Most hardwoods have $SG > 0.35$
- Hardwoods typically dried to low MCs



Source: Wood Handbook

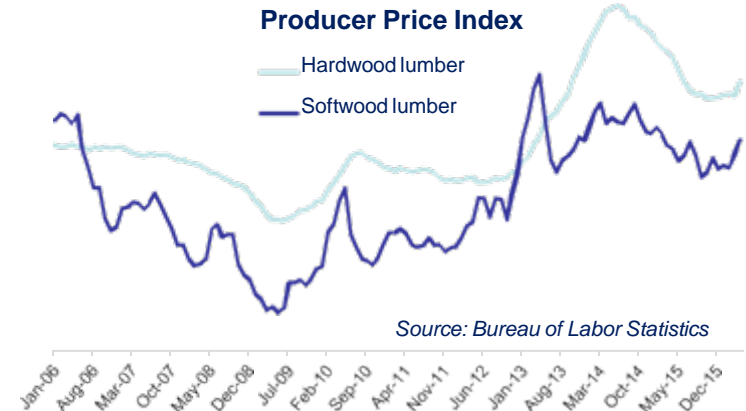
Material Considerations

- Shrinkage (hardwoods ~30% higher)
- Adhesion issues
- Mechanical properties



Cost Considerations

- ⑩ Softwood lumber price: **\$314**
 - – #2&btr West SPF, KD (09.09.2016*)
- ⑩ Hardwood lumber prices: **\$510**
 - – #2Com 4/4 poplar, KD (08.26.2016**)
- Wood is ~**50%** of CLT mfg. costs (glue is 10%)
- Europe: spruce CLT ~\$700/m³; beech ~\$3,200/m³
- CLT in general costs **10-15%** more than steel/concrete
 - However, structural frame is <20% of total building cost



Hardwood CLT - Procurement Issues

- Is there enough wood to sustain a hardwood CLT industry?
- Average western dimension mill capacity ~180MMBF
- Considering width-thickness ratios, process factors, and lumber prices, some sizes and grades are favored.
- One large CLT plant (~24MMBF**) needs access to ~5 average dimension mills' supplies.
- However, average hardwood sawmill capacity ~6.7MMBF*
 - How much of mill's output suitable for CLT?

Birch CLT - Austria

- Hasslacher Norica Timber / TU Graz
- Birch (*Betula pendula*)
- $\rho_{12\%MC} = 594 \text{ kg/m}^3$ (37 lb/ft³)
- n=20, 5-ply, x-section ~24x8 in, MUF
- Tested according EN 1995-1-1
 - MOE = 15,524 MPa (COV=4.3%)
 - MOR = 38 MPa (COV=11.6%)
 - Tensile strength of joints 55.7 MPa
 - Compressive strength $\sigma_c = 5.8 \text{ MPa}^2$



HASSLACHER
NORICA TIMBER

Slide by Omar Espinoza

Beech CLT - Switzerland

- Bern University of Applied Sciences
- European beech (*Fagus sylvatica*)
- $\rho = 690 \text{ kg/m}^3$ (43 lb/ft³)
- $n=13$, 120 mm (4¾ in), layers=various
- Values higher than spruce CLT, especially rolling shear (~5x), bending (1.7x) and compression perpendicular to grain (~5x).



UMaine – Advanced Structures and Composite Center

- 100,000 ft² R&D facility
- Established in 1996 – Current lab opened 2000
- ~\$160 million in contracts since 2001
- More than 500 industrial clients 60 full-time staff/faculty
- 25 graduate/75 undergraduate students



Mass Timber – UMaine's Objectives

- To become the leader in the Northeast U.S. for Mass Timber information, R&D, and commercialization facilitation.
- Coordinate efforts answering the important questions that a developer/investor needs answered when considering siting a Mass Timber plant in Maine.
- Put our world-class, ISO 17025 accredited wood composites laboratory to work supporting the Mass Timber industry.
- Educate students (e.g. engineers and wood scientists) to support these emerging technologies



- UMaine ISO 17025 Scope of Accreditation includes PRG 320.
- UMaine staff sit on PRG 320 ANSI Committee.
- February 2018: Two public announcements of CLT manufacturers intending to site facilities in Maine.

For More Information

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Benjamin Herzog
Wood Technologist
(207) 581-2360
benjamin.herzog@maine.edu

DeVallance: CLT Funding Overview

2012: Development of Low-Grade Hardwood Cross-Laminated Timbers (USDA/NIFA), Hovanec – MS degree at WVU

- Focus on yellow-poplar adhesion research

2013: Innovation in Cross Laminated Timbers from Low-Value Hardwoods (WVU Hardwood Research Trust), includes Rafael

- Press system development and adhesion bond testing (mixed species and treated vs non-treated)

2014: Demand and Product Innovations for Green Products Sourced from Appalachian Hardwoods

- Focus on preliminary research and demonstration of full size mixed yellow-poplar and red maple CLT panels including a workshop

Project 1: USDA/NIFA

In 2012, USDA/NIFA awarded a grant titled “Development of Low-Grade Hardwood Cross-Laminated Timbers”

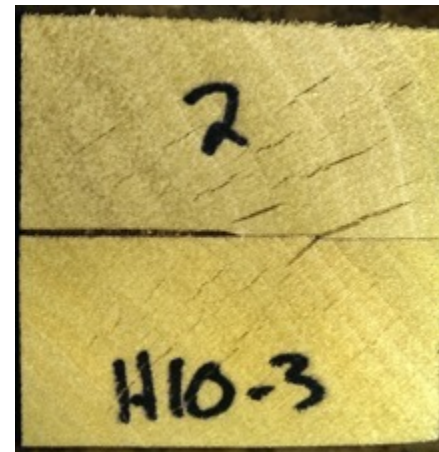
- Low-valued, low-quality yellow-poplar (*Liriodendron tulipifera*) is abundant in the Appalachian Region of the United States, but highly under-utilized
- Collaboration between: Virginia Tech (VT), West Virginia University (WVU), University of Tennessee (UT), and Southern Virginia Higher Education Center (SVHEC)
- Main goal: Develop methods and data that allow for the future use of low-valued hardwoods (in-particular yellow-poplar) in CLT manufacturing

More Information at: <http://www.reeis.usda.gov/web/crisprojectpages/0231112-development-of-low-grade-hardwood-cross-laminated-timbers.html>

Project 1: USDA/NIFA

WVU determined that yellow-poplar adhesion is sufficient to meet APA PRG-320

- Preferred CLT adherends are 1" thick with radial bonding surfaces
- Alternating layers with radial and tangential bonding surfaces could also produce adequate results
- No detectable bond strength and durability of yellow-poplar was equal to (and in many cases greater) than hard pine reference samples



Project 2: Hardwood Research Trust

WVU is currently researching CLTs from mixtures of low-value Appalachian hardwoods through Hardwood Research Trust funding

- Large press arrived June 10, 2016 to begin making large panels in 20-foot length
- Adhesion testing on treated and non-treated Appalachian hardwoods and mixed species was conducted
- Full size CLTs using Yellow-poplar, mixed maple, and other low-grade/value hardwoods: Objective evaluate optimized lay-up, inclusion of mixed species, orientation, NDE and structural grading

Project 3: WERC Project

Title: “Demand and Product Innovations for Green Products Sourced from Appalachian Hardwoods”

US Forest Service, Wood Education Resource Center Grant funded in 2011 and completed in 2016 (CLT was small portion)



Development of CLT panels using low-value, low-quality hardwoods

Hardwood CLT Research Efforts at WVU

Wood Science and Technology Program
and
Appalachian Hardwood Center
Division of Forestry and Natural Resources
West Virginia University, PO Box 6125
Morgantown, WV 26506-6125

Contact: David DeVallance
david.devallance@mail.wvu.edu

304/293-0029

<https://www.davis.wvu.edu/faculty-staff/directory/david-devallance>

Cross Laminated Timber from Low-value Northeastern Woods

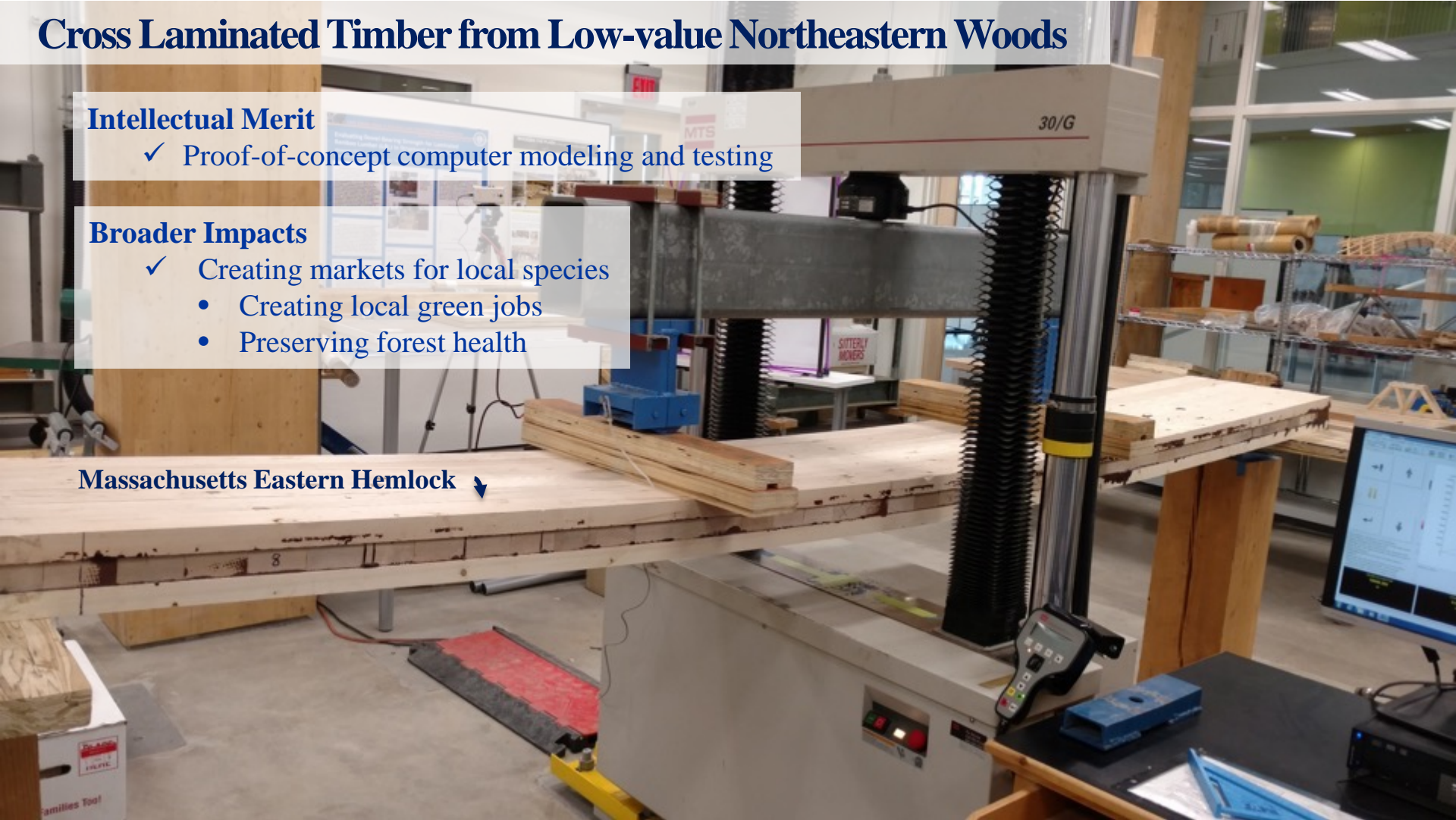
Intellectual Merit

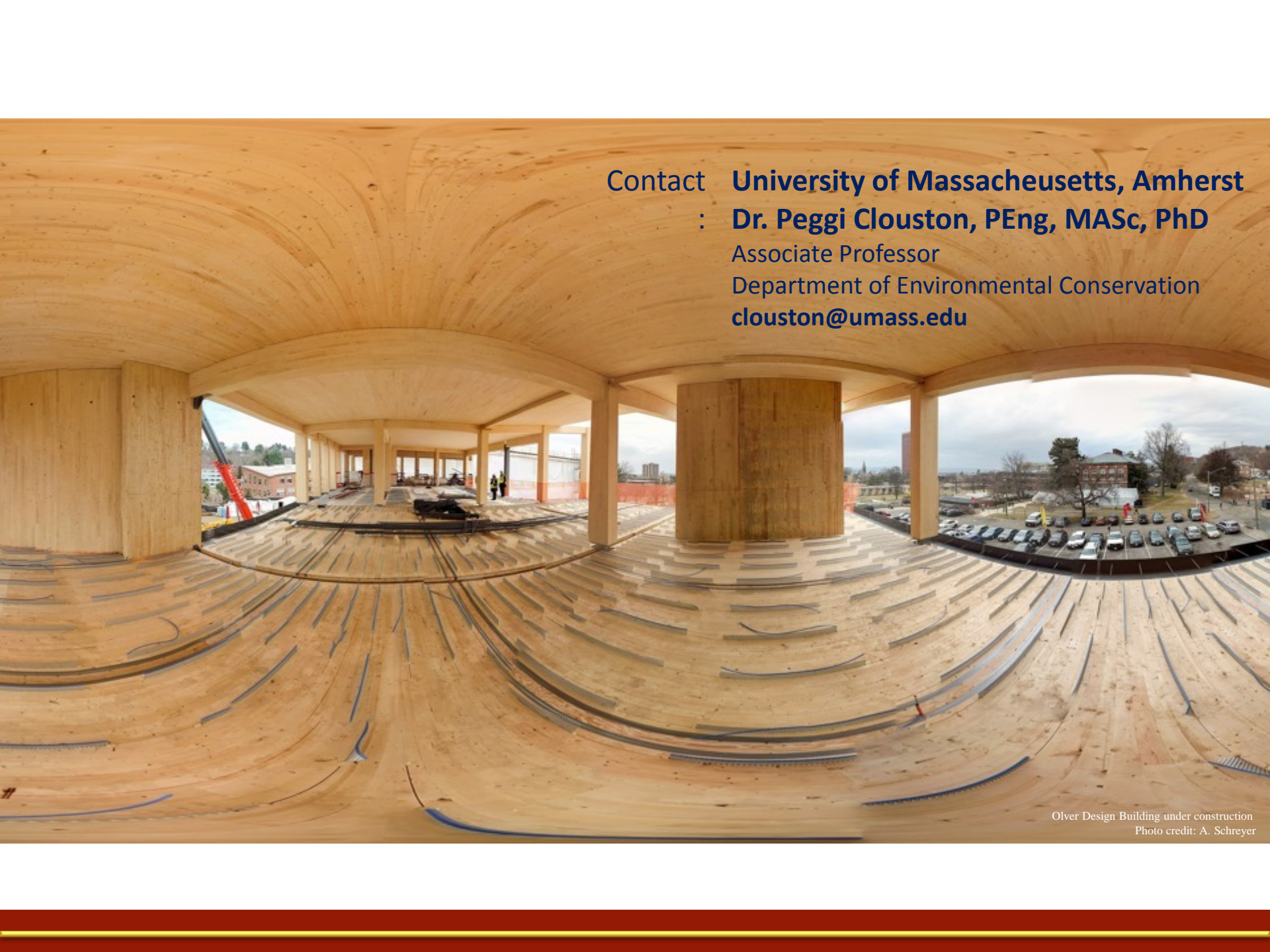
- ✓ Proof-of-concept computer modeling and testing

Broader Impacts

- ✓ Creating markets for local species
 - Creating local green jobs
 - Preserving forest health

Massachusetts Eastern Hemlock ↴





Contact **University of Massachusetts, Amherst**
: **Dr. Peggi Clouston, PEng, MAsC, PhD**
Associate Professor
Department of Environmental Conservation
clouston@umass.edu

Olver Design Building under construction
Photo credit: A. Schreyer

Bonding Mixed Hardwood Species for CLT Production



Michigan
Technological
University



The WU+D Institute - Mission



Increase the utilization of wood-based products in sustainable and resilient building construction through education/training, research/product development and communication of technical and design solutions.

- Timber industry is critical to South Carolina's economy
- Wood is once again a choice building material
- Collaboration makes Clemson the leader in wood research and education

Pilot Panel Manufacture



SYP Cross Laminated Timber



PATRICIA LAYTON CLEMSON
UNIVERSITY

Director

Wood Utilization + Design
Institute

321 Harris Smith Building

[864.505.5904](tel:864.505.5904)

Clemson.edu/wud

facebook.com/wudclemson/

FUNDED PROGRAMS

SLB has approved funding for the following programs:



AMERICAN WOOD COUNCIL

American Wood Council

For work on building standards to maintain and expand acceptance of appearance and structural softwood lumber in the marketplace.



reThink Wood

To promote the values and benefits of appearance and structural lumber products.



Wood, Naturally

Residential Program: to implement a communications program promoting the use of structural and appearance softwood lumber in and around the home and develop and execute an association partnership program.



WoodWorks[™]
WOOD PRODUCTS INSTITUTE

WoodWorks

To grow the market share for appearance and structural softwood lumber in light commercial and multi-family construction.



SLB Funded Research

To expand opportunities for softwood lumber



Tall Wood Innovation

To provide research for mass timber building systems for mid and high-rise buildings that rely primarily on softwood lumber products.



Evaluations

Specific and relevant metrics are a condition of Softwood Lumber Board funding.



WoodWorks provides free technical support as well as education and resources related to the code-compliant design of non-residential and multi-family wood buildings.

Partners

Funding Partners



2018 National Partners



ad more >

ASK AN EXPERT

Have a question? Email us >

What are common construction tolerance limits for light-frame wood construction?

Click for detailed answer

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If you're looking to create a mass timber project team, contact us at help@woodworks.org for help locating experienced wood design professionals in your area.

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Design Professional Membership

Design Professionals need to stay abreast of progressive wood industry issues and changing building design standards. To help professionals stay informed about the technical issues affecting the wood industry, the American Wood Council (AWC) offers a Design Professional Membership.

The American Wood Council (AWC) provides wood design and construction information to assist engineers and architects, develops structural and fire performance data on a wide range of traditional and engineered wood products, and engages in long-term research.

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- Member discounts on [Technical Publications](#).
- AWC IMPACT newsletter.
- AWC WoodPost newsletter.
- [Wood Design Focus](#), the Forest Products Society quarterly journal (PDF Only) of contemporary wood engineering.
- [Wood Design & Building](#), a quarterly North American magazine on design and construction of modern wood buildings.
- Frequent updates on wood industry developments, association activity, new publications, and special reports on engineering, building codes, standards, fire technology, and research projects.
- Announcements of seminars offering CEU credits.
- Access to AWC's group on LinkedIn®.

FEATURED PROJECT

T3: Timber, Transit, Technology

T3 (Timber, Transit, Technology) is the first commercial property in the United States to use wood for its structure and interior.

// [Read More](#)

Light-Frame Construction

Nail-Laminated Timber (NLT)

NLT Design + Construction Guide Download

Cross-Laminated Timber (CLT)

CLT Handbook Download

Dowel-Laminated Timber (DLT)

Glue-Laminated Timber (Glulam)

Design Tools

BUILDING BETTER

Multifamily

ARTICLE

How Wood Can Maximize the Value of Multi-Story Projects

Next Steps

- Select target segment process technology and scale
 - Glulam
 - NLT (LignoLoc)
 - DLT
 - CLT
 - CLT Plywood
- Work collectively on market develop presence
 - Bring together Eastern hardwood's best thinkers
 - Reach out to the machine tool base
 - Attend Ligna 2019 as a trade group initiative
- Go after federal, state, local, and private equity funding



Federal-State Marketing Improvement Program

Fiscal Year 2018 Request for Applications

Funding Opportunity Number: USDA-AMS-TM-FSMIP-G-18-0004

Publication Date: March 7, 2018

Application Due Date: 11:59 PM Eastern Time on May 7, 2018

Mass Timber

- These products are at the intersection of construction and woodworking!
- Who is better at woodworking – the softwood sector or the hardwood sector?

Thank you - questions



Image by Fine Homebuilding Magazine