HARDWOOD MASS TIMBER

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

PATRICK DONAHUE
218-788-2705
pdonahue@d.umn.edu
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?
Glulam

Image by StructureCraft

Image by American Wood Council
NAIL LAMINATED
LIGNOLOC

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

- 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

(KILN DRIED) BASE MATERIAL (e.g. BOARDS)
- strength (stiffness)
- trimming
- finger jointing

(FINGER JOINTED) LAMELLAS
- (four-side) planing
- edge bonding

SINGLE-LAYER PANELS
- (four-side) planing
- surface bonding

ENGINEERED WOOD PRODUCTS
- surface bonding

CROSS LAMINATED TIMBER (CLT)

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

Slide by of American Wood Council
CLT Production Line (MUF/EPI)

Images by Reinhard Brandner
CLT Process Line (PUR)

Image by Joulin

Image by WoodTec
Since 1952, a leading producer of machinery and systems, as well as service provider, for the woodworking industry.
Welcome to the WEINIG Group - Machines and systems for solid wood and panel processing.
Engineered Wood & Secondary Mfg

We offer a variety of lines of engineered wood processing and Radio Frequency (RF) gluing equipment for products including LVL, Panel, I-Joist, OSB, MDF, particleboard, moulded door skins, pulp, gypsum fiber, finger joint lines, etc. Each machine is made according to your specifications with our quality guarantee. We are constantly applying new innovations to our products so they are more durable, efficient and easier to maintain. Whether it’s our fully enclosed Bundle Cut Saw or our fully automated control systems we are dedicated to providing you the best solution in the industry.
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.
Plants and machines

Kallesoe Machinery has more than 45 years of experience in the design, construction and manufacturing of machines and plants. Our unique expertise will make you better equipped to take the lead in your field, with the latest technology in the wood lamination industry.

Our innovative design phase, many years of experience and the use of new and advanced technology guarantee:

- Long life time for plants and machines
- 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.

Choose your favoured equipment below for more information.
WHY HARDWOOD CLT?

SUPERIOR MECHANICAL PROPERTIES

C24 SOFTWOOD CLT

MIXED SPECIES HARDWOOD CLT

SAME STRUCTURAL CAPACITY WITH LESS MATERIAL VOLUME

C24 SOFTWOOD CLT

MIXED SPECIES HARDWOOD CLT

IMPROVED APPEARANCE, DURABILITY AND FIRE RESISTANCE

FINISHED CONCRETE FLOOR

3/4" EPS

5 LAM SOFTWOOD SLAB

SOFTWOOD CLT FLOOR SECTION

HARDWOOD SLAB SURFACE AS FINISHED FLOOR

HARDWOOD CLT FLOOR SECTION

Design and material development by IKD, Photo by IKD. www.i-k-design.com
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: \( \text{SG} \geq 0.35 \)
  1 per layer
• Grades: \#2\&btr (//) , \#3\&btr (\(\square\))
• \(\text{MC} = 12 \%\)
• Most hardwoods have \(\text{SG} > 0.35\)
• Hardwoods typically dried to low MCs

*Source: Wood Handbook*

Slide by Omar Espinoza
Material Considerations

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

Source: Wood Handbook

Franke, S. (2016)

Slide by Omar Espinoza
Cost Considerations

- **Softwood lumber price**: $314
  - #2&btr West SPF, KD (09.09.2016*)

- **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

*Random Lengths

**Hardwood Market Report

Source: Bureau of Labor Statistics

Slide by Omar Espinoza
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*)
- $\rho_{12\%MC} = 594 \text{ kg/m}^3 (37 \text{ lb/ft}^3)$
- $n=20$, 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 $\perp = 5.8 \text{ MPa}^2$

Slide by Omar Espinoza
Beech CLT - Switzerland

- Bern University of Applied Sciences
- European beech (*Fagus sylvatica*)
- \( \rho = 690 \text{ kg/m}^3 \) (43 lb/ft\(^3\))
- \( n=13, \ 120 \text{ mm (4}\frac{3}{4}\text{ in)}, \text{ layers=vary} \)
- 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
Russell Edgar  Benjamin Herzog
Wood Composites Manager  Wood Technologist
(207) 299-4215  (207) 581-2360
russell.edgar@maine.edu  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
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

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
Bonding Mixed Hardwood Species for CLT Production

Objective: To provide baseline technical data on the adhesion properties for using northern hardwoods in CLT products.

To study:
- Glue line shear strength
- Bonding durability
- Dimensional stability

Materials include:
- Eight northern hardwoods species including ring porous and diffuse porous wood with specific gravity ranging from 0.37 to 0.64
- Two commercially available cold-setting structural adhesives

Contact Information
Xinfeng Xie
School of Forest Resources and Environmental Science
Michigan Technological University
Houghton, Michigan
(906) 487-2294; xinfengx@mtu.edu
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
Clemson.edu/wud
facebook.com/wudclemson/
SLB has approved funding for the following programs:

- **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**
  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, modol ullamcorper turpis.

- **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.
Join Us at AWC

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.

For $100/yr*, Design Professional Members receive:

- Optional listing in AWC Design Professional Services Directory with description of professional services.
- 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®.
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
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