

Cross Laminated Timber Technology: Manufacturing, Materials and Specification

Baltimore Wood Solutions Fair

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Learning Objectives

At the end of this program, participants will be able to:

1. Attendees will understand the process by which ANSI/APA PRG 320 CLT Standard and product certification processes were developed.
2. Attendees will observe key steps in the CLT manufacturing process and learn about the current state of production in North America
3. Attendees will observe resources such as APA Product Reports for CLT manufacturers for guidance in Designer Specifications
4. Attendees will Standard CLT grades and design properties and will be implemented through building codes



Outline

CLT Manufacturing

- 1) Scope
- 2) Key steps for CLT manufacturing processes
- 3) ANSI/APA PRG 320 CLT Standard
- 4) Standard CLT grades and design properties
- 5) Custom products
- 6) Product certification
- 7) Conclusion

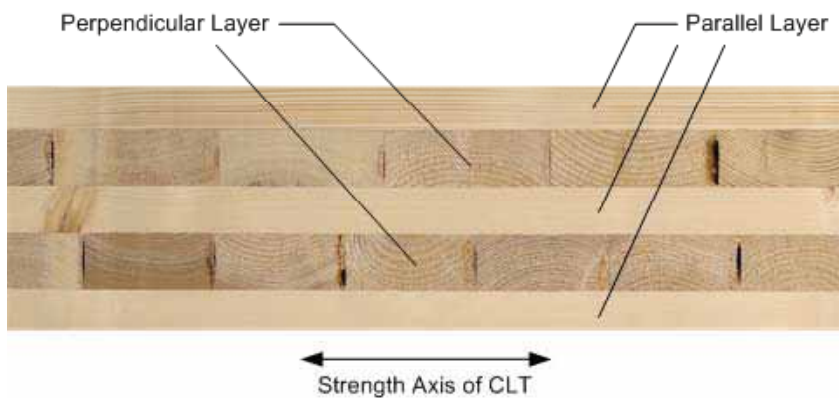


Scope: CLT Definition

- A prefabricated solid engineered wood panel made of at least three orthogonally bonded layers of solid-sawn lumber or structural composite lumber (SCL) that are laminated by gluing of longitudinal and transverse layers with structural adhesives to form a solid rectangular-shaped, straight, and plane timber intended for roof, floor, or wall applications
- Mechanically connected or non-face-bonded CLTs are outside the scope

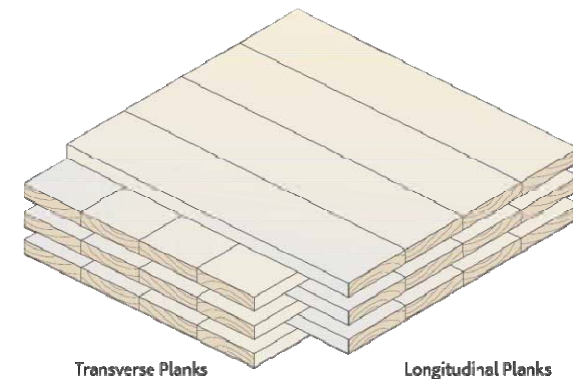


CLT Cross Section

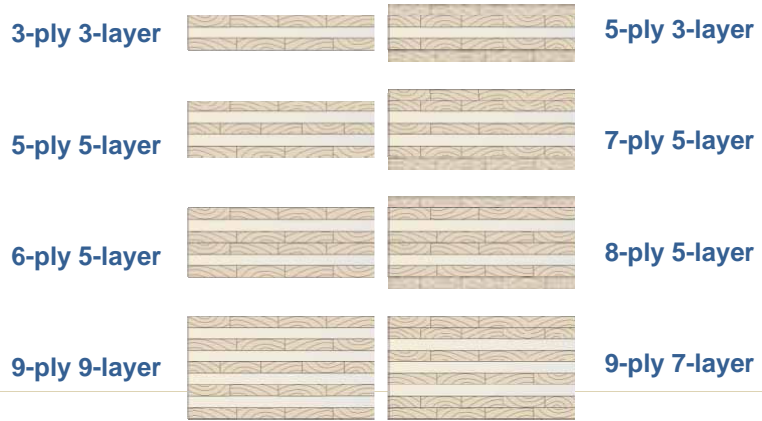


CLT Plies and Layers

- Alternate plies and layers

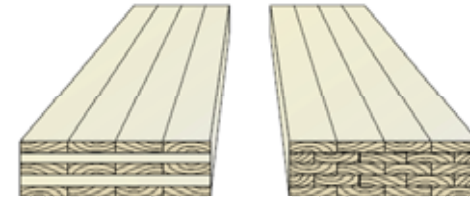


Examples of CLT Configurations

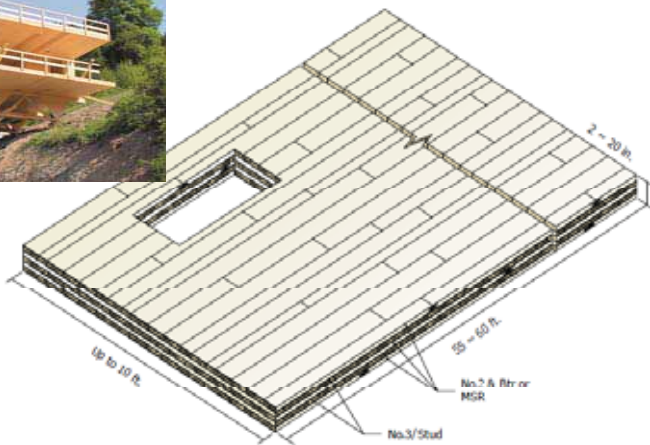


CLT & Glulam

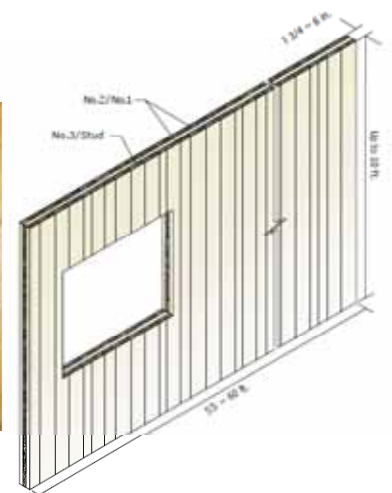
Cross-Laminated Timber CLT Glulam



Floors or Roofs



Walls



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Key Components for CLT

- **Lumber**
 - Species
 - Grades
- **Joints**
 - End joints
 - Face joints
 - Edge joints
- **Adhesives**
 - Pressing
 - Curing



Reference: Holzbau Unterrainer



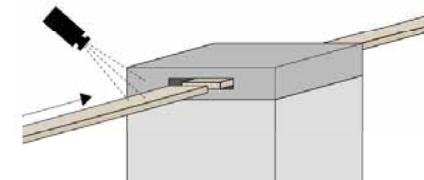
Key Steps in CLT Manufacturing

- **Lumber processing**
 - Grading, MC check, cutting, end-jointing, planing
- **Adhesive application and CLT layup**
- **Pressing and curing**
- **CLT processing**
- **QA and trademarking**
- **Packaging and shipment**



Key Steps in CLT Manufacturing

- **Lumber processing**
 - Grading, MC check, cutting, end-jointing, planing

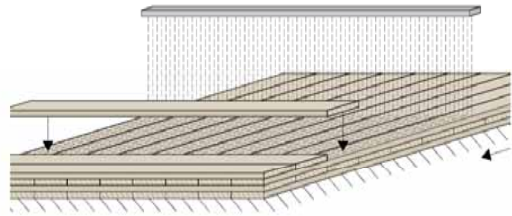


Reference: Brettsperrholz.org



Key Steps in CLT Manufacturing

- Adhesive application and layup

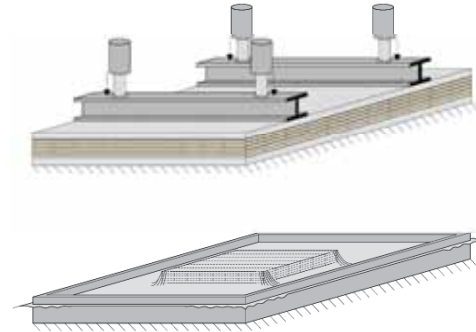


Reference: Brettspierholz.org



Key Steps in CLT Manufacturing

- Pressing and curing



Reference: Brettspierholz.org



Pressing and Curing

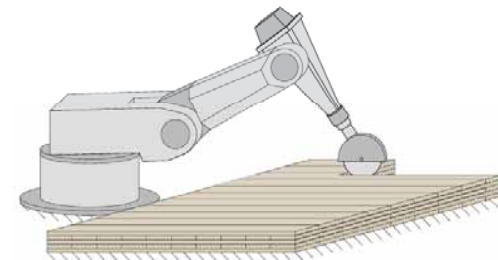


Courtesy Nordic Engineered Wood



Key Steps in CLT Manufacturing

- CLT processing



Reference: Brettspierholz.org



CLT Processing



Courtesy Nordic Engineered Wood



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CLT Standards – A Necessity

- All CLT projects in North America so far have been based on case-by-case approval by local jurisdictions
- To facilitate product acceptance, consensus-based product and design standards are essential



Courtesy Structuriam



Benefit of A Product Standard

- Consensus-based standard for code adoption
- Consistent product quality and reliability
- Independent third-party inspection
- Improved product availability
- Designers can focus on design and innovation



Courtesy Nordic Engineered Wood



ANSI/APA PRG 320

- As an ANSI-accredited standards developer, APA initiated the development of ANSI/APA PRG 320, *Performance Standard for Cross-Laminated Timber*, in 2010
- Approved by ANSI in December 2011



ANSI/APA PRG 320

- **Open Process**
 - 35 Voting members: 18 U.S., 16 CAN, and 1 EU
 - 22 Observers: 12 U.S., 7 CAN, and 3 Australians
- **Balanced Interest**
 - 4 Manufacturers, 8 Suppliers, 7 Users, and 12 General Interests
- **Intended for a bi-national (U.S. and Canada) standard**



ANSI/APA PRG 320

- The current version is PRG 320-2012, approved by ANSI in October 2012



ANSI/APA PRG 320

- **Key Considerations**
 - **Dry-Use**
 - Kiln-dried lumber (12%) or SCL laminations
 - **Species** – Any softwood species meeting PS20 or CSA O141 and a specific gravity of 0.35 or higher
 - **Outermost layers** – minimum 1200f-1.2E MSR or VG No. 2
 - **Core layers** – minimum VG No. 3



ANSI/APA PRG 320

▪ Key Considerations (continued)

- Lamination thickness: 5/8" to 2" due to face bond consideration
- Net lamination width:
 - 1.75 x thickness for parallel layers (i.e., 2x3)
 - 3.5 x thickness for perpendicular layers (i.e., 2x6) due to interlaminar shear and creep consideration for non-edge bonded layers unless proven otherwise by testing



ANSI/APA PRG 320

▪ Key Considerations (continued)

- Max CLT thickness: 20"
- CLT tolerance at the time of manufacturing
 - Thickness: $\pm 1/16$ " or 2%, whichever is greater
 - Width: $\pm 1/8$ "
 - Length: $\pm 1/4$ "



ANSI/APA PRG 320

▪ Key Considerations (continued)

- Adhesives
 - U.S.: AITC 405 + PS1 Heat Performance
 - Canada: CSA O112.10 + ASTM D7247 Heat durability + PS1 Heat Performance
- Mandatory requirements for end joints and face joints
- Non-mandatory for edge joints



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ANSI/APA PRG 320

Standard CLT grades

4 “E-Rated” CLT grades

- E1:** 1950f-1.7E SPF MSR (//) + No. 3 SPF (⊥)
- E2:** 1650f-1.5E DF-L MSR (//) + No. 3 DF-L (⊥)
- E3:** 1200f-1.2E ES, NS, or WW (//) + MSR No. 3 ES, NS, or WW (⊥)
- E4:** 1950f-1.7E SP MSR (//) + No. 3 SP (⊥)



ANSI/APA PRG 320

Standard CLT grades (continued)

3 “V-Graded” CLT grades

- V1:** No. 2 DF-L (//) + No. 3 DF-L (⊥)
- V2:** No. 1/No. 2 SPF (//) + No. 3 SPF (⊥)
- V3:** No. 2 SP (//) + No. 3 SP (⊥)

Appearance classifications are included in the non-mandatory Appendix



ANSI/APA PRG 320

- Properties are determined in accordance with the “Shear Analogy” model
- Other models are permissible if approved by an approved agency

Table A7 The Allowable Bending Capacities (kN) for CLT listed in Table A1 (for use in the U.S.)

CLT Grade	Dimensional Properties (in.) or (U.S.) Units						Moisture Content						Moisture Strength					
	h	b	t	h	b	t	h	b	t	h	b	t	h	b	t	h	b	t
E1	4.10	1.50	1.50	1.50														
	4.70	1.50	1.50	1.50	1.50	1.50												
	5.30	1.50	1.50	1.50	1.50	1.50	1.50	1.50										
E2	4.10	1.50	1.50	1.50														
	4.70	1.50	1.50	1.50	1.50	1.50												
	5.30	1.50	1.50	1.50	1.50	1.50	1.50	1.50										
E3	4.10	1.50	1.50	1.50														
	4.70	1.50	1.50	1.50	1.50	1.50												
	5.30	1.50	1.50	1.50	1.50	1.50	1.50	1.50										
E4	4.10	1.50	1.50	1.50														
	4.70	1.50	1.50	1.50	1.50	1.50												
	5.30	1.50	1.50	1.50	1.50	1.50	1.50	1.50										
V1	4.10	1.50	1.50	1.50														
	4.70	1.50	1.50	1.50	1.50	1.50												
	5.30	1.50	1.50	1.50	1.50	1.50	1.50	1.50										
V2	4.10	1.50	1.50	1.50														
	4.70	1.50	1.50	1.50	1.50	1.50												
	5.30	1.50	1.50	1.50	1.50	1.50	1.50	1.50										
V3	4.10	1.50	1.50	1.50														
	4.70	1.50	1.50	1.50	1.50	1.50												
	5.30	1.50	1.50	1.50	1.50	1.50	1.50	1.50										

For SI: 1 in. = 25.4 mm; 1 ft = 304.8 mm



ANSI/APA PRG 320

Assumptions of some mechanical moduli of lumber in the model:

- $E_{90} = E_0 / 30$
- $G_0 = E_0 / 16$
- $G_{90} = G_0 / 10 = E_0 / 160$



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ANSI/APA PRG 320

- It is impractical to list all possible CLT layups
- Custom CLT grades are permitted when approved by an approved agency in accordance with the qualification and mechanical test requirements specified in PRG 320



Courtesy Structurlam



Custom Products

- The designers are encouraged to contact CLT manufacturers for available, optimized, and economical custom products for project needs



Courtesy Structurlam



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CLT Primary Production in North America

- **Nordic Engineered Wood, Chibougamau, Quebec**



CLT Primary Production in North America

- **Structurlam, Penticton, British Columbia**



CLT Primary Production in North America

- **SmartLam, Montana, U.S.A.**



Other CLT Production in North America

- **Others plants:**
 - **CST Innovations, BC, Canada**
 - **Montana, U.S. (in planning)**
 - **Eastern U.S. (in planning)**



ANSI/APA PRG 320

- ANSI/APA PRG 320-2011 has been approved by the IBC Structural Committee for adoption into the 2015 IBC
- CLT manufactured to PRG 320 is recognized as a code-compliant construction material in the U.S.
- Adoption of PRG 320-2012 is expected for the 2015 IRC
- Canadian code adoption in CSA O86 is underway



CLT Product Certification

- Just like most structural wood products, a product certification by an independent third-party agency is required in accordance with PRG 320
- In the U.S., the third-party must be accredited under ISO 17020
- In Canada, the third-party must be accredited under ISO 65

INTERNATIONAL
STANDARD

ISO/IEC
17020

First edition
1998-11-19

General criteria for the operation of various
types of bodies performing inspection

Critères généraux pour le fonctionnement de différents types d'organismes
prestataires de l'inspection

GUIDE 65

General requirements for
bodies operating product
certification systems



CLT Product Certification

- Approved 2015 IBC provisions:

SECTION 202 DEFINITIONS

CROSS-LAMINATED TIMBER. A prefabricated engineered wood product consisting of at least three layers of solid-sawn lumber or structural composite lumber where the adjacent layers are cross-oriented and bonded with structural adhesive to form a solid wood element.

Add new text as follows:

2303.1.4 Structural glued cross-laminated timber. Cross-laminated timbers shall be manufactured and identified as required in ANSI/APA PRG 320-2011.

Add new standard to Chapter 35 as follows:

ANSI

ANSI/APA PRG 320-2011 Standard for Performance-Rated Cross-Laminated Timber



CLT Product Certification

- The CLT must be qualified based on a mechanics-based model and confirmed by qualification tests of
 - Gluebond durability,
 - Full-scale bending, and
 - Full-scale shear
- The CLT must be under a quality assurance program audited by an approved agency



Mechanical tests being conducted at FPIInnovations, Quebec



CLT Product Certification

- The CLT products in conformance with PRG 320 must be identified with marks containing
 - CLT grade
 - CLT thickness or identification
 - Mill name or identification number
 - Approved agency name or logo
 - Symbol of “ANSI/APA PRG 320”
 - “Top” stamp on the top face of custom CLT panels used for roof or floor if manufactured with an unbalanced layout



Product Certification

- The approved agency may provide documentation for product certification
- For example, APA provides Product Reports for CLT certification (www.apawood.org)



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Conclusion

- ANSI/APA PRG 320 provides a consensus-based standard for CLT products that can be used as a basis for the CLT design standard
- Consistent product quality provided by the product standard is important for the broad acceptance of CLT products



CLT Specification Guide

- **CLT in conformance with the ANSI/APA PRG 320 standard**
- **End-use application**
- **Thickness and dimensions**
- **Design capacities ($F_b S$, EI_{eff} , and GA_{eff} in major and minor strength directions)**
- **Appearance classification (if any)**
- **Prefabrication requirements according to design drawings**
- **Trademark and certificates**
- **Protection for shipment**



> Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

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Questions?



Courtesy Nordic Engineered Wood

