WOODWORKS
WOOD PRODUCTS COUNCIL

Introducing Cross Laminated Timber (CLT)

New Opportunities for Timber Construction

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

Cross laminated timber (CLT) is an engineered wood building system designed to complement light- and heavy-timber framing options. Because of its high strength and dimensional stability, it can be used as an alternative to concrete, masonry and steel in many building types. This presentation will introduce CLT with a series of project examples that demonstrate its use and associated benefits in a range of applications. Information on manufacturing, specification and code-related considerations will also be discussed.

Learning Objectives

1. Review completed CLT projects that demonstrate a range of applications and system configurations.
2. Discover how CLT can be used under current and future building codes and standards.
3. Discuss benefits of using CLT in place of concrete and steel, including structural versatility, prefabrication, lighter carbon footprint and reduced labor costs.
4. Discuss the fire characteristics of CLT, including the benefits of charring, current seismic approaches that can be used for CLT buildings, and how the acoustic and moisture performance of CLT assemblies can inform the design of a project.

Outline

- What is CLT?
  - Mass Timber
  - The Appeal
  - History
  - Availability
- Using CLT
  - Project Examples
  - Best applications
  - Cost effective design
  - Building Codes and Standards

Outline

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New Class of Wood Products

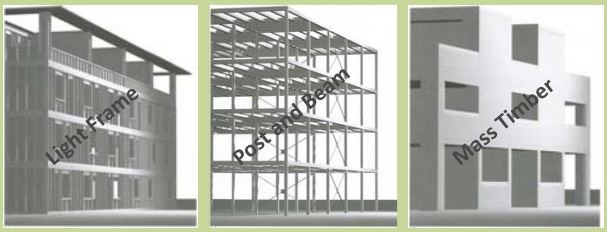
Mass Timber Structures

- Incorporating timber plate elements
- Including large timber elements such as solid sawn, NLT, LVL, LSL, glulam, and CLT
- A structural system resisting both vertical and lateral loads

The new heavy timber movement is motivated by….

- Demand for lower impact structures
- Manufacturing Technology
- Material Technology
- Advances in Pre-fabrication
- Sophisticated Suppliers

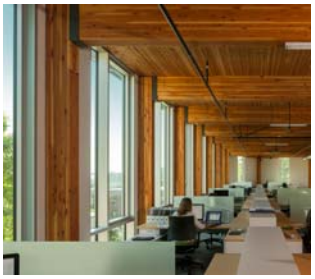
BUILDING FRAME SYSTEMS



MASS TIMBER IS A CATEGORY OF FRAMING STYLES OFTEN USING SMALL WOOD MEMBERS FORMED INTO LARGE PANELIZED SOLID WOOD CONSTRUCTION INCLUDING CLT, NLT OR GLULAM PANELS FOR FLOOR, ROOF AND WALL FRAMING

MASS TIMBER
WHAT IS IT?

HEAVY TIMBER
Federal Center South, Seattle, WA
Photo: Benjamin Benschneider



MASS TIMBER
Bullitt Center, Seattle, WA
Photo: John Stamets

Glue Laminated Timber (Glulam)
Beams & columns

Cross-Laminated Timber (CLT)
Solid sawn laminations

Cross-Laminated Timber (CLT)
SCL laminations

Photo: Freres Lumber

Photo: StructureCraft

Photo: LendLease

Photo: LEVER Architecture

Dowel-Laminated Timber (DLT)

Photo: StructureCraft

Nail-Laminated Timber (NLT)

Photo: Think Wood

Glue-Laminated Timber (GLT)
Plank orientation

Photo: StructureCraft

Photo: StructureCraft

Photo: Ema Peter

Photo: Manasc Isaac Architects/Fast + Epp

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Photo: JCEDC

Photo: William Horne

Photo: LEVER Architecture

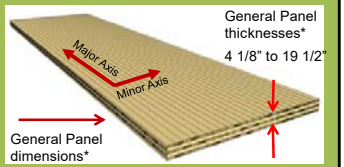
Photo: David Sundberg/Esto
Organschi Architecture

Photo: ©Albert Vecerka/Esto

Photo: Christian Columbres

MASS TIMBER PRODUCTS
CROSS-LAMINATED TIMBER (CLT)

With solid sawn laminations



General Panel thicknesses*
4 1/8" to 19 1/2"

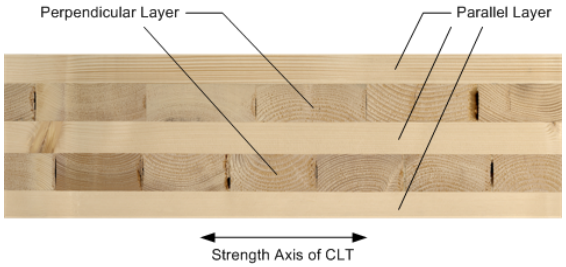
General Panel dimensions*
4 to 12 ft wide
14 to 64 ft long
*Consult with manufacturers for available panel sizes

Cross-Laminated Timber (CLT)

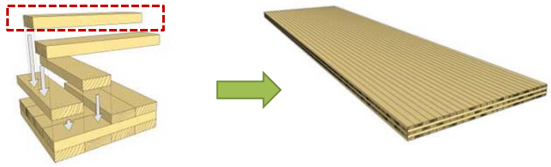
with SCL laminations

Photos: Freres Lumber

CLT Composition



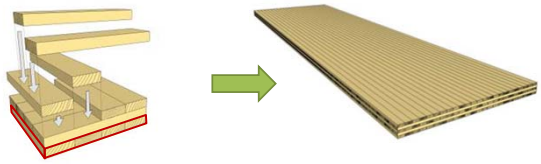
Structural Composition of CLT



Laminations: (Per PRG 320-2012)

- 5/8" to 2" thick
- 2.4" - 9.5" wide
- Machine Stress Rated or Visually Graded Dimensional Lumber or SCL
- Dried to 12% Moisture Content before layup.
- A common NA thickness is 1 3/8" (planed 2x stock)
- PRG 320 provides thickness to width requirements of laminations

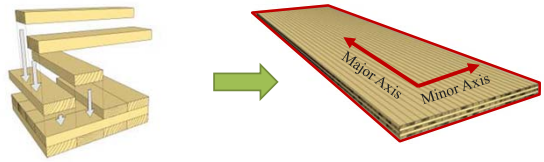
Structural Composition of CLT



Layers: (Per PRG 320-2012)

- Oriented in orthogonal arrangement
- Odd number of symmetric layers most common
- Double parallel exterior layers permitted
- Unbalanced layup permitted
- Reference glu-lam adhesive standard (AITC 405)

Structural Composition of CLT



Panels, also known as Billets.

- 20 inch max thickness in PRG 320
- Up to 8 ft or more wide per manufacturer and shipping
- Up to 40 ft or more long per manufacturer and shipping
- Major axis: stronger, stiffer, usually long direction
- Minor axis: less strong and stiff, usually short direction

Cross-Laminated Timber (CLT)

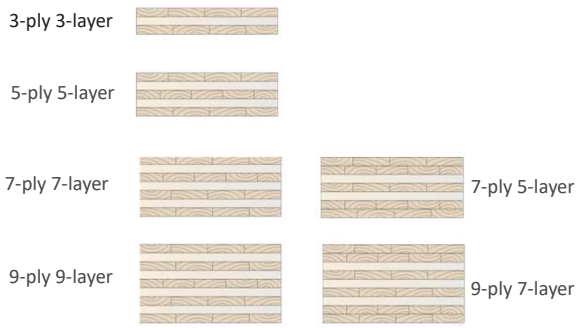
With SCL laminations

Photos: Freres Lumber

CLT Fabrication Press

Photo Credit: DR Johnson

Common CLT Layups

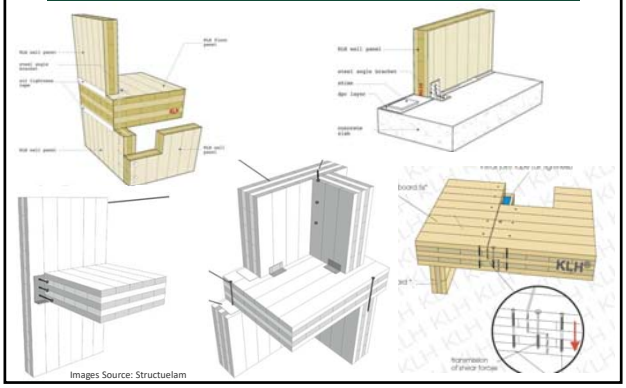


CLT: A Prefabricated Material

- Finished panels are planed, sanded, cut to size. Then openings are cut with precise CNC routers.
- Third party inspection at factory.

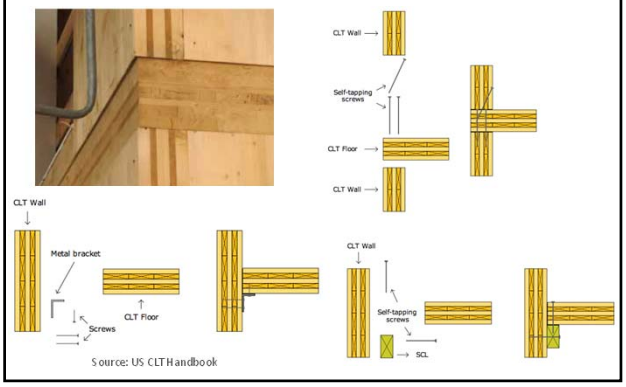
- Custom engineered for material efficiency.
- Custom designed for project.
- Each panel numbered, delivered & installed in predetermined sequence

How to use CLT - Assembly



Images Source: Structuelam

How to use CLT - Assembly



Source: US CLT Handbook

What is the appeal of CLT?

- Sustainability
  - Embodied Carbon
- Performance
- Construction Efficiency

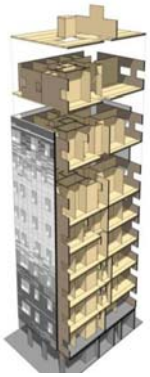
Reduced Embodied Carbon

Volume of wood used	950 m^3
Carbon sequestered and stored (CO_2e)	760 metric tons
Avoided greenhouse gases (CO_2e)	320 metric tons
Total potential carbon benefit (CO_2e)	1,080 metric tons

Carbon savings from the choice of wood in this one building are equivalent to:


1,615 passenger vehicles off the road for a year


Enough energy to operate a home for 803 years



Stadhaus, London, UK
Architect: Waugh Thistleton Architects
Photo credit: Waugh Thistleton Architects

What is the appeal of CLT?

- Sustainability
  - Reduced Embodied Carbon
  - Minimal waste production
- Performance
- Construction Efficiency

Minimal Waste

Why are designers drawn to CLT?

- Sustainability
  - Reduced Embodied Carbon
  - Minimal waste production
  - Highly Energy Efficient
- Performance
- Construction Efficiency

Energy Efficient

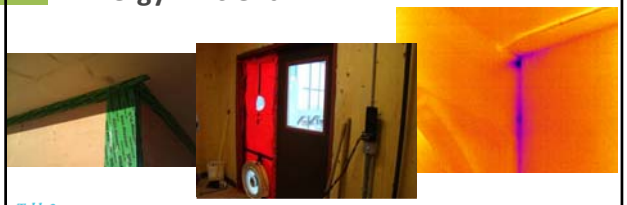


Table 2
Thermal resistance of typical softwood at various thicknesses and 12% moisture content

Thickness	1 in. (25 mm)	4 in. (100 mm)	6 in. (150 mm)	8 in. (200 mm)
R-value ($h \cdot ft^2 \cdot {}^\circ F \cdot Btu^{-1}$)	1.25	5.00	7.50	10.00
RSI ($m^2 \cdot K \cdot W^{-1}$)	0.22	0.88	1.30	1.80

CLT has an R-value of approximately 1.25 per inch of thickness.
Source: US CLT Handbook

What is the appeal of CLT?

- Sustainability
  - Reduced Embodied Carbon
  - Minimal waste production
  - Highly Energy Efficient
- Performance
  - Disaster Resilient
- Construction Efficiency

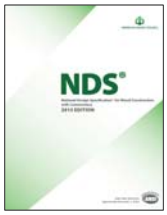
Disaster Resilient
Seismic R Under Alternate Means

What is the appeal of CLT?

- **Sustainability**
  - Reduced Embodied Carbon
  - Minimal waste production
  - Energy Efficient
- **Performance**
  - Disaster Resilient
  - Fire Resistant
- **Construction Efficiency**

Fire Test Results

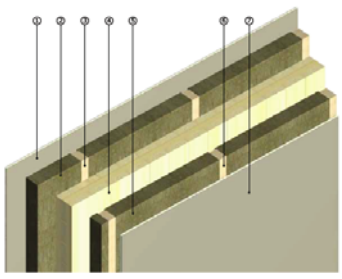
- ASTM E119 Fire Endurance Test
  - 5-Ply CLT (6-7/8" thick)
  - 5/8" Type X GWB each side
  - 2 hour target
  - Actual 3 hours 6 minutes
- 2015 NDS Chapter 16 includes char rates for CLT to achieve up to 2 hour fire rating



What is the appeal of CLT?

- **Sustainability**
  - Reduced Embodied Carbon
  - Minimal waste production
  - Highly Energy Efficient
- **Performance**
  - Disaster Resilient
  - Good Fire Resistance
  - High performing Acoustics
- **Construction Efficiency**

High Performing Acoustics



Why are designers drawn to CLT?

- **Sustainability**
  - Reduced Embodied Carbon
  - Minimal waste production
  - Highly Energy Efficient
- **Performance**
  - Disaster Resilient
  - Good Fire Resistance
  - High performing Acoustics
  - Structural Flexibility
- **Construction Efficiency**

Structural Flexibility

Photo Credit: APA

What is the appeal of CLT?

Sustainability	• Reduced Embodied Carbon • Minimal waste production • Highly Energy Efficient
Performance	• Disaster Resilient • Good Fire Resistance • High performing Acoustics • Structural Flexibility
Construction Efficiency	• ~75% lighter than concrete

75% Lighter Weight Than Concrete

What is the appeal of CLT?

Sustainability	• Reduced Embodied Carbon • Minimal waste production • Highly Energy Efficient
Performance	• Disaster Resilient • Good Fire Resistance • High performing Acoustics • Structural Flexibility
Construction Efficiency	• ~75% lighter than concrete • Reduced construction time

Reduced Construction Time

Murray Grove, London UK

- 8 stories of CLT over 1 story concrete podium
- 8 stories built in 27 days (~1/2 the time of precast concrete)

Franklin Elementary School, Franklin, WV

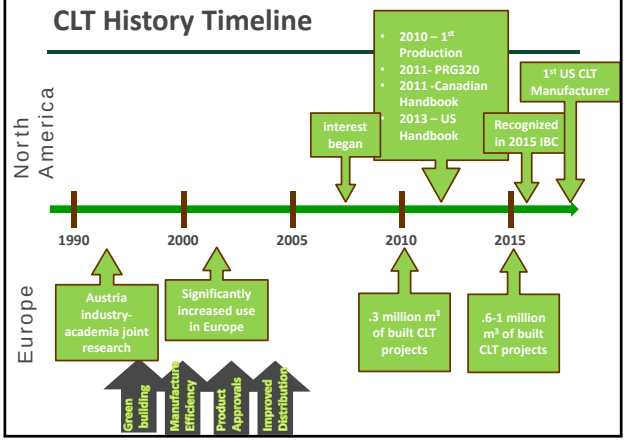
- 45,200 ft² 2 story elementary school
- 8 weeks to construct

What is the appeal of CLT?

Sustainability	• Reduced Embodied Carbon • Minimal waste production • Highly Energy Efficient
Performance	• Disaster Resilient • Good Fire Resistance • High performing Acoustics • Structural Flexibility
Construction Efficiency	• ~75% lighter than concrete • Reduced construction time • Pre-fabricated and Precise

Pre-fabricated and Precise

CLT History Timeline



Outline

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  - Best applications
  - Cost effective design
  - Building Codes and Standards

- 1st Commercial CLT "Building" in US
- $145/sqft completed project cost
- Structural shell complete in < 5 days
- Saved 30% in foundation costs
- Saved 6-12% over CMU

Long Hall, Whitefish, MT
Designer: Darryl Byle, Jason Hatten

- Completed in 2013
- 1st Commercial CLT Building in US built with North American CLT
- CLT used only in the roof

Promega GMP Facility, Fitchburg, WI
Architect: Uihlein Wilson Architects

Cooley Landing Education Center

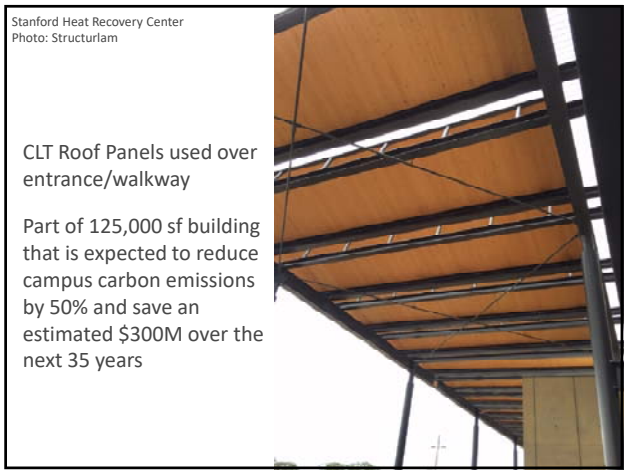
East Palo Alto, CA


3,500 sf
CLT Roof Panels
Glulam Roof Beams
East Palo Alto Cooley Landing Education Center
Photos: Structurlam


East Palo Alto Cooley Landing Education Center
Photo: Structurlam


East Palo Alto Cooley Landing Education Center
Photo: Structurlam


New Stanford Heat Recovery Center
Stanford, CA
Image Credit: ZGF Architects


Stanford Heat Recovery Center
Photo: Structurlam
CLT Roof Panels used over entrance/walkway
Part of 125,000 sf building that is expected to reduce campus carbon emissions by 50% and save an estimated $300M over the next 35 years


Stanford Heat Recovery Center
Photo: Structurlam

Chicago Horizon Pavilion
Chicago, IL

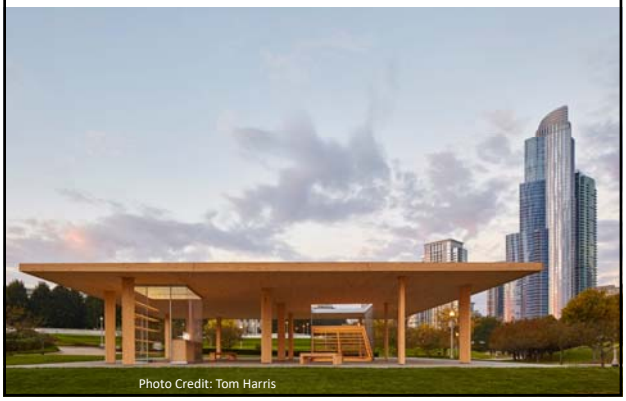


Photo Credit: Tom Harris

56’ square kiosk

2 Layers of 3-ply, 4-1/8” CLT roof panels in opposite directions, each panel 8’ x 56’, creating 2 way spanning plate

Chicago Horizon Pavilion
Photos: Tom Harris

Chicago Horizon Pavilion
Photos: Aaron Forrest

Total roof structure thickness 8-1/4”

Spans up to 30 feet between columns at points

Western Oregon University
Richard Woodcock Education Center
Monmouth, OR

Image Credit: Western Oregon University and Mahlum Architects

2 story, 57,000 sf

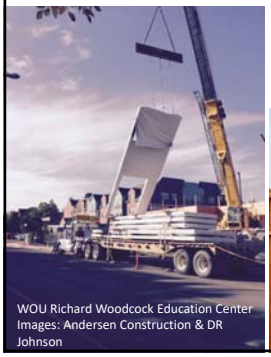
Offices, classrooms, and gathering spaces

CLT utilized for floor plates and bearing/shaft walls

1st project to utilize US manufactured CLT

WOU Richard Woodcock Education Center
Top Photo: Oregon Dept. of Forestry
Bottom Image: Mahlum Architects

Project is currently under construction, anticipated completion fall 2016



WOU Richard Woodcock Education Center
Images: Andersen Construction & DR Johnson

Benefits of CLT Shaft Walls:

- 23 CLT Panels used to form two stairwells
- Each Panel was 5-ply, 6-7/8" thick, 7.5' x 24'
- Each panel weighed 3,330 lbs which is about 20,000 lbs less than a concrete panel of the same size

Source: Andersen Construction

WOU Richard Woodcock Education Center
Image: DR Johnson

Oregon Zoo Elephant Lands
Portland, OR

Photo Credit: SRG Partnership

2,000 sf visitor center

CLT utilized for roof panels

Use of CLT allowed elimination of 20 percent of the steel beams originally needed to support the standard wood decking

1st Oregon CLT project

Oregon Zoo Elephant Lands
Top Photo: Oregon Zoo
Bottom Photo: Oregon Live

Oregon Zoo Elephant Lands
Photos: SRG Partnership, Equilibrium Engineers, Oregon Zoo

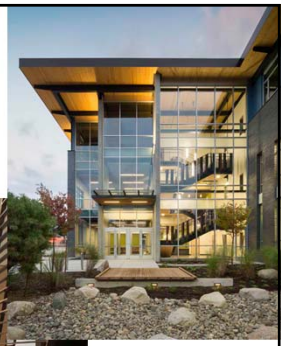
International Community Health Services
Shoreline Clinic
Shoreline, WA

Photo Credit: Andrew Pogue Photography

45,000 sf, 3 story medical and dental services center

CLT utilized for roof panels with large expressed overhangs

Completed Fall 2014



ICHS Shoreline Clinic
Photos: ICHS


ICHS Shoreline Clinic
Photos: ICHS

Project currently pending LEED Gold approval

Largest CLT project in State of WA at time of construction

Use of CLT roof panels resulted in schedule and labor savings, with the panels being set in a matter of days


ICHS Shoreline Clinic
Photo: ICHS

Sauter Timber Production Facility
Rockwood, TN


Photo Credit: Andreas Sauter, Tim Clay Photography

9,000 sf Industrial production facility

CLT roof and wall panels, glulam beam & column frame

23’ tall walls

$55/sf installed structure cost

2015 Wood Design Award Winner

Sauter Timber Production Facility
Photos: Andreas Sauter, Tim Clay Photography


Sauter Timber Production Facility
Photo: Andreas Sauter, Tim Clay Photography

Glulam Moment Frame Provides Facility’s Lateral Resistance

Rocky Mountain Institute – Basalt, CO

Image Credit: Rocky Mountain Institute


Image Credit: Rocky Mountain Institute


Photo Credit: The Aspen Times

Rocky Mountain Institute Innovation Center

- Location: Basalt, CO
- 2 stories
- 15,600 sf
- Goal- 100 year design life

Energy Efficient Office Design

- High energy efficiency construction was a goal not only because it is "green" but because it just "makes sense"
- Targeting Net Zero Energy
- Cross-laminated timber used for floor structure utilizes beetle-kill lumber from British Columbia.
- Use of CLT allowed structure depth to be minimized, allowing natural daylight to penetrate further into building


Photo Credit: StructureLam

Redstone Arsenal Hotel
Huntsville, AL


Image Credit: Lend Lease

62,600 sf, 4 story hotel, 92 private rooms

CLT utilized for walls, roof panels, and floor panels

1,557 CLT Panels; Typical floor panel is 8'x50' & weighs 8,000 lbs

Completed Late 2015

Redstone Arsenal Hotel
Photos: Lend Lease & Schaefer

Franklin Elementary School
Franklin, WV


Photo Credit: Pam Wean, MSES Architects

45,200 sf, 2 story school

CLT utilized for walls, roof panels, and floor panels

CLT chosen for its construction schedule benefits

Completed January 2015

Photo Credit: Pam Wean, MSES Architects

Integrated Design Building
University of Massachusetts, Amherst, MA

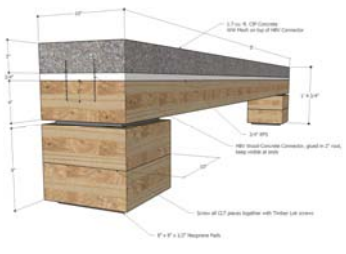

Image Credit: Leers Weinzapfel Associates

87,500 sf facility with: classrooms, lounges, meeting rooms, materials-testing lab, green-building lab, wood shop, digital fabrication lab, cafe, exhibit space, and library

UMASS Integrated Building Design Images: Leers Weinzapfel Associates

Currently under construction, expected opening date: January 2017. Total project budget: $52M

UMASS Integrated Building Design Image: Leers Weinzapfel Associates



CLT Panels utilized in floor systems with composite concrete topping slab

UMASS Integrated Building Design Image: UMASS Building and Construction Technology

Brelsford WSU Visitor Center
Pullman, WA

Photo Credit: Washington State University

4,277 sf, 1 story visitor center

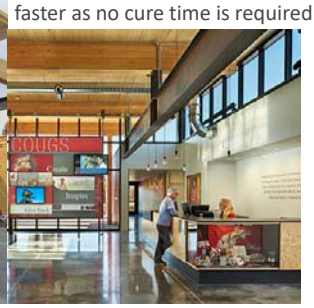
CLT utilized for roof panels with large, expressed overhangs

Completed Late 2013

Brelsford WSU Visitor Center
Photos: WSU & Benjamin Benschneider

CLT Benefits: Structure Mass, Thickness & Construction Speed

4" CLT roof panels were 6 times lighter and 1/3 thinner than concrete roof panels. Installed faster as no cure time is required



Brelsford WSU Visitor Center Photos: WSU & Benjamin Benschneider

Wood Innovation Design Center
Prince George, British Columbia
8 Levels/6 Stories
97 feet tall
Completed Fall 2014

Architect: Michael Green Architecture
Structural Engineer: Equilibrium Consulting
Contractor: PCL Constructors Westcoast
Photos: Ema Peter Photography

- Completed in 2012
- 10 stories
- ~ 105 ft. tall, > 18.6 K sqft.
- 3 million in R&D
- Poor soils required a much lighter building

Forte', Victoria Harbor, Melbourne, Australia
Architect: Lend Lease

Forte', Victoria Harbor, Melbourne, Australia
Architect: Lend Lease

How do you minimize product costs?

1. Use the minimum thickness possible
    1. Floors are usually controlled by vibrations.
    2. Fire rating requirements can effect thickness of panel.
2. Minimize material waste
    1. Keep in mind press sizes available.
    2. Selection of splice type effects % waste.
    3. Openings can be accommodated with out cutting holes in panels.
3. Minimize factory CNC work
    1. Consider field accommodation techniques for MEP
    2. Openings can be accommodated with out cutting holes in panels.
4. Use the standard product options
    1. Species
    2. Finish
    3. Lay-up
5. Choose the right application for CLT.

CLT as an alternate to Concrete/Masonry

Model Building Code Acceptance

2015 International Building Code

CLT is Defined – 2015 IBC

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:

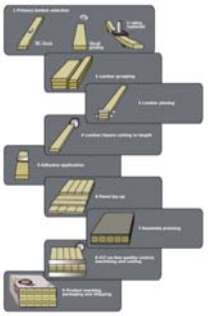
ANSI

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

CLT Product Standardization

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

Building Code -Product Standard



APA/ANSI PRG 320

- 7 stress classes
- Quality assurance testing
- Identification marking

CLT Grade	CLT Thickness (in.)	Lamination Thickness in CLT Lay-up (in.)							Major Strength Direction			Minor Strength Direction	
		∥	⊥	∥	⊥	∥	⊥	∥	$F_bS_{eff,0}$ (lb.-ft./ft.)	$EI_{eff,0}$ (10^6 lb.-in.^{2}/ft.)	$GA_{eff,0}$ (10^3 lb./ft.)	$F_bS_{eff,90}$ (lb.-ft./ft.)	$EI_{eff,90}$ (10^6 lb.-in.^{2}/ft.)
E1	4 1/8	1 3/8	1 3/8	1 3/8					4,525	115	0.46	160	3.1
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			10,400	440	0.92	1,370	81
	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	18,375	1,089	1.4	3,125	309
E2	4 1/8	1 3/8	1 3/8	1 3/8					3,825	102	0.53	165	3.6
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			8,825	389	1.1	1,430	95
	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	15,600	963	1.6	3,275	360
	4 1/8	1 3/8	1 3/8	1 3/8					2,800	81	0.35	110	2.3
E3	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			6,400	311	0.69	955	61

Code Approvals - Product Reports

APA PRODUCT REPORT

Structurlam CrossLam
Structurlam Products LP — **PR-L314**
Issued May 23, 2013

Products: Structurlam CrossLa
Structurlam Products LP
2176 Government Street
Penticton, British Columbia, Ca
(250) 492-8912
www.structurlam.com

APA PRODUCT REPORT

Nordic X-Lam
Nordic Engineered Wood — **PR-L306**
Revised May 23, 2013

Products: Nordic X-Lam
Nordic Engineered Wood
1100 Avenue des Canadiens-de-Montréal, Suite 504
Montreal, Québec, Canada H3B 2S2
(514) 871-8526
www.nordicewp.com

Product Reports

Table 1. Allowable Design Properties[a] for Nordic X-Lam (for use in the U.S.)

CLT Grade	Major Strength Direction						Minor Strength Direction					
	$F_{b,0}$ (psi)	E_0 (10^6 psi)	$F_{t,0}$ (psi)	$F_{c,0}$ (psi)	$F_{v,0}$ (psi)	$F_{r,0}$ (psi)	$F_{b,90}$ (psi)	E_{90} (10^6 psi)	$F_{t,90}$ (psi)	$F_{c,90}$ (psi)	$F_{v,90}$ (psi)	$F_{r,90}$ (psi)
E1	1,950	1.7	1,375	1,800	135	45	500	1.2	250	650	135	45

For SI: 1 psi = 0.006895 MPa

[a] Tabulated values are allowable design values and not permitted to be increased for the lumber size adjustment factor in accordance with the NDS. The design values shall be used in conjunction with the section properties provided by the CLT manufacturer based on the actual layup used in manufacturing the CLT panel (see Table 2).

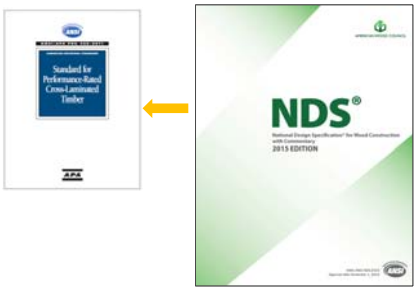
Table 2. The Allowable Bending Capacities[a] for Nordic X-Lam Listed in Table 1 (for use in the U.S.)

CLT Grade[b]	Layup[c]	Thickness (in.)	Lamination Thickness (in.) in CLT Layup						Major Strength Direction				Minor Strength Direction			
			∥	⊥	∥	⊥	∥	⊥	∥				∥			
									M_{allow} (lbf-ft/ft)	$EI_{eff,flat}$ (10^6 lbf-in^2/in)	$GA_{eff,flat}$ (10^6 lbf/in)	$V_{r,flat}$ (lbf/ft)	M_{allow} (lbf-ft/ft)	$EI_{eff,flat}$ (10^6 lbf-in^2/in)	$GA_{eff,flat}$ (10^6 lbf/in)	$V_{r,flat}$ (lbf/ft)
E1	7l-3s	3 1/8	1 1/64	1 1/16	1 1/64				2,525	46	0.34	1,070	95	1.4	0.47	380
	10l-3s	4 1/8	1 3/8	1 3/8	1 3/8				4,525	115	0.46	1,430	160	3.1	0.61	495
	13l-5s	5 1/8	1 1/64	1 1/16	1 1/64	1 1/16	1 1/64		5,800	194	0.69	1,470	705	35	0.94	1,000
	17l-5s	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8		10,400	440	0.92	1,970	1,370	81	1.2	1,430
	22l-7s	8 1/4	1 3/8	1 1/16	1 3/8	1 1/16	1 3/8	1 1/16	15,975	853	1.4	2,400	2,160	194	1.5	1,560
	24l-7l	9 5/8	1 3/8x2	1 3/8	1 3/8	1 3/8	1 3/8x2		23,700	1,404	2.0	3,200	1,370	81	1.9	1,430
	31l-9l	12 3/8	1 3/8x2	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8x2	36,700	2,794	2.4	3,875	3,125	309	2.5	1,950

For SI: 1 in. = 25.4 mm; 1 ft = 304.8 mm; 1 lbf = 4.448N

[a] Tabulated values are allowable design values and not permitted to be increased for the lumber size adjustment factor in accordance with the NDS.
[b] The CLT grades are developed based on ANSI/APA PRG 320, as permitted by the standard.
[c] The layup designation refers to the panel thickness (in mm), the number of layers, and the layup combination ("s" for standard perpendicular layers, and "l" for doubled outermost parallel layers).

Structural Design Standardization



National Design Specification for Wood Construction
2015 Edition

CLT in NDS 2015

New **Chapter 10** in 2015 NDS covering Adjustment Factors for CLT

Formatting Similar to Wood Structural Panels

Table 10.3.1 Applicability of Adjustment Factors for Cross-Laminated Timber

		ASD only	ASD and LRFD					LRFD only		
		Load Duration Factor	Wet Service Factor	Temperature Factor	Beam Stability Factor	Column Stability Factor	Bearing Area Factor	Format Conversion Factor	Resistance Factor	Time Effect Factor
$F_b(S_{eff})' = F_b(S_{eff})$	x	C_D	C_M	C_t	C_L	-	-	2.54	0.85	λ
$F_c(A_{parallel})' = F_c(A_{parallel})$	x	C_D	C_M	C_t	-	-	-	2.70	0.80	λ
$F_v(I_b)' = F_v(I_b)$	x	C_D	C_M	C_t	-	-	-	2.88	0.75	λ
$F_s(Ib/Q)_{eff}' = F_s(Ib/Q)_{eff}$	x	-	C_M	C_t	-	-	-	2.88	0.75	-
$F_{c\perp}(A_{parallel})' = F_{c\perp}(A_{parallel})$	x	C_D	C_M	C_t	-	C_P	-	2.40	0.90	λ
$F_{c\perp}(A)' = F_{c\perp}(A)$	x	-	C_M	C_t	-	-	C_b	1.67	0.90	-
$(EI)_{app}' = (EI)_{app}$	x	-	C_M	C_t	-	-	-	-	-	-
$(EI)_{app,min}' = (EI)_{app,min}$	x	-	C_M	C_t	-	-	-	1.76	0.85	-

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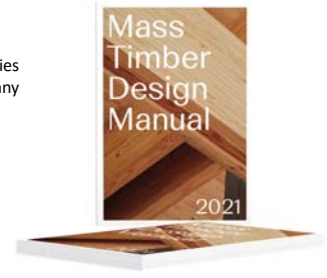

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Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

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