CLT Shear Wall and Diaphragm Design with SDPWS 2021

Presented by:

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Photo credit: KPFF / Reid Zimmerman

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

AIA Approved Continuing Education

Course Description

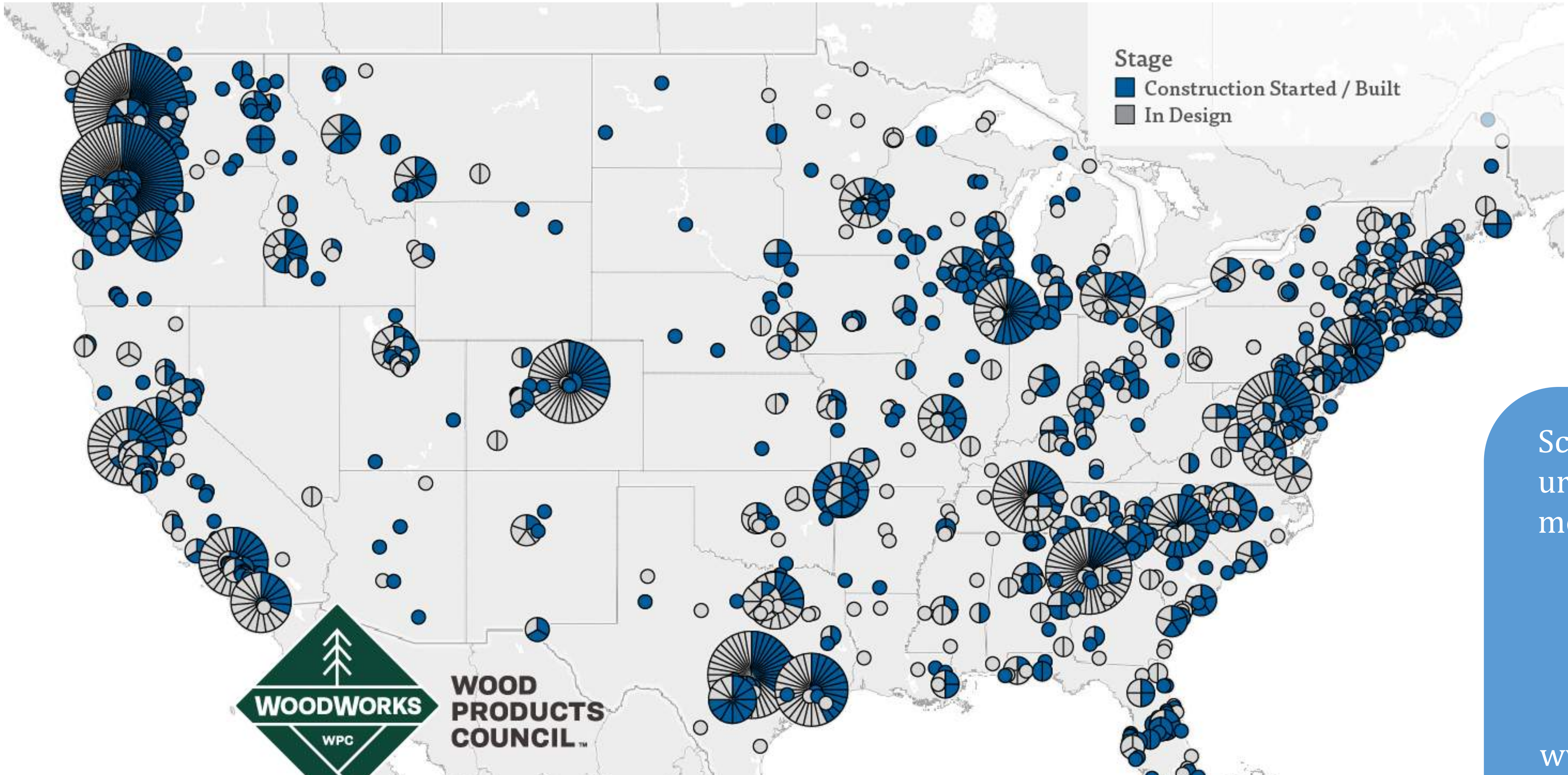
The use of cross-laminated timber (CLT) as structural floor and roof panels has seen incredible growth in the US over the past decade. However, its use as part of a seismic and wind force-resisting system—either as a diaphragm or shear wall—has only recently been codified. This has resulted in designing CLT lateral systems through alternative means. This presentation will introduce new provisions for CLT shear wall and diaphragm design, in the American Wood Council's 2021 Special Design Provisions for Wind and Seismic (SDPWS). The presentation will cover the detailing and design requirements for the newly defined CLT shear walls and diaphragms found in the SPDWS and the range of seismic design parameters (e.g., R values) recognized for CLT shear wall in ASCE 7-22.

Learning Objectives

1. Develop and understanding of design challenges related to using CLT for wind and seismic resistance while meeting the intent if the building code.
2. Discuss the new provisions in the 2021 Edition of Special Design Provisions for Wind and Seismic applicable to all lateral system.
3. Understand the new detailing options and path to code acceptance of several CLT shear wall systems.
4. Review the engineering design requirements for using CLT floors and roof assemblies as horizontal diaphragms for wind and seismic resistance.

Current State of Mass Timber Projects

As of Q1 2025, in the US, **2,427** multi-family, commercial, or institutional projects have been constructed with, or are in design with, mass timber. https://www.woodworksinnovationnetwork.org/projects/



Source: WoodWorks, March 31, 2025

** This total includes modern mass timber and post-and-beam structures built since 2013*

Scan this code or use the url to find the map and more details online.

www.woodworks.org/resources/mapping-mass-timber/


Ascent
Milwaukee, WI
Korb + Associates Architects
Thronton Tomasetti
Photo: C.D. Smith Construction


Condominiums on the
Marina in Lost Rabbit
Madison, MS
dunaway/WILLIAMS Architects
McQueen Structural Engineers
Photo: Andrew Welch

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

Candlewood Suites at Redstone Arsenal

Huntsville, AL

Photo Credit: Lend Lease

Photo Credit: IHG® Army Hotels

Candlewood Suites at Redstone Arsenal

Huntsville, AL

Photo Credit: Lendlease

Candlewood Suites at Fort Liberty, NC

Photo Credit: MLP Solutions and Sterling Structural

Virtuoso

Vancouver, BC

Image: Adera

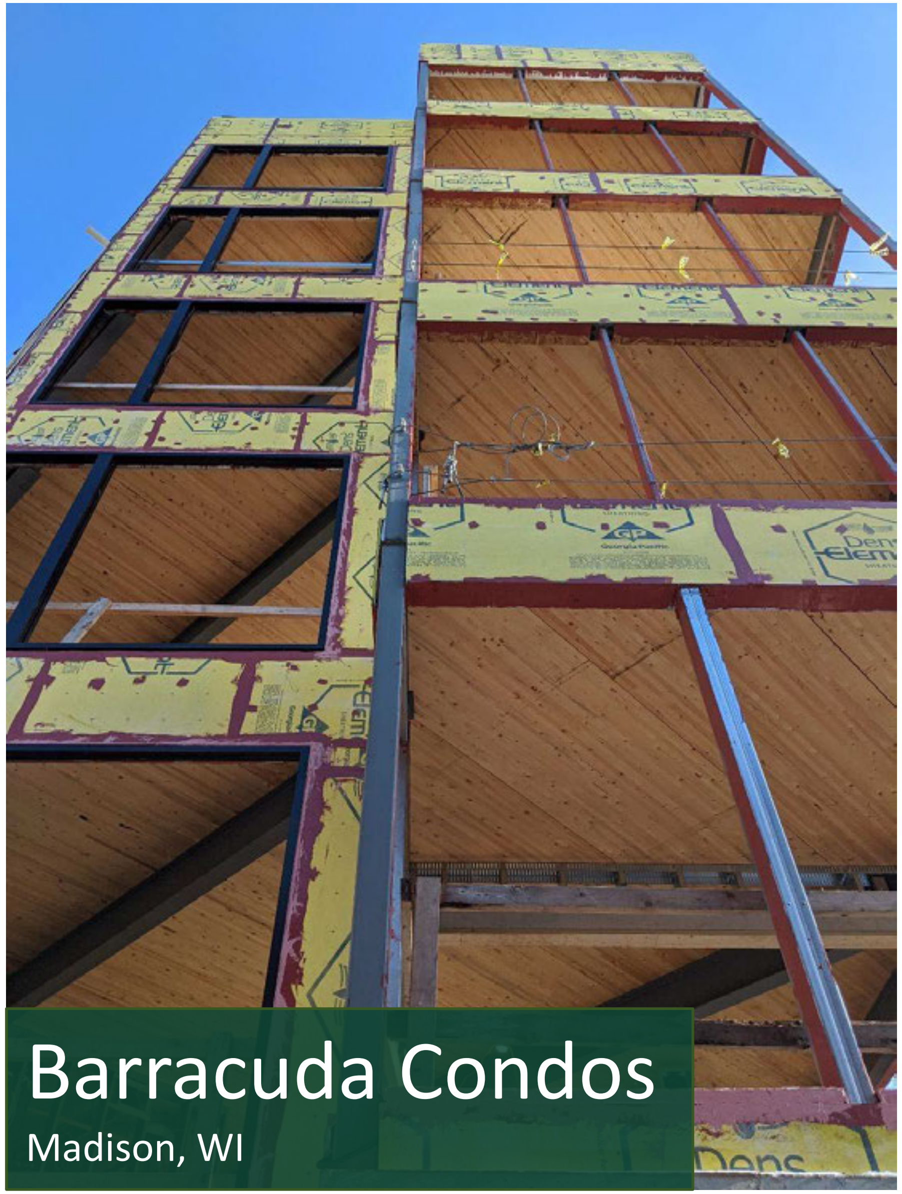
Image: Seagate Structures

UMass Olver Design Building

Amherst, MA

Photo Credit: Alex Schreyer

Hybrid Mass Timber and Steel Framing



Barracuda Condos
Madison, WI

Photo Credit: WoodWorks

Brentwood Library

Brentwood, CA

Photo Credit: Blake Marvin/Holmes

CrossFit Center

Spokane, WA

Photo Credit: WoodWorks

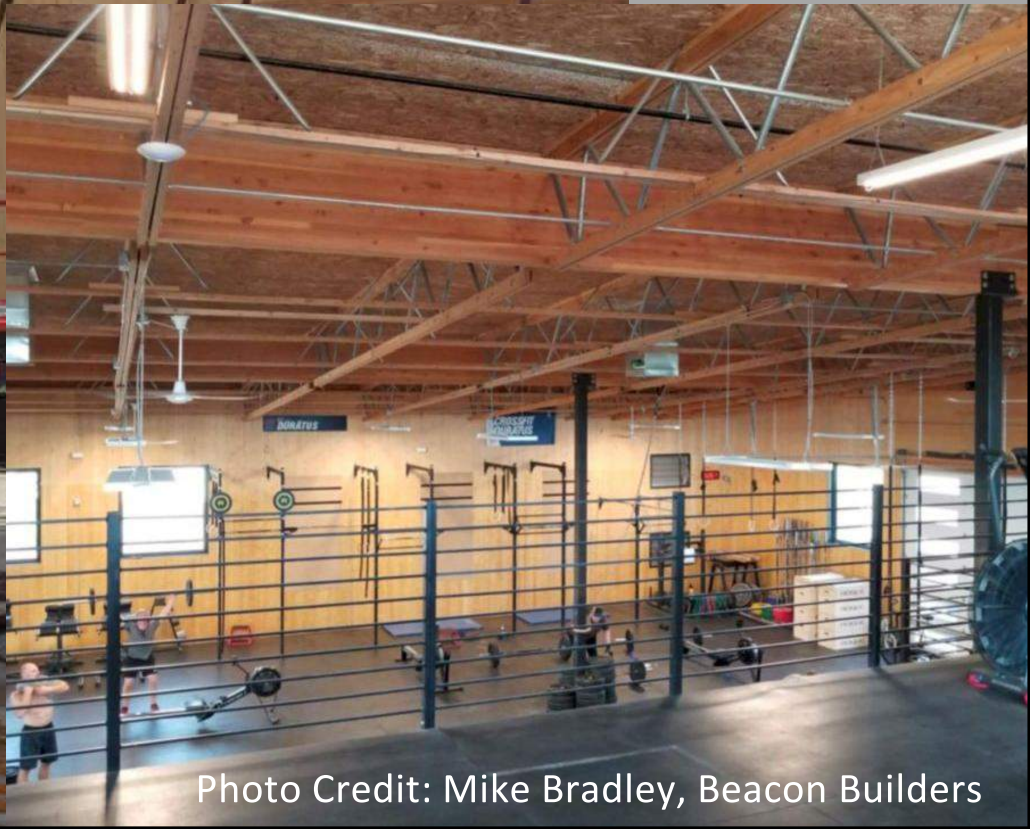


Photo Credit: Mike Bradley, Beacon Builders

Cooley Landing Education Center

East Palo Alto, CA

Photo Credit: Michael O’Calahan

Cross-Laminated Timber

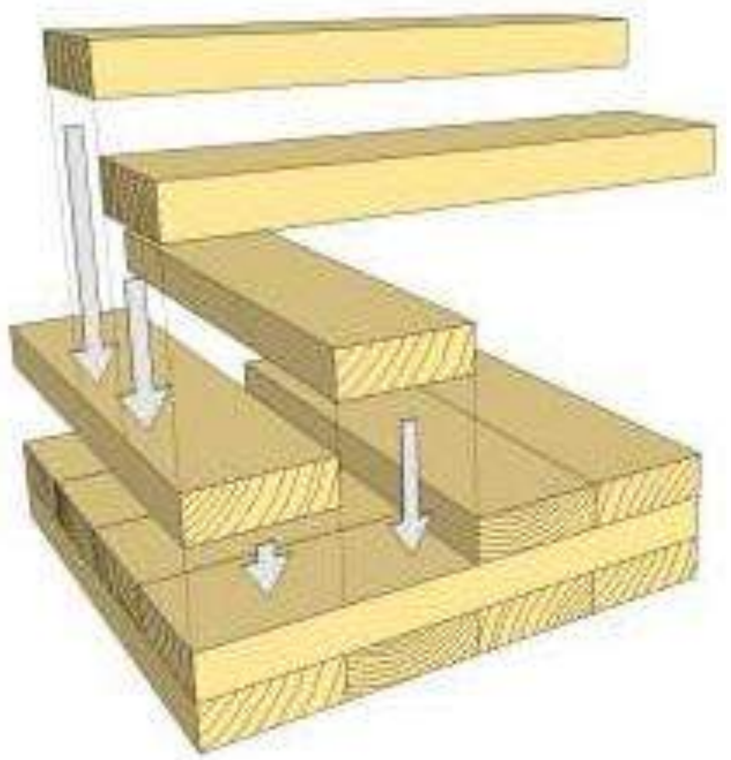
What is CLT?

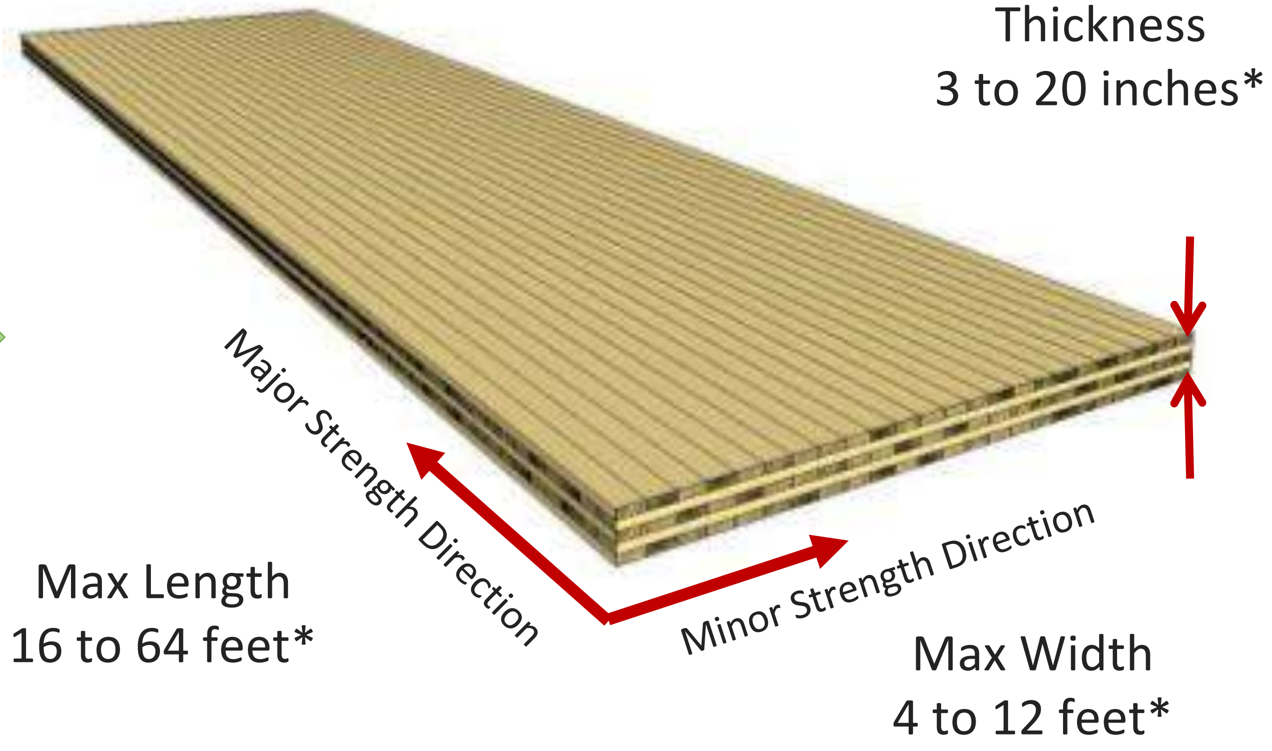
3+ layers of laminations

Solid Sawn or Structural Composite Lumber Laminations

Cross-Laminated Layup

Glued with Structural Adhesives

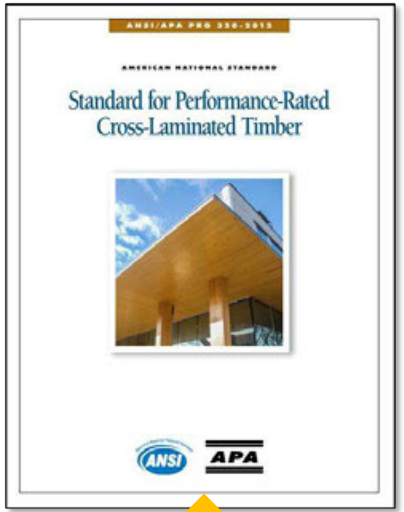


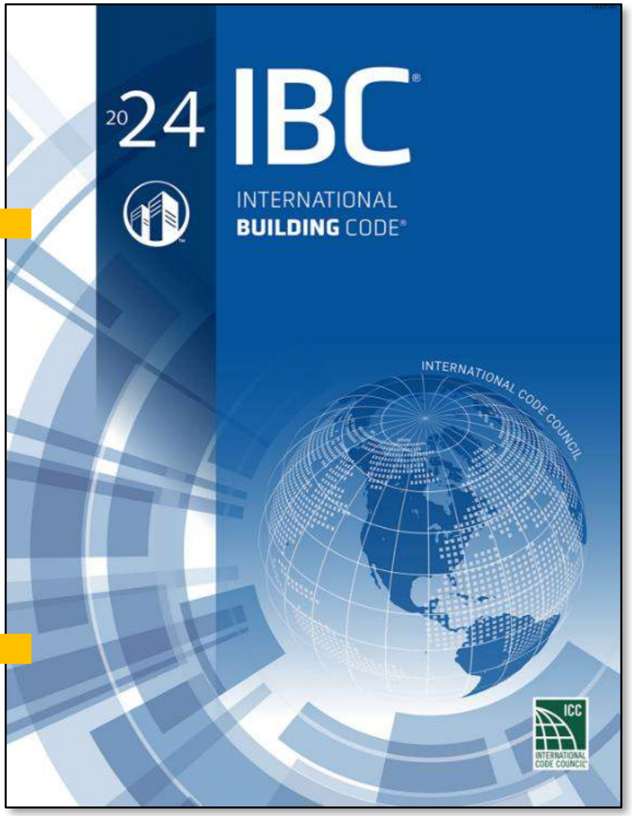


*All dimensions are approximate.
Consult with manufacturers

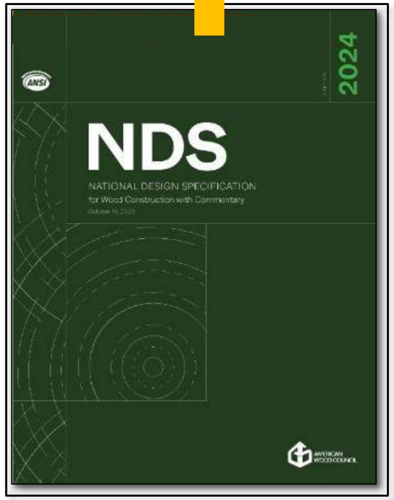
CLT Product Standards and Code Acceptance

ANSI/APA PRG 320
CLT Product Standard



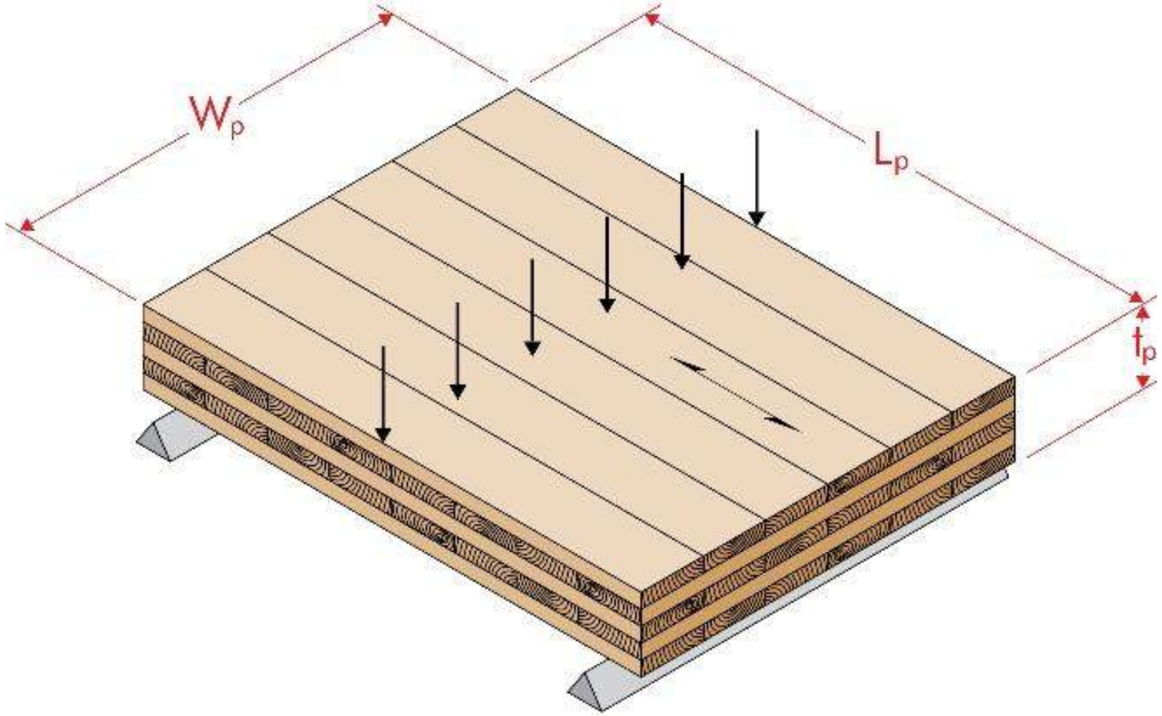


AWC's NDS
for CLT structural design

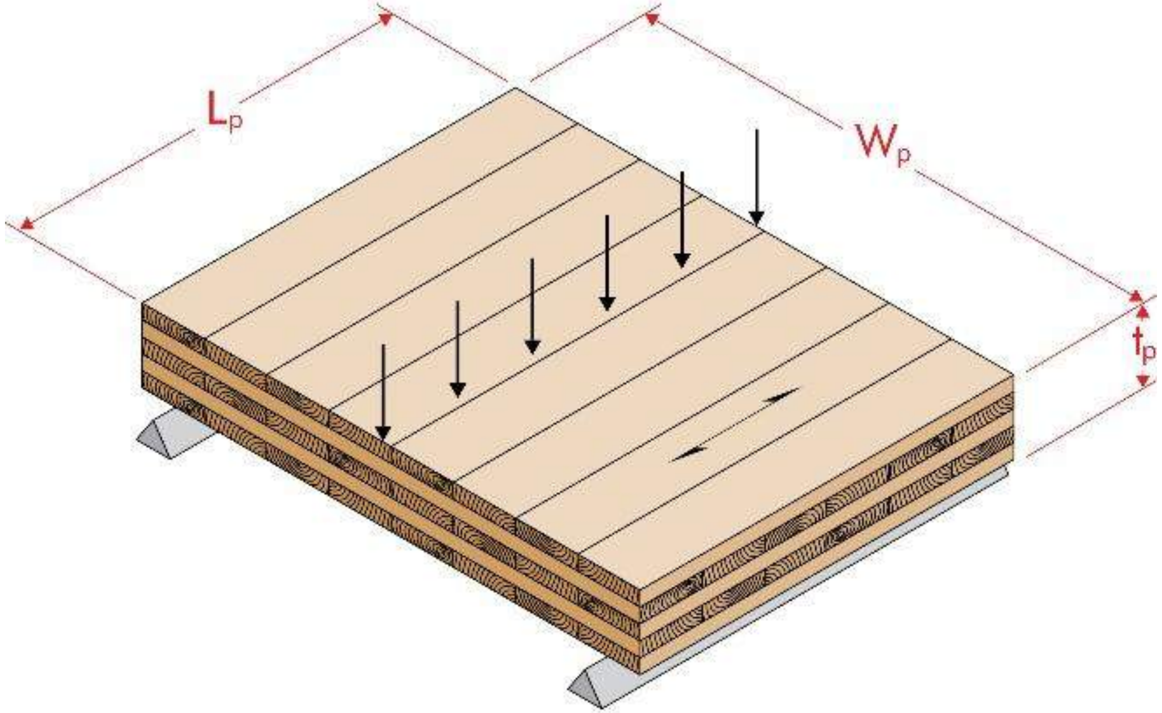


International Building Code
2015 thru 2024 editions

FLATWISE Panel Loading



Span in MAJOR Strength Direction
“Parallel” Direction
Uses subscript ‘0’ in Notation



Span in MINOR Strength Direction
“Perpendicular” Direction
Uses subscript ‘90’ in Notation

Reference & Source: ANSI/APA PRG 320

PRG 320 Defined Layups

CLT Grade (basic)

Layup

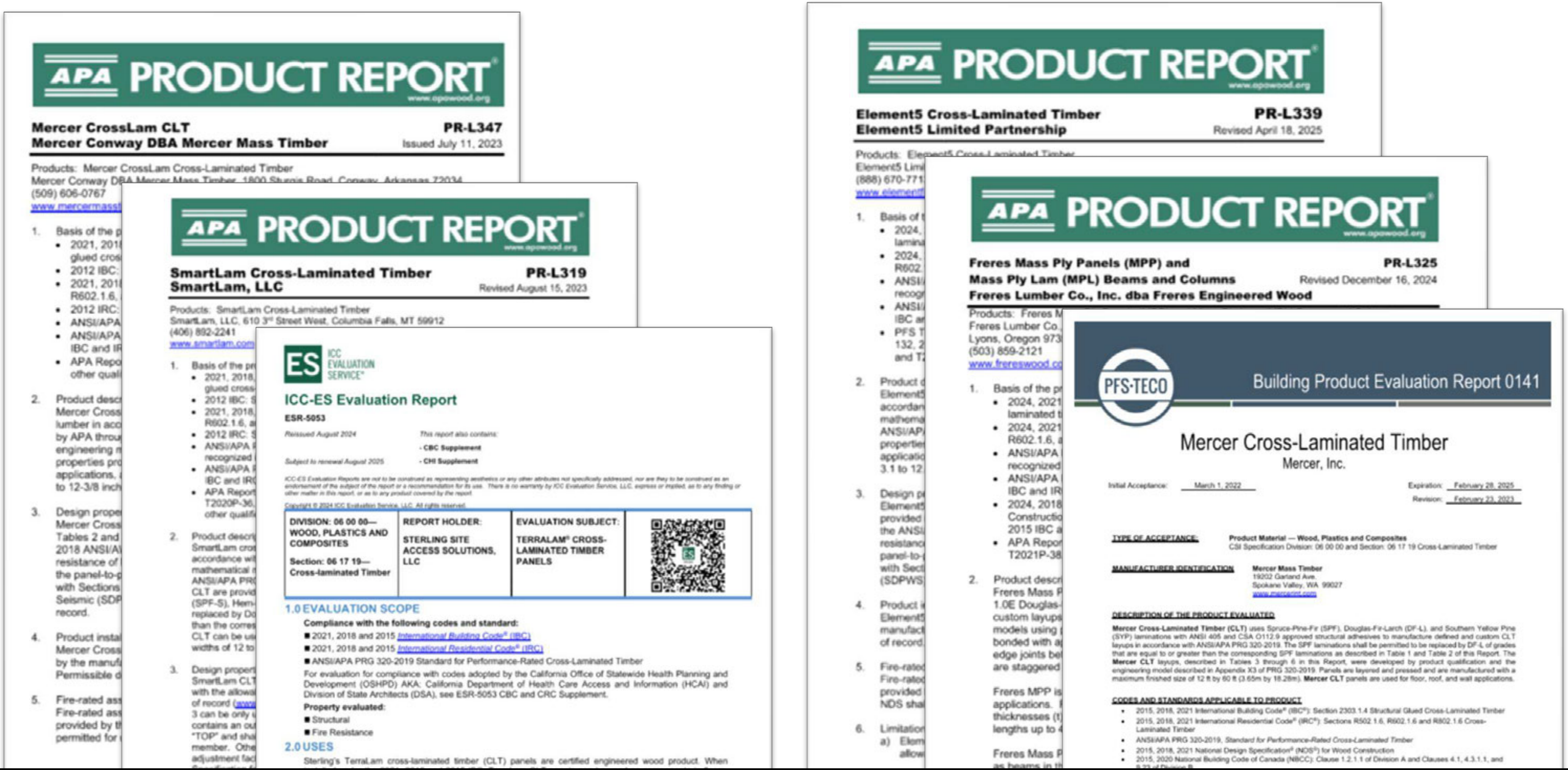
Panel Properties

TABLE A2

ASD REFERENCE DESIGN VALUES[a] FOR BASIC CLT GRADES AND LAYUPS (FOR USE IN THE U.S.)

CLT Grade	Lamination Thickness (in.) in CLT Layup								Major Strength Direction				Minor Strength Direction			
	t_p (in.)	=	⊥	=	⊥	=	⊥	=	$(F_bS)_{eff,f,0}$ (lbf-ft/ft of width)	$(EI)_{eff,f,0}$ (10^6 lbf-in.^{2}/ft of width)	$(GA)_{eff,f,0}$ (10^6 lbf/ft of width)	$V_{s,0}$ (lbf/ft of width)	$(F_bS)_{eff,f,90}$ (lbf-ft/ft of width)	$(EI)_{eff,f,90}$ (10^6 lbf-in.^{2}/ft of width)	$(GA)_{eff,f,90}$ (10^6 lbf/ft of width)	$V_{s,90}$ (lbf/ft of width)
E1	4 1/8	1 3/8	1 3/8	1 3/8					4,525	115	0.46	1,490	160	3.1	0.61	495
E1	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			10,400	440	0.92	2,480	1,370	81	1.2	1,490
E1	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	3,475	3,150	313	1.8	2,480
E2	4 1/8	1 3/8	1 3/8	1 3/8					3,825	102	0.53	1,980	165	3.6	0.56	660
E2	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			8,825	389	1.1	3,300	1,440	95	1.1	1,980
E2	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	4,625	3,300	364	1.7	3,300
E3	4 1/8	1 3/8	1 3/8	1 3/8					2,800	81	0.35	1,160	110	2.3	0.44	385
E3	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			6,400	311	0.69	1,930	955	61	0.87	1,160
E3	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	11,325	769	1.0	2,700	2,210	234	1.3	1,930
E4	4 1/8	1 3/8	1 3/8	1 3/8					4,525	115	0.50	1,820	140	3.4	0.62	605
E4	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			10,400	440	1.0	3,025	1,230	88	1.2	1,820
E4	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	18,400	1,089	1.5	4,225	2,850	338	1.9	3,025
	4 1/8	1 3/8	1 3/8	1 3/8					3,825	101	0.46	1,650	160	3.1	0.55	550

3rd Party Product Qualification of CLT



CLT Product Reports

CLT Grade
(basic or custom)

Layup

Panel Properties

Table 1. Allowable Design Properties[a] for Lumber Laminations Used in SmartLam CLT (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)	$F_{s,0}$ (psi)	$F_{b,90}$ (psi)	E_{90} (10^6 psi)	$F_{t,90}$ (psi)	$F_{c,90}$ (psi)	$F_{v,90}$ (psi)	$F_{s,90}$ (psi)
SL-V4	775	1.1	350	1,000	135	45	775	1.1	350	1,000	135	45

For SI: 1 psi = 0.006895 MPa

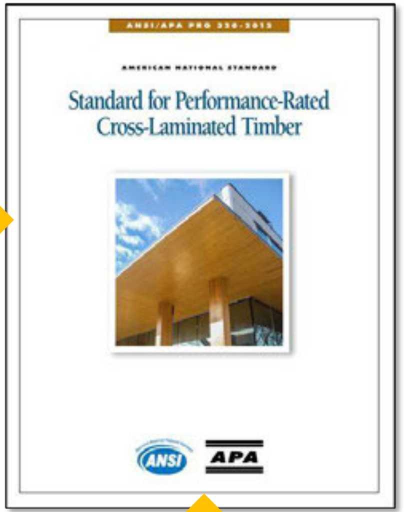
[a] Tabulated values are allowable design values and not permitted to be increased for the lumber flat use or size factor in accordance with the NDS. The design values shall be used in conjunction with the section properties provided by the CLT manufacturer based on the actual layup used in manufacturing the CLT panel (see Tables 2 and 3).

Table 2. Allowable Design Capacities[a] for SmartLam Balanced CLT (for Use in the U.S.)

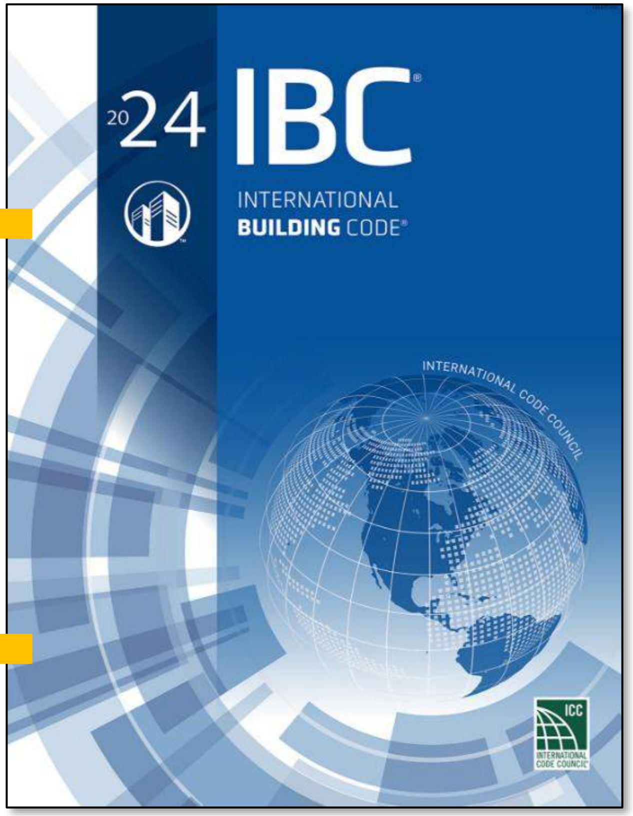
CLT Grade	Layup #	Thick-ness (in.)	Lamination Thickness (in.) in CLT Layup									Major Strength Direction				Minor Strength Direction			
			=	⊥	=	⊥	=	⊥	=	⊥	=	$F_bS_{eff,0}$ (lbf-ft/ft)	$EI_{eff,0}$ (10^6 lbf-in.^{2}/ft)	$GA_{eff,0}$ (10^6 lbf/ft)	$V_{s,0}$ (lbf/ft)	$F_bS_{eff,90}$ (lbf-ft/ft)	$EI_{eff,90}$ (10^6 lbf-in.^{2}/ft)	$GA_{eff,90}$ (10^6 lbf/ft)	$V_{s,90}$ (lbf/ft)
SL-V4[b]	3-alt	4 1/8	1 3/8	1 3/8	1 3/8							1,800	74	0.41	1,430	245	2.9	0.41	495
	4-maxx	5 1/2	1 3/8	1 3/8 x 2	1 3/8							2,925	161	0.49	1,740	975	23	0.85	990
	5-alt	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8					4,150	286	0.83	1,980	2,120	74	0.83	1,430
	5-maxx	6 7/8	1 3/8 x 2	1 3/8	1 3/8 x 2							5,150	355	1.4	2,460	245	2.9	0.86	495
	6-maxx	8 1/4	1 3/8 x 2	1 3/8 x 2	1 3/8 x 2							7,200	596	1.2	2,875	975	23	1.3	990
	7-alt	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			7,325	707	1.2	2,500	4,825	283	1.2	1,960
	7-maxx	9 5/8	1 3/8 [illegible]	[illegible]	[illegible]	[illegible]	1 3/8 [illegible]					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

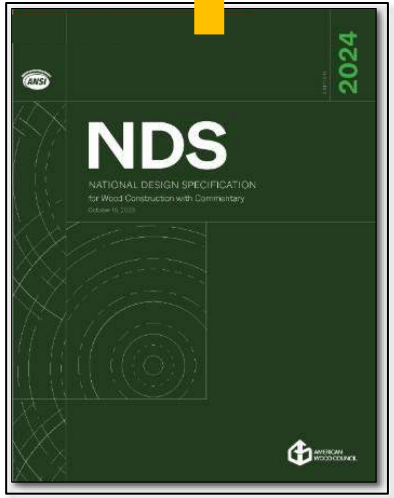
CLT Product Standards and Code Acceptance

ANSI/APA PRG 320



3rd Party Product Reports



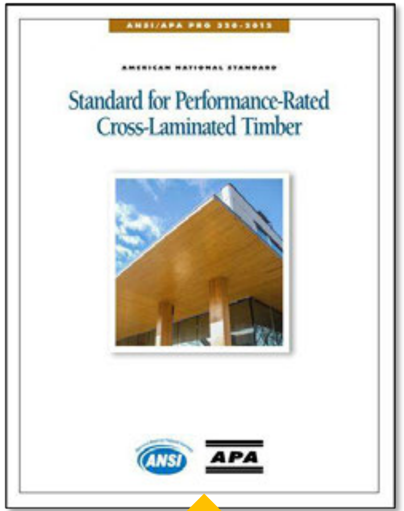


AWC's NDS for CLT structural design

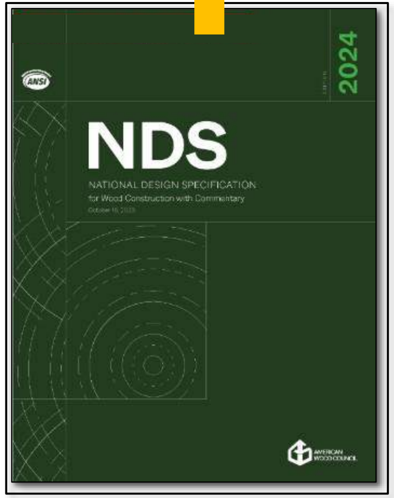
International Building Code

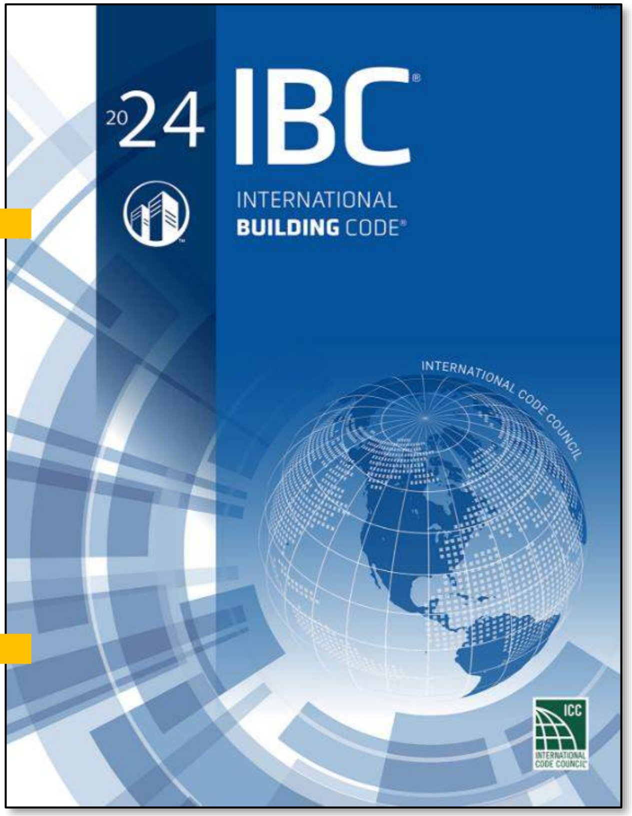
CLT Product Standards and Code Acceptance

ANSI/APA PRG 320
CLT Product Standard



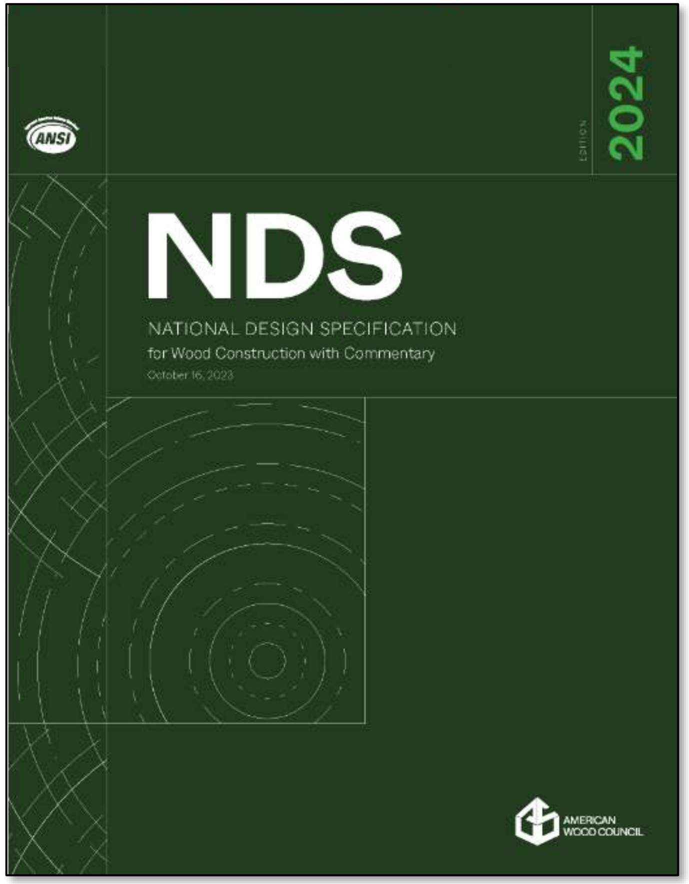
AWC's NDS
for CLT structural design





International Building Code

Structural Design Standardization



National Design Specification for Wood Construction
2015, 2018, 2021 Editions

Table 10.3.1 Applicability of Adjustment Factors for Cross-Laminated Timber

	ASD only	ASD and LRFD	LRFD only
$F_b(S_{eff})' = F_b(S_{eff})$			
$F_t(A_{parallel})' = F_t(A_{pa}$			
$F_v(t_v)' = F_v(t_v)$			
$F_s(Ib/Q)_{eff}' = F_s(Ib/$			
$F_c(A_{parallel})' = F_c(A_p$			
$F_{c\perp}(A)' = F_{c\perp}(A)$			
$(EI)_{app}' = (EI)_{app}$			
$(EI)_{app\text{-}min}' = (EI)_{app}$			

Figure 12I End Distance, Edge Distance and Fastener Spacing Requirements in Narrow Edge of Cross-Laminated Timber

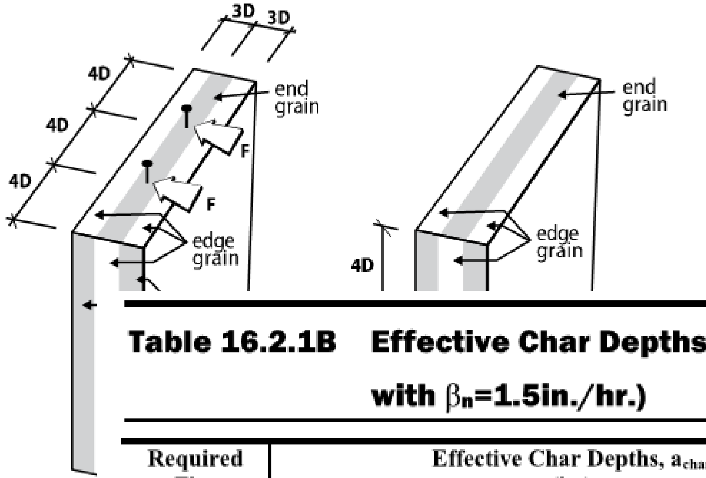
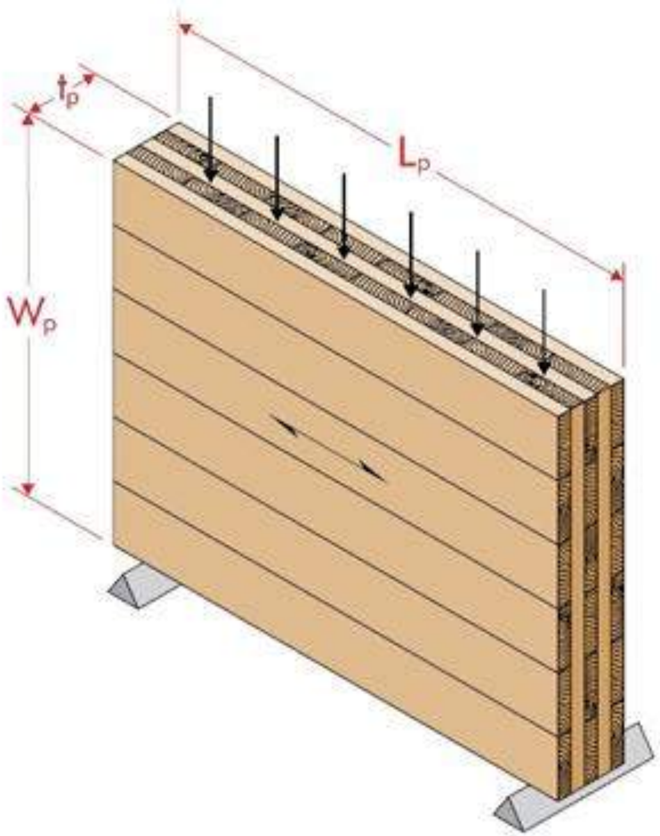


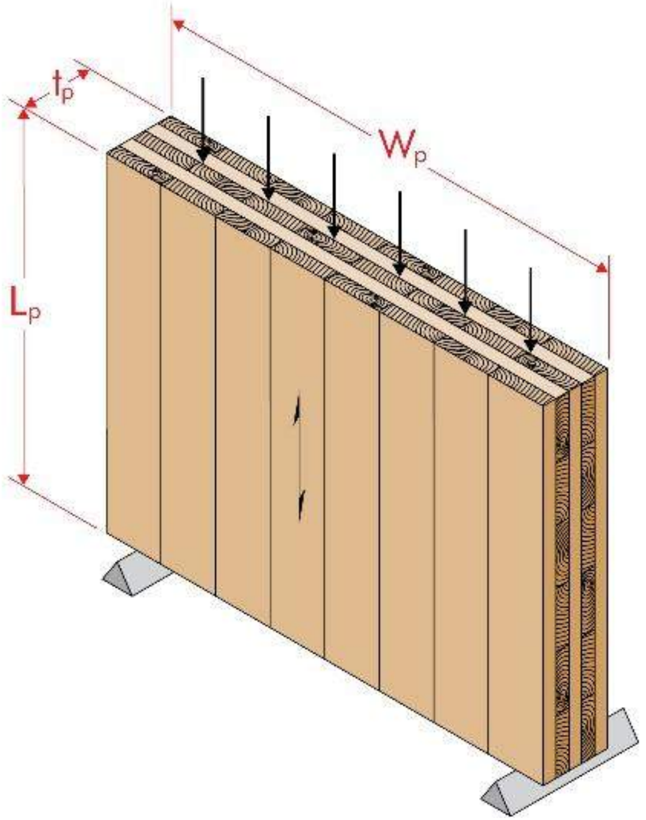
Table 16.2.1B Effective Char Depths (for CLT with β_n=1.5in./hr.)

Required Fire Endurance (hr.)	Effective Char Depths, a_{char} (in.)								
	lamination thicknesses, h_{lam} (in.)								
	5/8	3/4	7/8	1	1-1/4	1-3/8	1-1/2	1-3/4	2
1-Hour	2.2	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.8
1½-Hour	3.4	3.2	3.1	3.0	2.9	2.8	2.8	2.8	2.6
2-Hour	4.4	4.3	4.1	4.0	3.9	3.8	3.6	3.6	3.6

EDGEWISE Panel Loading



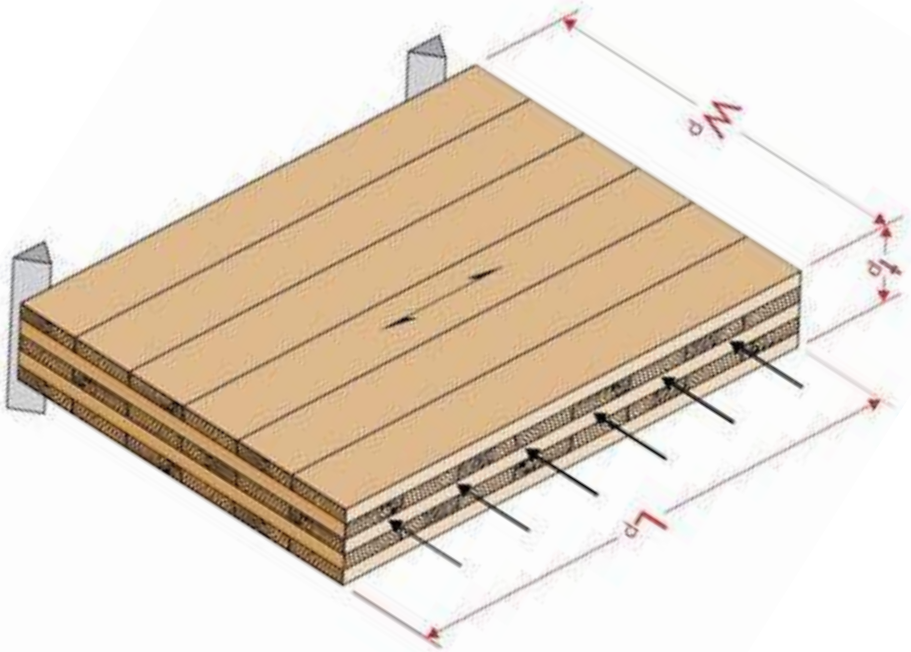
Span in MAJOR Strength Direction



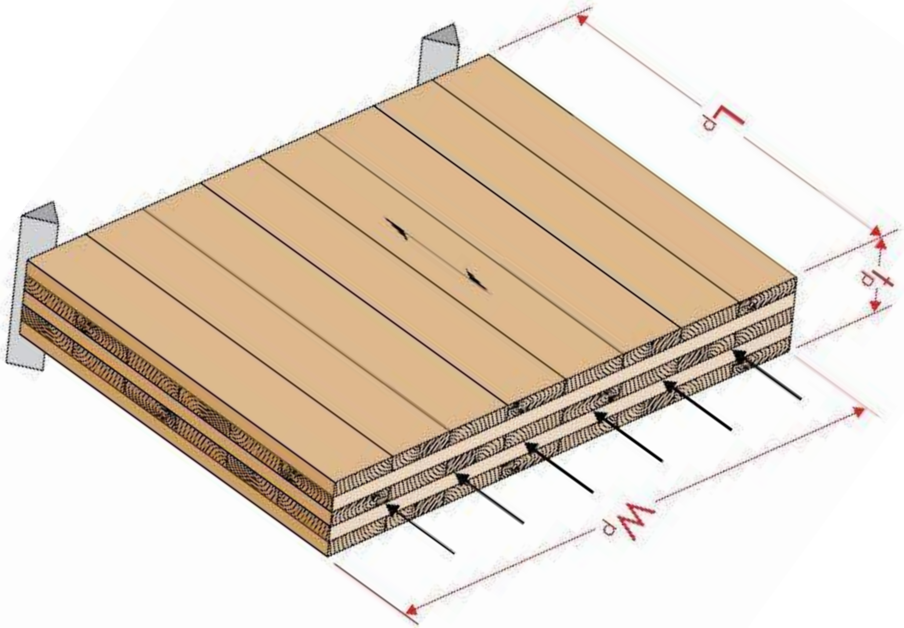
Span in MINOR Strength Direction

Reference & Source: ANSI/APA PRG 320-2017

EDGEWISE Panel Loading



Span in MAJOR Strength Direction



Span in MINOR Strength Direction

Reference & Source: ANSI/APA PRG 320-2017

CLT in In-Plane (Edgewise) Strength

TABLE 4—REFERENCE DESIGN VALUES FOR IN-PLANE SHEAR OF THE KALESNIKOFF CLT PANELS[1]

CLT GRADE	LAYUP[2]	THICKNESS t_p (in.)	IN-PLANE SHEAR STRESS		IN-PLANE SHEAR CAPACITY[3]	
			$F_{v,e,0}$ (psi)	$F_{v,e,90}$ (psi)	$F_{v,e,0}\,t_p$ (lbf/ft of width)	$F_{v,e,90}\,t_p$ (lbf/ft of width)
E1	3-ply	4 1/8	105[4]	105[4]	5,200[4]	5,200[4]
	5-ply	6 7/8	165[5]	165[5]	13,600[5]	13,600[5]
	7-ply	9 5/8	165[5]	165[5]	19,100[5]	19,100[5]
	9-ply	12 3/8	165[5]	165[5]	24,500[5]	24,500[5]
E1.1	3-ply	3.67	105[4]	105[4]	4,600[4]	4,600[4]
	5-ply	5.84	165[5]	165[5]	11,600[5]	11,600[5]
	7-ply	8.02	165[5]	165[5]	15,900[5]	15,900[5]
	9-ply	10.19	165[5]	165[5]	20,200[5]	20,200[5]
E1.2	3-ply	4.50	105[4]	105[4]	5,700[4]	5,700[4]
	5-ply	7.50	165[5]	165[5]	14,900[5]	14,900[5]
	7-ply	10.50	165[5]	165[5]	20,800[5]	20,800[5]
	9-ply	13.50	165[5]	165[5]	26,700[5]	26,700[5]

Source: ICC-ES/APA Joint Evaluation Report ESR 5105

100 to 290 PSI Edgewise Shear Capacity

= 1.2 to 3.5 kips/ft (ASD)

per inch of thickness!

Consult with the Manufacturers for Values

Multiply by Cd = 1.6

for short term ASD strength

Table 5. ASD Edgewise Design Values for Mercer CLT 1.4V Grade Panels

No. of Layers	CLT Layup Designation	Thickness, t_p (in.)	Edgewise Shear Stress [a][b]	
			$F_{v,e,0}$ (psi)	$F_{v,e,90}$ (psi)
3	CLT3-082	3.24	190	215
	CLT3-090	3.54	190 [c]	215 [c]
	CLT3-090T	3.54	190[c]	215[c]
	CLT3-097	3.84	190 [c]	215 [c]
	CLT3-100	3.94	190 [c]	215 [c]
	CLT3-105	4.14	190 [c]	215 [c]
5	CLT5-137	5.40	240	235
	CLT5-150	5.91	240 [d]	235 [d]
	CLT5-152T	6.00	240 [d]	235 [d]
	CLT5-160	6.30	240 [d]	235 [d]
	CLT5-175	6.90	240 [d]	235 [d]
7	CLT7-222	8.76	240 [d]	235 [d]
	CLT7-245	9.66	240 [d]	235 [d]
9	CLT9-285	11.22	240 [d]	235 [d]
	CLT9-315	12.42	240 [d]	235 [d]

Source: PFS-TECO Report BP-0141

CLT <u>Panels</u> can have 5 - 20+ kips/ft in-plane shear capacity

Lateral Systems

Mass Timber Design

Lateral framing systems

Central Core – concrete shearwalls

Photo Credit: Structurecraft


Mass Timber Design
Lateral framing systems
Interior steel moment frame
Photo Credit: WoodWorks


Mass Timber Design
Lateral framing systems
Steel Braced Frame
Photo Credit: John Stamets

Mass Timber Design

Lateral framing systems

Light-frame wood shearwalls

Photo Credit: WoodWorks

Mass Timber Design

Lateral framing systems

CLT Shearwalls

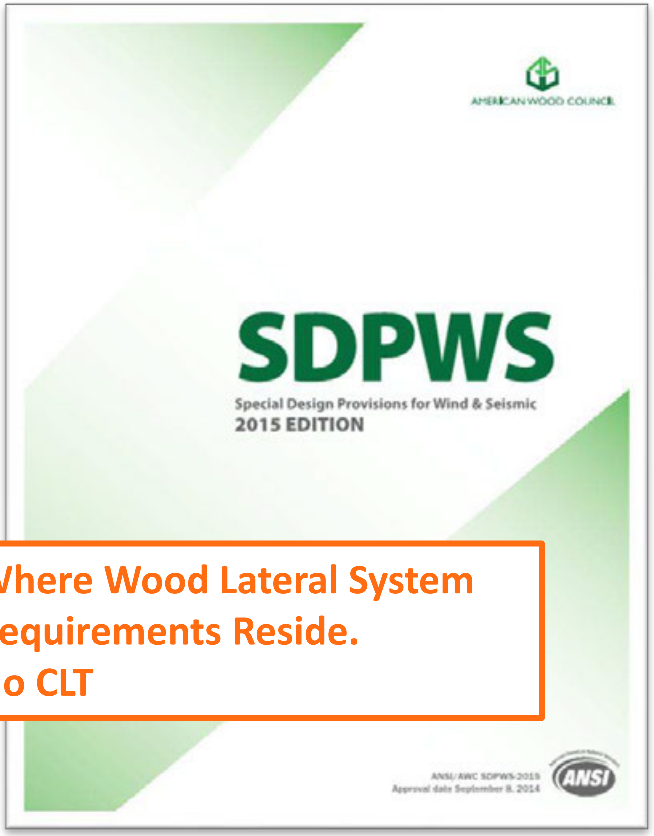
Photo Credit: Alex Schreyer

What R Value Can I use?

$R = 3!$

or 4 or 1.5?

CLT in the U.S. Building Code – IBC 2018 (Lateral)

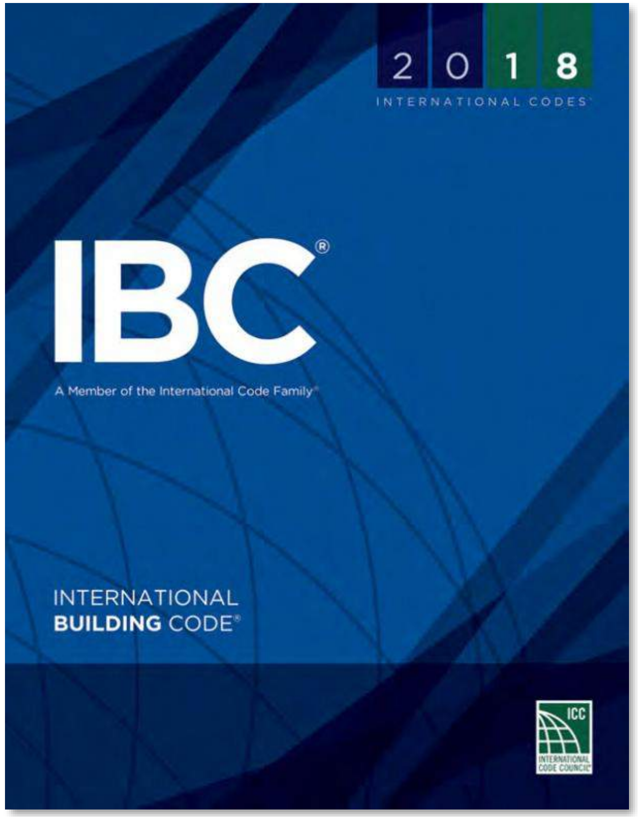


Where Wood Lateral System Requirements Reside.
No CLT

AWC SDPWS 2015

Where Seismic (R values) and Wind Systems are Referenced.
No CLT

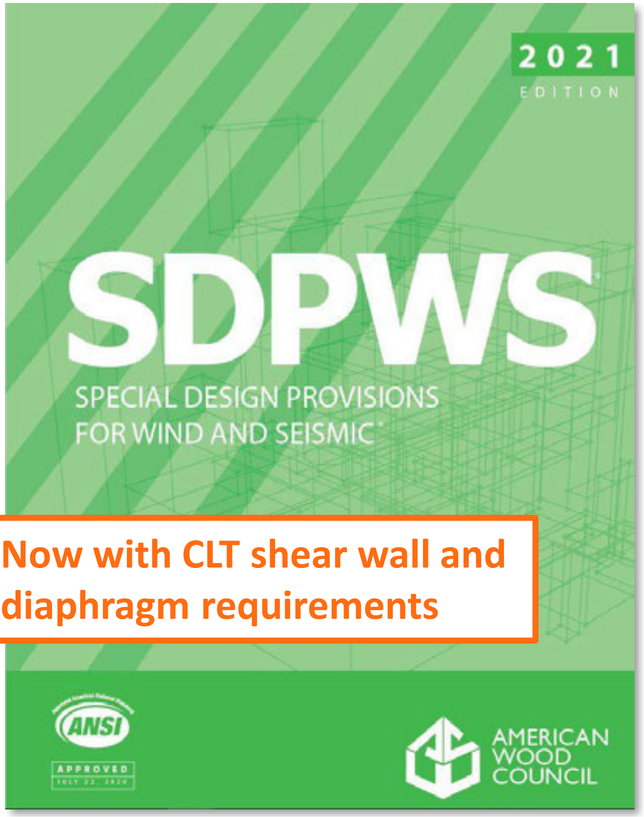
ASCE/SEI 7-16



2018 International Building Code

No explicitly recognized requirements for CLT Lateral Systems in 2018 IBC

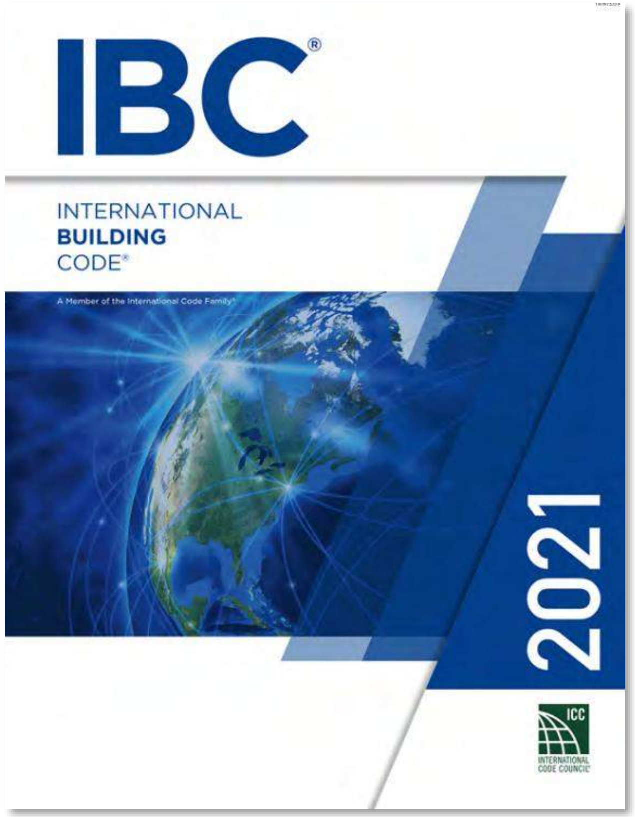
CLT in the U.S. Building Code – IBC 2021 (Lateral)



Now with CLT shear wall and diaphragm requirements

AWC SDPWS 2021

ASCE/SEI 7-16



2021 International Building Code

New Requirements for CLT Lateral Systems in SDPWS 2021!
Referenced from IBC 2021

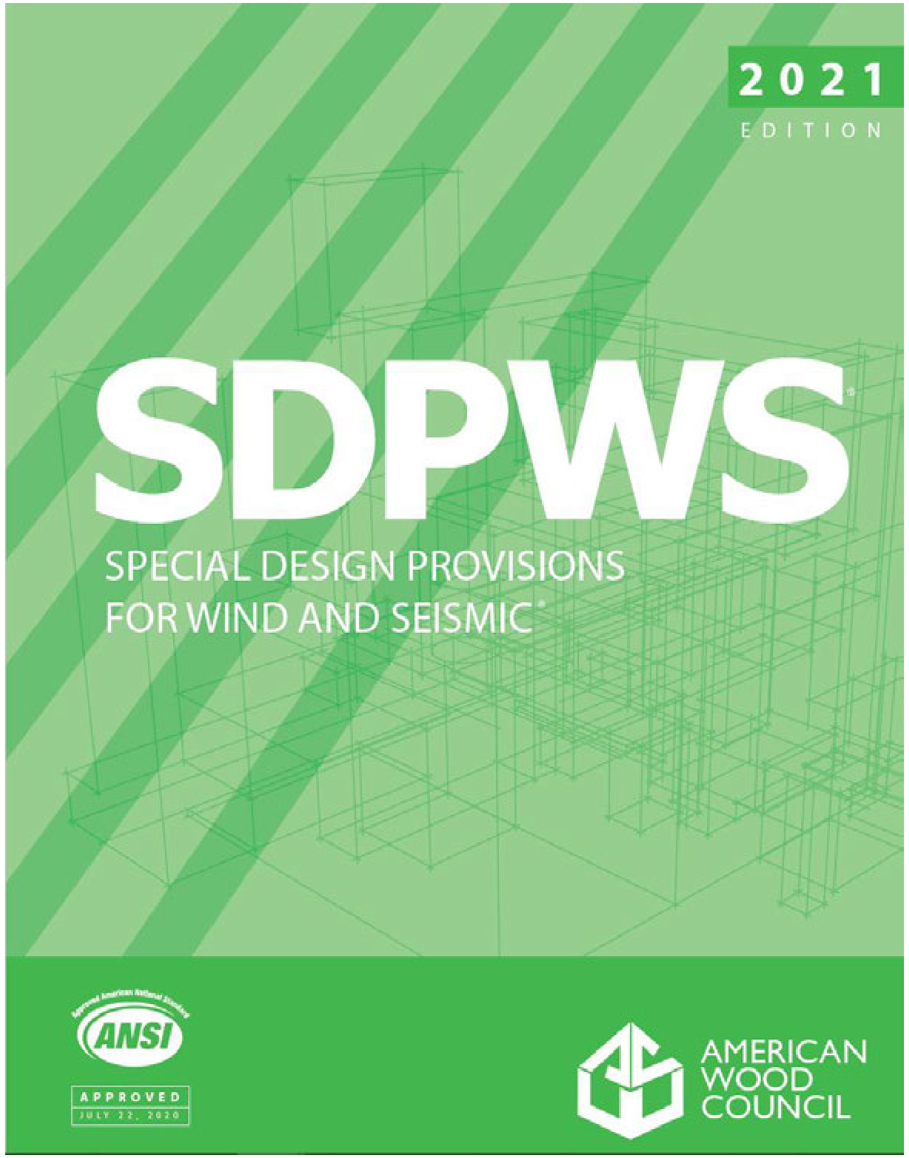
2021 Special Design Provisions for Wind and Seismic

Top Changes Relevant to CLT Lateral Systems:

- New unified nominal shear capacity
- New CLT Shear Wall requirements
- New CLT Diaphragm requirements

View for free at awc.org

PowerPoint IS NOT the CODE!



2021 Special Design Provisions for Wind and Seismic

Top Changes Relevant to CLT Lateral Systems:

- **<u>New unified nominal shear capacity</u>**
- New CLT Shear Wall requirements
- New CLT Diaphragm requirements

View for free at awc.org

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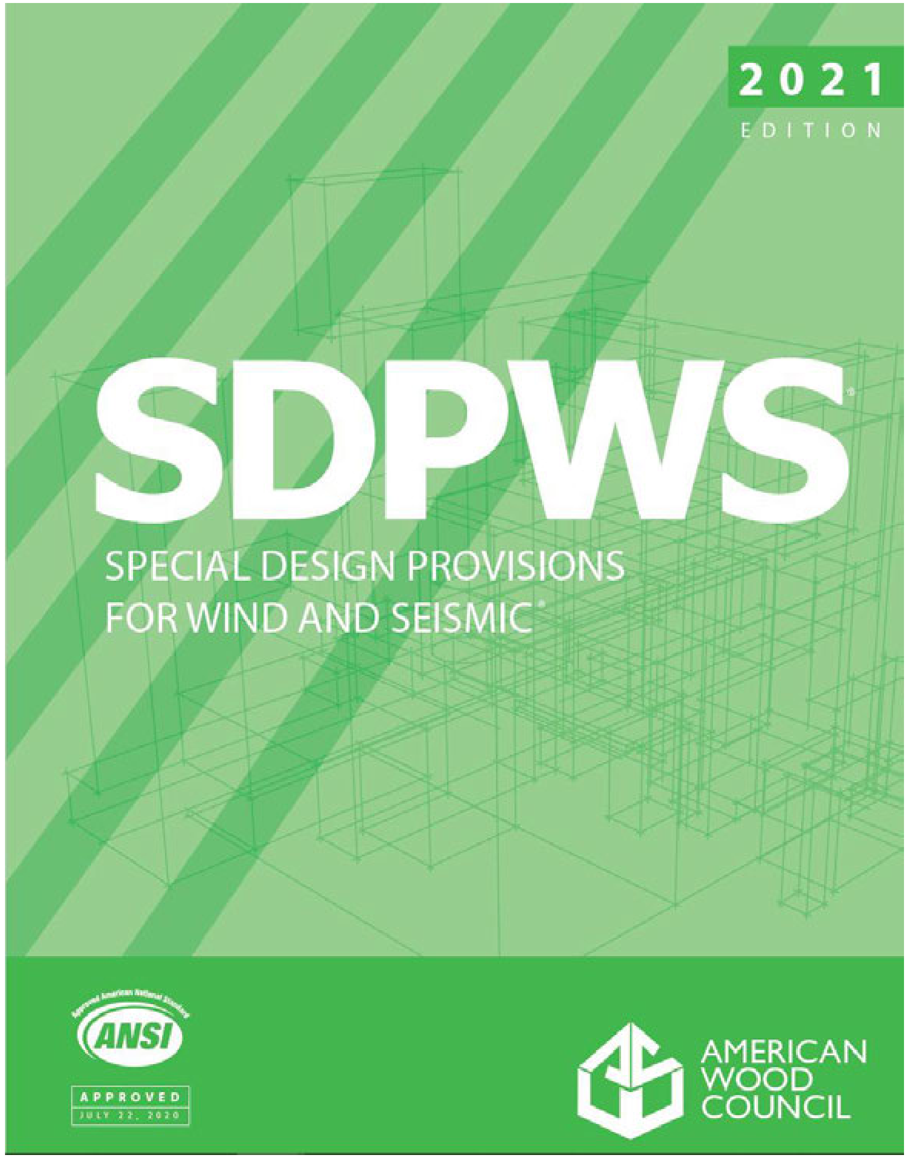


2021 SDPWS – Unified Nominal Shear Capacity

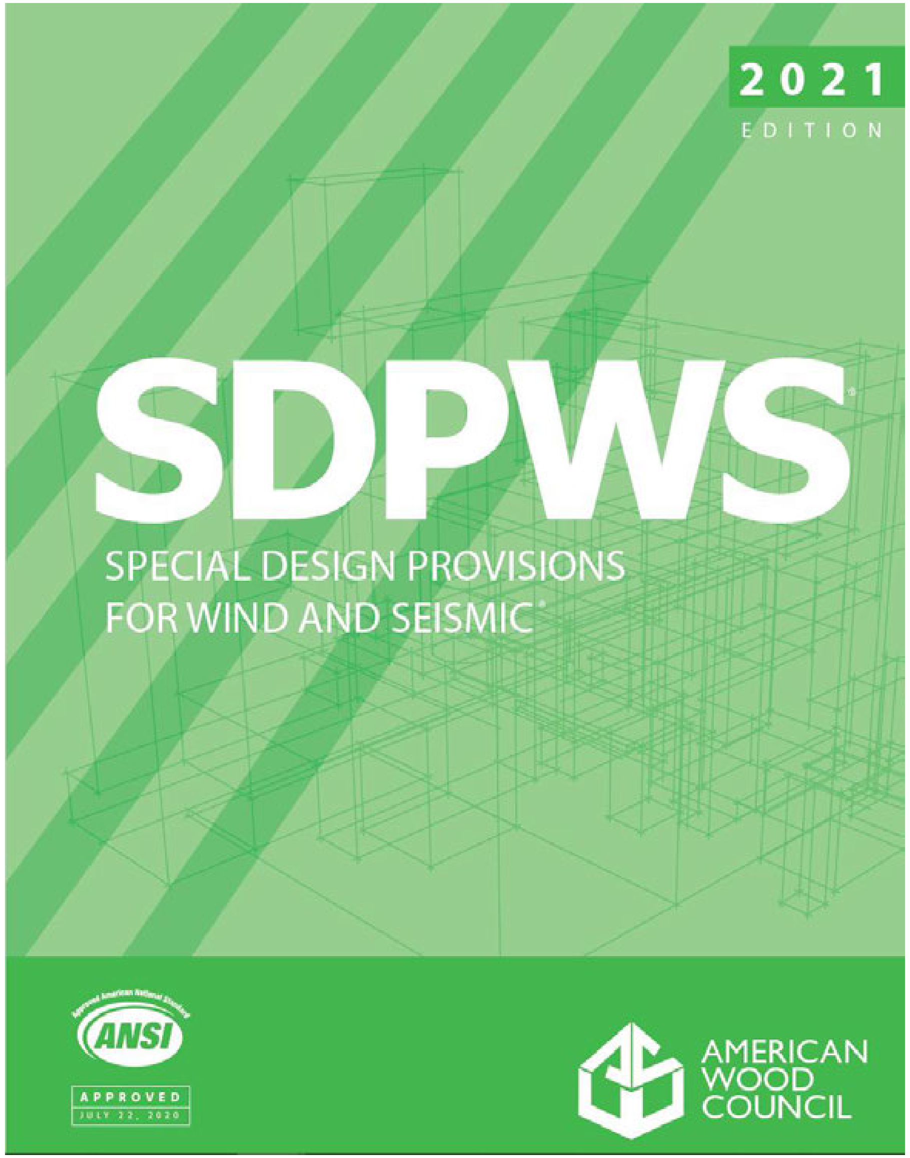
For sheathed wood frame shear walls and diaphragms, SDPWS 2015 has two nominal shear capacities

v_s Nominal shear capacity for seismic loads

v_w Nominal shear capacity for wind loads

SDPWS 2021 has one nominal shear capacity for both wind and seismic (for wood frame and CLT)

v_n Nominal shear capacity

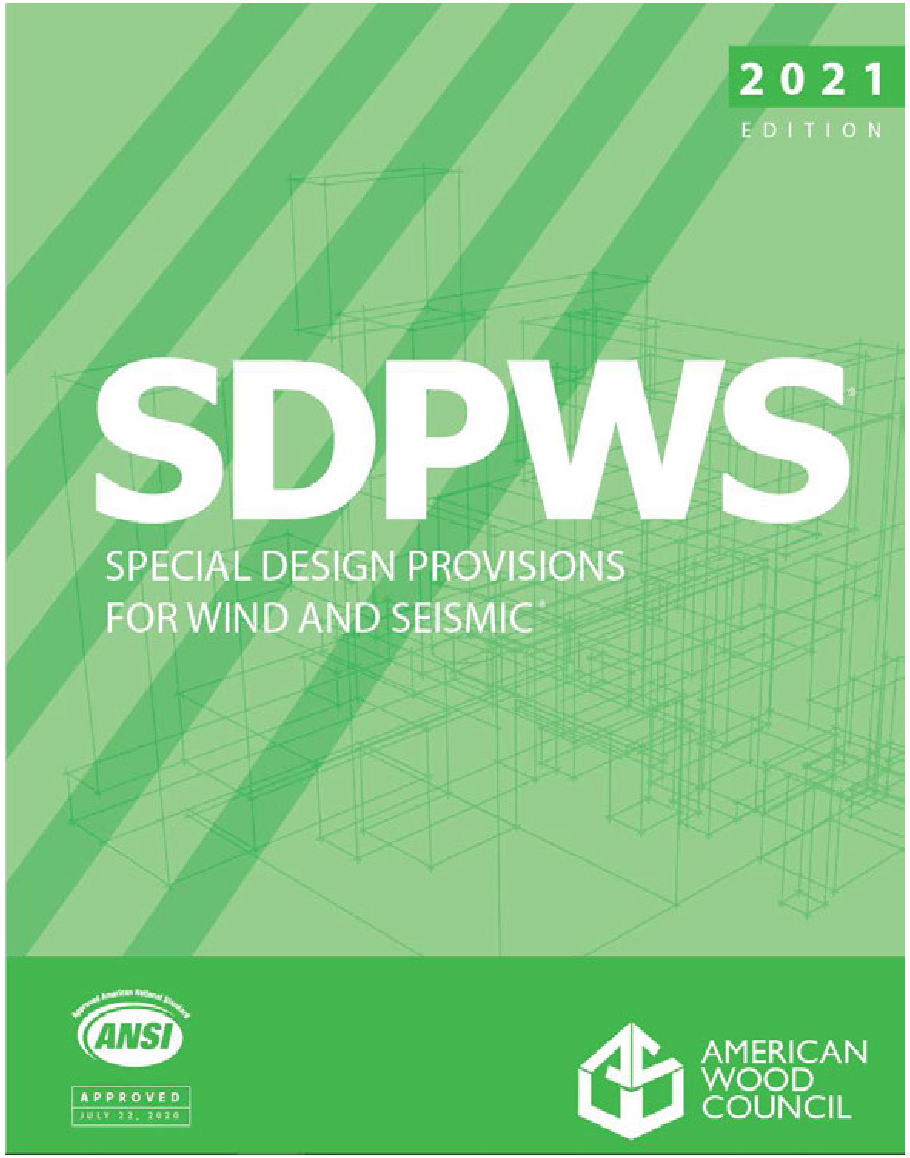


2021 SDPWS – Unified Nominal Shear Capacity

To calculate the ASD or LRFD shear capacity, SDPWS 2021 has different reduction factors for wind and seismic

	Design shear capacity	
	ASD	LRFD
Wind	$v_n/2.0$	$0.8\ v_n$
Seismic	$v_n/2.8$	$0.5\ v_n$

SDPWS 2021 Section 4.1.4



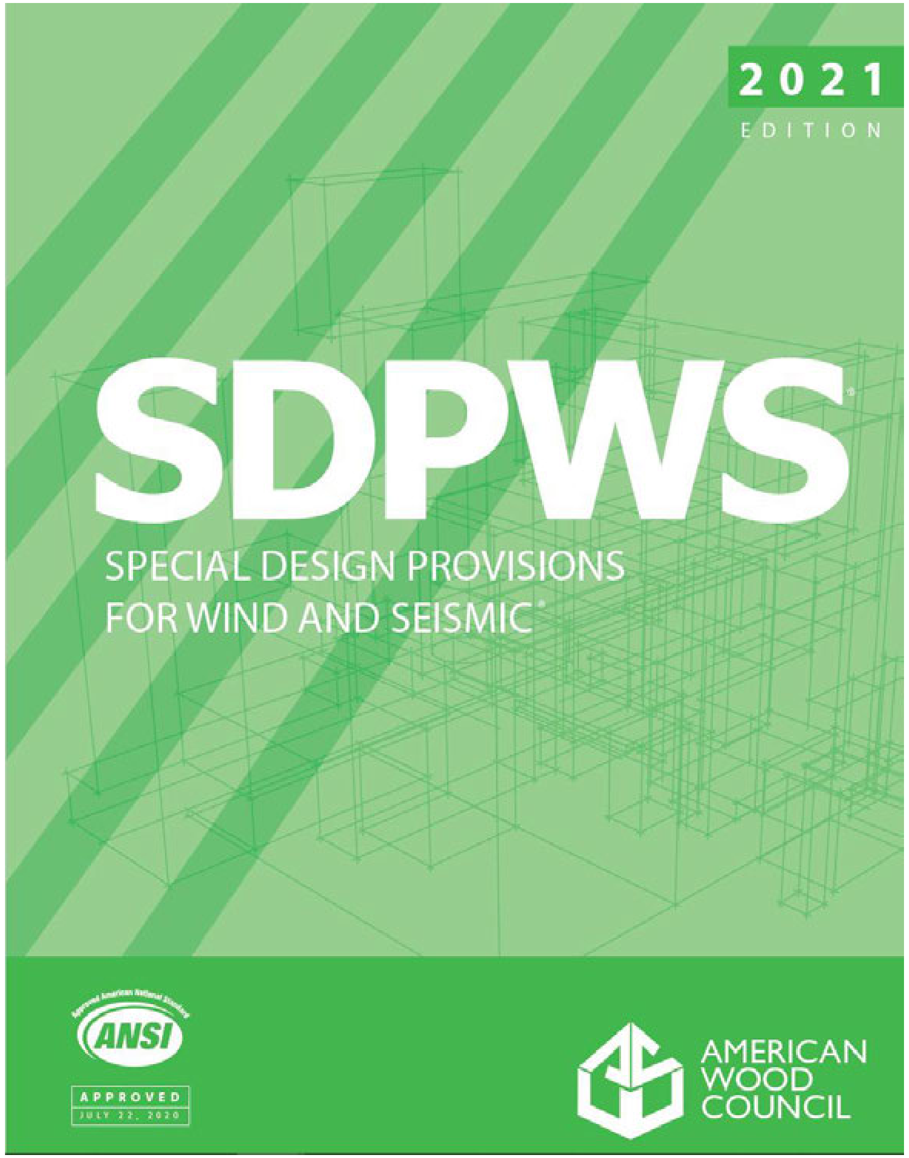
2021 Special Design Provisions for Wind and Seismic

Top Changes Relevant to CLT Lateral Systems:

- » New unified nominal shear capacity
- » **New CLT Shear Wall requirements**
- » New CLT Diaphragm requirements

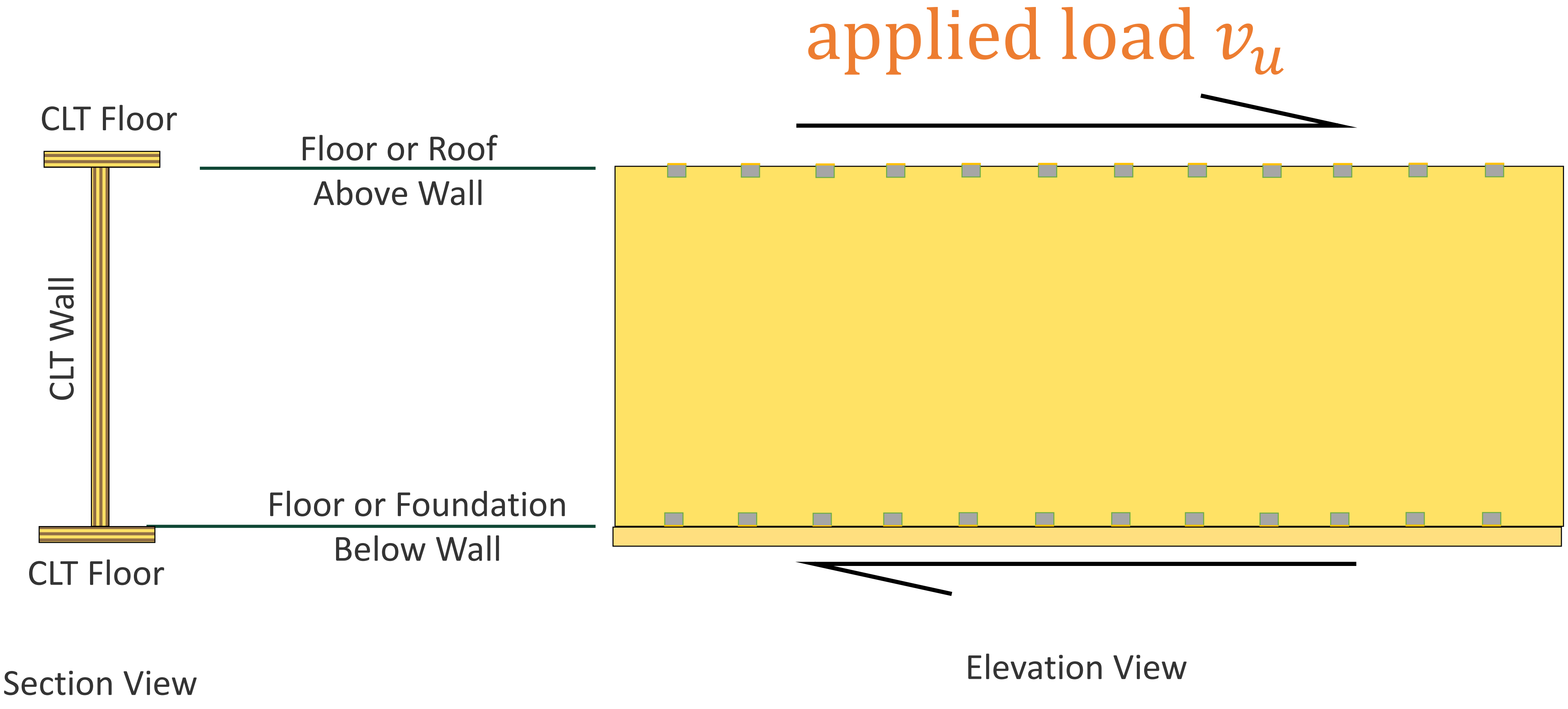
View for free at awc.org

PowerPoint IS NOT the CODE!



CLT Shear Walls in SDPWS 2021

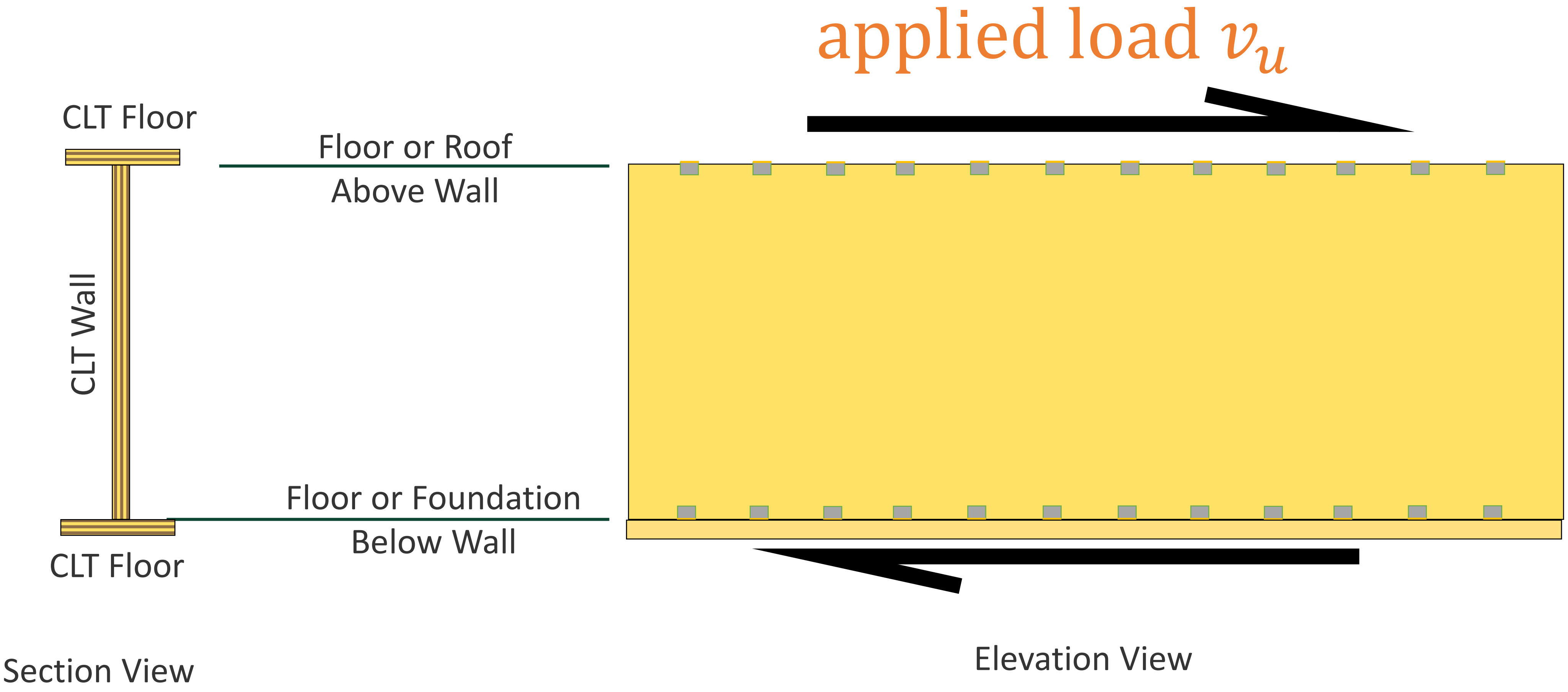
Platform Framed CLT Construction



SDPWS 2021 Section 4.1.4

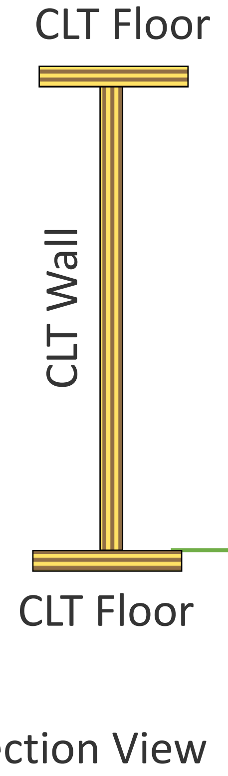
CLT Shear Walls in SDPWS 2021

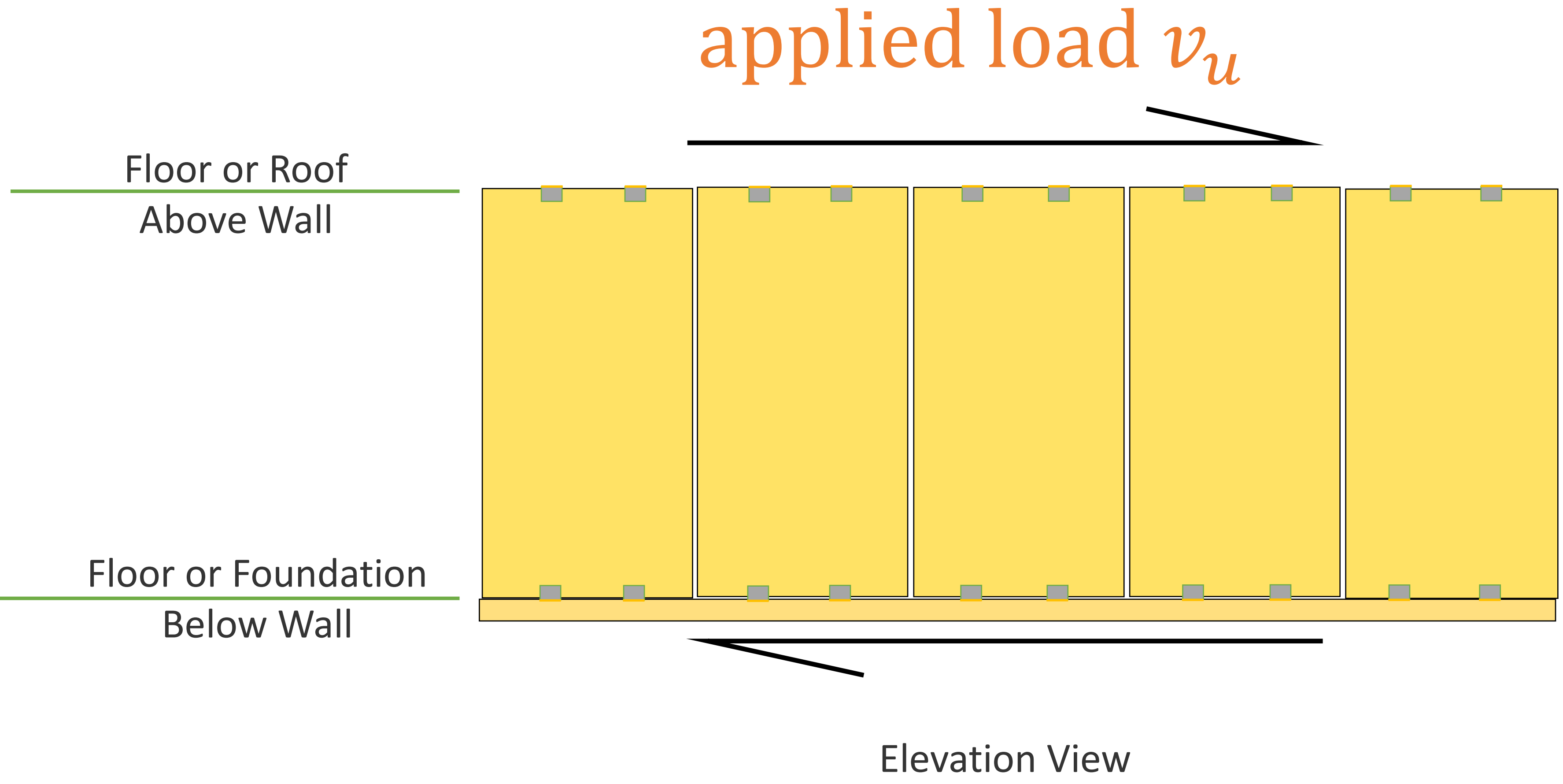
Platform Framed CLT Construction



CLT Shear Walls in SDPWS 2021

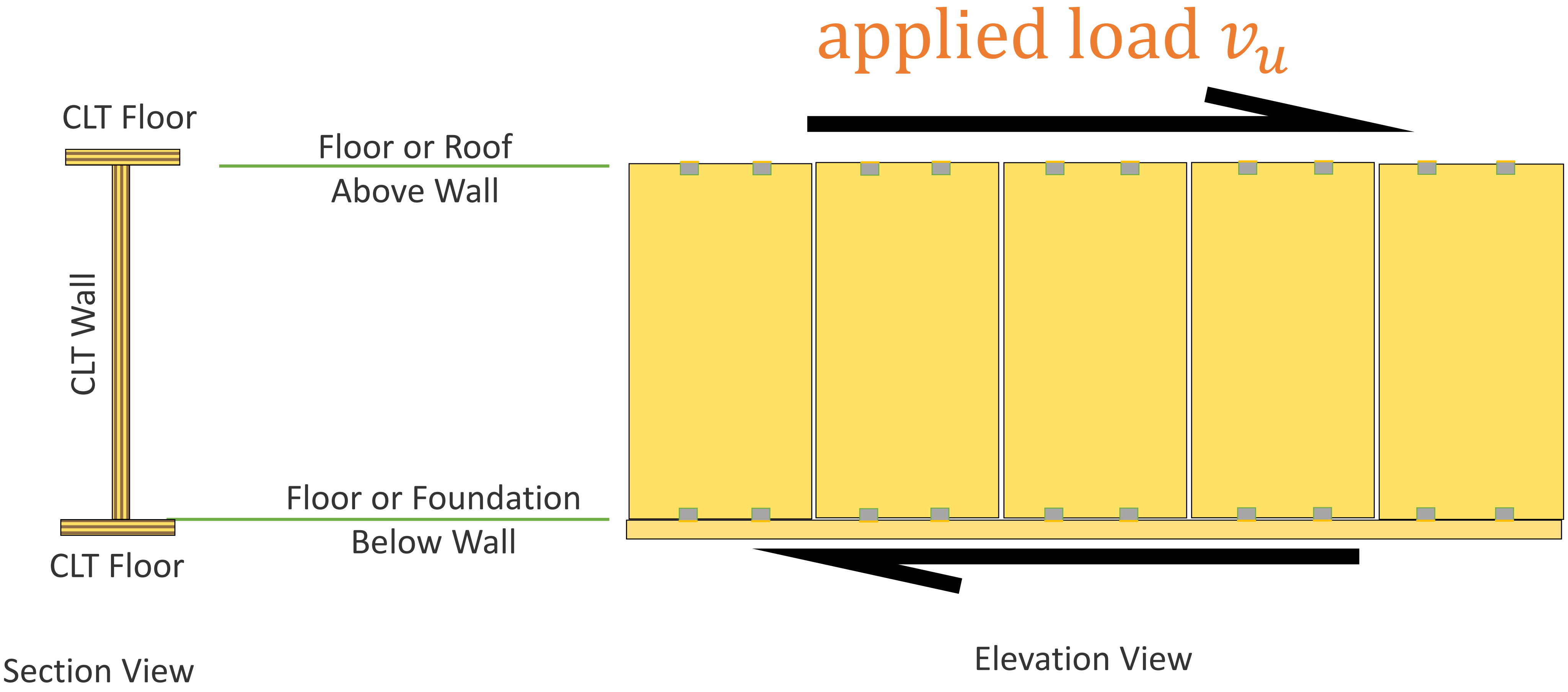
Platform Framed CLT Construction





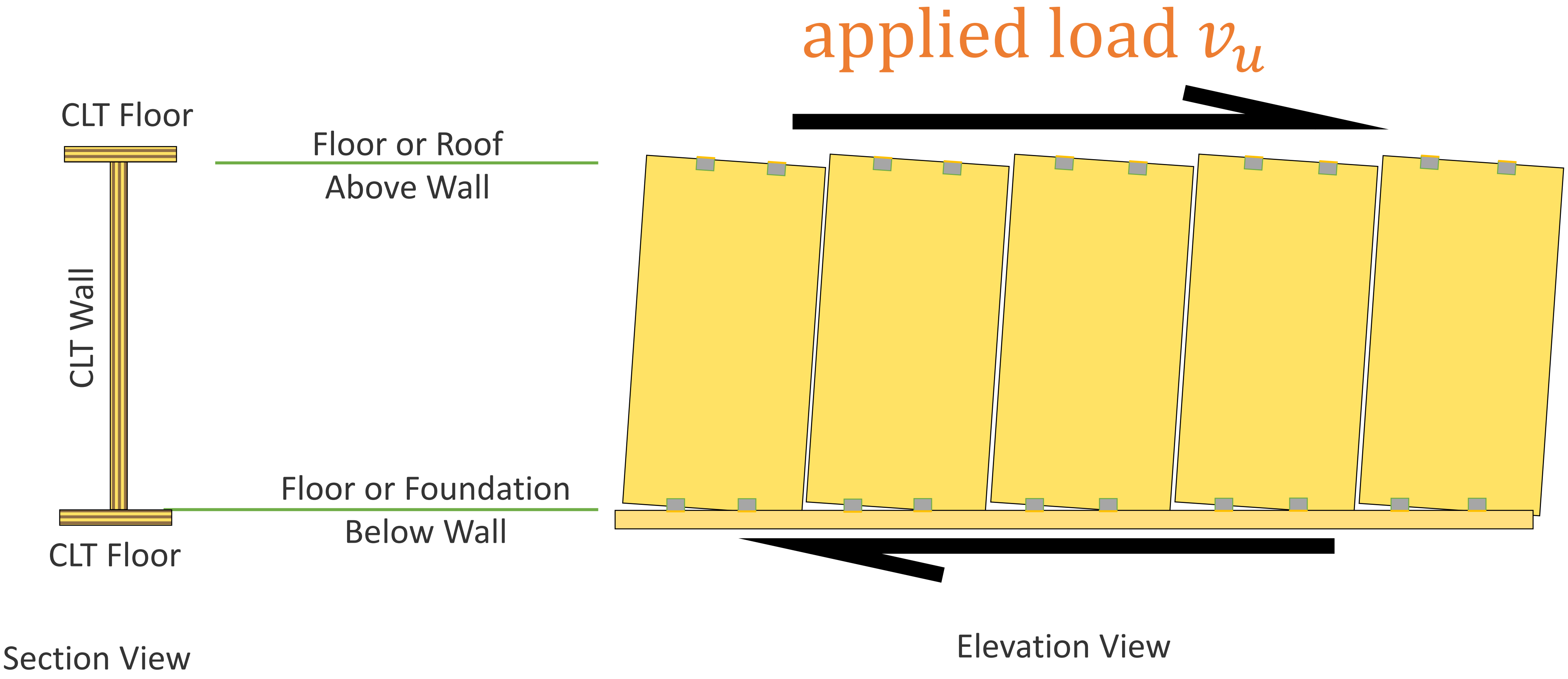
CLT Shear Walls in SDPWS 2021

Platform Framed CLT Construction



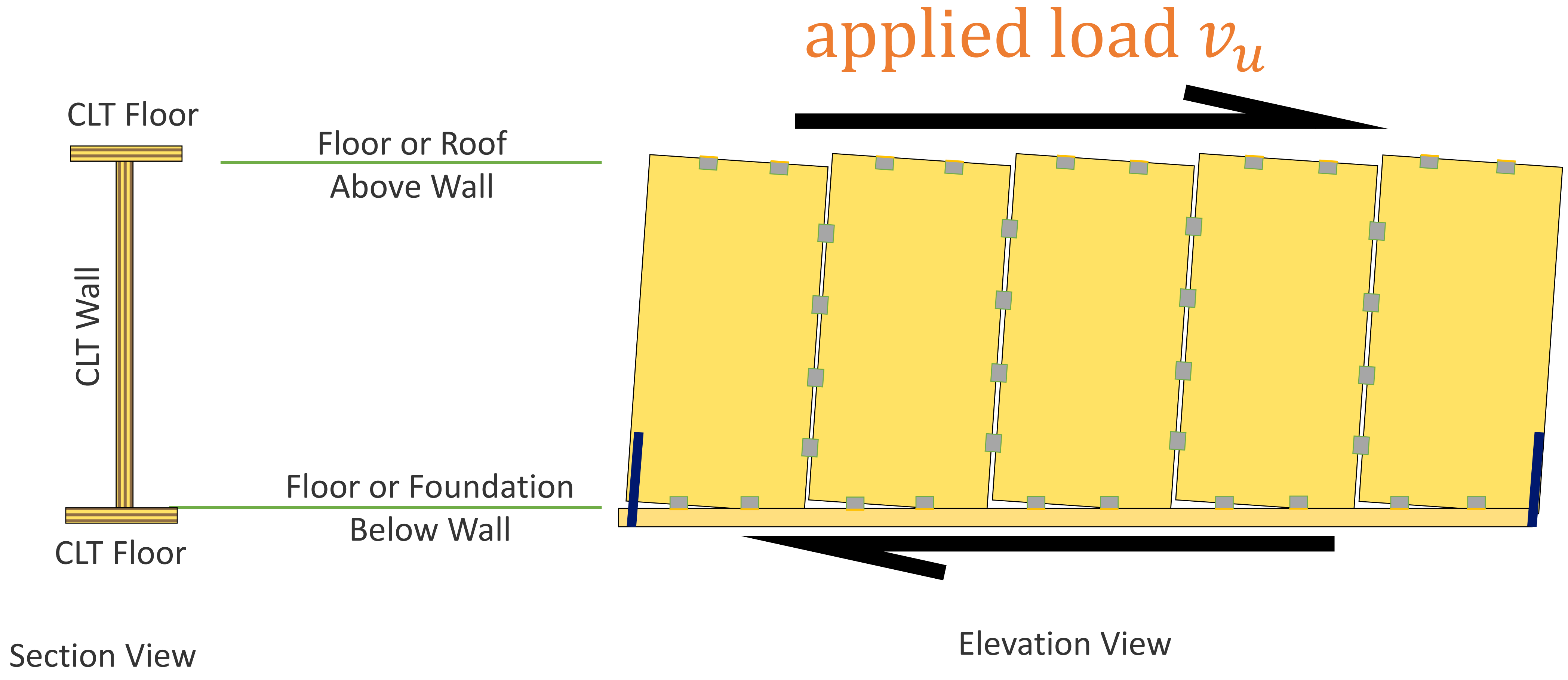
CLT Shear Walls in SDPWS 2021

Platform Framed CLT Construction



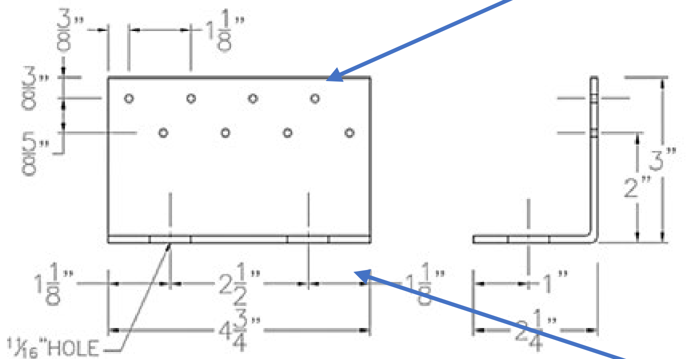
CLT Shear Walls in SDPWS 2021

Platform Framed CLT Construction



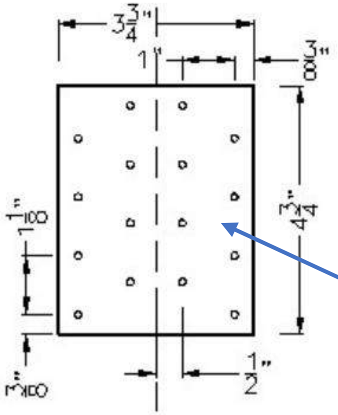
Platform Framed CLT Shear Walls

(8) 16d Box nails



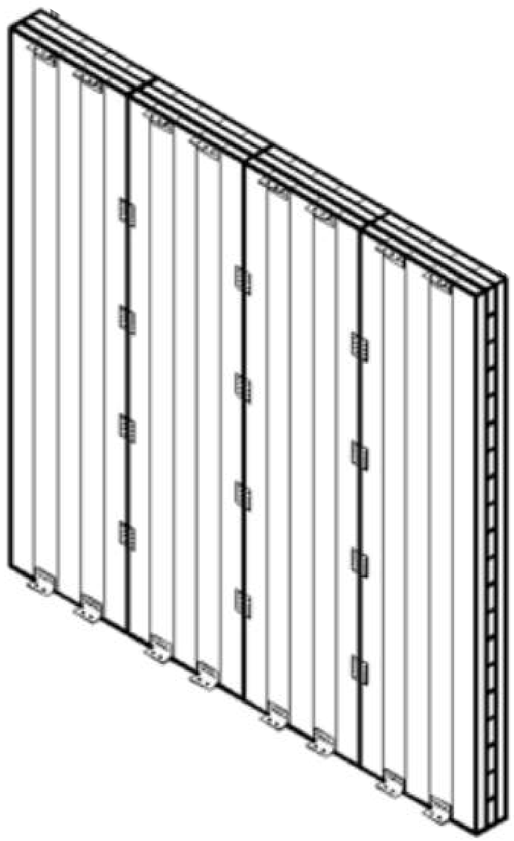
(2) 5/8” bolts
or lag screws

Top and Bottom of Wall Connector
.105” A653 Grade 33 Steel



(8) 16d Box nails
each side

Panel to Panel Connector
.105” A653 Grade 33 Steel



Shear Wall System

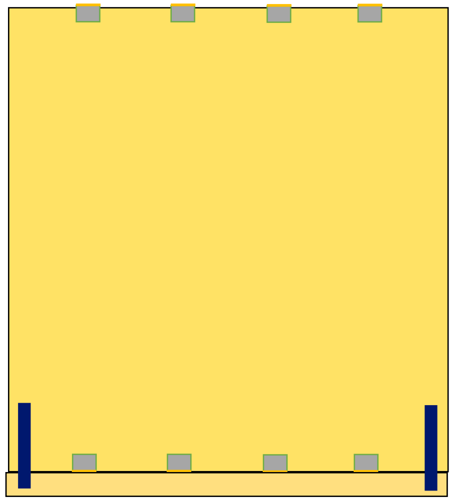
CLT Shear Walls in SDPWS 2021

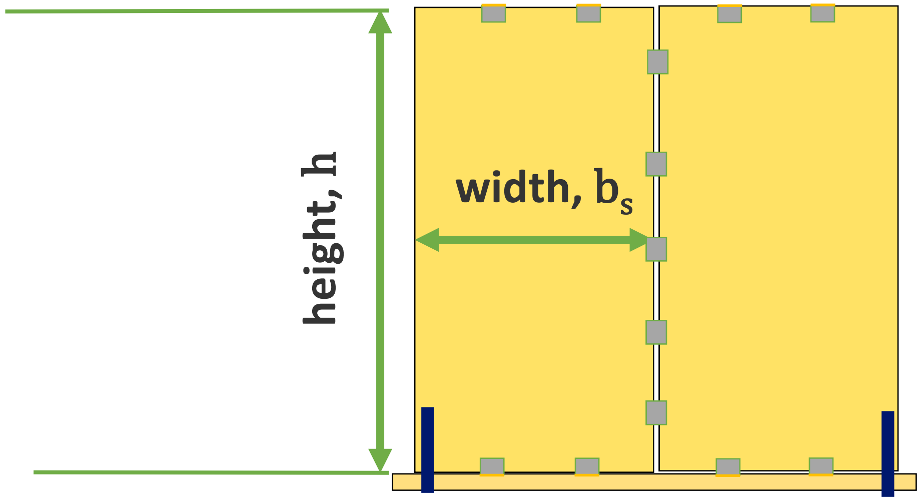
CLT Shear Walls

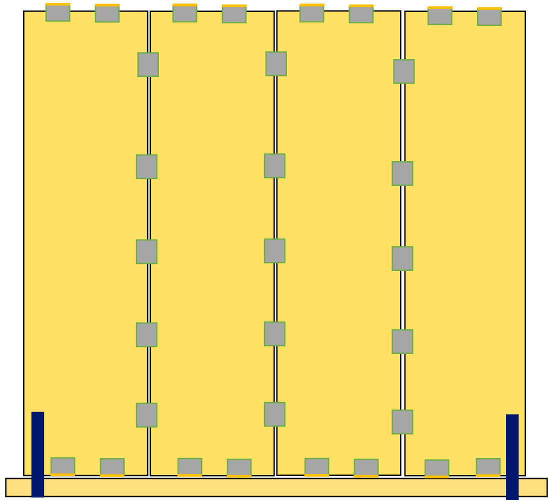
not meeting Appendix B

CLT Shear Walls

meeting SDPWS 2021 Appendix B







Seismic Design Category A
or SDC B and ≤ 65’ tall
in SDPWS 4.6.3 Exception

Panel aspect ratios
$2 \leq h/b_s \leq 4$

with shear resistance provided by high aspect ratio panels only (SDPWS B.3.7)

Panel aspect ratios
$h/b_s = 4$

$R = 3!$

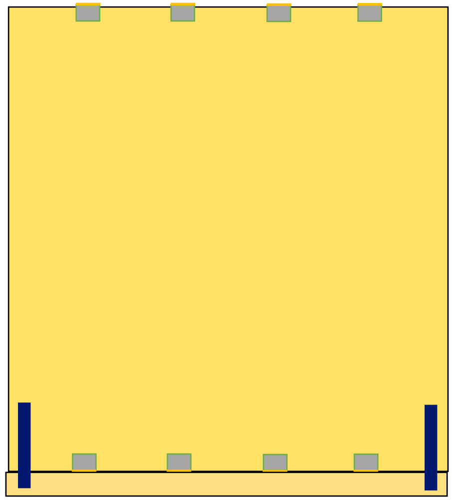
or 4 or 1.5?

R Values for CLT Shear Walls in SDPWS 2021

(other)

CLT Shear Walls

not meeting Appendix B



R = 1.5

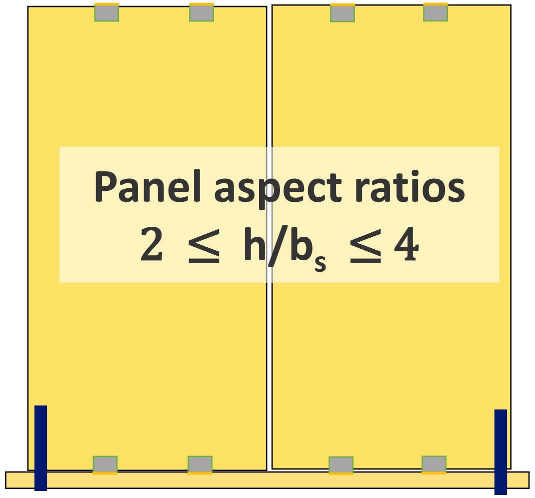
C_d = 1.5 Ω_o = 2.5

In SDPWS 2021 4.6.3

Platform Framed

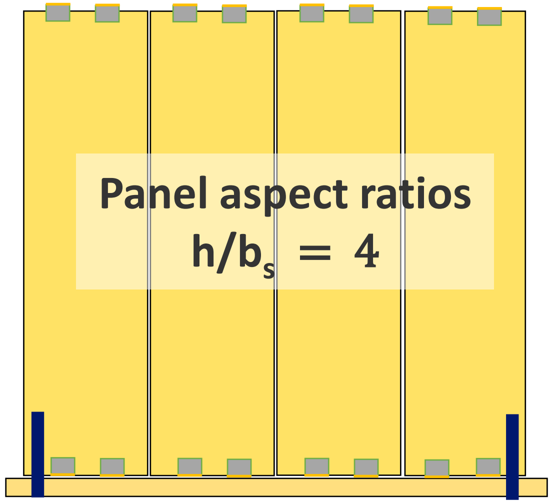
CLT Shear Walls

meeting SDPWS 2021 Appendix B



R = 3.0*

C_d = 3.0 Ω_o = 3.0



R = 4.0*

C_d = 4.0 Ω_o = 3.0

* ASCE 7-22

CLT Shear Walls in SDPWS 2021

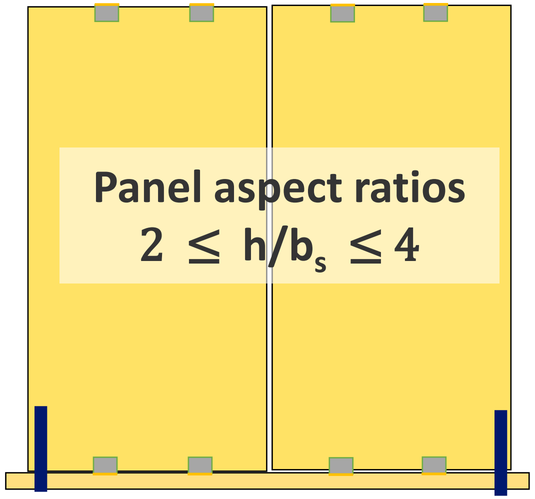
Platform Framed

CLT Shear Walls

meeting SDPWS 2021 Appendix B

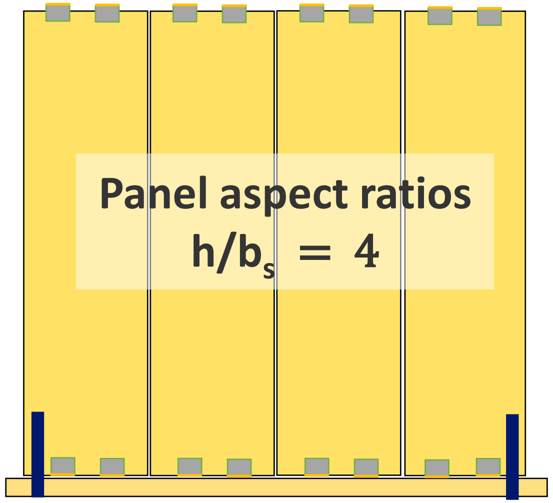
Additional important requirements

- Platform framed CLT floors over CLT walls
- Only specific connectors recognized
- CLT walls which are not designated shear walls need to meet same panel aspect ratio limits and connection detailing requirements
- Hold-downs designed to 2.0 times the design shear capacity
- Only gravity loads on panel directly attached to hold-down can be used to resist overturning moment



R = 3.0*

$C_d = 3.0 \;\; \Omega_o = 3.0$



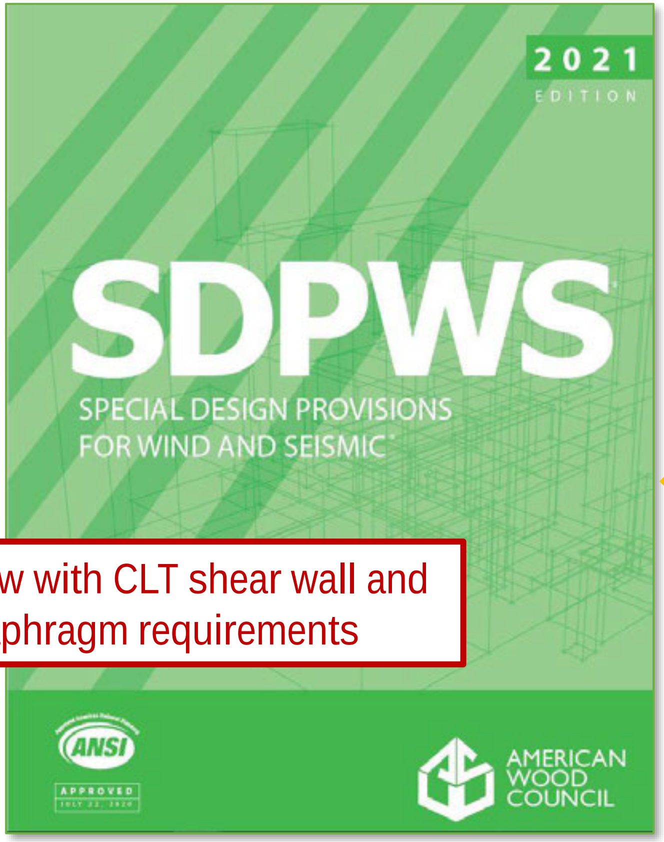
R = 4.0*

$C_d = 4.0 \;\; \Omega_o = 3.0$

* ASCE 7-22

CLT in the U.S. Building Code – Lateral in IBC 2021

SDPWS 2015

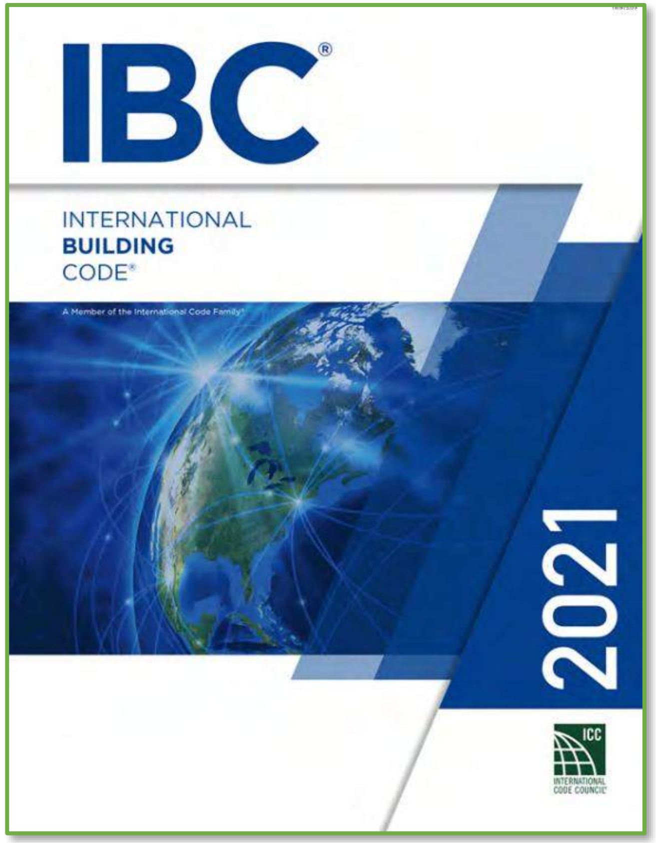


Now with CLT shear wall and diaphragm requirements

AWC SDPWS 2021

Where Seismic (R values) and Wind Systems are Referenced. No CLT

ASCE/SEI 7-16

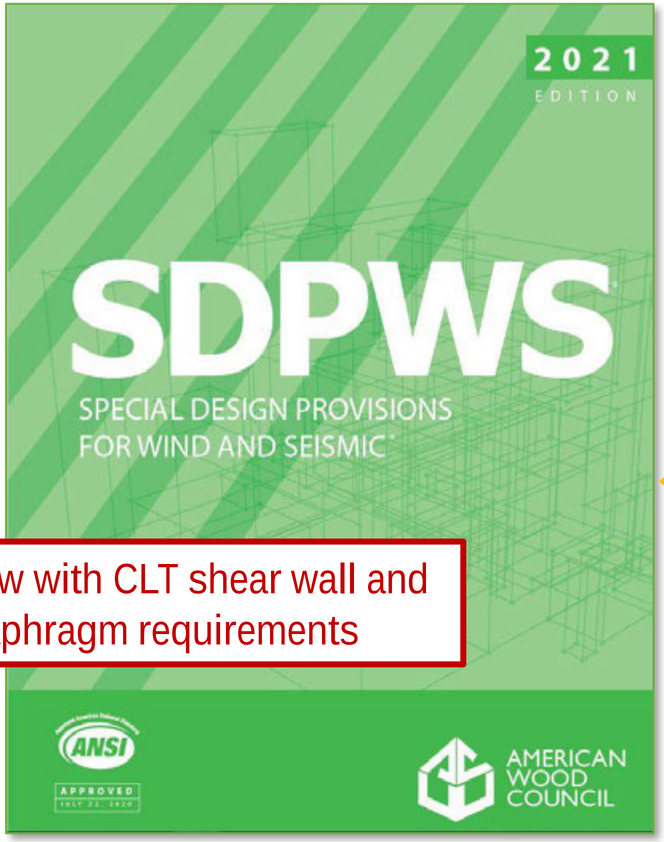


2021 International Building Code

New Requirements for CLT Lateral Systems!

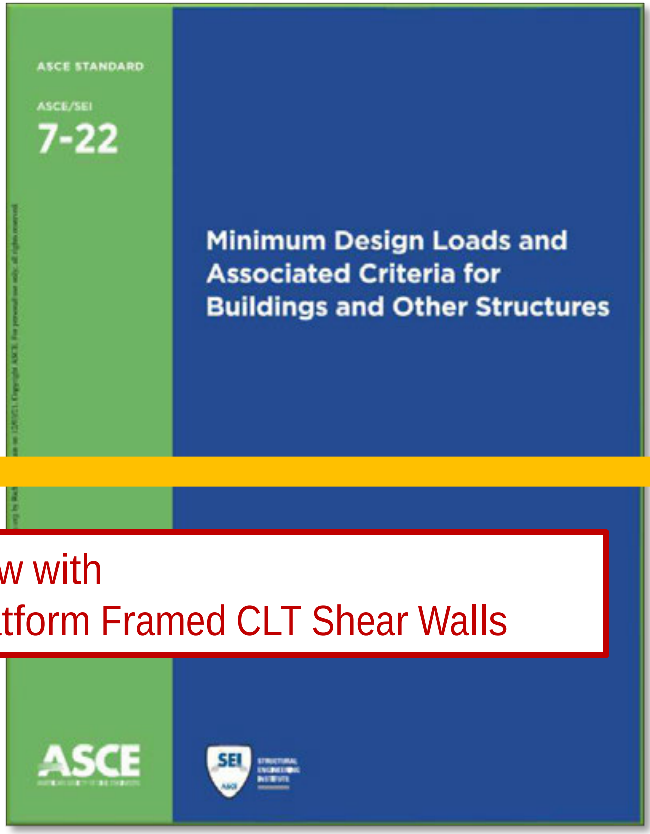
(but R values for CLT Shear Walls not in ASCE 7-16)

CLT in the U.S. Building Code – Lateral in the IBC 2024?



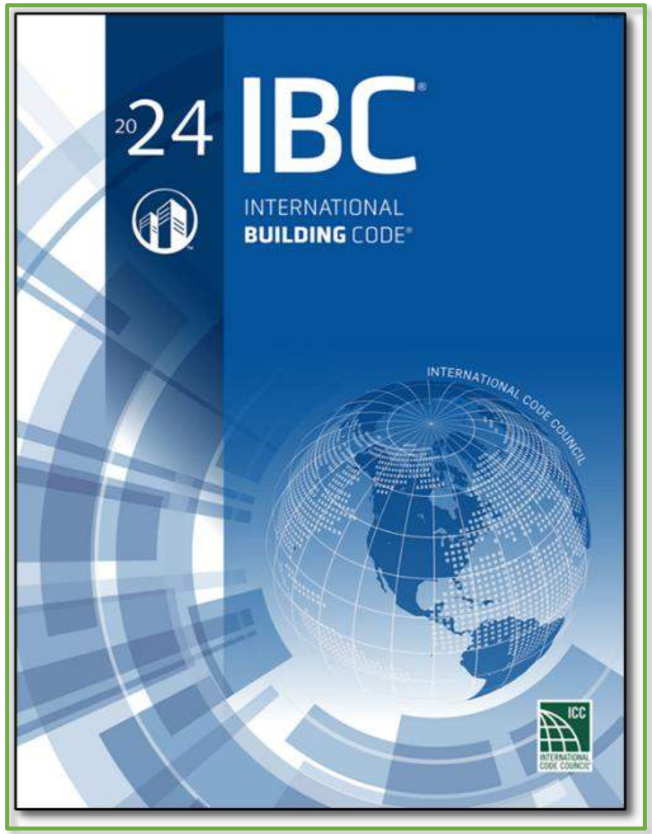
Now with CLT shear wall and diaphragm requirements

AWC SDPWS 2021



Now with
Platform Framed CLT Shear Walls

ASCE/SEI 7-22



2024 IBC

Full Recognition of CLT Lateral Systems

State of Oregon Statewide Alternative

State of Oregon
Building Codes Division
Better Buildings for Oregon

Statewide Alternate Method
January 2015

No. 15-01
Cross-Laminated Timber Provisions
(Ref.: ORS 455.060)

Statewide Alternate Methods *are approved by the Division administrator in consultation with the appropriate advisory board. The advisory board's review includes technical and scientific facts of the proposed alternate method. In addition:*

- *Building officials shall approve the use of any material, design or method of construction addressed in a statewide alternate method;*
- *The decision to use a statewide alternate method is at the discretion of the designer; and*
- *Statewide alternate methods do not limit the authority of the building official to consider other proposed alternate methods encompassing the same subject matter.*

Code Edition: 2014 Oregon Structural Specialty Code (OSSC)

Code Section: OSSC Section 602.4 Type IV, Heavy Timber

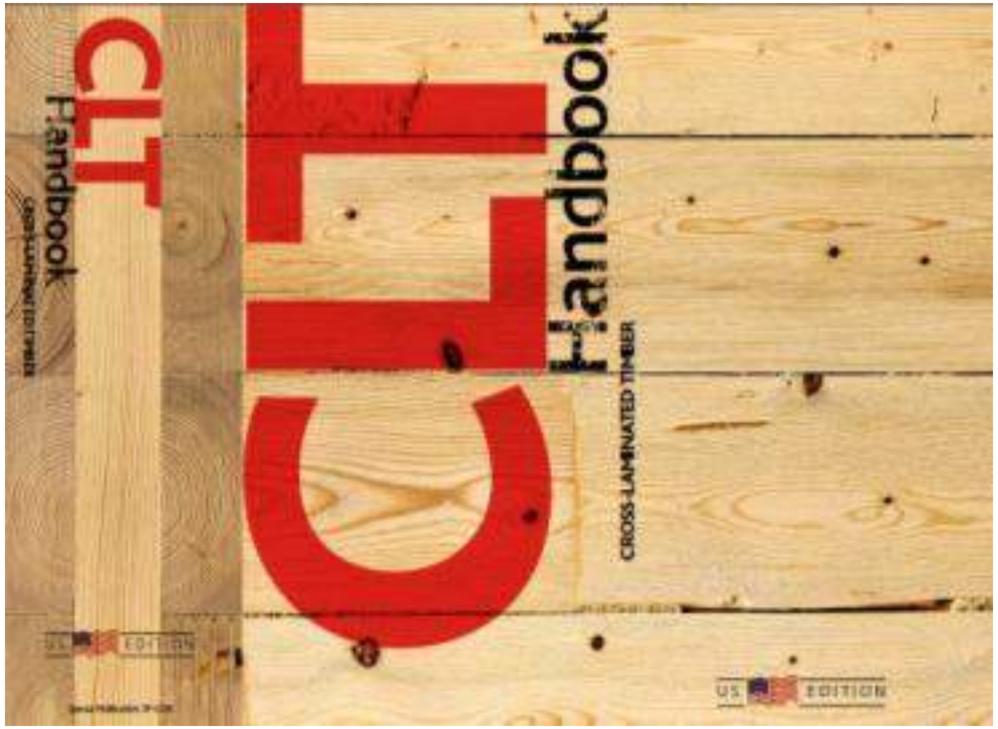
Date: January 15, 2015

Initiated by: Building Codes Division

Subject: Cross-Laminated Timber

Background:

Cross-laminated timber (CLT) is an emerging wood product with applications in both residential and non-residential buildings. Oregon BCD has prepared this alternate method which recognizes nationally adopted acceptance of CLT in Type IV Construction through the International Codes Council process. This classification will allow roughly 50 percent taller and larger buildings than



State of Oregon Statewide Alternative

ASCE 7-10 Table 12.2-1 modified by Oregon Buildings Code Division

Table 12.2-1 Design Coefficients and Factors for Seismic Force-Resisting Systems

Seismic Force-Resisting System	ASCE 7 Section Where Detailing Requirements Are Specified	Response Modification Coefficient, R^a	Overstrength Factor, Ω_0^g	Deflection Amplification Factor, C_d^b	Structural System Limitations Including Structural Height, h_n (ft) Limits[c]				
					Seismic Design Category				
					B	C	D^d	E^d	F^e
A. BEARING WALL SYSTEMS									
15. Light-frame (wood) walls sheathed with wood structural panels rated for shear resistance	14.5	6 ½	3	4	NL	NL	65	65	65
19. Cross-laminated timber shear walls[f]	14.1 and 14.5	2	2 ½	2	NL	NL	NL	NL	NL

Post-Tensioned Mass Timber Rocking Walls

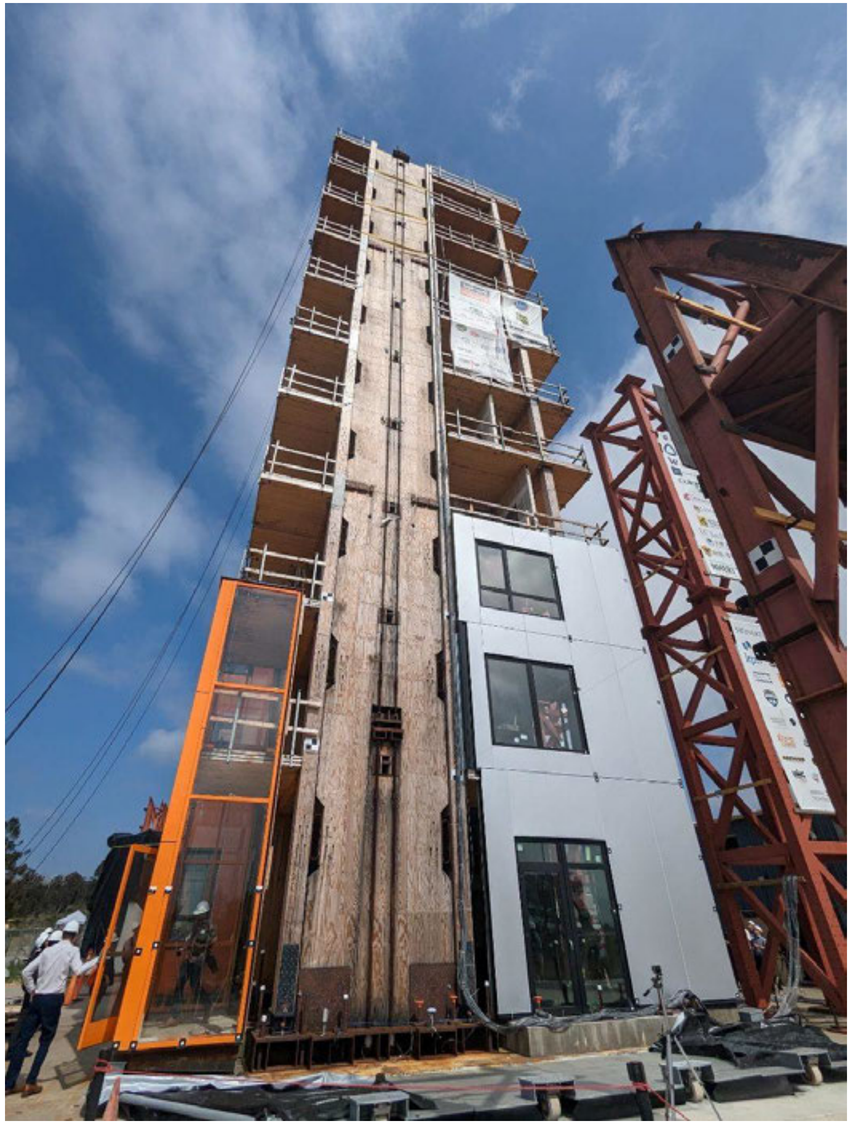


Photo: Scott Breneman/WoodWorks

Source: S. PEI et al. http://nheritallwood.mines.edu/

Full Range of CLT Shear Walls!

R=3!!

Or 4 or 1.5?

Or 2 or 6?

See the WoodWorks Expert Tip

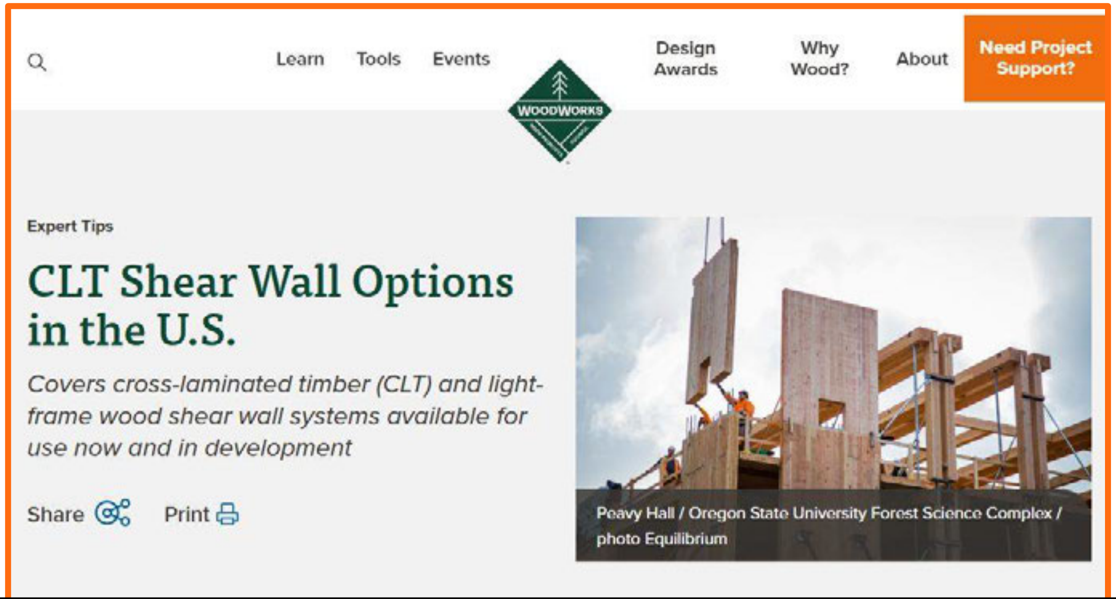
CLT Shear Wall Options in the U.S.

https://www.woodworks.org/resources/clt-shear-wall-options-in-the-u-s/

TABLE 1 – Timber shear wall structural parameters

System	Standards	Seismic Design Coefficients			Structural Height Limit per Seismic Design Category (ft)			
		R	Ω_0	C_d	A	B	C	D
SDPWS Appendix B CLT shear walls	SDPWS 2021 ASCE 7-22	3	3	3	NL	65	65	65
(with shear resistance provided by high-aspect-ratio panels only)		4	3	4	NL	65	65	65
SDPWS Section 4.6.3 Exception CLT shear walls	SDPWS 2021	1.5	2.5	1.5	NL	65	NP	NP
Mass timber rocking shear walls	Targeting SDPWS 2027 and ASCE 7-28	TBD (> 5)	TBD	TBD	NL	TBD (> 100 ft)		
Oregon SAM CLT path 2 shear walls	Oregon SAM 15-01	2	2.5	2	NL	65	65	65
Light-frame wood walls sheathed with WSPs	SDPWS ASCE 7	6.5	3	4	NL	NL	NL	65

NL = No Limit
NP = Not permitted



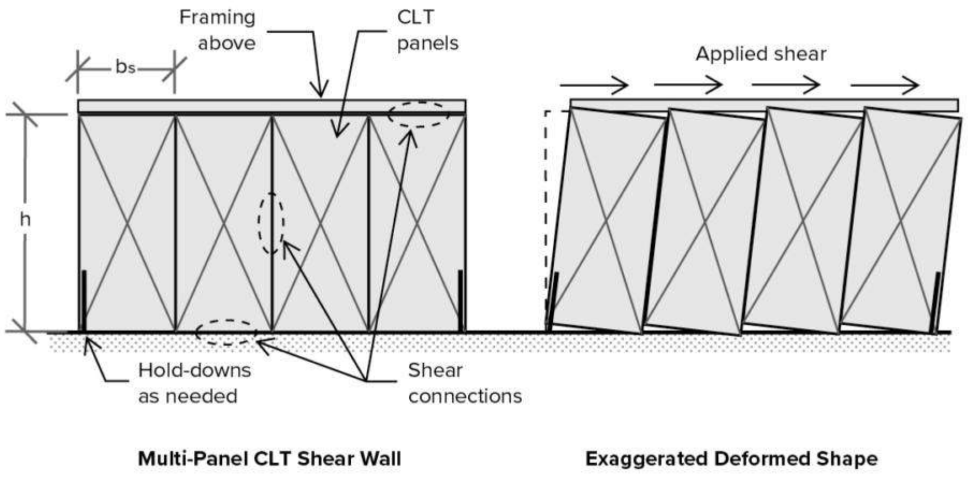


FIGURE 1: Multi-panel CLT shear wall construction*

CLT Diaphragms

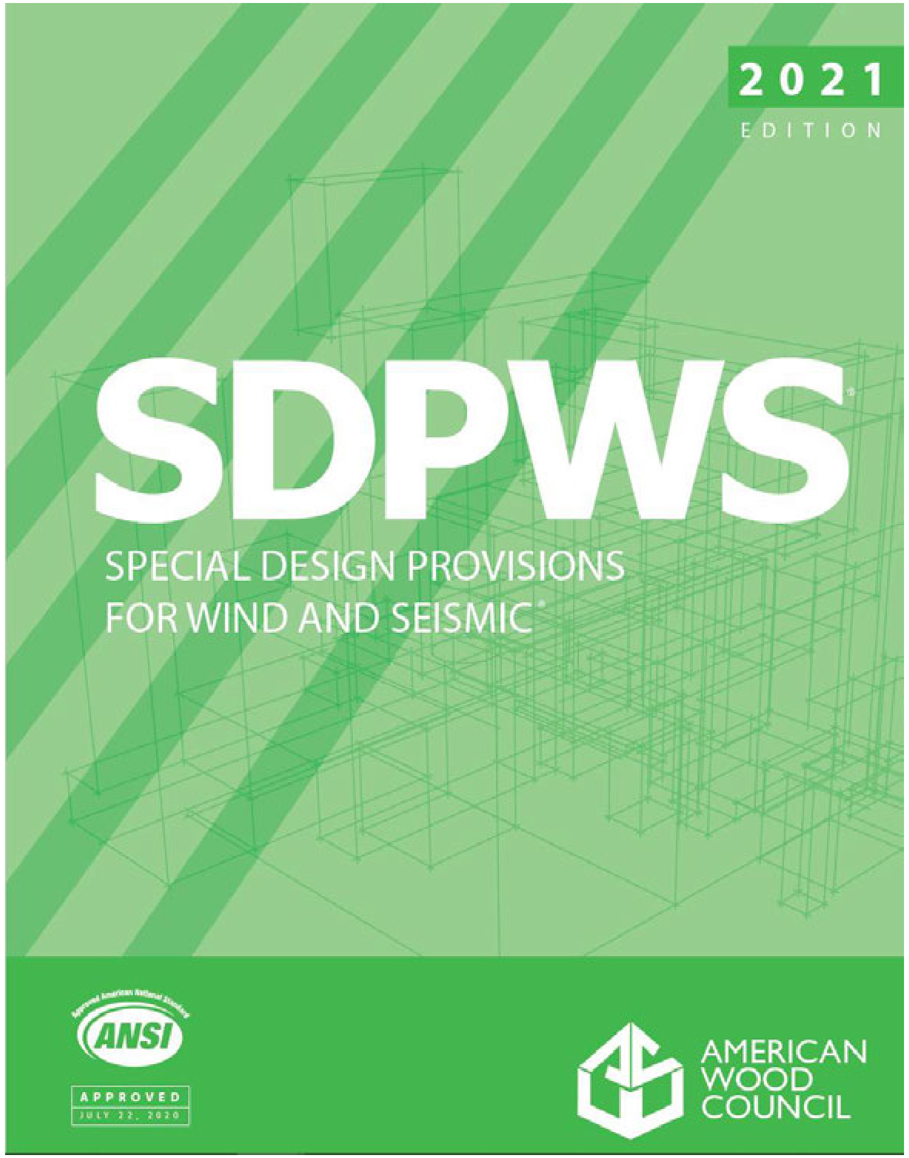
2021 Special Design Provisions for Wind and Seismic

Top Changes Relevant to CLT Lateral Systems:

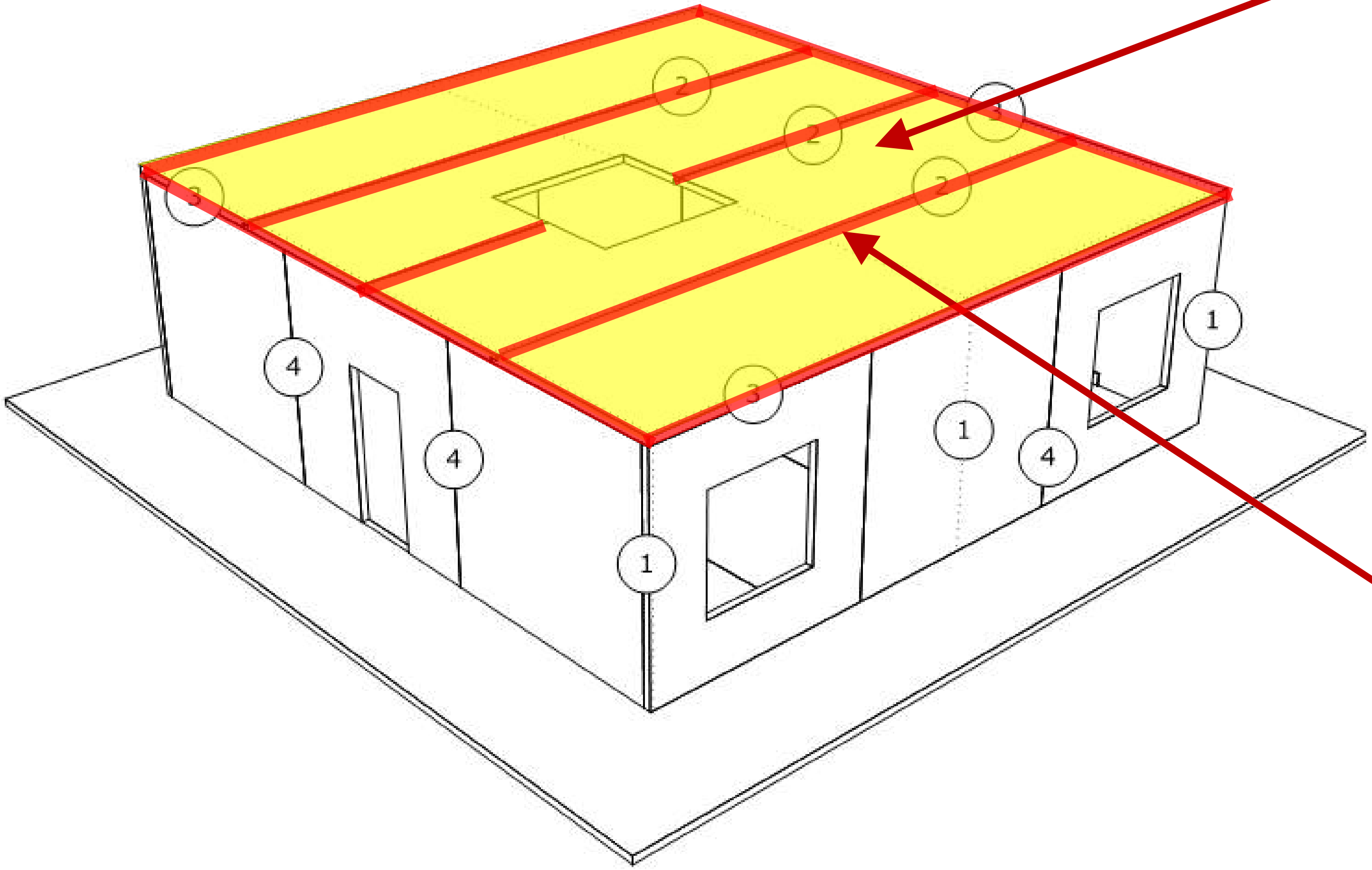
- New unified nominal shear capacity
- New CLT Shear Wall requirements
- **New CLT Diaphragm requirements**

View for free at awc.org

PowerPoint IS NOT the CODE!



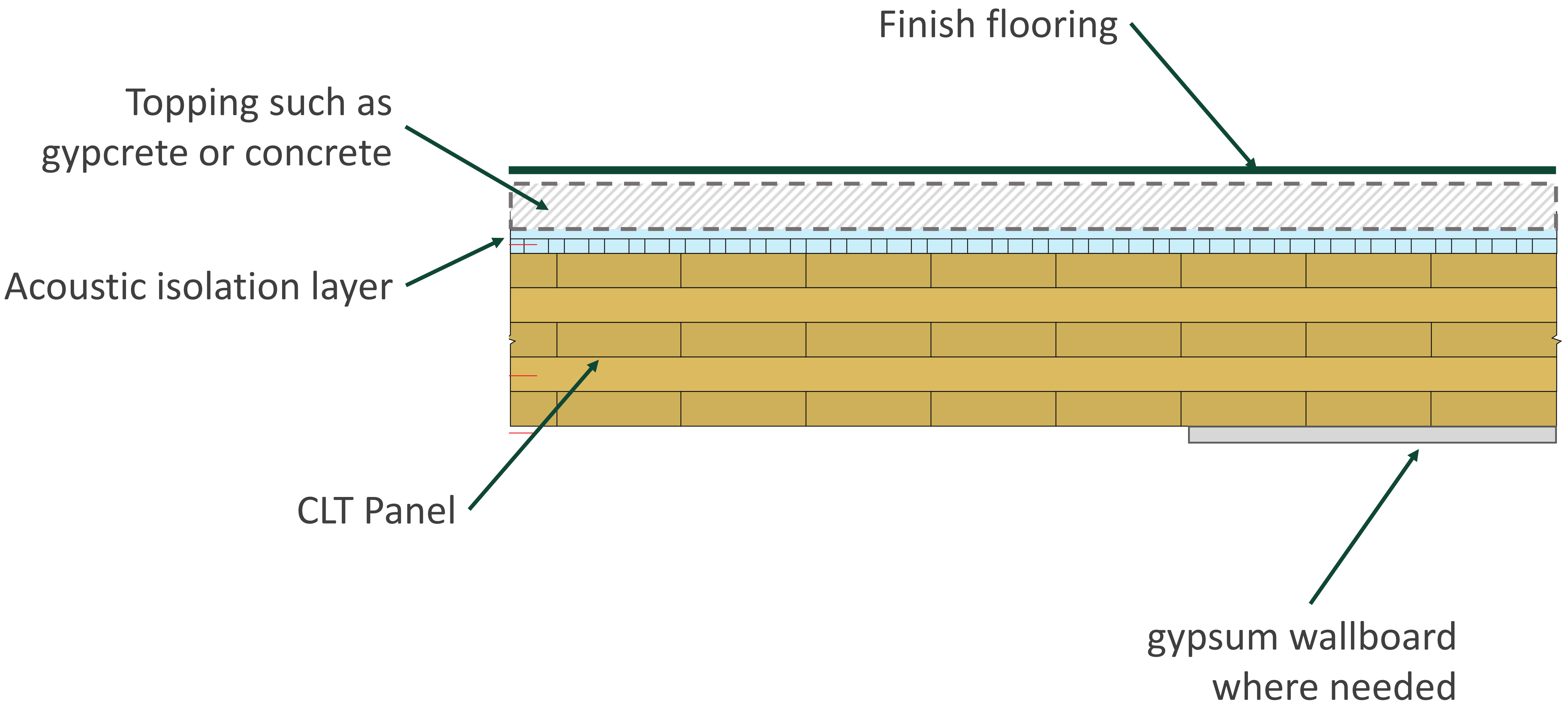
CLT Diaphragms



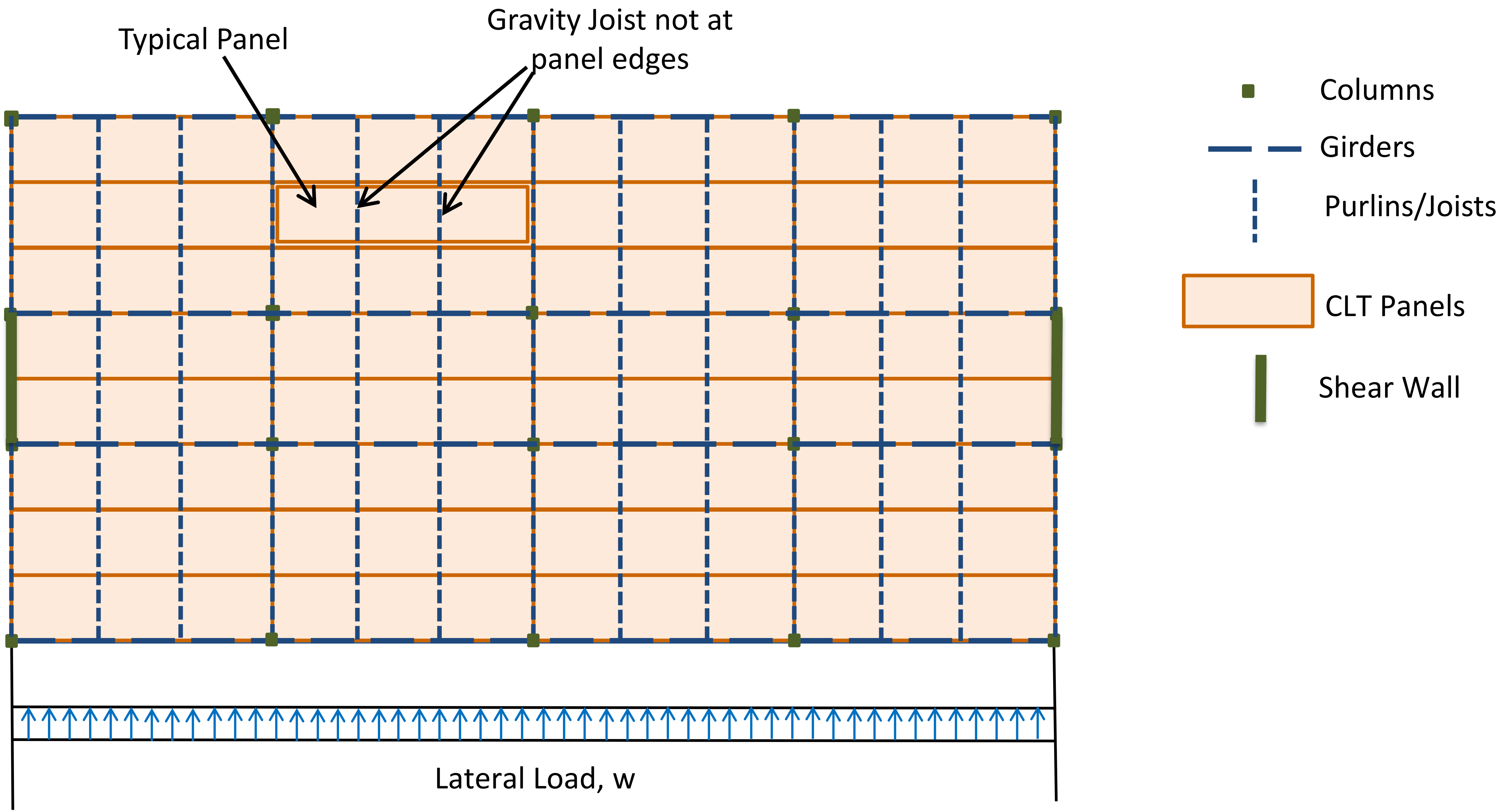
Strength of CLT rarely governs.

Strength of Connections covered by NDS and Proprietary Fastener Evaluation Reports

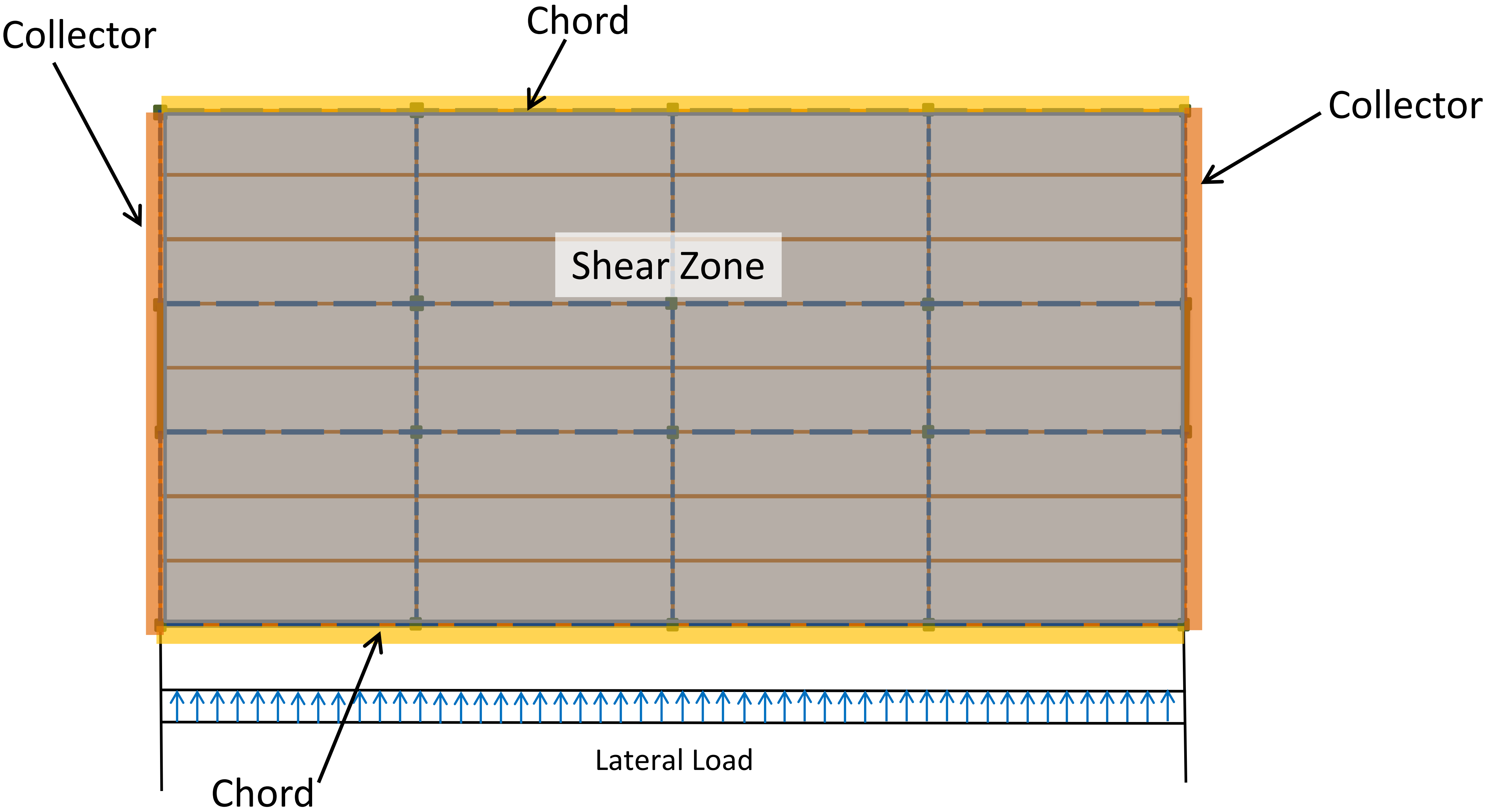
Typical CLT Floor Assembly



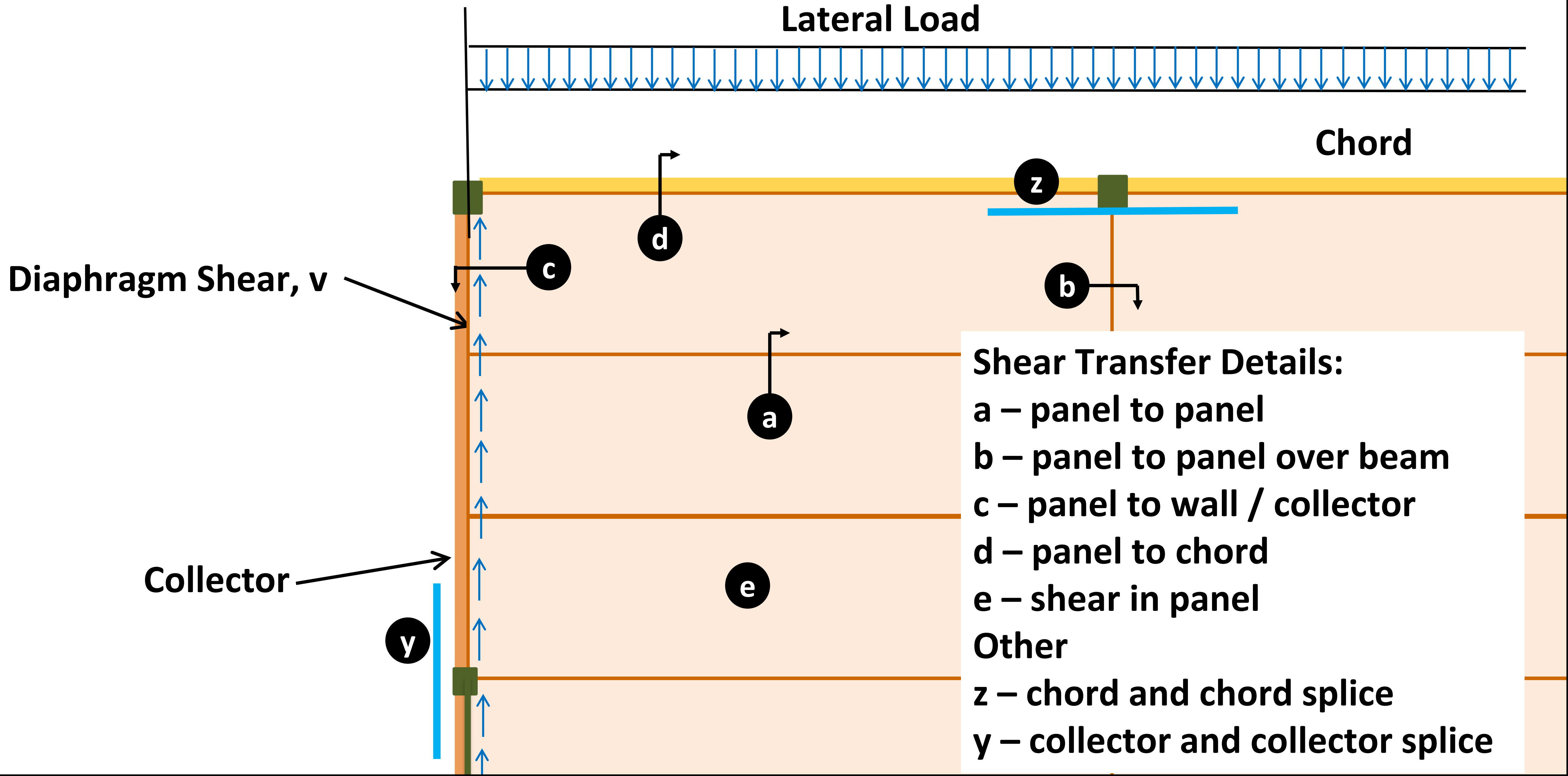
Generic Mass Timber Floor System



Example CLT Diaphragm Design



Example CLT Diaphragm Design



2021 Special Design Provisions for Wind and Seismic

4.5 Cross-Laminated Timber (CLT) Diaphragms

4.5.1 Application Requirements

CLT diaphragms shall be permitted to be used to resist lateral forces provided the deflection in the plane of the diaphragm, as determined by calculations, tests, or analogies drawn therefrom, does not exceed the maximum permissible deflection limit of attached load distributing or resisting elements. Permissible deflection shall be that deflection that will permit the diaphragm and any attached elements to maintain their structural integrity and continue to support their prescribed loads as determined by the applicable building code or standard.

4.5.2 Deflection

CLT diaphragm deflection shall be determined using principles of engineering mechanics.

4.5.3 Unit Shear Capacity

CLT diaphragms shall be designed in accordance with principles of engineering mechanics using design values for wood members and connections in accordance with NDS provisions.

The nominal unit shear capacity, v_n, of CLT diaphragms shall be based on the nominal shear capacity for dowel-type fastener connections used to transfer diaphragm shear forces, as calculated per 4.5.4, Item 1. ASD allowable shear capacity or LRFD factored shear resistance for the CLT diaphragm and diaphragm shear connections shall be determined in accordance with 4.1.1.

4.5.4 Additional CLT Diaphragm Design Requirements

CLT diaphragms shall meet the following additional requirements:

1. The nominal shear capacity for dowel-type fastener connections used to transfer diaphragm shear forces between CLT panels and between CLT panels and diaphragm boundary elements (chords and collectors) shall be taken as 4.5Z*, where Z* is Z multiplied by all applicable NDS adjustment factors except C_D, K_F, ϕ, and λ; and Z shall be controlled by Mode III_s or Mode IV fastener yielding in accordance with NDS 12.3.1.
2. Connections used to transfer diaphragm shear forces shall not be used to resist diaphragm tension forces.
3. Wood elements, steel parts, and wood or steel chord splice connections shall be designed for 2.0 times the diaphragm forces associated with the shear forces induced from the design loads.

Exceptions:

1. Wood elements and wood splice connections shall be permitted to be designed for 1.5 times the diaphragm forces associated with the shear forces induced by the wind design loads.
2. Where dowel-type fasteners are used in chord splice connections and the connection is controlled by Mode III_s or Mode IV fastener yielding in accordance with NDS 12.3.1, fasteners in the connection shall be permitted to be designed for 1.5 and 1.0 times the diaphragm forces associated with the shear forces induced by the prescribed seismic and wind design loads, respectively.

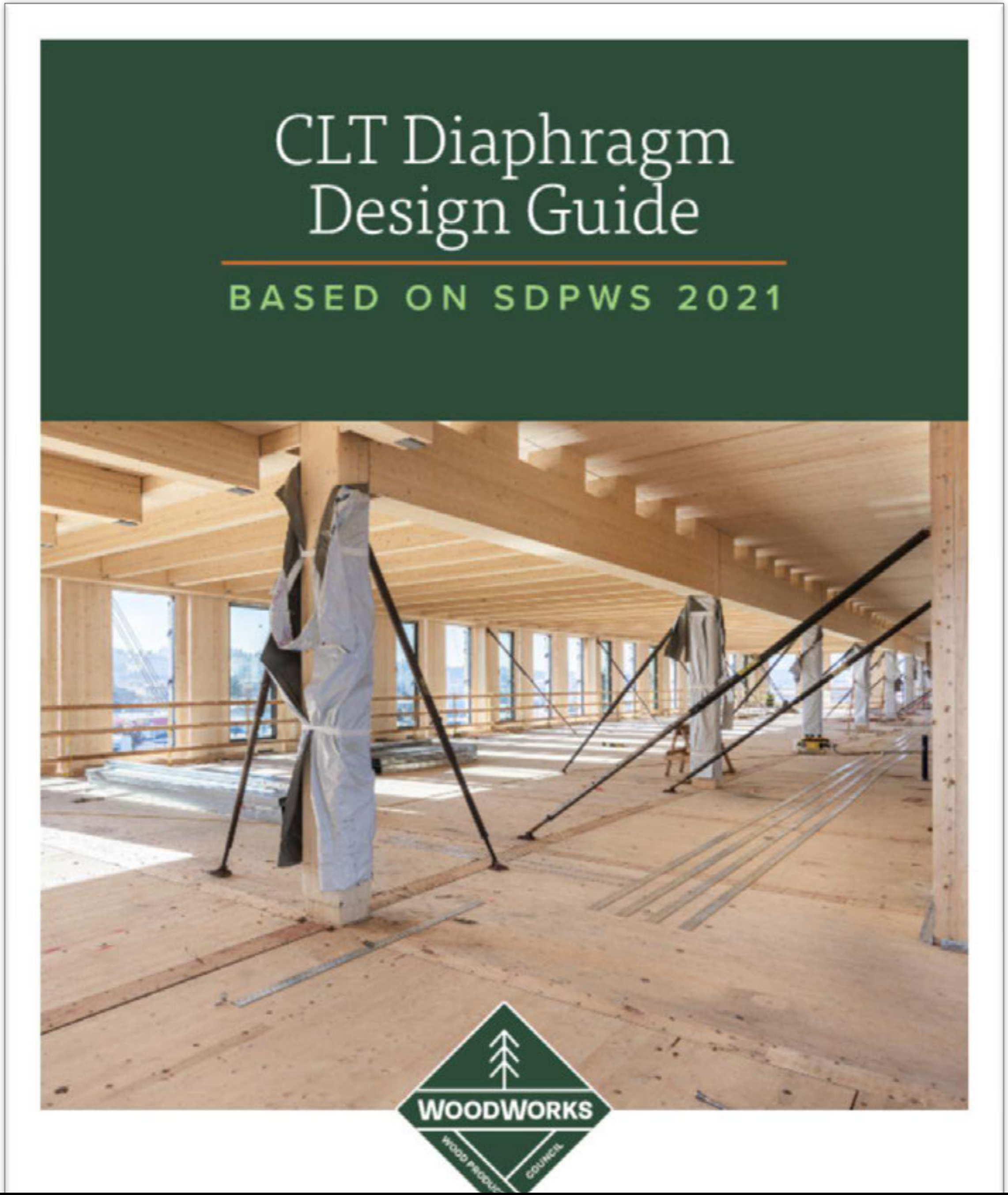
Diaphragm chord elements and chord splice connections using materials other than wood or steel shall be designed using provisions in NDS 1.4.

Only 1 page of requirements for CLT Diaphragms

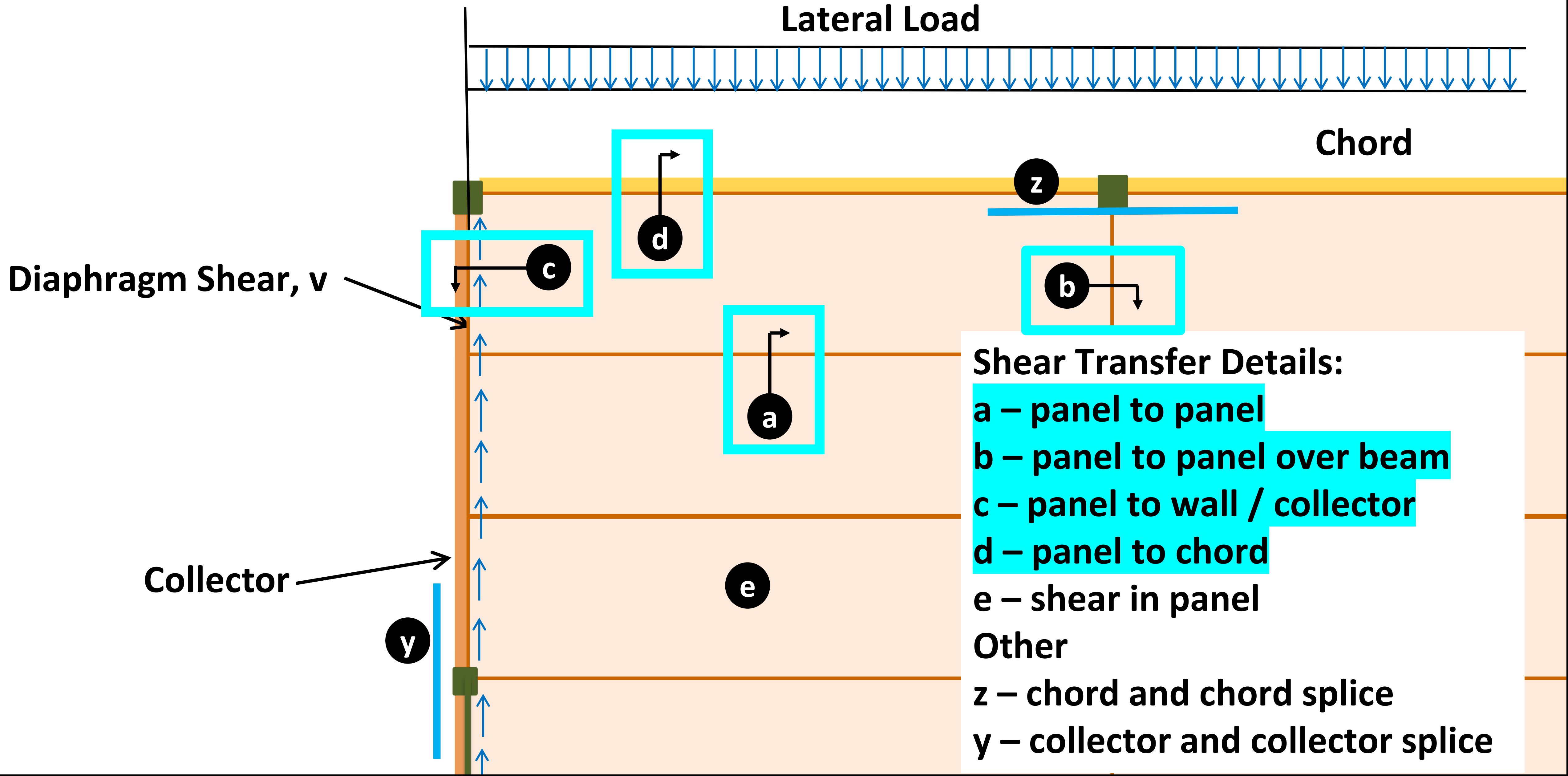
WoodWorks published Design Guide:

https://www.woodworks.org/resources/clt-diaphragm-design-guide/

140+ pages



CLT Diaphragm Shear Transfer Connections



Shear Transfer Details:

a – panel to panel

b – panel to panel over beam

c – panel to wall / collector

d – panel to chord

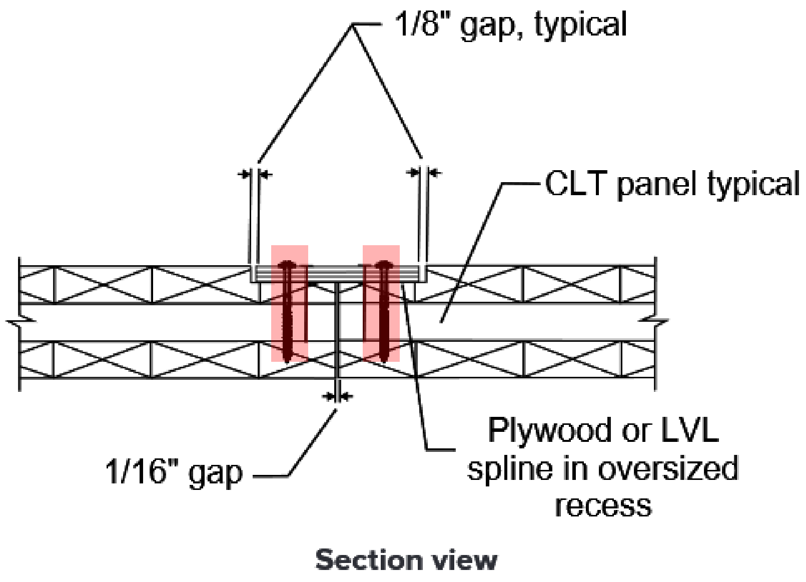
e – shear in panel

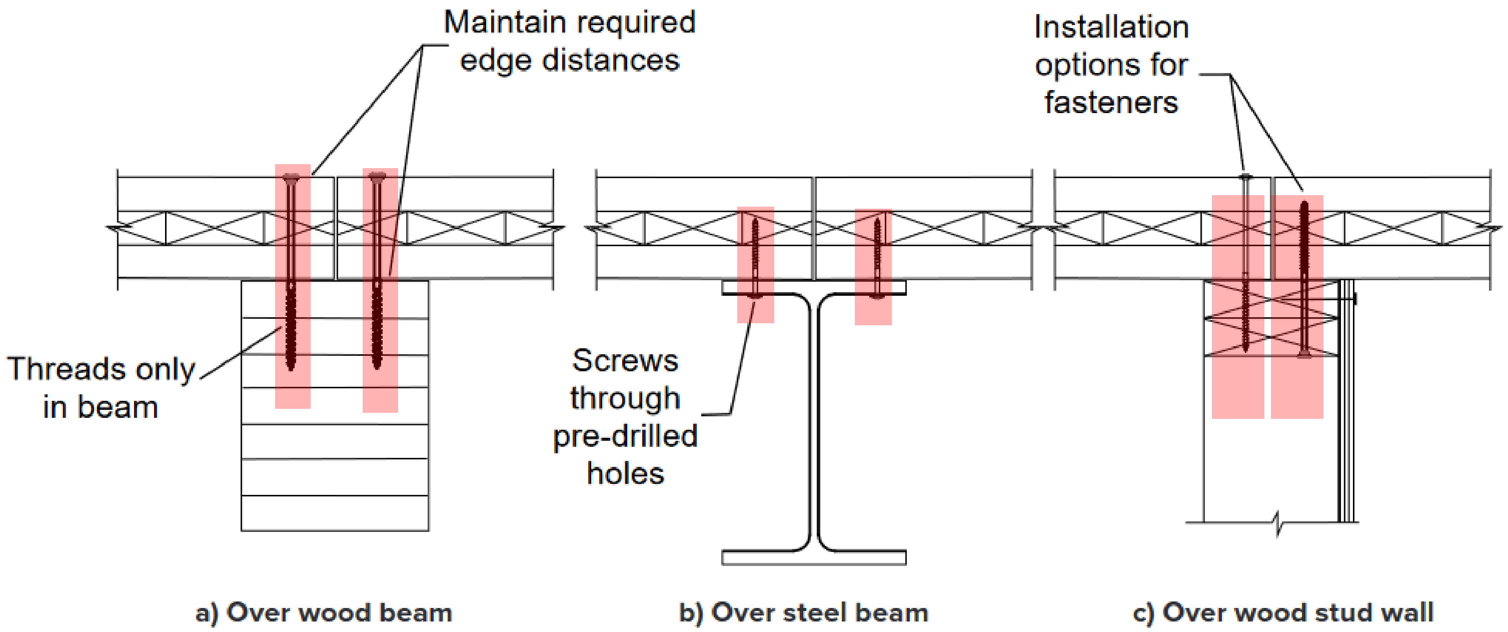
Other

z – chord and chord splice

y – collector and collector splice

CLT Diaphragm Shear Connections





2021 Special Design Provisions for Wind and Seismic

4.5 Cross-Laminated Timber (CLT) Diaphragms

4.5.1 Application Requirements

CLT diaphragms shall be permitted to be used to resist lateral forces provided the deflection in the plane of the diaphragm, as determined by calculations, tests, or analogies drawn therefrom, does not exceed the maximum permissible deflection limit of attached load distributing or resisting elements. Permissible deflection shall be that deflection that will permit the diaphragm and any attached elements to maintain their structural integrity and continue to support their prescribed loads as determined by the applicable building code or standard.

4.5.2 Deflection

CLT diaphragm deflection shall be determined using principles of engineering mechanics.

4.5.3 Unit Shear Capacity

CLT diaphragms shall be designed in accordance with principles of engineering mechanics using design values for wood members and connections in accordance with NDS provisions.

The nominal unit shear capacity, v_n, of CLT diaphragms shall be based on the nominal shear capacity for dowel-type fastener connections used to transfer diaphragm shear forces, as calculated per 4.5.4, Item 1. ASD allowable shear capacity or LRFD factored shear resistance for the CLT diaphragm and diaphragm shear connections shall be determined in accordance with 4.1.1.

4.5.4 Additional CLT Diaphragm Design Requirements

CLT diaphragms shall meet the following additional requirements:

1. The nominal shear capacity for dowel-type fastener connections used to transfer diaphragm shear forces between CLT panels and between CLT panels and diaphragm boundary elements (chords and collectors) shall be taken as 4.5Z*, where Z* is Z multiplied by all applicable NDS adjustment factors except C_D, K_F, ϕ, and λ; and Z shall be controlled by Mode III_s or Mode IV fastener yielding in accordance with NDS 12.3.1.
2. Connections used to transfer diaphragm shear forces shall not be used to resist diaphragm tension forces.
3. Wood elements, steel parts, and wood or steel chord splice connections shall be designed for 2.0 times the diaphragm forces associated with the shear forces induced from the design loads.

Exceptions:

1. Wood elements and wood splice connections shall be permitted to be designed for 1.5 times the diaphragm forces associated with the shear forces induced by the wind design loads.
2. Where dowel-type fasteners are used in chord splice connections and the connection is controlled by Mode III_s or Mode IV fastener yielding in accordance with NDS 12.3.1, fasteners in the connection shall be permitted to be designed for 1.5 and 1.0 times the diaphragm forces associated with the shear forces induced by the prescribed seismic and wind design loads, respectively.

Diaphragm chord elements and chord splice connections using materials other than wood or steel shall be designed using provisions in NDS 1.4.

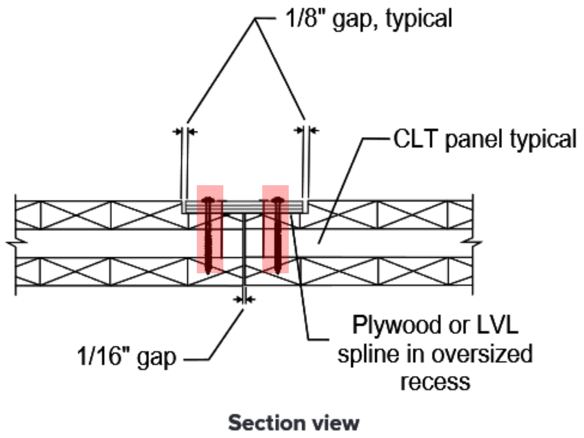
4.5.4 Additional CLT Diaphragm Design Requirements

CLT diaphragms shall meet the following additional requirements:

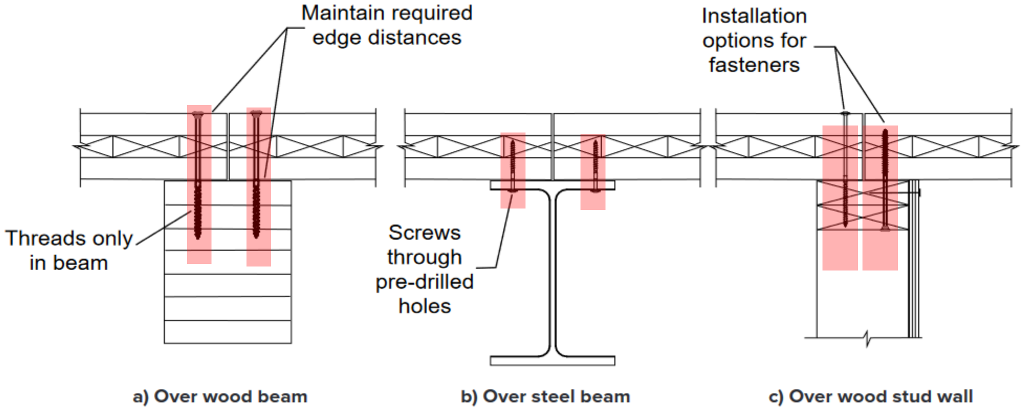
1. The nominal shear capacity for dowel-type fastener connections used to transfer diaphragm shear forces between CLT panels and between CLT panels and diaphragm boundary elements (chords and collectors) shall be taken as 4.5Z*, where Z* is Z multiplied by all applicable NDS adjustment factors except C_D, K_F, ϕ, and λ; and Z shall be controlled by Mode IIIs or Mode IV fastener yielding in accordance with NDS 12.3.1.

Requirements for the shear connections

CLT Diaphragm Shear Connections



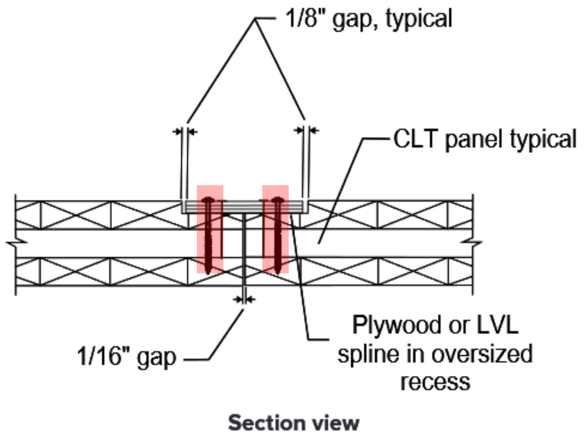
1) Diaphragm shear connections between adjacent CLT panels and between CLT and diaphragm boundary elements (chords and collectors) shall use <u>dowel-type fasteners in shear</u> to transfer diaphragm shear forces.

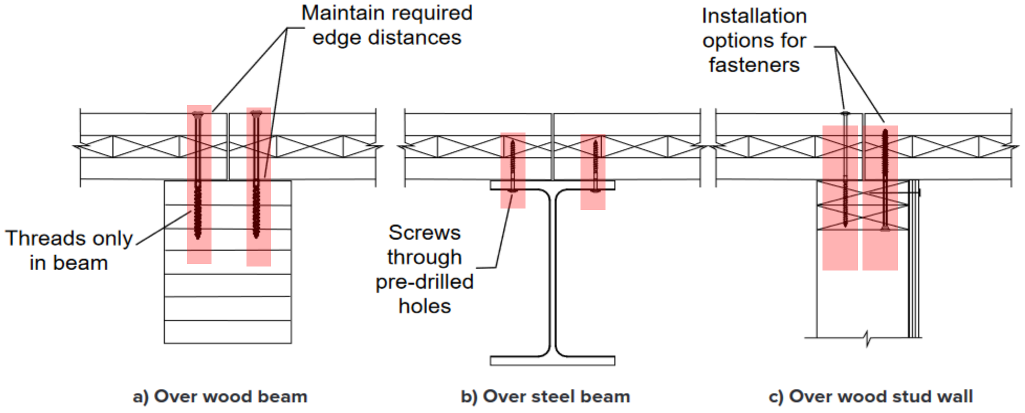


<u>Nails or screws</u> installed perpendicular to the face of the CLT are dowel-type fasteners in shear.

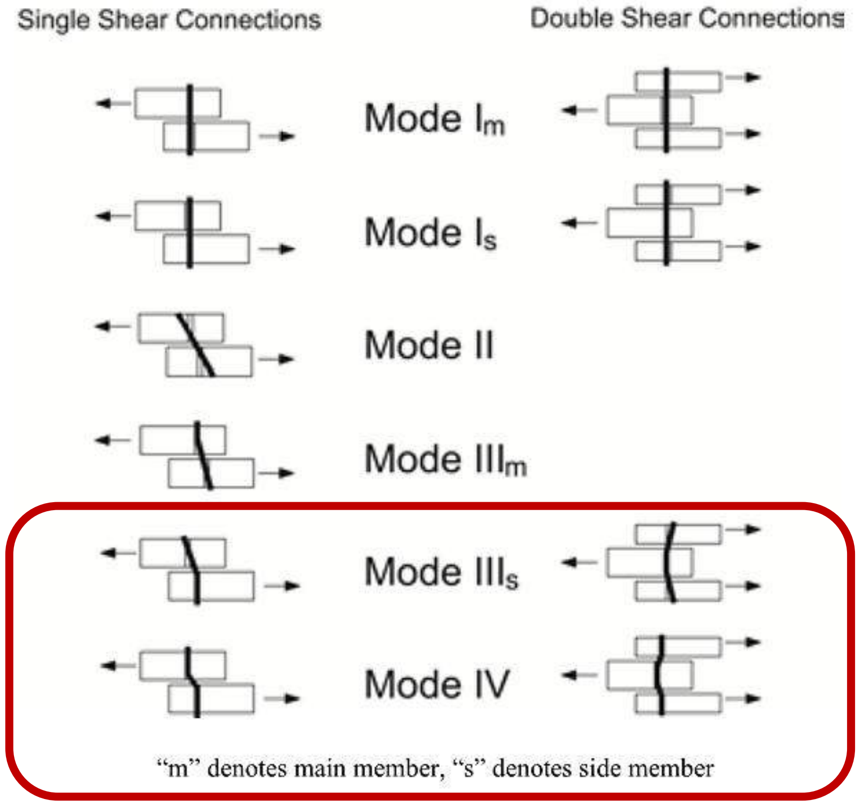
SDPWS 2021 Section 4.5.3

CLT Diaphragm Shear Connections



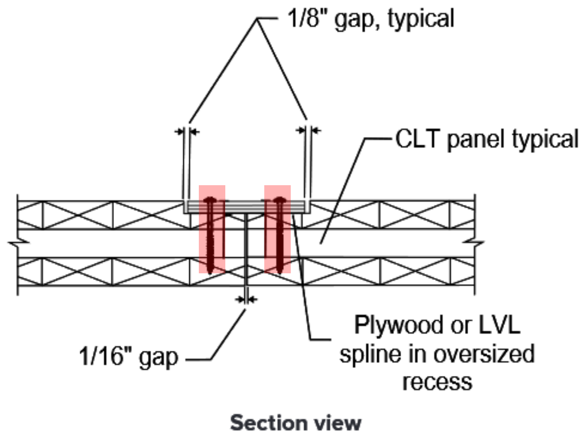


2) The reference design value of the fastener connection, Z, shall be calculated per NDS 12.3.1 and only connections controlled by fastener yield Mode IIIs or Mode IV are permitted.



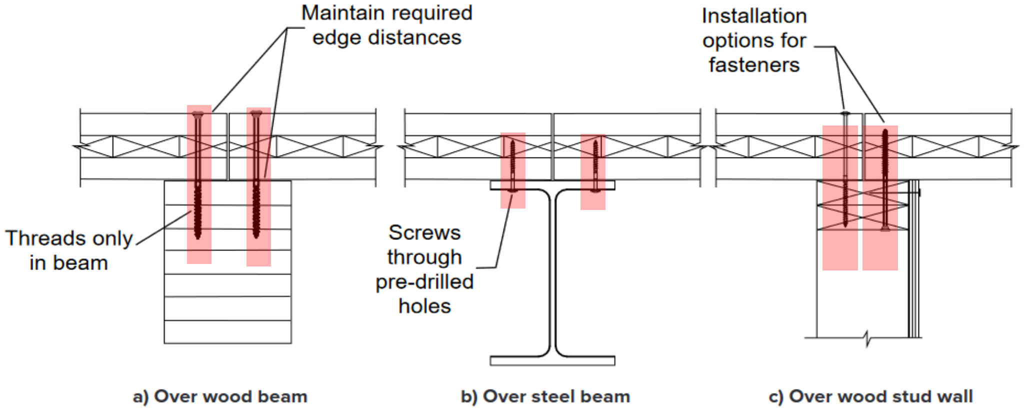
Skinny fasteners usually controlled by these modes

CLT Diaphragm Shear Connections



3) The nominal shear capacity for the dowel-type fastener connection shall be taken as 4.5 Z*

$$V_n = 4.5\ \mathrm{Z}^*$$



where Z^* is reference lateral capacity Z multiplied by all applicable factors *except* C_D, K_F, ϕ, $\lambda = 1.0$

SDPWS 2021 Section 4.5.4(1)

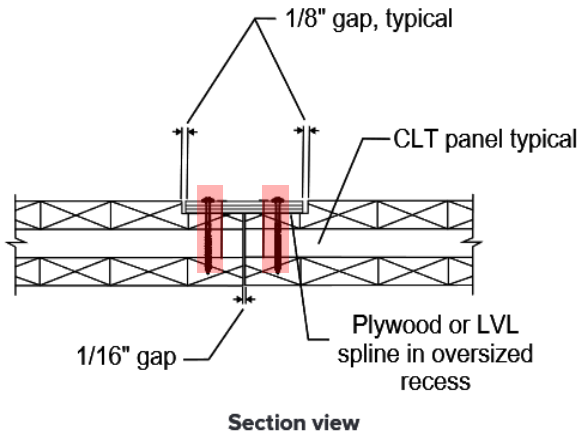
Table 11.3.1 Applicability of Adjustment Factors for Connections

	ASD Only	ASD and LRFD									LRFD Only		
	Load Duration Factor [1]	Wet Service Factor	Temperature Factor	Group Action Factor	Geometry Factor [3]	Penetration Depth Factor [3]	End Grain Factor [3]	Metal Side Plate Factor [3]	Diaphragm Factor [3]	Toe-Nail Factor [3]	Format Conversion Factor	Resistance Factor	Time Effect Factor
											K_F	ϕ	
Lateral Loads													
Dowel-type Fasteners (e.g. bolts, lag screws, wood screws, nails, spikes, drift bolts, & drift pins) $Z^* = \boxed{Z \ x}$	1.0	C_M	C_t	C_g	C_Δ	-	C_{eg}	-	1.0	C_{tn}	1.0	1.0	1.0

Also 1.0 for CLT Diaphragm Shear Connections

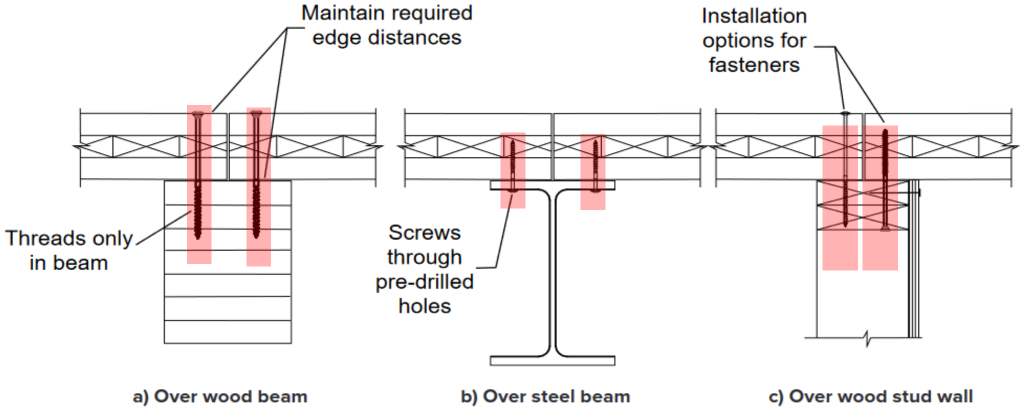
SDPWS 2021 Section 4.5.4(1) and NDS Table 11.3.1

CLT Diaphragm Shear Connections



4) The nominal unit shear capacity for a connection with uniform fastener spacing, s, can be found as

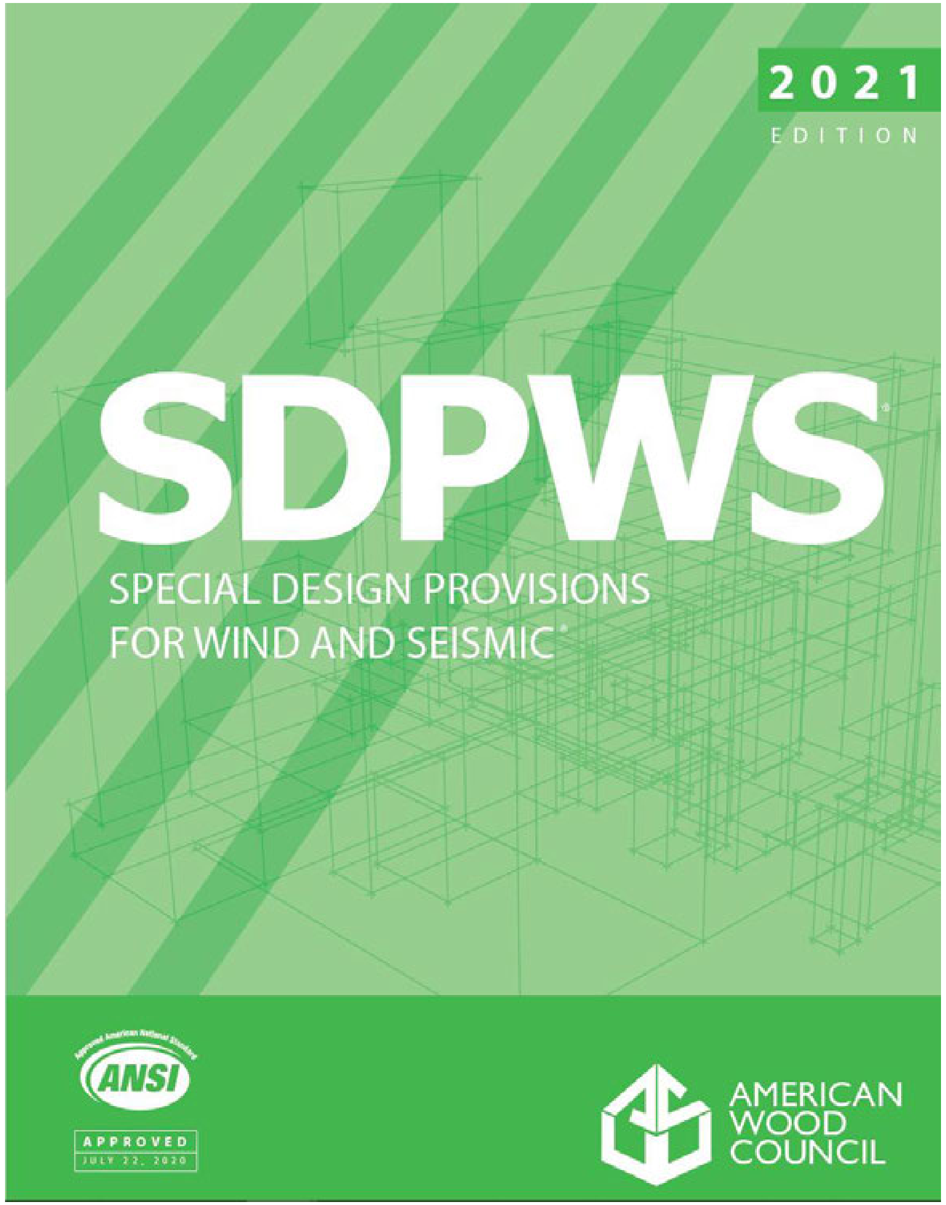
$$v_n = \frac{4.5\, Z^*}{s}$$



The factors of SDPWS 2021 Section 4.1.4 are applied to reduce to ASD or LFRD, wind or seismic unit design shear capacity

SDPWS 2021 Section 4.5.4(1)

2021 SDPWS – Unified Nominal Shear Capacity



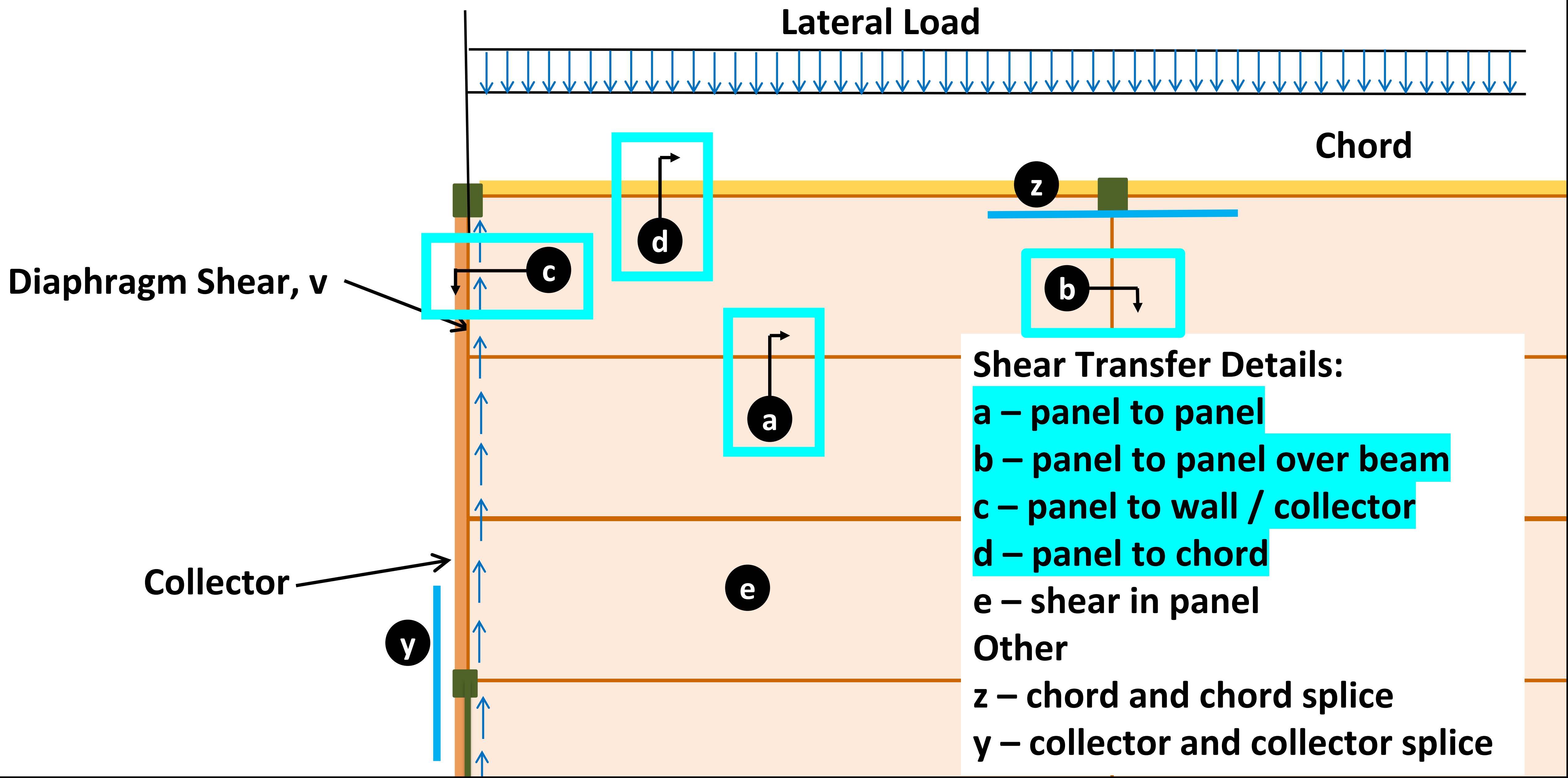
To calculate the ASD or LRFD shear capacity, SDPWS 2021 has different reduction factors for wind and seismic

	Design shear capacity	
	ASD	LRFD
Wind	$v_n/2.0$	$0.8\ v_n$
Seismic	$v_n/2.8$	$0.5\ v_n$

ASD seismic design capacity:

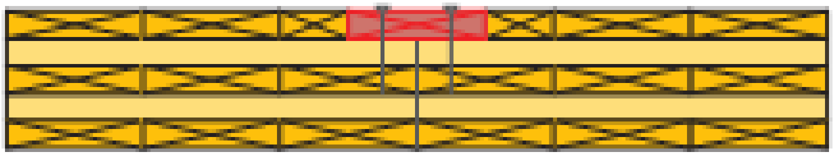
$4.5\ Z^* / 2.8 = 1.61\ Z^* \approx C_D\ Z = 1.6\ Z$

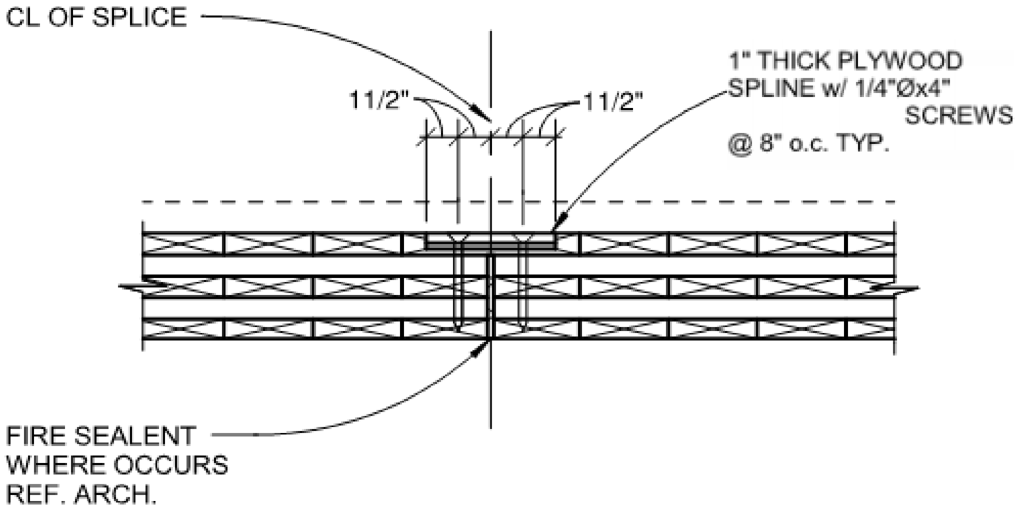
CLT Diaphragm Shear Transfer Connections

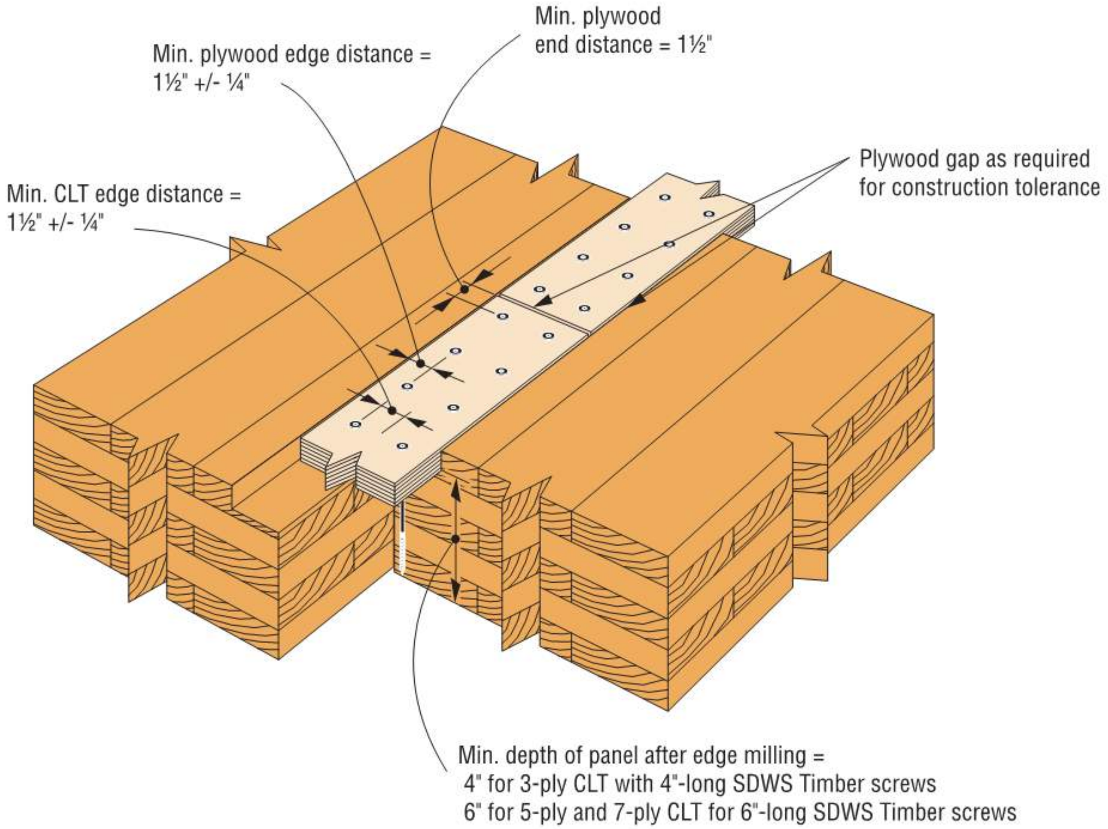


Panel to Panel Connection Styles

- Single Surface Spline







Source: Simpson Strong-Tie

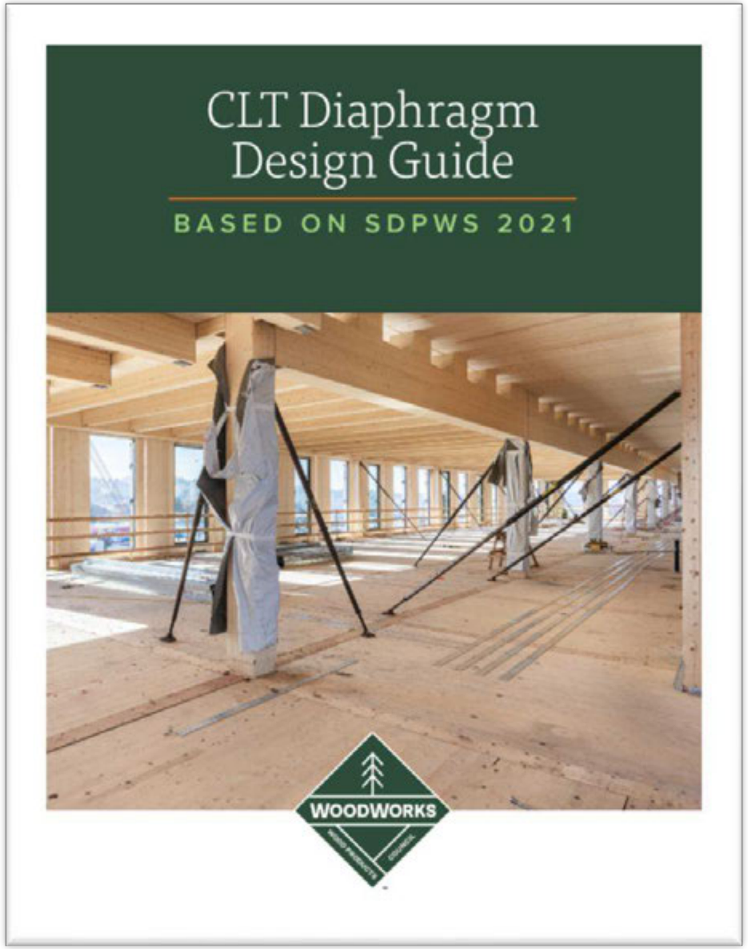
CLT Diaphragm Design Guide

https://www.woodworks.org/resources/clt-diaphragm-design-guide/

Precalculated nominal shear capacities

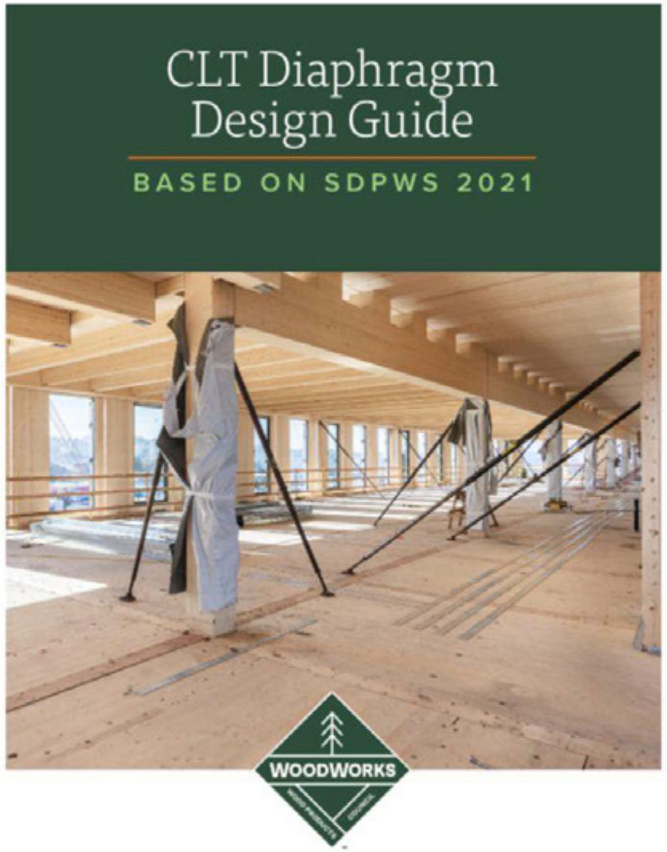
TABLE A.1.4: Nominal diaphragm shear capacity for spaced fastener in spline *continued*

Spline Material	Fastener	Nominal Diaphragm Shear Capacity of Fasteners, $v_n = 4.5Z^*/S$, @ Spacing, $S^{a,c}$ (plf)					Reference Spline Shear Capacity, $F_v t_v{}^b$ (plf)
		12-in. o.c.	6-in. o.c.	4-in. o.c.	3-in. o.c.	2-in. o.c.	
CLT SG = 0.50							
General sheathing (23/32)	8d common nail	331	661	992	1,323	1,984	1,176
General sheathing (23/32)	10d common nail	389	779	1,168	1,558	2,337	1,176
General sheathing (23/32)	Example screw 1	364	729	1,093	1,457	2,186	1,176
General sheathing (23/32)	Example screw 2	430	860	1,290	1,720	2,581	1,176
Structural 1 sheathing (23/32)	8d common nail	398	796	1,194	1,592	2,388	1,512
Structural 1 sheathing (23/32)	10d common nail	465	930	1,395	1,859	2,789	1,512
Structural 1 sheathing (23/32)	Example screw 1	425	850	1,275	1,699	2,549	1,512
Structural 1 sheathing (23/32)	Example screw 2	508	1,016	1,524	2,031	3,047	1,512
General sheathing (7/8)	10d common nail	425	850	1,275	1,700	2,550	1,440
General sheathing (7/8)	16d common nail	488	975	1,463	1,951	2,926	1,440
General sheathing (7/8)	Example screw 1	388	776	1,164	1,551	2,327	1,440
General sheathing (7/8)	Example screw 2	464	928	1,392	1,856	2,784	1,440
Structural 1 sheathing (7/8)	10d common nail	519	1,037	1,556	2,074	3,111	1,584
Structural 1 sheathing (7/8)	16d common nail	589	1,178	1,768	2,357	3,535	1,584
Structural 1 sheathing (7/8)	Example screw 1	463	926	1,389	1,852	2,778	1,584
Structural 1 sheathing (7/8)	Example screw 2	560	1,121	1,681	2,242	3,363	1,584
General sheathing (1-1/8)	10d common nail	485	969	1,454	1,939	2,908	1,920



CLT Diaphragm Design Guide

https://www.woodworks.org/resources/clt-diaphragm-design-guide/



Precalculated nominal shear capacities

TABLE A.1.4: Nominal diaphragm shear capacity for spaced fastener in spline *continued*

Spline Material	Fastener	Nominal Diaphragm Shear Capacity of Fasteners, $v_n = 4.5Z'/S$, @ Spacing, $S^{a,c}$ (plf)					Reference Spline Shear Capacity, $F_v t_v{}^b$ (plf)
		12-in. o.c.	6-in. o.c.	4-in. o.c.	3-in. o.c.	2-in. o.c.	
CLT SG = 0.50							
General sheathing (23/32)	8d common nail	331	661	992	1,323	1,984	1,176
General sheathing (23/32)	10d common nail	389	779	1,168	1,558	2,337	1,176
General sheathing (23/32)	Example screw 1	364	729	1,093	1,457	2,186	1,176
General sheathing (23/32)							
Structural 1 sheathing (23/32)							
Structural 1 sheathing (23/32)							
Structural 1 sheathing (23/32)							
Structural 1 sheathing (23/32)							
General sheathing (7/8)							
General sheathing (7/8)							
General sheathing (7/8)							
General sheathing (7/8)							
Structural 1 sheathing (7/8)							
Structural 1 sheathing (7/8)							
Structural 1 sheathing (7/8)							
Structural 1 sheathing (7/8)							
General sheathing (1-1/8)							

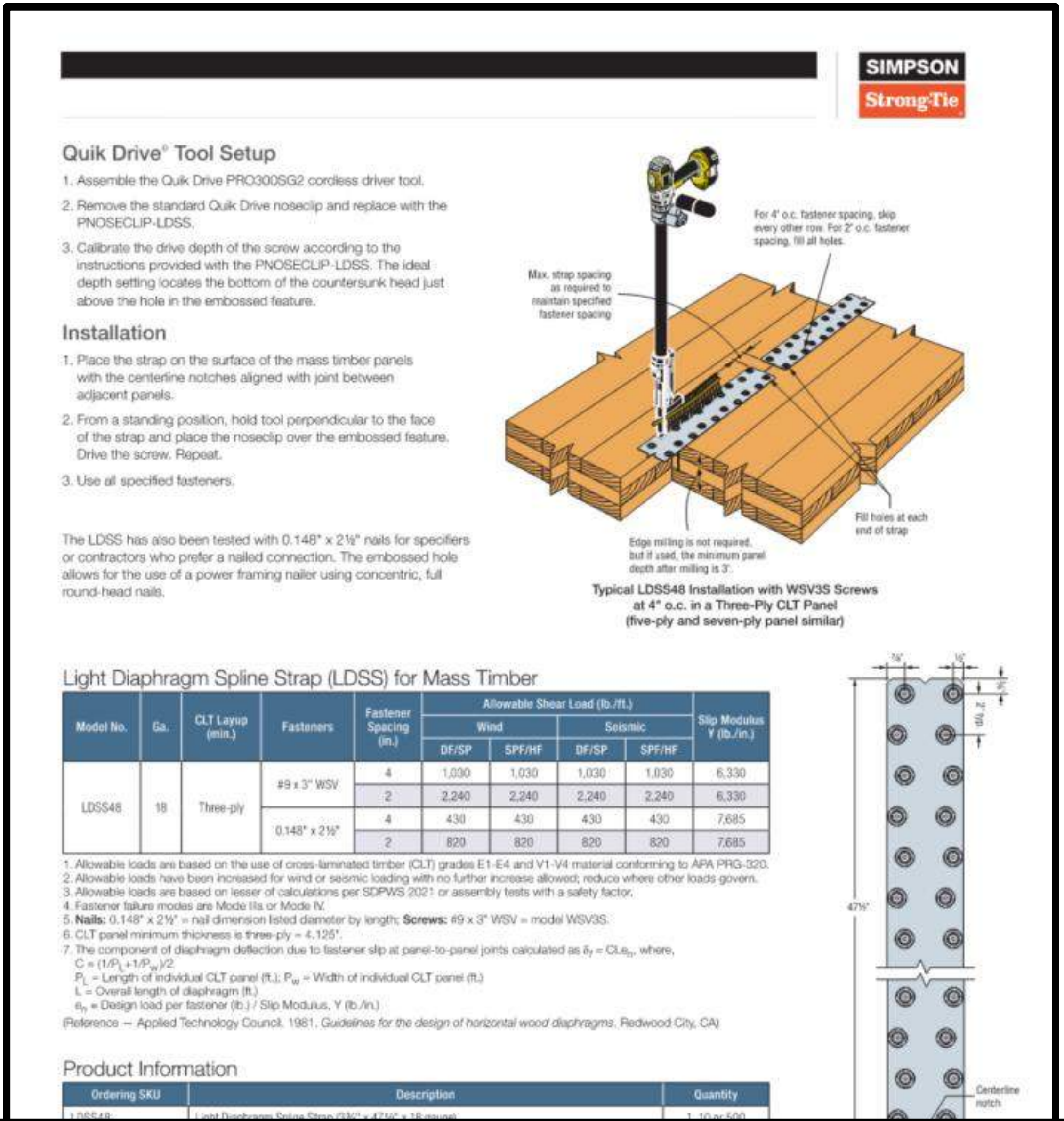
Precalculated ASD seismic shear capacities

TABLE A.1.5: ASD diaphragm seismic shear capacity for spaced fasteners in spline *continued*

Spline Material	Fastener	ASD Seismic Diaphragm Capacity of Fasteners, $v_{asd} = (4.5/2.8)Z'/S$, @ Spacing, $S^{a,b,c}$ (plf)				
		12-in. o.c.	6-in. o.c.	4-in. o.c.	3-in. o.c.	2-in. o.c.
CLT SG = 0.50						
General sheathing (23/32)	8d common nail	118	236	354	472	709
General sheathing (23/32)	10d common nail	139	278	417	556	834
General sheathing (23/32)	Example screw 1	130	260	390	520	781
General sheathing (23/32)	Example screw 2	154	307	461	614	922

Vendor Specific Steel Spline Straps

Source: Simpson Strong-Tie



SIMPSON Strong-Tie

Quik Drive® Tool Setup

1. Assemble the Quik Drive PRO300SG2 cordless driver tool.
2. Remove the standard Quik Drive noseclip and replace with the PNOSECLIP-LDSS.
3. Calibrate the drive depth of the screw according to the instructions provided with the PNOSECLIP-LDSS. The ideal depth setting locates the bottom of the countersunk head just above the hole in the embossed feature.

Installation

1. Place the strap on the surface of the mass timber panels with the centerline notches aligned with joint between adjacent panels.
2. From a standing position, hold tool perpendicular to the face of the strap and place the noseclip over the embossed feature. Drive the screw. Repeat.
3. Use all specified fasteners.

The LDSS has also been tested with 0.148" x 2½" nails for specifiers or contractors who prefer a nailed connection. The embossed hole allows for the use of a power framing nailer using concentric, full round-head nails.

Typical LDSS48 Installation with WSV3S Screws at 4" o.c. in a Three-Ply CLT Panel (five-ply and seven-ply panel similar)

Light Diaphragm Spline Strap (LDSS) for Mass Timber

Model No.	Ga.	CLT Layup (min.)	Fasteners	Fastener Spacing (in.)	Allowable Shear Load (lb./ft.)				Slip Modulus Y (lb./in.)
					Wind		Seismic		
					DF/SP	SPF/HF	DF/SP	SPF/HF	
LDSS48	18	Three-ply	#9 x 3" WSV	4	1,030	1,030	1,030	1,030	6,330
				2	2,240	2,240	2,240	2,240	6,330
			0.148" x 2½"	4	430	430	430	430	7,685
				2	820	820	820	820	7,685

1. Allowable loads are based on the use of cross-laminated timber (CLT) grades E1-E4 and V1-V4 material conforming to APA PRG-320.
2. Allowable loads have been increased for wind or seismic loading with no further increase allowed; reduce where other loads govern.
3. Allowable loads are based on lesser of calculations per SDPWS 2021 or assembly tests with a safety factor.
4. Fastener failure modes are Mode IIIs or Mode IV.
5. **Nails:** 0.148" x 2½" = nail dimension listed diameter by length; **Screws:** #9 x 3" WSV = model WSV3S.
6. CLT panel minimum thickness is three-ply = 4.125".
7. The component of diaphragm deflection due to fastener slip at panel-to-panel joints calculated as $\delta_f = CLe_n$, where,
   $C = (1/P_L + 1/P_W)/2$
   P_L = Length of individual CLT panel (ft.); P_W = Width of individual CLT panel (ft.)
   L = Overall length of diaphragm (ft.)
   e_n = Design load per fastener (lb.) / Slip Modulus, Y (lb./in.)

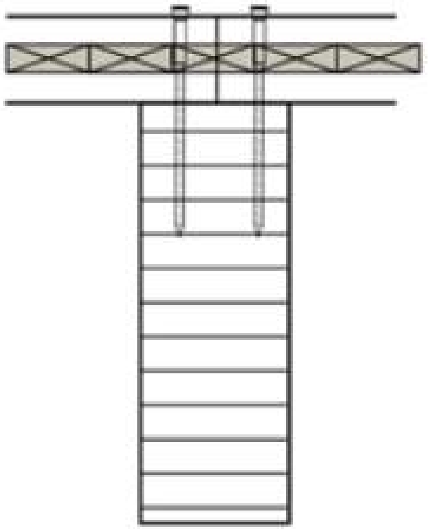
(Reference — Applied Technology Council. 1981. *Guidelines for the design of horizontal wood diaphragms*. Redwood City, CA)

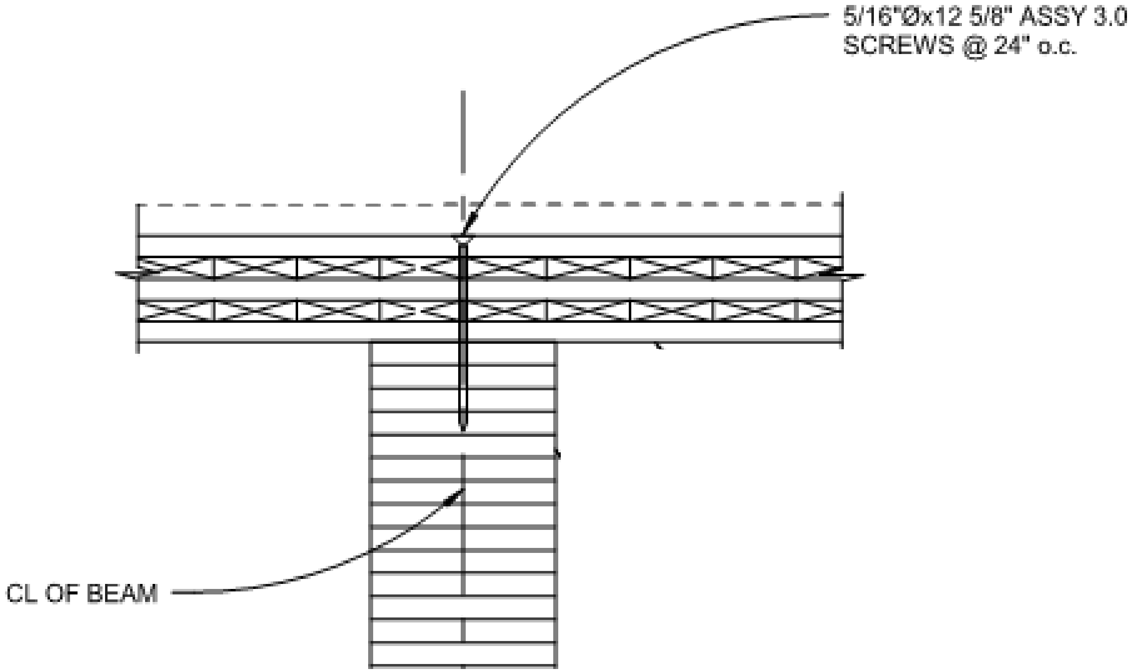
Product Information

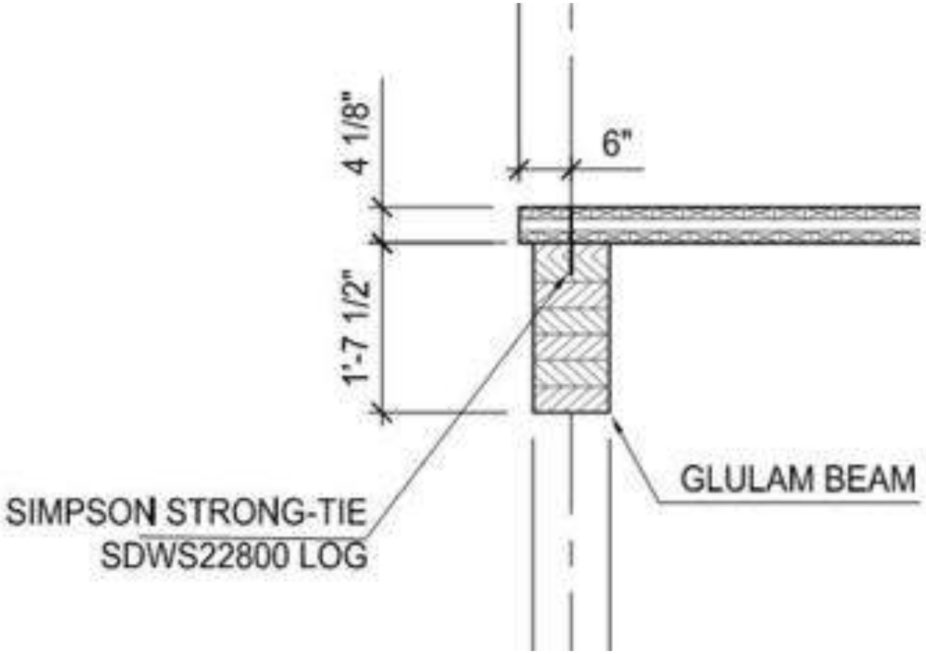
Ordering SKU	Description	Quantity

Source: Rothoblaas

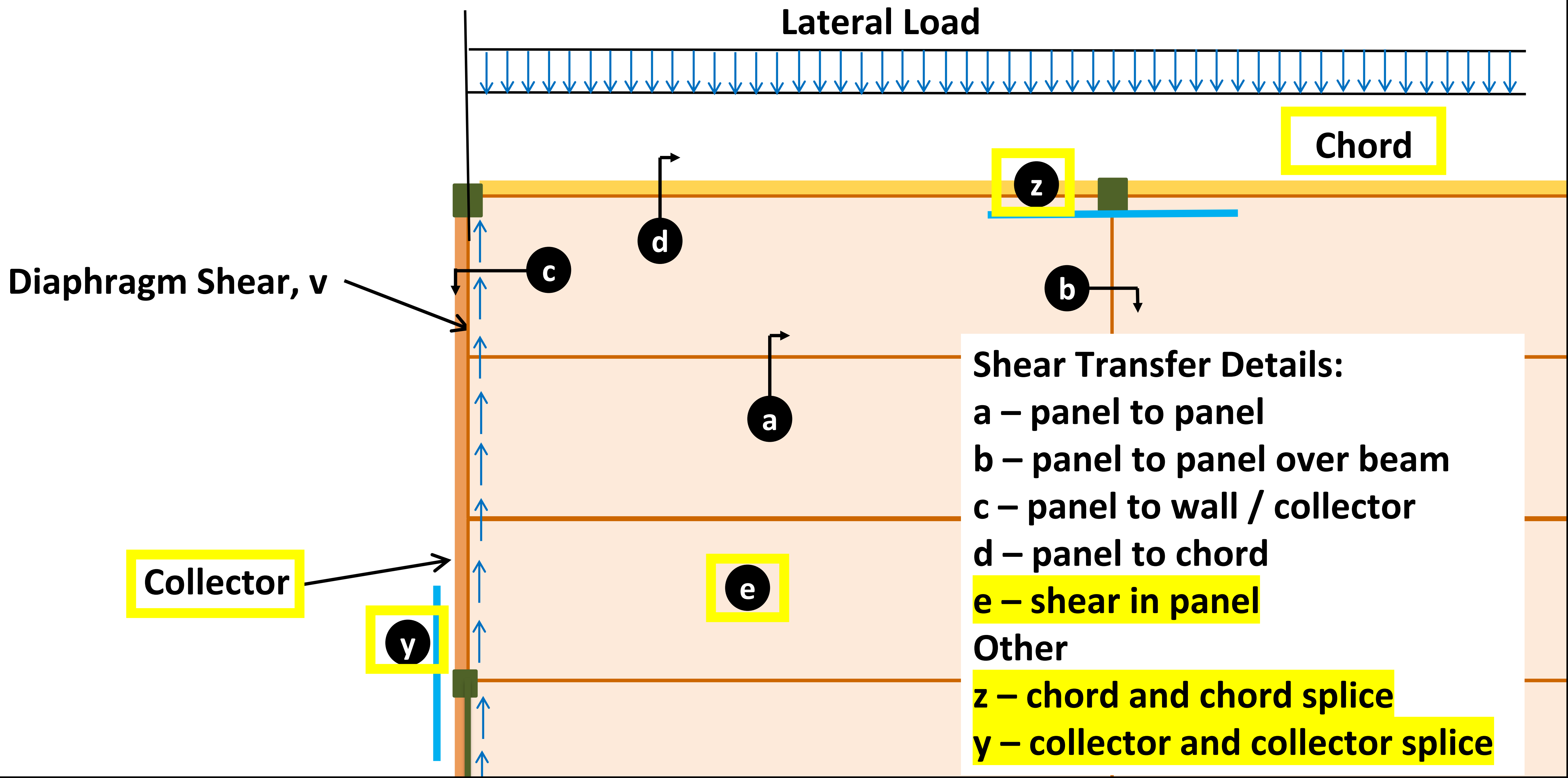
Panel to Beam Connection Styles







Other CLT Diaphragm Components



Shear Transfer Details:

a – panel to panel

b – panel to panel over beam

c – panel to wall / collector

d – panel to chord

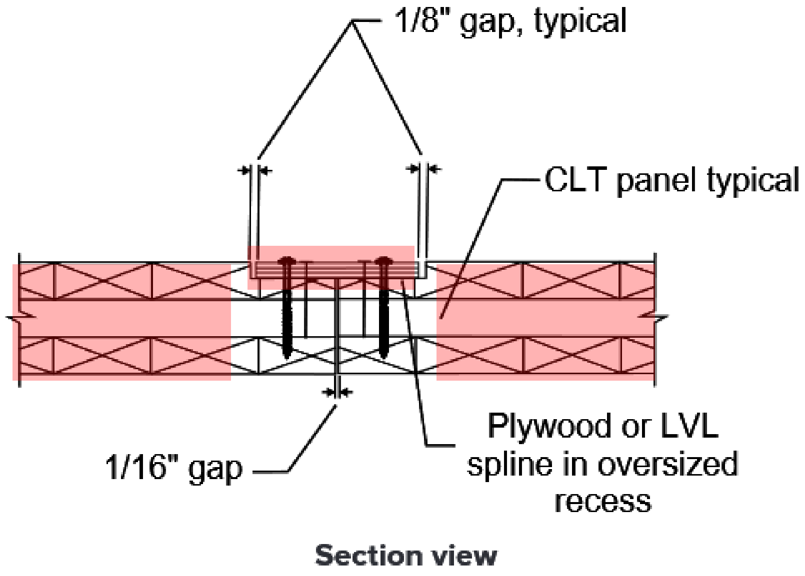
e – shear in panel

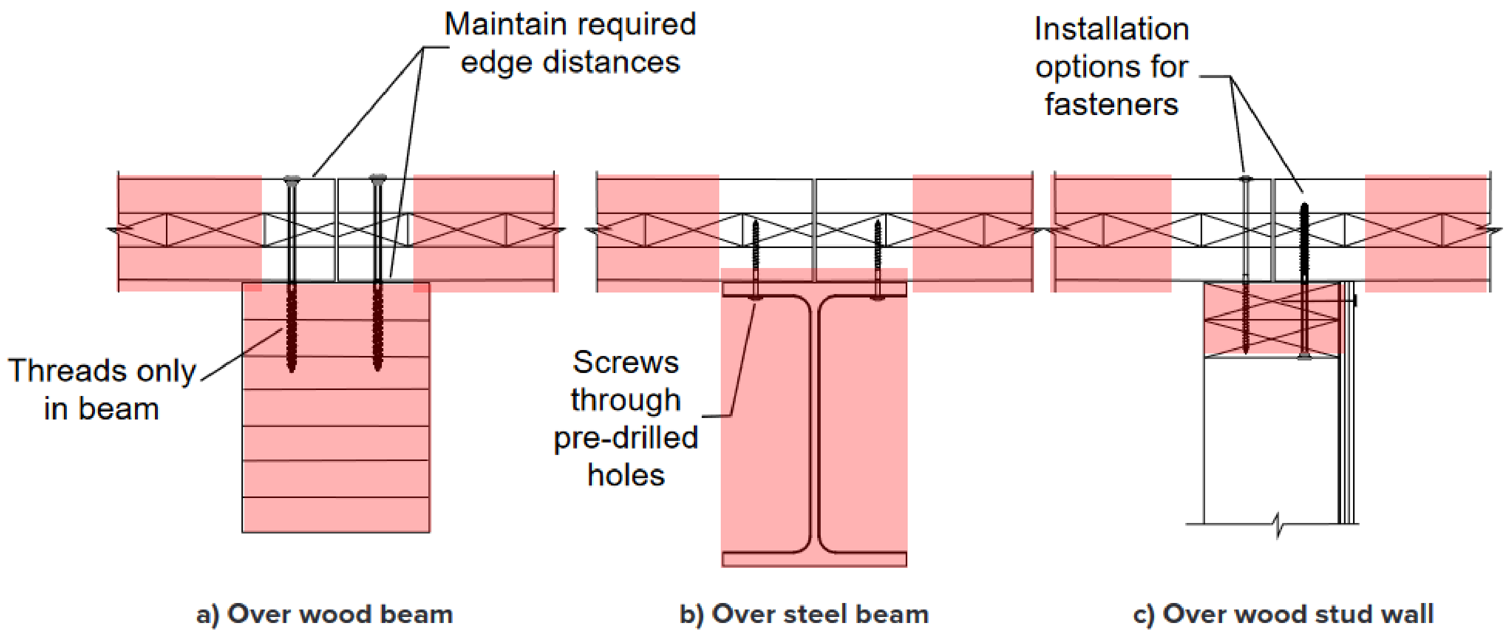
Other

z – chord and chord splice

y – collector and collector splice

Other CLT Diaphragm Components





Designed for **amplified** diaphragm design forces

Other Diaphragm Components

4.5 Cross-Laminated Timber (CLT) Diaphragms

4.5.1 Application Requirements

CLT diaphragms shall be permitted to be used to resist lateral forces provided the deflection in the plane of the diaphragm, as determined by calculations, tests, or analogies drawn therefrom, does not exceed the maximum permissible deflection limit of attached load distributing or resisting elements. Permissible deflection shall be that deflection that will permit the diaphragm and any attached elements to maintain their structural integrity and continue to support their prescribed loads as determined by the applicable building code or standard.

4.5.2 Deflection

CLT diaphragm deflection shall be determined using principles of engineering mechanics.

4.5.3 Unit Shear Capacity

CLT diaphragms shall be designed in accordance with principles of engineering mechanics using design values for wood members and connections in accordance with NDS provisions.

The nominal unit shear capacity, v_n, of CLT diaphragms shall be based on the nominal shear capacity for dowel-type fastener connections used to transfer diaphragm shear forces, as calculated per 4.5.4, Item 1. ASD allowable shear capacity or LRFD factored shear resistance for the CLT diaphragm and diaphragm shear connections shall be determined in accordance with 4.1.1.

4.5.4 Additional CLT Diaphragm Design Requirements

CLT diaphragms shall meet the following additional requirements:

1. The nominal shear capacity for dowel-type fastener connections used to transfer diaphragm shear forces between CLT panels and between CLT panels and diaphragm boundary elements (chords and collectors) shall be taken as 4.5Z*, where Z* is Z multiplied by all applicable NDS

tener yielding in accordance with NDS 12.3.1.

2. Connections used to transfer diaphragm shear forces shall not be used to resist diaphragm tension forces.
3. Wood elements, steel parts, and wood or steel chord splice connections shall be designed for 2.0 times the diaphragm forces associated with the shear forces induced from the design loads.

Exceptions:

1. Wood elements and wood splice connections shall be permitted to be designed for 1.5 times the diaphragm forces associated with the shear forces induced by the wind design loads.
2. Where dowel-type fasteners are used in chord splice connections and the connection is controlled by Mode III_s or Mode IV fastener yielding in accordance with NDS 12.3.1, fasteners in the connection shall be permitted to be designed for 1.5 and 1.0 times the diaphragm forces associated with the shear forces induced by the prescribed seismic and wind design loads, respectively.

Diaphragm chord elements and chord splice connections using materials other than wood or steel shall be designed using provisions in NDS 1.4.

3. Wood elements, steel parts, and wood or steel chord splice connections shall be designed for 2.0 times the diaphragm forces associated with the shear forces induced from the design loads.

Exceptions:

1. Wood elements and wood splice connections shall be permitted to be designed for 1.5 times the diaphragm forces associated with the shear forces induced by the wind design loads.
2. Where dowel-type fasteners are used in chord splice connections and the connection is controlled by Mode III_s or Mode IV fastener yielding in accordance with NDS 12.3.1, fasteners in the connection shall be permitted to be designed for 1.5 and 1.0 times the diaphragm forces associated with the shear forces induced by the prescribed seismic and wind design loads, respectively.

Other CLT Diaphragm Components

Component Design Capacity ≥ Increased Diaphragm Design Forces

$$v' \geq \gamma_D \, v$$

$v' =$ Adjusted capacity calculated <u>per the NDS</u> *not 4.5 Z**

v = wind or seismic diaphragm design force

$\gamma_D =$ 2.0 for wood and steel components, except:

1.5 wood members resisting wind loads

1.5 chord splice connections controlled by Mode IIIs or IV (seismic)

1.0 chord splice connections controlled by Mode IIIs or IV (wind)

*See **SDPWS 2021 Section 4.5.4** for the full information*

Additional Resources

Additional Information

Short Paper Available from woodworks.org

https://www.woodworks.org/resources/clt-diaphragm-design-for-wind-and-seismic-resistance/

WOODWORKS
WOOD PRODUCTS COUNCIL

CLT Diaphragm Design for Wind and Seismic Resistance

Using SDPWS 2021 and ASCE 7-22

Cross-laminated timber (CLT) has become increasingly prominent in building construction and can be seen in buildings throughout the world. Specifically, the use of CLT floor and roof panels as a primary gravity force-resisting component has become relatively commonplace. Now, with availability of the 2021 *Special Design Provisions for Wind and Seismic* (SDPWS 2021) from the American Wood Council (AWC), U.S. designers have a standardized path to utilize CLT floor and roof panels as a structural diaphragm. Prior to publication of this document, projects typically had to receive approval to use CLT as a structural diaphragm on a case-by-case basis from the local Authority Having Jurisdiction (AHJ).

This paper highlights important provisions of SDPWS 2021 for CLT diaphragm design and recommendations developed by the authors in the more extensive *CLT Diaphragm Design Guide*, based on SDPWS 2021, published by WoodWorks – Wood Products Council.

AWC SDPWS 2021

SDPWS 2021 is the first edition to provide direct provisions for CLT to be used as an element in a diaphragm or shear wall. To differentiate between CLT and light-frame lateral force-resisting systems, it adopts the terminology *sheathed wood-frame* for light-frame diaphragms (SDPWS §4.2) and shear walls (SDPWS §4.3), and includes new sections for CLT diaphragms (SDPWS §4.5) and shear walls (SDPWS §4.6). SDPWS 2021 is referenced in the 2021 International Building Code (IBC).

Shear Capacity

SDPWS 2021 has a single nominal shear capacity for each set of construction details, v_n, defined in §4.1.4 for use with both wind and seismic design. From this nominal shear capacity, the Allowable Stress Design (ASD) and Load and Resistance Factor Design (LRFD) wind and seismic design capacities are determined by dividing by the ASD reduction factor, Ω_D, or multiplying by a resistance factor, ϕ_D, for LRFD design as summarized in Table 1. For sheathed wood-frame diaphragms, the SDPWS

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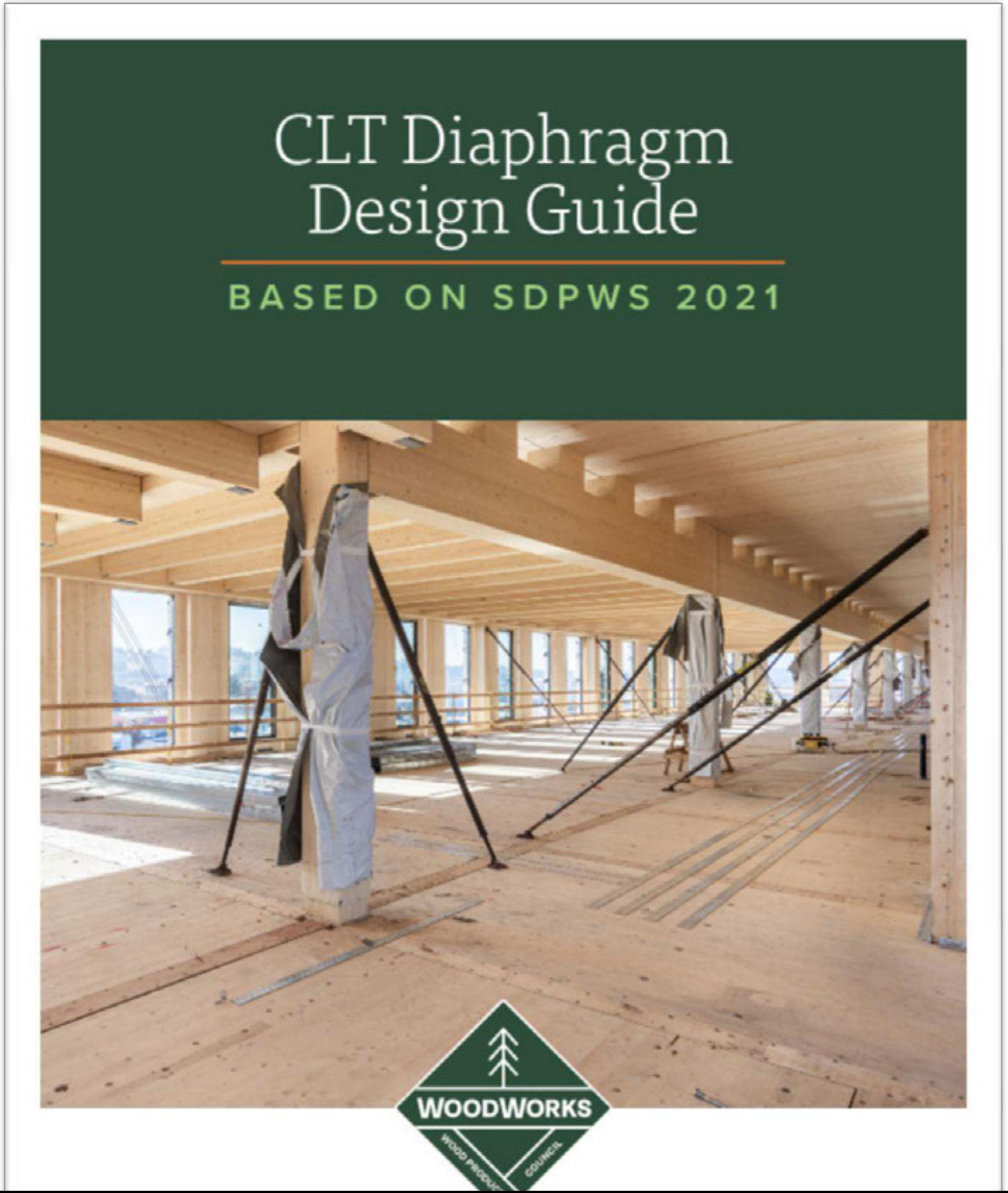
KPFF Consulting Engineers

Additional Information

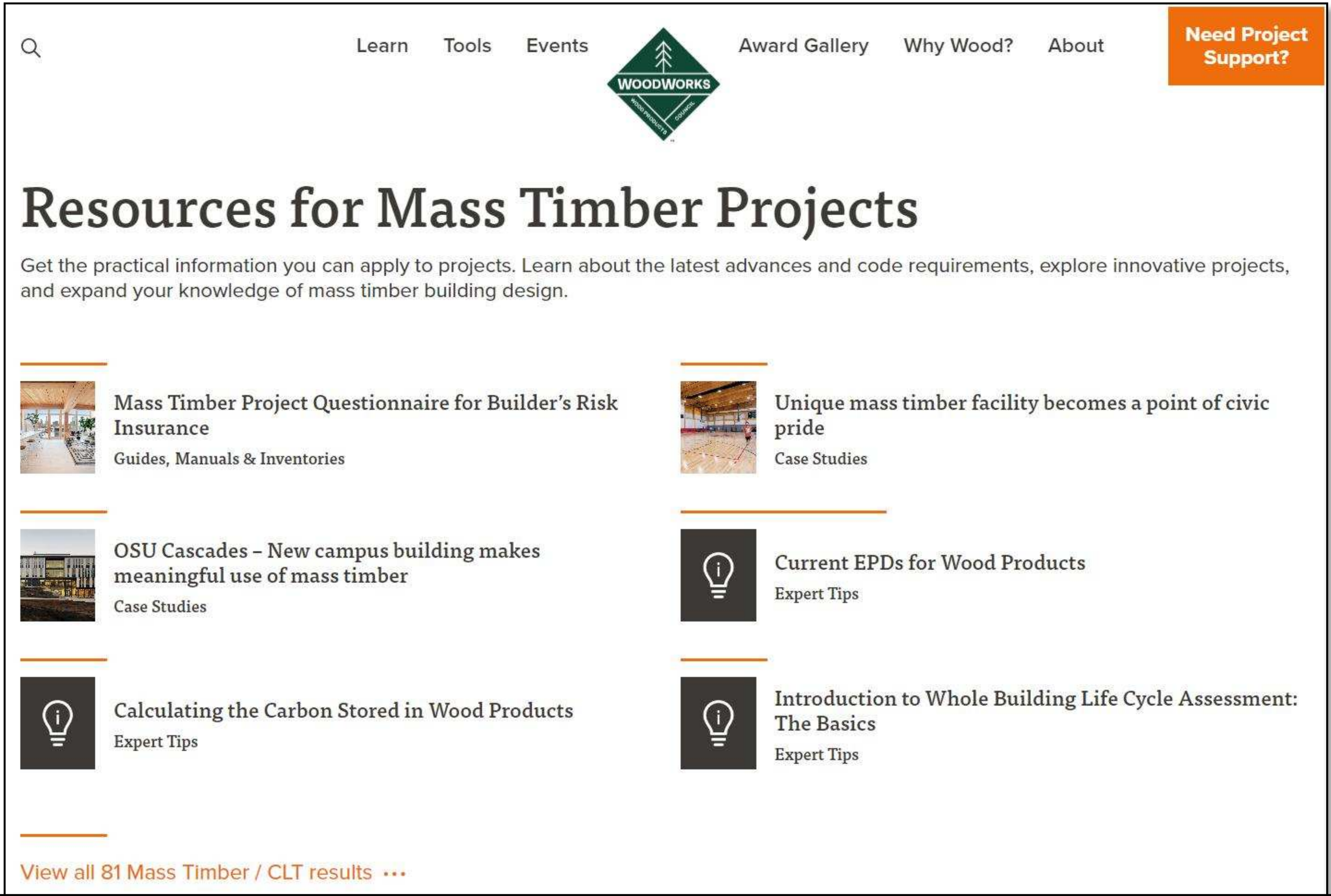
Extensive guide available from woodworks.org

https://www.woodworks.org/resources/clt-diaphragm-design-guide/

- Detailing for constructability
- Determination of diaphragm flexibility
- Calculation of diaphragm deflections
- Precalculated connection capacities
- Combination SDPWS γ_D and ACSE 7 Ω_o
- Worked examples



Additional Resources – WoodWorks.org



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