2021 Special Design Provisions for Wind and Seismic (SDPWS)

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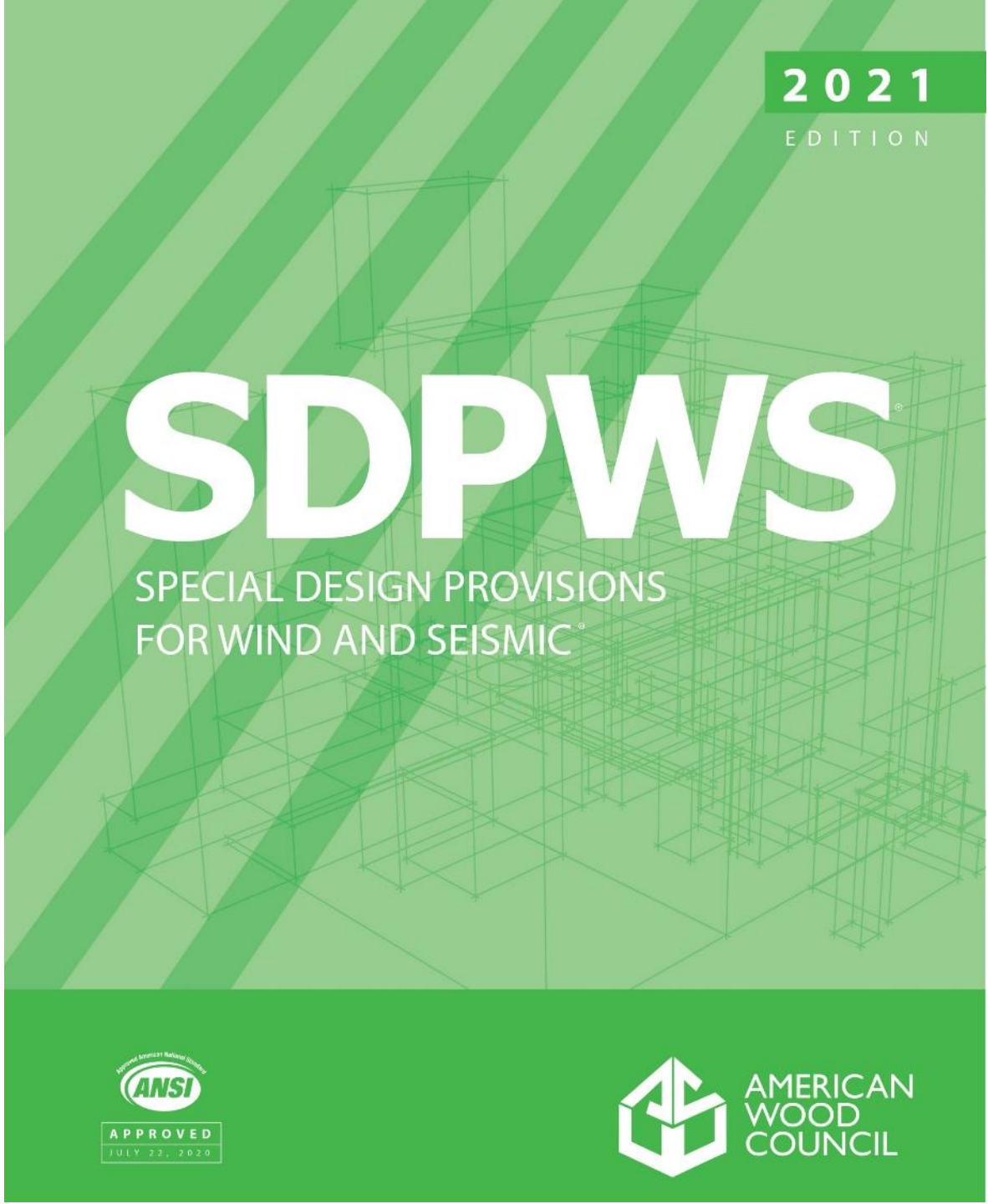


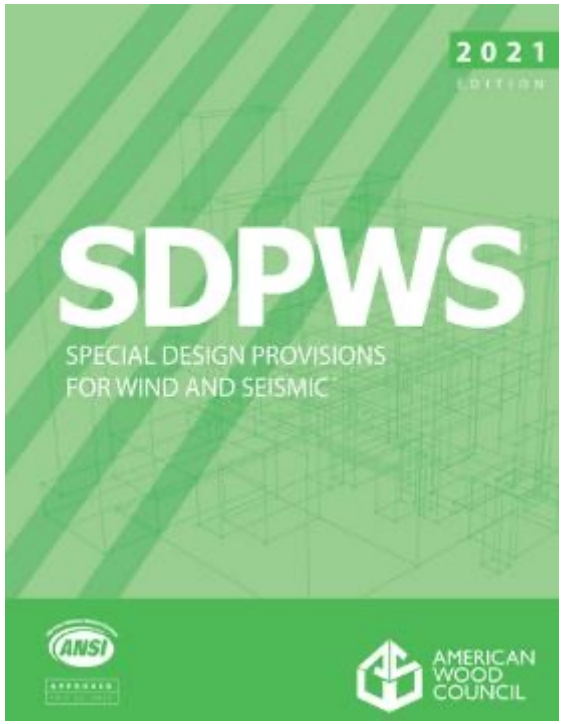
LEARNING OBJECTIVES

Upon completion, participants will be:

1. Introduced to new Cross-Laminated Timber (CLT) shear wall and diaphragm provisions of 2021 SDPWS

2. Become familiar with how 2021 SDPWS is referenced in the International Building Code

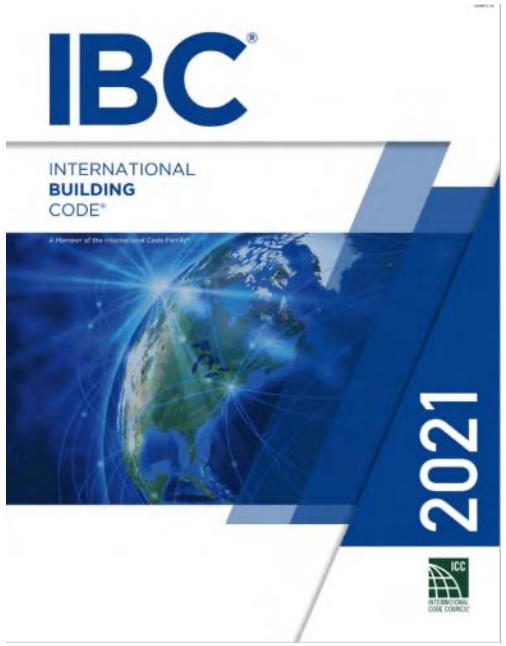
3. Gain awareness of CLT shear wall seismic coefficients in NEHRP Provisions (2020a) proposed for inclusion in ASCE 7-22

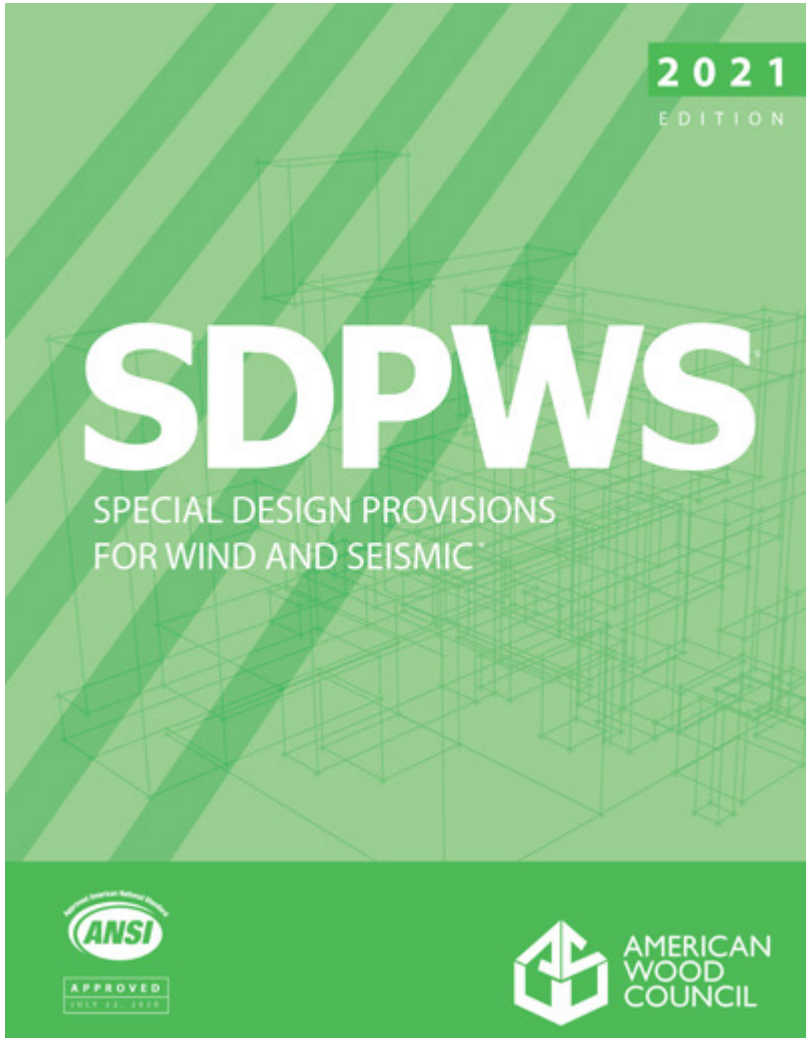


CODE REFERENCE OF STANDARD

2021 IBC

- References 2021 SDPWS in Section 2305 for lateral design and construction



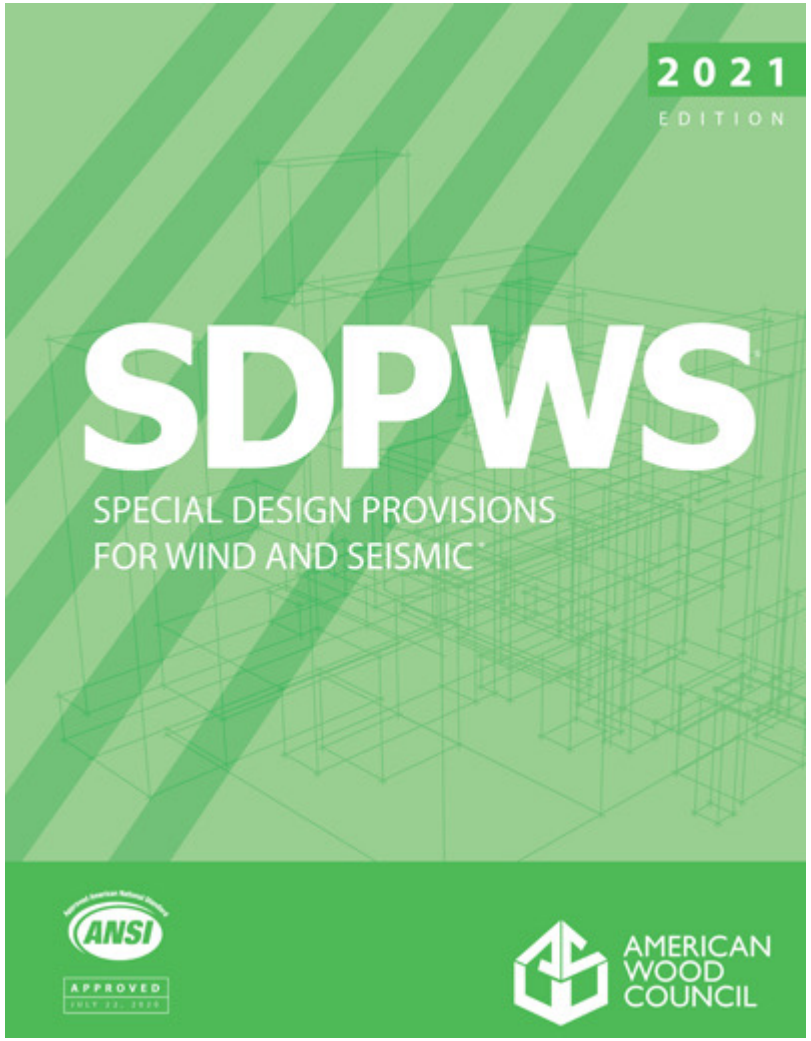


GENERAL OVERVIEW

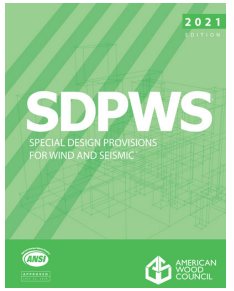
2.1 General

2.1.1 Scope

The provisions of this document cover materials, design and construction of wood members, fasteners, and assemblies to resist wind and seismic forces.



CHAPTER 4



Chapter 4 - Lateral Force-Resisting Systems

- 4.1 – General
- 4.2 – Sheathed Wood-Frame Diaphragms
- 4.3 – Sheathed Wood-Frame Shear Walls
- 4.4 – Wood Structural Panels Designed to Resist Combined Shear and Uplift from Wind
- 4.5 – Cross-Laminated Timber (CLT) Diaphragms
- 4.6 – Cross-Laminated Timber (CLT) Shear Walls

CLT DIAPHRAGMS

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

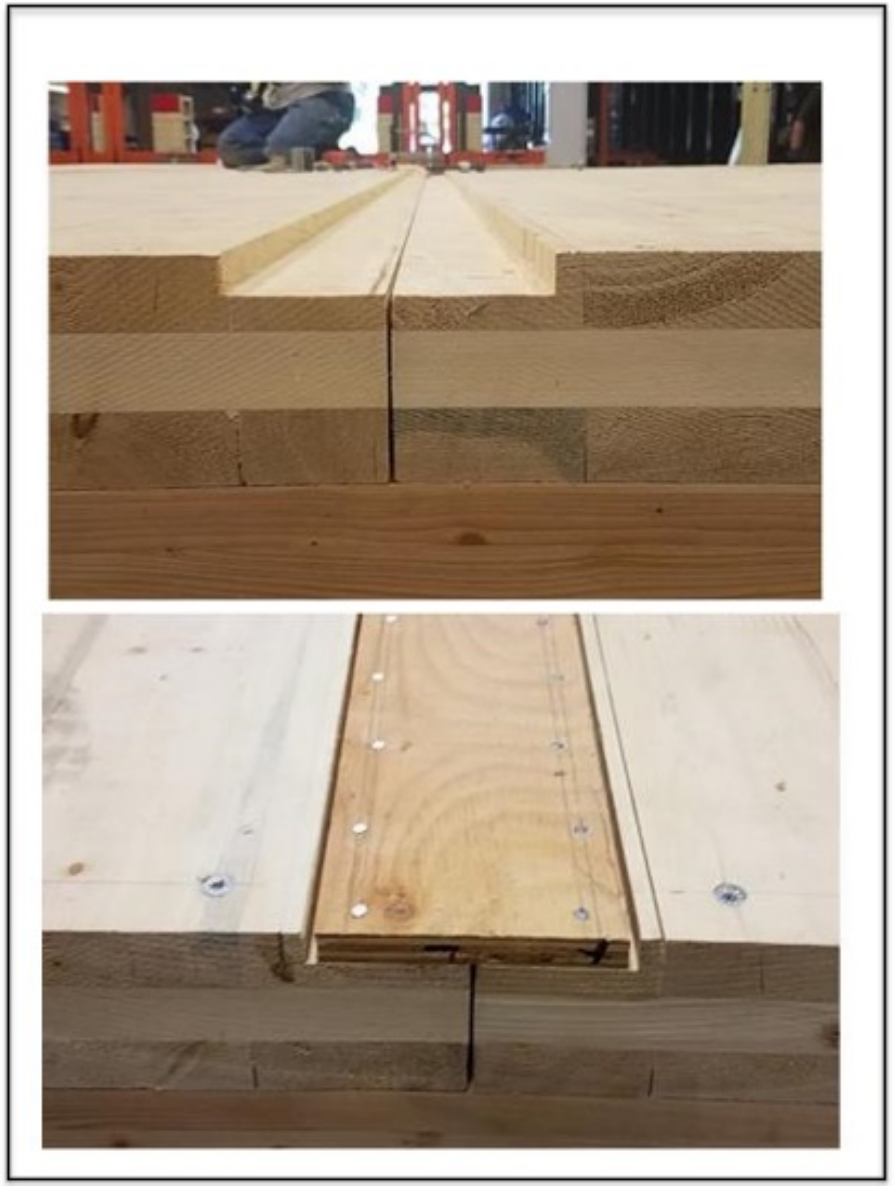
CLT diaphragms shall meet the following additional requirements:

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 IIIs 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:

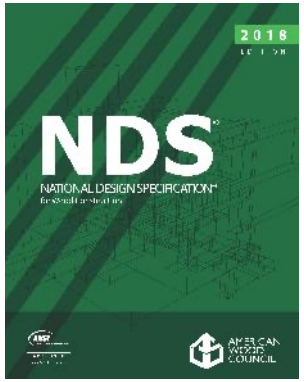
1. Wood elements and wood splice connections shall be permitted to be designed for 1.5 times the diaphragm forces associated with the shear forces induced by the wind design loads.
2. Where dowel-type fasteners are used in chord splice connections and the connection is controlled by Mode III_s or Mode 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.

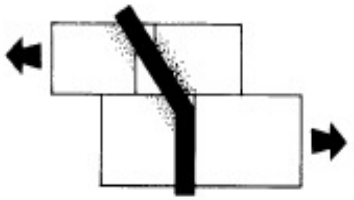
Diaphragm chord elements and chord splice connections using materials other than wood or steel shall be designed using provisions in NDS 1.4.



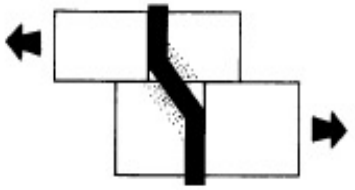
CLT DIAPHRAGMS

- CLT diaphragm provisions in new Section 4.5
  - Requirements for ***engineered design***
  - Nominal unit shear capacity, v_n, based on fasteners with calculated Z controlled by Yield Mode III_s or IV (per NDS 12.3.1)
  - Use of 4.5Z* targets development of a minimum nominal unit shear capacity of 2.8 x ASD unit shear capacity for seismic (commensurate with nailed wood structural panel diaphragms)
- Other elements (wood elements and steel parts and chord splice connections) of the diaphragm designed for increased forces to meet the minimum strength objective





Yield Mode III_s



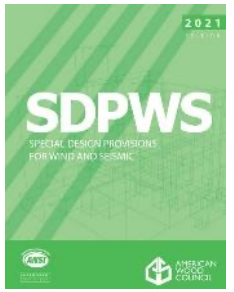
Yield Mode IV

CHAPTER 4

4.1.4 Shear Capacities

4.1.4.1 For seismic design of diaphragms and shear walls, the ASD allowable shear capacity shall be determined by dividing the nominal shear capacity in 4.1.2 by the ASD reduction factor of 2.8 and the LRFD factored shear resistance shall be determined by multiplying the nominal shear capacity by a resistance factor, ϕ_D, of 0.50. No further increases shall be permitted.

4.1.4.2 For wind design of diaphragms and shear walls, the ASD allowable shear capacity shall be determined by dividing the nominal shear capacity in 4.1.2 by the ASD reduction factor of 2.0 and the LRFD factored shear resistance shall be determined by multiplying the nominal shear capacity by a resistance factor, ϕ_D, of 0.80. No further increases shall be permitted.



Design capacity

Seismic:

- ASD: $v_n / 2.8$
- LRFD: $0.5\ v_n$

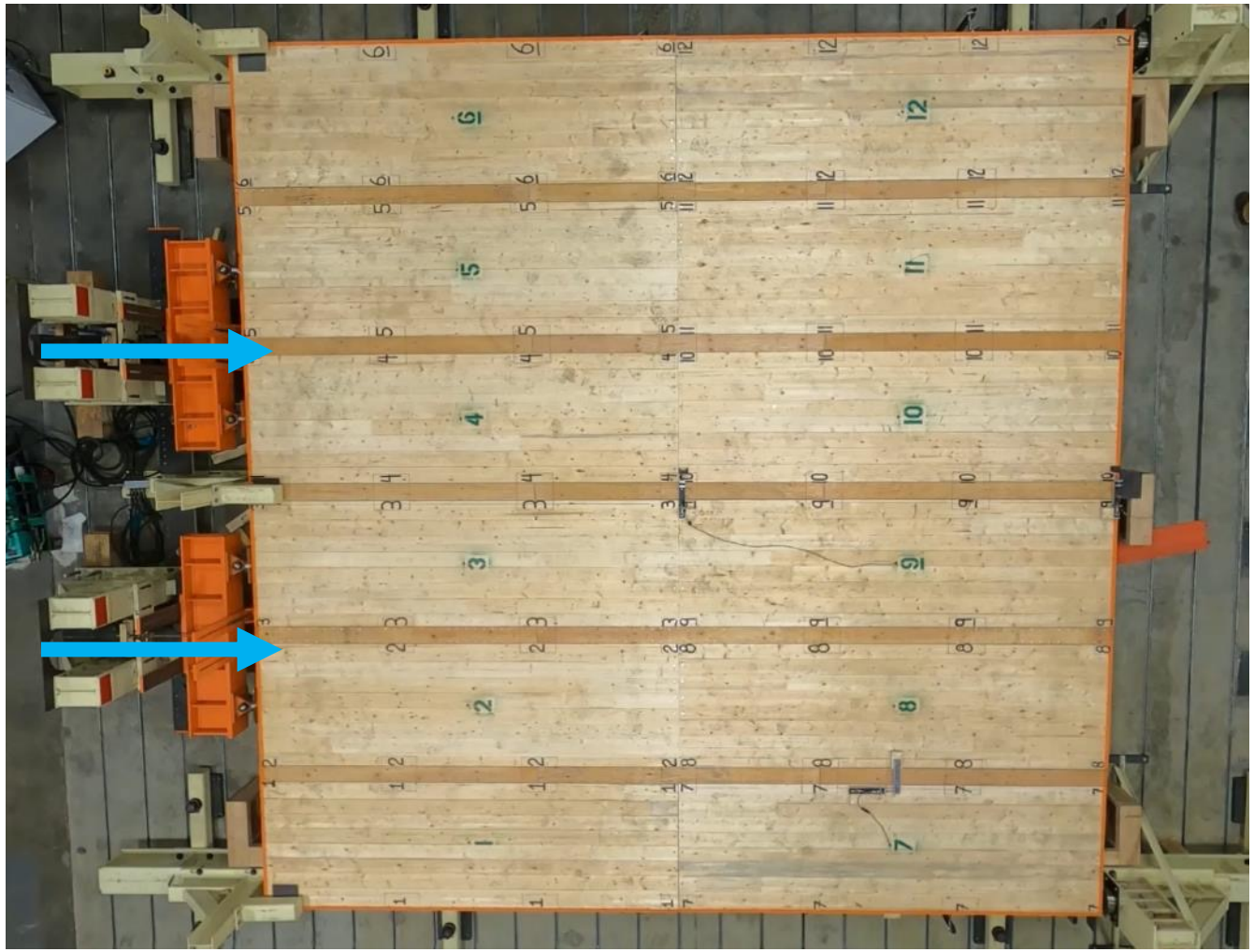
Wind:

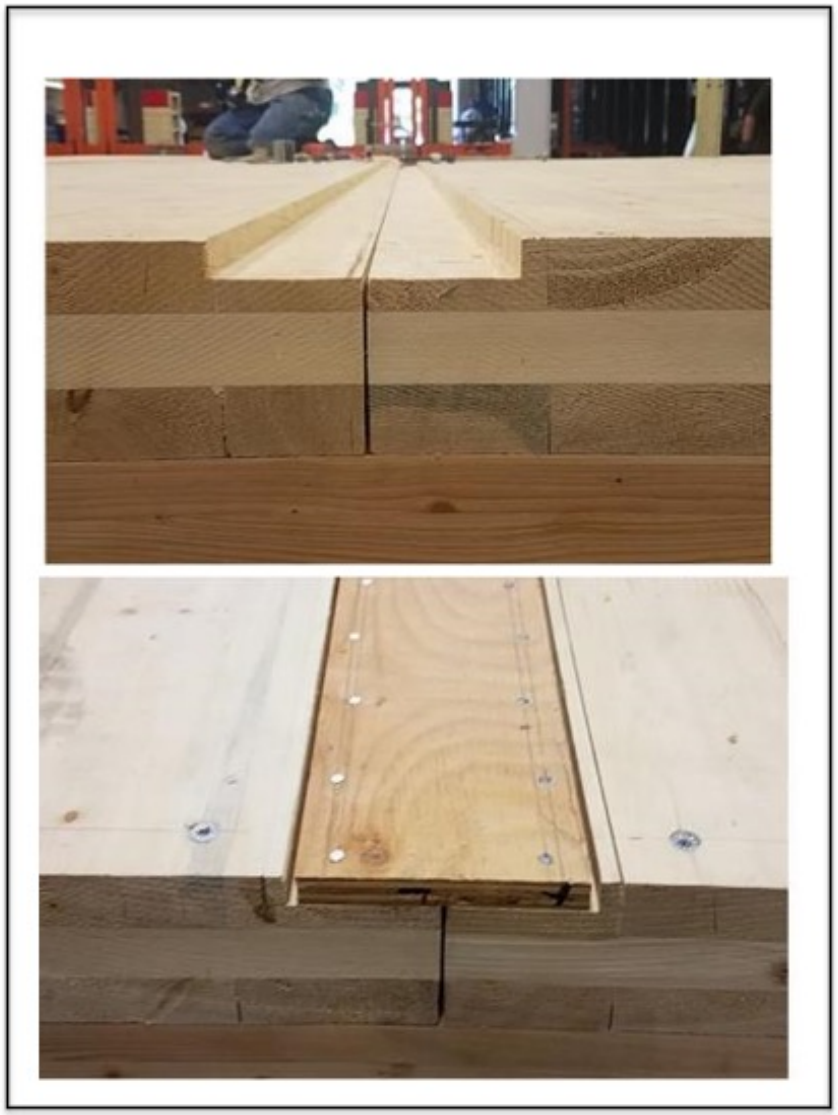
- ASD: $v_n / 2.0$
- LRFD: $0.8\ v_n$

where:

v_n = nominal shear capacity

DIAPHRAGM TESTING





ASCE 7-22 PROPOSED CHANGE

NEHRP Provisions (2020a) and ASCE 7-22:

- Adds line items to Table 12.2-1 featuring cross-laminated timber (CLT) shear walls

Seismic Force-Resisting System	ASCE 7 Section Where Detailing Requirements Are Specified	R	Ω_0	C_d	Structural System Limitations Including Structural Height, h_n (ft) Limits[d]				
					Seismic Design Category				
					B	C	D	E	F
A. BEARING WALL SYSTEMS									
...									
19. Cross laminated timber shear walls	14.5	3	3	3	65	65	65	65	65
20. Cross laminated timber shear walls with shear resistance provided by high aspect ratio panels only	14.5	4	3	4	65	65	65	65	65

BACKGROUND

Cross-laminated timber (CLT)

Stadthaus, London, 2009

Residential

9 stories

9 weeks of CLT construction

4 laborers

1 supervisor

Photo credit: Will Pryce

BACKGROUND

Photo credit: Will Pryce

BACKGROUND

Photo credit: Will Pryce

BACKGROUND

Ft. Drum, NY (4-story), 2017; Courtesy Jeff Morrow, Lendlease

CHAPTER 4

CLT Shear Wall Provisions in new Section 4.6

- References **Appendix B** for design provisions applicable for wind and seismic (including areas of high seismic hazard)
- Criteria for areas of low seismic hazard

4.6.3 Shear Capacities

4.6.3.1 ASD allowable shear capacity or LRFD factored shear resistance for CLT shear wall systems shall be determined in accordance with 4.1.1.

4.6.3.2 Nominal Unit Shear Capacities: Nominal unit shear capacities for CLT shear wall systems used to resist wind or seismic forces shall be in accordance with the requirements in Appendix B, where design and construction is in accordance with Appendix B.

Exception: Approved CLT shear wall systems, other than those in accordance with Appendix B, shall be permitted to resist wind forces, and to resist seismic forces in Seismic Design Category A (see 2.1.2) and in Seismic Design Category B where R=1.5, C_d=1.5 and Ωo=2.5, and with structural height limit of 65', unless other values are approved.

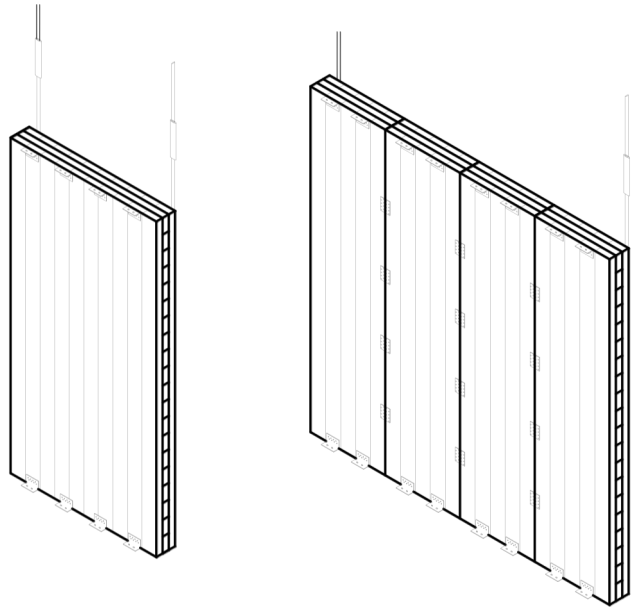
APPENDIX B

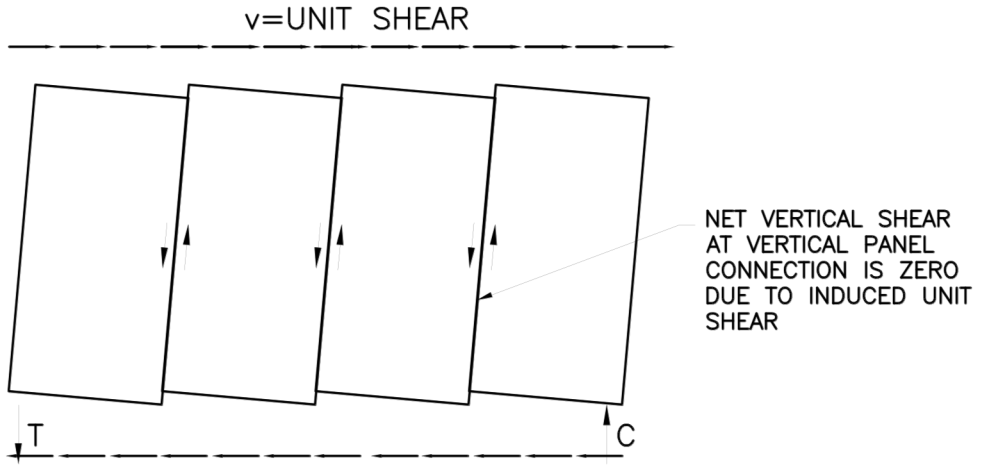
Appendix B provides mandatory requirements for CLT shear walls

Application Requirements include:

- Platform construction whereby CLT floor panels bear on and are supported by CLT walls below
- CLT wall panels of aspect ratio (h/b_s) between 2:1 and 4:1
- Shear resisted by prescribed nailed metal connectors
- Overturning-induced uplift resisted by hold-downs

- Two defined systems in Appendix B:
  - *CLT shear wall*
  - *CLT shear wall with shear resistance provided by high aspect ratio panels only*

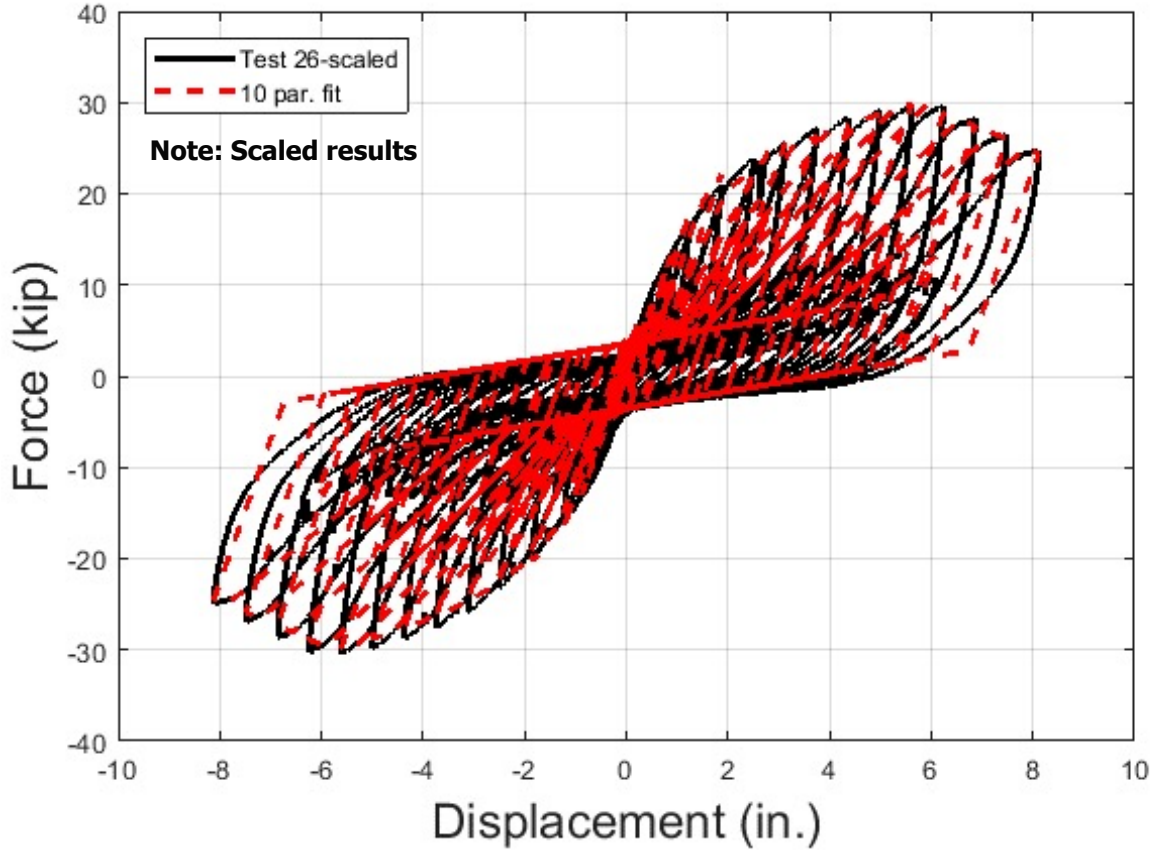




SHAKE TABLE TESTING

Courtesy of USDA FPL and Colorado State University

NUMERICAL MODELING



Courtesy of USDA FPL and Colorado State University

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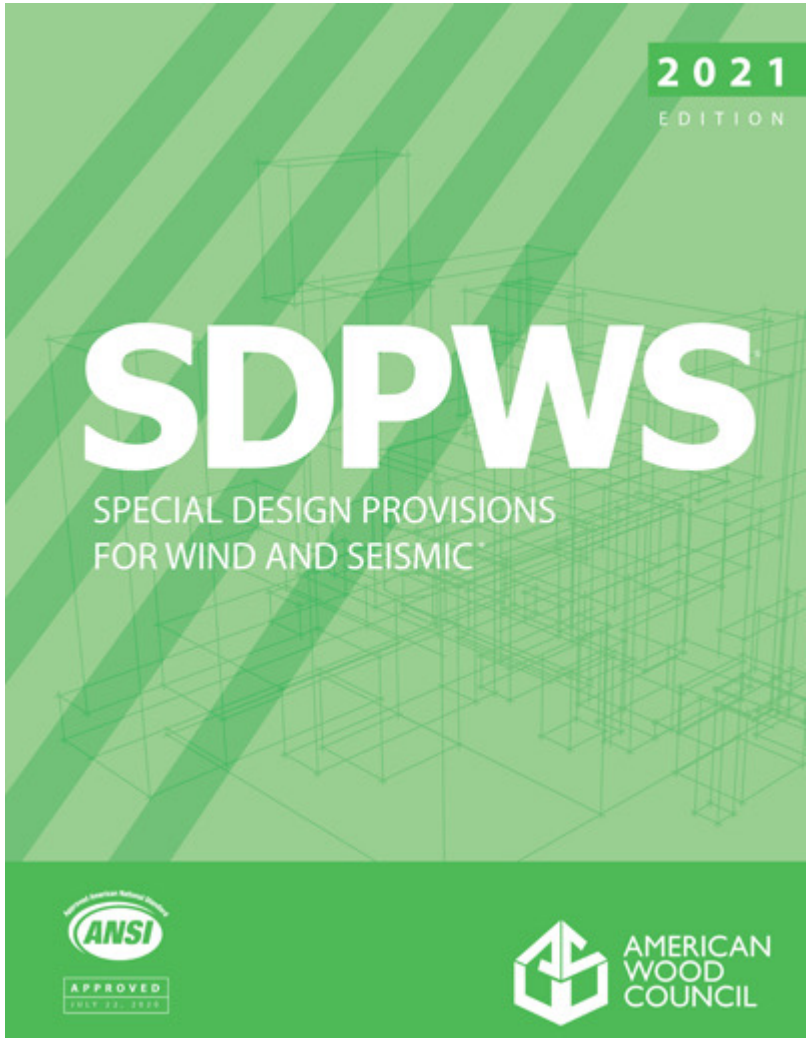
- Available at AWC.org



QUESTIONS?

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