



No. 15-01
Cross-Laminated Timber
Seismic Force-Resisting Systems (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.

Specialty code: 2019 Oregon Structural Specialty Code (OSSC) – Section 1613
Date: Issued—Jan. 15, 2015
Last updated—Oct. 1, 2019
Initiated by: Building Codes Division
Subject: Cross-Laminated Timber (CLT) — Seismic Force-Resisting System

Background:

Cross-laminated timber (CLT) is an emerging wood product with applications in both residential and non-residential buildings. CLT is defined in Chapter 2 and recognized as a viable construction material subject to specific construction requirements within Chapters 6, 23 and Appendix P of the 2019 OSSC. Oregon Building Codes Division (BCD) has prepared this alternate method which recognizes CLT as a seismic force-resisting system (SFRS) for the application of ASCE 7-16 Section 12.2.

CLT is a prefabricated solid engineered wood panel made of at least three orthogonally bonded layers of solid-sawn lumber or structural composite lumber (SCL). The layers are laminated by gluing longitudinal and transverse layers with structural adhesives to form a solid rectangular-shaped, straight, and plane (flat) timber intended for use in roof, floor and wall applications. Panels can be prefabricated based on the project design and can arrive at the job site with windows and doors pre-cut. Although size varies by manufacturer and design parameters, they can be roughly as large as 54 feet long x 10 feet wide x 20 inches thick and include 3, 5, 7 or more layers. These panels are dimensionally stable and load rated in a similar fashion to other existing codified engineered wood products.

Structures exceeding the design parameters contained in this ruling will need to follow the quantitative performance-based design criteria as outlined in Chapter 1 of ASCE 7-16. Local governments are not allowed to require additional regulatory systems or procedures under this ruling.



Discussion:

Prescriptive design parameters

The American Society of Civil Engineers (ASCE) publication ASCE 7-16 is the standard referenced by Section 1613 of the 2019 OSSC for the development of seismic design loads and associated criteria for structures. Chapter 12 of ASCE 7-16 establishes seismic design coefficients and factors for various types of SFRS's typically used in building construction. These design coefficients and factors for SFRS's, identified in Table 12.2-1 of ASCE 7-16, are the Response Modification Coefficient, R , the Overstrength Factor, Ω_o and the Deflection Amplification Factor, C_d , which were developed through testing, analysis and historical knowledge to be parameters that develop acceptable seismic performance when using the basic seismic analysis procedure in the standard.

The Response Modification Coefficient, R , based on the seismic force-resisting system selected for the design, reduces the seismic demand on the system based on its ductility. Ductility is the ability of a structure to undergo larger deformations without collapsing. Studies have demonstrated that more ductile systems perform better in seismic events because of their inherent ability to dissipate energy. The more ductile a system is, the larger the value of R , and the smaller the design forces. Designing a more ductile system using a value of $R=1$ (no reduction in seismic demand based on ductility) would result in unnecessarily large lateral loads and costly building design.

The Overstrength Factor, Ω_o , is an amplification factor that is applied to the basic seismic design forces to estimate the maximum expected force that will develop. The purpose of applying the overstrength load combinations to the design of specific structural elements is to prevent non-ductile failures in the structural system. A non-ductile failure would essentially mean the structure could collapse in a rapid fashion.

The Deflection Amplification Factor, C_d amplifies the calculated deflections to predict the expected maximum deformations from the design earthquake ground motions. C_d amplifies the deflection of the structure based on the basic seismic analysis procedure and as with the R and Ω_o is applied to each system in a structure.

These seismic design coefficients and factors have not been established at this time for CLT but the group responsible for developing these criteria in the nation is near the end of performing the testing and analysis required by FEMA P-695. It is expected that the parameters for CLT will be added to Table 12.2-1 of the next iteration of ASCE 7 (ASCE 7-22). FEMA P-695, titled Quantification of Building Seismic Performance Factors, is a methodology that allows a team of knowledgeable professionals to identify seismic performance factors for new SFRS's. The methodology is consistent with the primary life-safety performance objectives of seismic regulations in the model building codes. The OSSC is based on the model building codes. Based on the work to date, including testing performed on an international level, the evaluation team unanimously find that establishing Seismic Design Coefficients and Factors of $R=2.0$, $\Omega_o = 2.5$ and $C_d = 2.0$ as design parameters for CLT construction are conservative values to use until the final results of the FEMA P-695 quantification process are available. This will allow for the use of the basic seismic design procedures following ASCE 7-16, Chapter 12. CLT systems are held to the serviceability requirements of OSSC Section 1604.3, and the story drift limitations for "all other structures" in ASCE 7-16 Section 12.12.

One of the key elements in designing a well performing seismic system where non-ductile behaviors, such as steel fracture is not the weak link, uses the principles outlined in the U.S. edition of the CLT Handbook. CLT Shear wall designs detailed with light gauge metal angle clips and light frame wood style hold downs will facilitate this behavior. Common connections for CLT assemblies include wall-

to-foundation, wall-to wall (straight or junction), floor-to-floor, wall-to-floor, and wall-to-roof. Panels may be connected to each other with half-lapped, single or double splines made from engineered wood products, while metal brackets, hold-downs and plates are used to transfer other forces. Mechanical fasteners may be dowel-type (e.g., nails, screws, glulam rivets, dowels, bolts) or bearing-type (e.g., split rings, shear plates).

Performance-Based Design Procedures

Projects that fall outside the prescriptive parameters of this statewide alternative method are not limited by these provisions or the provisions within the OSSC. Reference is made to Section 104.10 of the OSSC and Section 1.3.1.3 for Performance-Based Procedures in ASCE 7-16 as being viable alternatives. Oregon’s statewide building code should not be viewed as a limitation or preference for any method or material of construction which can meet performance or prescriptive requirements.

104.10 Alternative materials, design and methods of construction and equipment. The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety. Where the alternative material, design or method of construction is not approved, the building official shall respond in writing, stating the reasons why the alternative was not approved.

Conclusion:

Under application of the 2019 OSSC, CLT may be used as a seismic force resisting system subject to the following definitions, requisites and standards. All code references are to the 2019 OSSC:

I. Addressing Manufacturing and Identification Standards for all Cross-laminated timber (CLT) as used in this alternate method:

Structural glued cross-laminated timbers shall be manufactured and identified in accordance with ANSI/APA PRG 320-18, Standard for Performance-Rated Cross-Laminated Timber.

ANSI/APA PRG 320-18 is available for **free download** at the following URL:
<https://www.apawood.org/publication-search?q=PRG+320-2018&tid=1>

II. Addressing the Seismic Design Factors for CLT in Table 12.2-1 of ASCE 7-16:

Cross-laminated timber structures shall be considered a Bearing Wall SFRS per ASCE 7-16 Section 12.2.1.

ASCE 7-16, Table 12.2-1 *Design Coefficients and Factors for Seismic Force-Resisting Systems* shall be modified to include the following Item No. 19 under *Bearing Wall Systems*:

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^d	Overstrength Factor, Ω_o^b	Deflection Amplification Factor, C_d^c	Structural System Limitations Including Structural Height, h_n (ft) Limits ^d				
					Seismic Design Category				
					B	C	D ^e	E ^e	F ^f
A. BEARING WALL SYSTEMS									
19. Cross-laminated timber shear walls	14.1 and 14.5	<u>2</u>	<u>2½</u>	<u>2</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>

III. Addressing drift limitations in CLT structures:

CLT building systems shall comply with the serviceability requirements of OSSC Section 1604.3, and the story drift limitations for “All other structures” in ASCE 7-16 Section 12.12a.

The technical and scientific facts for this Statewide Alternate Method are approved.

Signature on file

1/30/2015

Mark Long, Administrator
Building Codes Division

Date