



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 previously permitted for CLT under Type V Construction using the prescriptive path (performance based designs can be used for buildings of any size)

CLT may be characterized as a flexible building system suitable for use in all assembly types. 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 of 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 7-10. Jurisdictions receiving plans using performance-based criteria should contact the Division for additional guidance on assessing peer reviews and the performance-based design criteria noted above. Local governments are not allowed to require additional regulatory systems or procedures under this ruling.

Technical Discussion:

A. Acceptance:

This ruling recognizes the code language of the 2015 International Building code and associated provisions that are reflected in the 2015 National Design Specification (NDS).

B. Fire Protection:

In terms of fire protection, CLT assemblies perform like heavy timber in that they char at a rate that is slow and predictable. CLT structures also tend not to have as many concealed spaces within floor and wall assemblies, which reduce the risk that a fire will spread.

As part of a project to produce a U.S. design manual for cross-laminated timber (CLT), AWC conducted a successful ASTM E119 fire endurance test on a CLT wall at NGC Testing Services in Buffalo, N.Y. A 5-ply CLT specimen (approximately 7 inches thick), was covered on each side with a single layer of 5/8" Type X gypsum wallboard. The wall was loaded to the maximum attainable load by the test equipment, although it remained significantly below the full design strength of the CLT. It was then exposed to a standard fire that reached over 1800 degrees Fahrenheit in the first 90 minutes of exposure. The wall functioned as a load bearing wall for over 180 minutes.

C. Engineering – Seismic Resizing Systems:

Prescriptive Design Parameters

The American Society of Civil Engineers (ASCE) publication ASCE 7-10 is the primary document used by the 2014 OSSC to develop the wind and seismic loading for structures. Chapter 12 of this document establishes the seismic design coefficients for the various types of structures typically constructed in the State of Oregon. These coefficients have been developed through testing, analytical and historical knowledge to be parameters that will develop reasonably safe structures. The basic design coefficients and factors for seismic force-resisting systems in Table 12.2-1 are the Response Modification Factor, R , the Overstrength Factor, Ω_o and the Deflection Amplification Factor, C_d .

The R factor, or response modification coefficient, results from simplifying the seismic design process so that linear elastic analysis can be used for most building designs. It is known from experience that structures can withstand greater seismic demands, without collapsing, than if they were designed to remain elastic during the earthquake. Designing for an expected design earthquake using a fully linear elastic ($R=1$) system would result in unnecessarily large lateral loads and a costly building design. Given this concern over the conservative nature of linear elastic design and its inherent high costs, the loads calculated for a fully linear elastic structure are reduced by the R factor to account for the fact the building is allowed to be damaged as long as it does not collapse (i.e., life-safety performance is provided, while allowing some building damage to occur). Thus, the larger the R factor, the smaller the design forces and the easier it is to find building components that can be used in the building design.

The Overstrength Factor, Ω_o , is an amplification factor that is applied to the elastic design forces to

estimate the maximum expected force that will develop. The purpose of applying the overstrength load combinations 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 which would not enable evacuation of the structure.

The Deflection Amplification Factor, C_d amplifies the deflection of the structure with the intention that the structure will yield (ductile response) deflections greater than that found from an elastic analysis. C_d amplifies the deflection of the structure based on an elastic analysis and as with the R and Ω_o is applied to each system in a structure.

These design 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 criteria. 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 seismic force-resisting systems. 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 feel that establishing Seismic Design Factors of $R=2.0$, an $\Omega_o = 2.5$ and a $C_d = 2.0$ as design parameters for CLT construction as 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 linear seismic design following ASCE 7-10, Chapter 12 linear methods. For drift limitations, CLT building systems are held to the same drift and serviceability requirements of other lateral force resisting systems including ASCE 7-10 Table 12.12-1 and IBC Section 1604.3.

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 104.11 of the OSSC and Section 1.3.1.3 for Performance-Based Procedures in ASCE 7-10 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.

104.11 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, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

Conclusion:

For the purposes of the 2014 OSSC, cross-laminated timber may be classified as Type IV construction subject to the following definitions, requisites and standards. All code references are to the 2014 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 320-12, Standard for Performance-Rated Cross-Laminated Timber.

ANSI/APA PRG 320-12 is available for **free download** at the following URL:

<http://www.apawood.org/SearchResults.aspx?q=PRG+320-2012&tid=1>

II. Definition:

CROSS-LAMINATED TIMBER. A prefabricated engineered wood product consisting of not less than 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.

III. Addressing the Scoping of CLT:

Cross-laminated timber (CLT) building systems shall comply with the provisions of the OSSC, the provisions for CLT in the 2015 NDS, the provisions in the U.S. edition of the CLT Handbook and the provisions outlined in this Statewide Alternate Method.

IV. Addressing dimensions for CLT in Type IV construction:

Cross-laminated timber (CLT) dimensions used in this alternate method are actual dimensions.

V. Addressing the use of CLT in Type IV exterior walls (OSSC Section 602.4):

Cross-laminated timber shall be permitted within exterior wall assemblies with a 2-hour rating or less, provided the exterior surface of the cross-laminated timber is protected by one the following:

1. Fire-retardant-treated wood sheathing complying with Section 2303.2 and not less than 15/32 inch (12 mm) thick;
2. Gypsum board not less than 1/2 inch (12.7 mm) thick; or
3. A noncombustible material.

VI. Addressing the use of CLT in Type IV floors (OSSC Section 602.4.4):

Cross-laminated timber shall be not less than 4 inches (102 mm) in thickness. Cross-laminated timber shall be continuous from support to support and mechanically fastened to

one another. Cross-laminated timber shall be permitted to be connected to walls without a shrinkage gap providing swelling or shrinking is considered in the design. Corbelling of masonry walls under the floor shall be permitted to be used.

VII. Addressing the use of CLT in Type IV roofs (OSSC Section 602.4.5):

Cross-laminated timber roofs shall be not less than 3 inches (76 mm) nominal in thickness and shall be continuous from support to support and mechanically fastened to one another.

VIII. Addressing the Seismic Design Factors for CLT in Table 12.2-1 of ASCE 7-10:

Cross-laminated timber structures shall be considered a bearing wall system as shown in the modifications to Table 12.2-1 of ASCE 7-10.

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, $C_d^{b,h}$	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									
1. Special reinforced concrete shear walls ^{l,m}	14.2	5	2 ½	5	NL	NL	160	160	100
2. Ordinary reinforced concrete shear walls	14.2	4	2 ½	4	NL	NL	NP	NP	NP
3. Detailed plain concrete shear walls ^l	14.2	2	2 ½	2	NL	NP	NP	NP	NP
4. Ordinary plain concrete shear walls ^l	14.2	1 ½	2 ½	1 ½	NL	NP	NP	NP	NP
5. Intermediate precast shear walls	14.2	4	2 ½	4	NL	NL	40 ^k	40 ^k	40 ^k
6. Ordinary Precast shear walls ^l	14.2	3	2 ½	3	NL	NP	NP	NP	NP
7. Special reinforced masonry shear walls	14.4	5	2 ½	3 ½	NL	NL	160	160	160
8. Intermediate reinforced masonry shear walls	14.4	3 ½	2 ½	2 ¼	NL	NL	NP	NP	NP
9. Ordinary reinforced masonry shear walls	14.4	2	2 ½	1 ¾	NL	160	NP	NP	NP
10. Detailed plain masonry shear walls	14.4	2	2 ½	1 ¾	NL	NP	NP	NP	NP
11. Ordinary plain masonry shear walls	14.4	1 ½	2 ½	1 ¼	NL	NP	NP	NP	NP
12. Prestressed masonry shear walls	14.4	1 ½	2 ½	1 ¾	NL	NP	NP	NP	NP
13. Ordinary reinforced AAC masonry shear walls	14.4	2	2 ½	2	NL	35	NP	NP	NP
14. Ordinary plain AAC masonry shear walls	14.4	1 ½	2 ½	1 ½	NL	NP	NP	NP	NP
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
16. Light-frame (cold-formed steel) walls sheathed with wood structural panels rated for shear resistance or steel sheets	14.1	6 ½	3	4	NL	NL	65	65	65
17. Light-frame walls with shear panels of all other materials	14.1 and 14.5	2	2 ½	2	NL	NL	35	NP	NP
18. Light-frame (cold-formed steel) wall systems using flat strap bracing	14.1	4	2	3 ½	NL	NL	65	65	65
19. Cross-laminated timber shear walls ^l	<u>14.1 and 14.5</u>	<u>2</u>	<u>2 ½</u>	<u>2</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>

IX. Addressing drift limitations in CLT structures:

CLT building systems shall comply with the drift and serviceability requirements of other lateral

force resisting systems including ASCE 7-10 Table 12.12-1 and IBC Section 1604.3 criteria.

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

(Signature on File)

Mark Long, Administrator
Building Codes Division

1/30/2015

Date