ANSI/APA PRG 320-2012

AMERICAN NATIONAL STANDARD

Standard for Performance-Rated Cross-Laminated Timber

Approved American National Standard

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AMERICAN NATIONAL STANDARD

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APA – The Engineered Wood Association

Approved October 30, 2012
American National Standards Institute

FOREWORD (This Foreword is not a part of American National Standard ANSI/APA PRG 320-2012)

This standard provides requirements and test methods for qualification and quality assurance for performance-rated cross-laminated timber (CLT), which is manufactured from solid-sawn lumber or structural composite lumber (SCL) intended for use in construction applications. Product performance classes are also specified.

The development of this consensus American National Standard was achieved by following the *Operating Procedures for Development of Consensus Standards* of *APA – The Engineered Wood Association,* approved by the American National Standards Institute (ANSI).

Inquiries or suggestions for improvement of this Standard should be directed to *APA – The Engineered Wood Association* at 7011 South 19th Street, Tacoma, WA 98466, www.apawood.org.

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1. SCOPE

Cross-laminated timber (CLT) panels referenced in this standard are defined in Section 3.2 and shall be qualified and trademarked in accordance with this standard. This standard provides dimensions and tolerances, performance requirements, test methods, quality assurance, and trademarking for CLT panels.

CLT panels shall be used in dry service conditions, such as in most covered structures, where the mean equilibrium moisture content of solid-sawn lumber is less than 16%. CLT panels qualified in accordance with the provisions of this standard are intended to resist the effects of moisture on structural performance as may occur due to construction delays, or other conditions of similar severity. Products carrying a trademark of this standard shall be used in accordance with the installation requirements prescribed in the recommendations provided by the CLT manufacturer, an approved agency, and/or its trade association. Finger joining, edge gluing, and face gluing between CLT panels, and camber of CLT panels are beyond the scope of this standard.

The annex contained in this standard is mandatory, while notes and appendices are non-mandatory. This standard incorporates the U.S. customary units as well as the International System of Units (SI). The values given in the U.S. customary units are the standard in the U.S. and the SI values given in parentheses are the standard in Canada.

2. REFERENCED DOCUMENTS

This standard incorporates dated references. Subsequent amendments or revisions to these references apply to this standard only when incorporated into this standard by amendments or revisions.

2.1 U.S. Standards

ANSI/AWC NDS-2012 National Design Specification for Wood Construction

AITC 405-2008 Standard for Adhesives for Use in Structural Glued Laminated Timber

ANSI/AITC A190.1-2007 Structural Glued Laminated Timber

ASTM D9-09ae1 Standard Terminology Relating to Wood and Wood-Based Products

ASTM D198-09 Standard Test Methods of Static Tests of Lumber in Structural Sizes

ASTM D907-11a Standard Terminology of Adhesives

ASTM D1037-06a Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials

ASTM D2395-07ae1 Standard Test Methods for Specific Gravity of Wood and Wood-Base Materials

ASTM D2559-10a Standard Specification for Adhesives for Bonded Structural Wood Products for Use Under Exterior Exposure Conditions

ASTM D2915-10 Standard Practice for Sampling and Data-Analysis for Structural Wood and Wood-Based Products

ASTM D3737-09 Standard Practice for Establishing Stresses for Structural Glued Laminated Timber (Glulam)

ASTM D4761-11 Standard Test Methods for Mechanical Properties of Lumber and Wood-Based Structural Material

ASTM D5055-11a Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists

ASTM D5456-11a Standard Specification for Evaluation of Structural Composite Lumber Products

ASTM D6815-09 Standard Specification for Evaluation of Duration of Load and Creep Effects of Wood and Wood-Based Products

ASTM D7247-07 Standard Test Method for Evaluating the Shear Strength of Adhesive Bonds in Laminated Wood Products at Elevated Temperatures

ASTM D7374-08 Standard Practice for Evaluating Elevated Temperature Performance of Adhesives Used in End-Jointed Lumber

US Product Standard PS 1-09 Structural Plywood

US Product Standard PS 20-10 American Softwood Lumber Standard

2.2 Canadian Standards

CAN/CSA O86-09 Engineering Design in Wood

CSA O112.10-08 Evaluation of Adhesives for Structural Wood Products (Limited Moisture Exposure)

CSA O122-06 Structural Glued-Laminated Timber

CSA O141-05 (R2009) Softwood Lumber

CSA O177-06 Qualification Code for the Manufacturers of Structural Glued-Laminated Timber

NLGA Standard Grading Rules for Canadian Lumber (2007)

NLGA SPS 1-2011 Special Products Standard for Fingerjoined Structural Lumber

NLGA SPS 2-2010 Special Products Standard for Machine Graded Lumber

NLGA SPS 4-2011 Special Products Standard for Fingerjoined Machine Graded Lumber

NLGA SPS 6-2010 Special Products Standard for Structural Face-Glued Lumber

2.3 International Standards

ISO Guide 65-1996 General Requirements for Bodies Operating Product Certification Systems

ISO/IEC 17011-2004 Conformity Assessment – General Requirements for Accreditation Bodies Accrediting Conformity Assessment Bodies

ISO/IEC 17020-1998 General Criteria for the Operation of Various Types of Bodies Performing Inspection

ISO/IEC 17025-2005 General Requirements for the Competence of Testing and Calibration Laboratories

3. TERMINOLOGY

3.1 Definitions

See the referenced documents for definitions of terms used in this standard.

3.2 Terms Specific to This Standard

Adhesive – a substance capable of holding materials together

Adherend – a material held to another material by an adhesive

Approved Agency (U.S.) – an established and recognized agency regularly engaged in conducting tests or furnishing inspection services, when such agency has been approved by regulatory bodies (see Qualified Inspection Agency and Qualified Testing Agency)

Approved Agency (Canada) – an established and recognized agency regularly engaged in conducting certification services, when such agency has been approved by regulatory bodies (see Qualified Certification Agency)

Bond – the attachment at an interface between adhesive and adherends or the act of attaching adherends together by adhesive

Bondline – the layer of adhesive that attaches two adherends

- ***Face bondline –*** the bondline joining the wide faces of laminations in adjacent layers
- ***Edge bondline –*** the optional bondline joining the narrow faces of adjacent laminations within one layer

Characteristic Values – the structural property estimate, typically a population mean for stiffness properties or a tolerance limit (5^{th} percentile with 75% confidence) for strength properties, as estimated from the test data that is representative of the population being sampled

Cross-Laminated Timber (CLT) – a prefabricated solid engineered wood panel made of at least three orthogonally bonded layers of solid-sawn lumber or structural composite lumber (SCL) that are laminated by gluing of longitudinal and transverse layers with structural adhesives to form a solid rectangular-shaped, straight, and plane timber intended for roof, floor, or wall applications

CLT Grade – a unique designation of a class of CLT panels having the same layup of different panel thicknesses

Note 1. The standard CLT grades in this standard are listed in Table 1. Custom CLT grades may be established in accordance with Section 7.2.1.

CLT Length – dimension of the CLT panel measured parallel to the major strength direction

Note 2. The length and width of CLT defined in this standard are based on the CLT panel dimension and may not be related to the end-use, such as wall, roof, and floor, applications.

CLT Panel – a single CLT billet formed by bonding laminations with a structural adhesive

CLT Thickness – dimension of the CLT panel measured perpendicular to the plane of the panel

CLT Width – dimension of the CLT panel measured perpendicular to the major strength direction

Curing – converting an adhesive into a fixed or hardened state by chemical and/or physical action

Delamination – the separation of layers in a laminate due to failure of the adhesive either in the adhesive itself or at the interface between the adhesive and the adherend

Edge (Panel Edge) – the narrow face of a panel that exposes the ends or narrow faces of the laminations

Edge Joints – joints made by gluing of the edges of adjacent laminations within a CLT layer

Effective Bonding Area – proportion of the lamination wide face averaged over its length that is able to form a close contact bond upon application of pressure

End Joints – joints made by gluing of the finger joints of the same laminations within a CLT layer prior to laminating adjacent layers

Face – one of the four longitudinal surfaces of a piece or panel

- ***Lamination narrow face –*** the face with the least dimension perpendicular to the lamination length
- ***Lamination wide face –*** the face with the largest dimension perpendicular to the lamination length
- ***Panel face –*** the face of the CLT length-width plane

Lamination – a piece of sawn lumber or structural composite lumber, including stress rated boards, remanufactured lumber, or end-joined lumber, which has been prepared and qualified for laminating

Layer – all laminations on one side of a face bondline for panel face or all laminations between two adjacent bondlines for others

- ***Parallel –*** the laminations oriented parallel to the major strength direction
- ***Perpendicular –*** the laminations oriented perpendicular to the major strength direction

Layup – an arrangement of layers in a CLT panel

Major Strength Direction – general direction of the grain of the parallel layers of the CLT panel and also referred to as the parallel direction

Manufacturing Standard – a document that establishes the minimum requirements for manufacturing practices, staff, facilities, equipment, and specific quality assurance processes, including inspection (in the U.S.) and/or certification (in Canada), by which the product is manufactured

Mill Specification – a manufacturing specification based on product evaluation to be used for quality assurance purposes by the manufacturer and the approved agency

Minor Strength Direction – perpendicular to the major strength direction of the CLT panel and also referred to as the perpendicular direction

Qualified Certification Agency (Canada) – an agency meeting the following requirements:

(a) has trained personnel to perform product certification in compliance with all applicable requirements specified in this standard,

(b) has procedures to be followed by its personnel in performance of the certification,

(*c*) has no financial interest in, or is not financially dependent upon, any single company manufacturing the product being certified,

(*d*) is not owned, operated, or controlled by any such company, and

(*e*) is accredited by a recognized accreditation body under ISO Guide 65

Qualified Inspection Agency (U.S.) – an agency meeting the following requirements:

(*a*) has trained personnel to verify that the grading, measuring, species, construction, bonding, workmanship, and other characteristics of the products as determined by inspection in compliance with all applicable requirements specified in this standard,

(*b*) has procedures to be followed by its personnel in performance of the inspection,

(*c*) has no financial interest in, or is not financially dependent upon, any single company manufacturing the product being inspected,

(*d*) is not owned, operated, or controlled by any such company, and

(*e*) is accredited by a recognized accreditation body under ISO/IEC 17020

Qualified Testing Agency – an agency meeting the following requirements:

(*a*) has access to the facilities and trained technical personnel to conduct testing on the characteristics of the products by sampling and testing in compliance with all applicable requirements specified in this standard,

(*b*) has procedures to be followed by its personnel in performance of the testing,

(*c*) has no financial interest in, or is not financially dependent upon, any single company manufacturing the product being tested,

(*d*) is not owned, operated, or controlled by any such company, and

(*e*) is accredited by a recognized accreditation body under ISO/IEC 17025

Recognized Accreditation Body – an organization complying with ISO/IEC 17011 and recognized by the regulatory body having jurisdiction as qualified to evaluate and accredit certification agencies, inspection agencies and/or testing agencies

Remanufactured Lumber – lumber that meets the requirements of Section 4.3.4 of ANSI/AITC A190.1 in the U.S. or NLGA SPS 1, 2, 4, or 6 in Canada

Structural Composite Lumber (SCL) – an engineered wood product that is intended for structural use and bonded with adhesives, and meeting the definition and requirements of ASTM D5456

Wood Failure (percent) – the area of wood fiber remaining at the bondline following the rupture of wood fibers from the specified shear test, expressed as a percentage of total area involved in such failure

4. SYMBOLS

A_{eff}	Effective cross-sectional area, in in.^{2}/ft (mm^2/m), of the composite CLT section for calculating the interlaminar shear capacity of CLT;
A_g	Gross cross-sectional area of CLT, in in.^{2}/ft (mm^2/m);
A_{net}	Net cross-sectional area, in in.^{2}/ft (mm^2/m), for calculating the compressive stress in the major strength direction of CLT;
E_0	Modulus of elasticity in bending parallel to the major strength direction of CLT, in psi (MPa);
E_{90}	Modulus of elasticity in bending perpendicular to the major strength direction of CLT, in psi (MPa); in this standard, $E_{90} = E_0 / 30$ for lumber;
$f_{b,0}$ and $F_{b,0}$	Characteristic bending strength and allowable bending stress parallel to the major strength direction of CLT, in psi (MPa);
$f_{b,90}$ and $F_{b,90}$	Characteristic bending strength and allowable bending stress perpendicular to the major strength direction of CLT, in psi (MPa);
$f_{c,0}$ and $F_{c,0}$	Characteristic compressive strength and allowable compressive stress parallel to the major strength direction of CLT, in psi (MPa);
$f_{c,90}$ and $F_{c,90}$	Characteristic compressive strength and allowable compression stress perpendicular to the major strength direction of CLT, in psi (MPa);
$f_{t,0}$ and $F_{t,0}$	Characteristic tensile strength and allowable tensile stress parallel to the major strength direction of CLT, in psi (MPa);
$f_{t,90}$ and $F_{t,90}$	Characteristic tensile strength and allowable tensile stress perpendicular to the major strength direction of CLT, in psi (MPa);
$f_{v,0}$ and $F_{v,0}$	Characteristic shear strength and allowable shear stress parallel to the major strength direction of CLT, in psi (MPa);
$f_{v,90}$ and $F_{v,90}$	Characteristic shear strength and allowable shear stress perpendicular to the major strength direction of CLT, in psi (MPa);
$f_{s,0}$ and $F_{s,0}$	Characteristic interlaminar (rolling) shear strength and allowable interlaminar (rolling) shear stress parallel to the major strength direction of CLT, in psi (MPa);
$f_{s,90}$ and $F_{s,90}$	Characteristic interlaminar (rolling) shear strength and allowable interlaminar (rolling) shear stress perpendicular to the major strength direction of CLT, in psi (MPa);

G_0 Modulus of rigidity in parallel to the major strength direction of CLT, in psi (MPa); in this standard, $G_0 = E_0 / 16$ for lumber;

G_{90} Modulus of rigidity in perpendicular to the major strength direction of CLT, in psi (MPa); in this standard, $G_{90} = G_0 / 10$ for lumber;

I_g Gross moment of inertia of CLT, in $in.^4/ft$ (mm^4/m);

I_{eff} Effective moment of inertia, in $in.^4/ft$ (mm^4/m), of the composite CLT section for calculating the bending stiffness of CLT;

S_{eff} Effective section modulus, in $in.^3/ft$ (mm^3/m), of the composite CLT section for calculating the moment capacity of CLT.

5. PANEL DIMENSIONS AND DIMENSIONAL TOLERANCES

5.1 Thickness

The thickness of CLT shall not exceed 20 inches (508 mm).

5.2 CLT Dimensional Tolerances

Dimension tolerances permitted at the time of manufacturing shall be as follows:

- Thickness: ± 1/16 inch (1.6 mm) or 2% of the CLT thickness, whichever is greater
- Width: ± 1/8 inch (3.2 mm) of the CLT width
- Length: ± 1/4 inch (6.4 mm) of the CLT length

Textured or other face or edge finishes are permitted to alter the tolerances specified in this section. The designer shall compensate for any loss in cross-section and/or specified strength of such alterations.

Note 3. The manufacturer may be contacted for recommendations.

5.3 Squareness

Unless specified otherwise, the length of the two panel face diagonals measured between panel corners shall not differ by more than 1/8 inch (3.2 mm).

5.4 Straightness

Unless specified otherwise, deviation of edges from a straight line between adjacent panel corners shall not exceed 1/16 inch (1.6 mm).

6. COMPONENT REQUIREMENTS

6.1 Laminations – Lumber

6.1.1 *Lumber species*

Any softwood lumber species or species combinations recognized by American Lumber Standards Committee (ALSC) under PS 20 or Canadian Lumber Standards Accreditation Board (CLSAB) under CSA O141 with a minimum published specific gravity of 0.35, as published in the National Design Specification for Wood Construction (NDS) in the U.S. and CSA O86 in Canada, shall be permitted for use in CLT manufacturing provided that other requirements specified in this section are satisfied. The same lumber species or species combination shall be used within a single layer of CLT. Adjacent layers of CLT shall be permitted to be made of different species or species combinations.

6.1.2 *Lumber grades*

The minimum grade of lumber in the parallel layers of CLT shall be 1200f-1.2E MSR or visual grade No. 2. The minimum grade of lumber in the perpendicular layers of CLT shall be visual grade No. 3. Remanufactured lumber shall be considered as equivalent to solid-sawn lumber when qualified in accordance with Section 4.3.4 of ANSI/AITC A190.1 in the U.S. or SPS 1, 2, 4, or 6 in Canada. Proprietary lumber grades meeting or exceeding the mechanical properties of the lumber grades specified above shall be permitted for use provided that they are qualified in accordance with the requirements of an approved agency.

Note 4. ASTM D5055 provides guidance for proprietary lumber grades used specifically in I-joist applications.

6.1.3 *Lamination sizes*

(a) ***Major Strength Direction –*** The net width of a lamination shall not be less than 1.75 times the lamination thickness for the parallel layers.

(b) ***Minor Strength Direction –*** If the laminations in the perpendicular (cross) layers are not edge bonded, the net width of a lamination shall not be less than 3.5 times the lamination thickness for the perpendicular (cross) layers unless the interlaminar shear strength and creep are evaluated by testing in accordance with Section 8.5.5 and the principles of ASTM D6815, respectively.

(c) ***Both Directions –*** The net thickness of a lamination for all layers at the time of gluing shall not be less than 5/8 inch (16 mm) or more than 2 inches (51 mm). In addition, the lamination thickness shall not vary within the same CLT layer.

6.1.4 *Moisture content*

The moisture content of the lumber at the time of CLT manufacturing shall be 12 ± 3%. The moisture content of the SCL at the time of CLT manufacturing shall be 8 ± 3%.

6.1.5 *Face-bonding surface*

All face-bonding surfaces shall be planed prior to face bonding and except for minor local variations, shall be free of raised grain, torn grain, skip, burns, glazing or other deviations from the plane of the surface that might interfere with the contact of sound wood fibers in the bonding surfaces. All face-bonding surfaces shall be free from dust, foreign matter, and exudation that are detrimental to satisfactory bonding.

Note 5. It may be necessary to plane the lamination surface within 48 hours of face bonding for some wood species.

6.1.6 *Face-bonding dimensional tolerances*

At the time of face-bonding, variations in thickness across the width of a lamination shall not exceed ±0.008 inch (0.2 mm). The variation in thickness along the length of a lamination shall not exceed ±0.012 inch (0.3 mm). Bow and cup shall not be so great that they will not be straightened out by pressure in bonding.

6.2 Laminations – Structural Composite Lumber

SCL products meeting the requirements of ASTM D5456 and the equivalent specific gravity specified in Section 6.1.1 shall be permitted for use. SCL laminations must also meet the requirements of Sections 6.1.3 through 6.1.6.

6.3 Adhesives

(a) In the U.S., adhesives used for CLT manufacturing shall meet the requirements of AITC 405 with the exception that Section 2.1.6 of AITC 405 (either ASTM D3434 or CSA O112.9) is not required. In addition, adhesives shall be evaluated for heat performance in accordance with Section 6.1.3.4 of DOC PS1.

(b) In Canada, adhesives shall meet the requirements of CSA O112.10, and Sections 2.1.3 and 3.3 (ASTM D7247 heat durability) of AITC 405. In addition, adhesives shall be evaluated for heat performance in accordance with Section 6.1.3.4 of DOC PS1.

(c) For use in both the U.S. and Canada, adhesives shall meet both (a) and (b) in this section.

Note 6. The intent of the heat performance evaluation is to determine whether an adhesive has exhibited heat delamination characteristics[1], which may increase the char rate of the CLT when exposed to fire in certain applications. If heat delamination occurs, the CLT manufacturer is recommended to consult with the adhesive manufacturer and the approved agency to develop an appropriate adjustment in product manufacturing and/or an end-use recommendation.

6.4 Lamination Joints

6.4.1 *General*

The lamination joints of CLT shall meet the requirements specified in this section.

6.4.2 *End joints in laminations*

The strength, wood failure, and durability of lamination end joints shall be qualified in accordance with Sections 5.5.1 and 5.5.2 of ANSI/AITC A190.1 and meet the requirements specified in Sections 4.5.4.2, 4.5.4.3, and 5.5.1.3 of that standard in the U.S., or shall be qualified in accordance with Section 9.5 of CSA O177 and meet the requirements specified therein in Canada.

6.4.3 *Edge and face joints in laminations*

The wood failure and durability of the face and edge (when required for structural performance) joints shall be qualified in accordance with Sections 4.5.4.1, 4.5.4.3, and 5.5.2 of ANSI/AITC A190.1 and meet all requirements, except for the shear strength, specified in Sections 4.5.4.1 and 4.5.4.3 of that standard in the U.S., or shall be qualified in accordance with Sections 9.2 and 9.3 of CSA O177 and meet all requirements, except for the shear strength, specified therein in Canada.

1 Information on heat delamination may be found in the *Proposed Heat Durability Test for Classifying Adhesives in Crossed-Layer Wood Products – An Exploratory Study* published by the FPInnovations, Canada, in November 2010.

7. CLT PERFORMANCE CRITERIA

CLT shall meet the performance requirements established in this section.

7.1 Layup Requirements

The arrangement of orthogonal layers shall be specified in the manufacturing standard of each CLT plant when qualified in accordance with the requirements specified in this section and by an approved agency.

7.2 Structural Performance Requirements

Structural performance shall be evaluated for each CLT layup unless otherwise noted in this section. CLT shall meet the minimum structural performance based on the properties shown in Table 1 multiplied by the section properties provided by the manufacturer and accepted by an approved agency when evaluated and confirmed by test results in accordance with Section 8.5. CLT panels manufactured with SCL layers, which do not meet Table 1 requirements, shall be qualified in accordance with Section 7.2.1.

TABLE 1
REQUIRED CHARACTERISTIC TEST VALUES[a,b,c,d] FOR PRG 320 CLT

	Major Strength Direction						Minor Strength Direction					
CLT Grades	$f_{b,0}$ (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)
E1	4,095	1.7	2,885	3,420	425	140	1,050	1.2	525	1,235	425	140
E2	3,465	1.5	2,140	3,230	565	190	1,100	1.4	680	1,470	565	190
E3	2,520	1.2	1,260	2,660	345	115	735	0.9	315	900	345	115
E4	4,095	1.7	2,885	3,420	550	180	1,205	1.4	680	1,565	550	180
V1	1,890	1.6	1,205	2,565	565	190	1,100	1.4	680	1,470	565	190
V2	1,835	1.4	945	2,185	425	140	1,050	1.2	525	1,235	425	140
V3	2,045	1.6	1,155	2,755	550	180	1,205	1.4	680	1,565	550	180

For SI: 1 psi = 0.006895 MPa

(a) See Section 4 for symbols.

(b) Tabulated values are test values and shall not be used for design. See Annex A for design properties.

(c) Custom CLT grades that are not listed in this table shall be permitted in accordance with Section 7.2.1.

(d) The characteristic values shall be determined as follows from the published allowable design value unless otherwise justified by the approved agency:

f_b = 2.1 x published allowable bending stress (F_b),

f_t = 2.1 x published allowable tensile stress (F_t),

f_c = 1.9 x published allowable compressive stress parallel to grain (F_c),

f_v = 3.15 x published allowable shear stress (F_v), and

f_s = 1/3 x calculated f_v.

Note 7. The "E" designation indicates a CLT layup based on the use of E-rated or MSR laminations in the parallel layers, and the "V" designation indicates a CLT layup based on the use of visually graded laminations in the parallel layers. Visually graded laminations are used in the perpendicular layers for both "E" and "V" layups. The specific species and grade of the parallel layers and the corresponding perpendicular layers for each "E" and "V" designation are based on the following layups:

- *E1: 1950f-1.7E Spruce-pine-fir MSR lumber in all parallel layers and No. 3 Spruce-pine-fir lumber in all perpendicular layers*
- *E2: 1650f-1.5E Douglas fir-Larch MSR lumber in all parallel layers and No. 3 Douglas fir-Larch lumber in all perpendicular layers*
- *E3: 1200f-1.2E Eastern Softwoods, Northern Species, or Western Woods MSR lumber in all parallel layers and No. 3 Eastern Softwoods, Northern Species, or Western Woods lumber in all perpendicular layers*
- *E4: 1950f-1.7E Southern pine MSR lumber in all parallel layers and No. 3 Southern pine lumber in all perpendicular layers*
- *V1: No. 2 Douglas fir-Larch lumber in all parallel layers and No. 3 Douglas fir-Larch lumber in all perpendicular layers*
- *V2: No. 1/No. 2 Spruce-pine-fir lumber in all parallel layers and No. 3 Spruce-pine-fir lumber in all perpendicular layers*
- *V3: No. 2 Southern pine lumber in all parallel layers and No. 3 Southern pine lumber in all perpendicular layers*

7.2.1 *Custom CLT grades*

Custom CLT grades are permitted when approved by an approved agency in accordance with the qualification and mechanical test requirements (see Sections 8.4 and 8.5) specified in this standard. In this case, a unique CLT grade designation shall be assigned by the approved agency if the custom product represents a significant product volume of the manufacturer to avoid duplication with an existing CLT grade designation that has been assigned to other manufacturers.

Note 8. Annex A provides the allowable bending capacities for some CLT grades and layups. The custom CLT grades are intended for layups that are different from the layups provided in Tables 1, A1, A2, A3, and A4, and may include double outer layers or unbalanced layups when clearly identified for installation, as required by the manufacturer and the approved agency.

7.3 Appearance Classifications

CLT panel appearance shall be as agreed to between the buyer and the seller.

Note 9. Appendix A contains examples of CLT appearance classifications for reference.

8. QUALIFICATION AND PRODUCT MARKING

8.1 Qualification Requirements

Required qualification tests for CLT components, such as lumber, adhesives, and end, face, and edge joints are provided in Section 6 and summarized in Table 2. This section provides requirements for plant qualification and CLT qualification tests to meet the structural performance levels specified in Table 1 and the section properties provided by the CLT manufacturer (see Annex A).

TABLE 2
SUMMARY OF QUALIFICATION REQUIREMENTS

Qualification for	Standard(s)	Referenced Section(s) in This Standard
Lumber	Grading Rules/Manufacturing Standard	6.1.1 to 6.1.4
SCL	ASTM D5456	6.2
Adhesives	AITC 405 or CSA O112.10	6.3
End Joints	Section 5.5.1 and 5.5.2 of ANSI/AITC A190.1 and/or Section 9.5 of CSA O177	6.4.2
Face Joints	Sections 4.5.4.1, 4.5.4.3, and 5.5.2 of ANSI/AITC A190.1 and Sections 9.2 and 9.3 of CSA O177	6.1.5, 6.1.6, 6.4.3, 8.2, and 8.3
Edge Joints (if applicable)	Sections 4.5.4.1, 4.5.4.3, and 5.5.2 of ANSI/AITC A190.1 and Sections 9.2 and 9.3 of CSA O177	6.4.3
CLT Panel Dimensions	–	5
CLT Panel Structural Performance	ASTM D198 or ASTM D4761	7.2 and 8.5

8.2 Plant Pre-Qualification

8.2.1 General

The CLT plant shall be pre-qualified for the manufacturing factors considered (see Section 8.2.2) using full-thickness qualification panels of 24 inches (610 mm) or more in the major strength direction and 18 inches (457 mm) or more in the minor strength direction (hereafter referred to as "Pre-qualification panels"). A minimum of two replicate CLT pre-qualification panels shall be manufactured for pre-qualification for each combination of factors considered in Section 8.2.2. The two replicate CLT pre-qualification panels shall not be extracted from a single full-size CLT panel.

Note 10. A pre-qualification panel of 24 inches (610 mm) or more in the minor strength direction is recommended, particularly for thicker CLT products.

Pre-qualification panels shall be prepared at the facility or at an alternative facility acceptable to the approved agency. All pre-qualification panels shall be:

(a) Of the same approximate length and width at the time of pressing;

(b) Pressed individually; and

(c) Taken from approximately the geometric centre of the larger panel, if applicable.

8.2.2 Fabrication of pre-qualification panels

Application of pressure to manufacture pre-qualification panels shall reflect the key characteristics of the manufacturing equipment, including the platen and glue spreader (as applicable) that is or will be used in the facility to be qualified. The applicability of the results shall be documented by the approved agency.

Note 11. For example, pre-qualification panels for facilities using a vacuum press or an air bag should be clamped using a vacuum press or an air bag inserted between the sample and the rigid platen. In addition, the sample preparation facility should distinguish between, for example, roller versus curtain coating and single spread versus double spread, which varies in the uniformity of the adhesive spread.

Factors considered for pre-qualification evaluation shall include assembly time, lumber moisture content, adhesive spread rate, clamping pressure, and wood surface temperature, as specified in the manufacturing standard of the plant and accepted by the approved agency.

8.2.3 Conditioning of pre-qualification panels

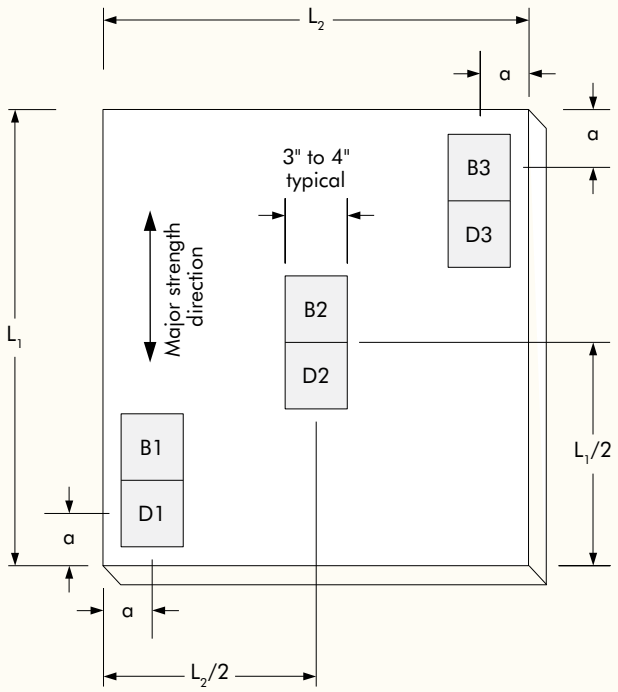
Pre-qualification panels shall be stored in an indoor environment for a minimum of 24 hours or until the adhesive has cured sufficiently to permit evaluation, whichever is longer.

Note 12. For panels larger than the specified pre-qualification panel size, the panels may be trimmed to the specified size to facilitate conditioning.

8.2.4 Specimens

Six square/rectangular specimens (three for block shear tests, i.e., "B" specimens and three for delamination tests, i.e., "D" specimens) shall be extracted from each pre-qualification panel at the locations shown in Figure 1 and labeled to indicate the panel number and the specimen position within the panel. If the pre-qualification panel is larger than the specified pre-qualification panel size, the pre-qualification sampling area shall be 24 inches (610 mm) to 36 inches (910 mm) square located at the geometric center of the panel.

FIGURE 1
BLOCK SHEAR ("B") AND DELAMINATION ("D") SPECIMEN LOCATIONS
a = 4 ± 1 inches, L_1 = 24 to 36 inches, and L_2 = 24 to 36 inches (1 inch = 25.4 mm)



8.2.5 *Test methods and requirements*

The specimens obtained in accordance with Section 8.2.4 shall be qualified and meet the requirements specified in Section 6.4.3 of this standard.

8.3 Qualification of Effective Bond Area

8.3.1 *General*

The manufacturer shall establish visual grading rules for the bonded faces and limit the average glue skip to maintain an average effective bond area of 80% or more.

Note 13. Alternatively, glue skips may be treated as delamination.

The manufacturer's visual grading rules established to achieve the effective bond area shall include major visual characteristics based on characteristic measurements consistent with standard lumber grading rules.

8.3.2 *Sample selection and inspection*

Samples shall be drawn from representative production of laminations meeting the manufacturer's visual grading rules and positioned in accordance with the in-plant manufacturing standard. The layer formed by the laminations shall be verified by the approved agency to provide an effective bond area of 80% or more over any randomly selected area not less than 48 inches (1,220 mm) square.

Note 14. A template with a square opening may be used to facilitate inspection.

8.4 Qualification for Structural Performance

Following plant pre-qualification, a representative sample of CLT panels shall be manufactured for qualification tests. The bending stiffness (EI), bending moment (f_bS), and interlaminar shear capacity (V_s) of CLT layups in both major and minor strength directions shall be tested in accordance with Section 8.5 to confirm the tabulated mechanical property values, as shown in Table 1, times the section properties provided by the CLT manufacturer (see Annex A). Depending on the number of layups intended for qualification, a qualification plan shall be developed and accepted by the approved agency in accordance with the principles prescribed in this section.

8.5 Mechanical Properties Qualification

8.5.1 Sampling

Test samples shall be representative of typical production and shall be sampled at the manufacturing facility by an approved agency using the layup intended for qualification. The sample size required for stiffness capacities shall be sufficient for estimating the population mean within 5% precision with 75% confidence, or 10 specimens, whichever is greater. In general, a sample size larger than 10 is needed when the coefficient of variation is greater than 13%. The sample size required for strength capacities shall be sufficient for estimating the characteristic value with 75% confidence in accordance with ASTM D2915.

8.5.2 Sample conditioning

CLT panel samples shall be stored in an indoor environment for a minimum of 24 hours or until the adhesive has cured sufficiently to permit evaluation, whichever is longer. The CLT samples at the time of mechanical tests shall have an average moisture content of not less than 8%.

8.5.3 Bending test methods

Bending tests shall be conducted flatwise (loads are applied perpendicular to the face layer of CLT) in accordance with the third-point load method of Sections 4 through 12 of ASTM D198 or ASTM D4761 using the specimen width of not less than 12 inches (305 mm) and the on-center span equal to approximately 30 times the specimen depth. The weight of the CLT panel is permitted to be included in the determination of the bending moment capacity.

8.5.4 Bending test requirements

The average bending stiffness (EI) and the characteristic bending moment (f_bS) determined from qualification tests shall meet or exceed the published allowable bending stiffness and allowable bending moment times 2.1, respectively, in the U.S. or the equivalent specified bending stiffness and bending moment capacity in Canada.

8.5.5 Shear test methods

Shear tests shall be conducted flatwise (loads are applied perpendicular to the face layer of CLT) in accordance with the center-point load method of Sections 4 through 12 of ASTM D198 or ASTM D4761 using the specimen width of not less than 12 inches (305 mm) and the on-center span equal to 5 to 6 times the specimen depth. The bearing length shall be sufficient to avoid bearing failure, but not greater than the specimen depth. All specimens are to be cut to length with no overhangs allowed.

8.5.6 Shear test requirements

The characteristic interlaminar shear capacity (V_s) determined from qualification tests shall meet or exceed the published allowable interlaminar shear capacity times 3.15 in the U.S. or the equivalent specified interlaminar shear capacity in Canada.

8.6 Process Changes Qualification

Material changes to the manufacturing process or facilities shall be subjected to subsequent qualification testing. The requirements of Sections 8.2, 8.3, and 8.4 shall be reapplied for material changes listed or equivalent to that listed in Table 3.

TABLE 3
SUBSEQUENT QUALIFICATION IN RESPONSE TO MATERIAL CHANGES

Category	Applicable Sections	Material Change (examples)	Notes
A	8.2, 8.3, 8.4	• Press equipment • Adhesive formulation class • Addition or substitution of species from a different species group • Changes to the visual grading rules that reduce the effective bond area or the effectiveness of the applied pressure (e.g., warp permitted)	Excludes replacement with identical press
B	8.2, 8.3	• Other changes to the manufacturing process or component quality not listed above • Adhesive composition (e.g., fillers and extenders)	Additional evaluation in accordance with Section 8.4 is at the discretion of the approved agency[a]
C	8.4	• Increase in panel width or length of more than 20%	

(a) It is recommended that changes involving two or more manufacturing parameters be subjected to evaluation in accordance with Section 8.4.

8.7 Mill Specification

Upon conformance with the requirements specified in this standard, a manufacturing specification or documentation unique to the product and mill shall be written based on product evaluation. This specification shall be used for quality assurance purposes by the manufacturer and the approved agency. Reference values shall be established during product evaluation or from applicable performance requirements in this standard.

8.8 Certification and Trademarking

8.8.1 Certification

CLT products represented as conforming to this standard shall bear the stamp of an approved agency which (1) either inspects the manufacturer or (2) has tested a random sampling of the finished products in the shipment being certified for conformance with this standard.

8.8.2 Product marking

CLT products represented as conforming to this standard shall be identified with marks containing the following information:

(a) CLT grade qualified in accordance with this standard;

(b) The CLT thickness or identification;

(c) The mill name or identification number;

(d) The approved agency name or logo;

(*e*) The symbol of "ANSI/APA PRG 320" signifying conformance to this standard;

(*f*) Any manufacturer's designations which shall be separated from the grade-marks or trademarks of the approved agency by not less than 6 inches (152 mm); and

(*g*) "Top" stamp on the top face of custom CLT panels used for roof or floor if manufactured with an unbalanced layup.

8.8.3 Frequency of marking

Non-custom and other required marks in this section shall be placed on standard products at intervals of 8 feet (2.4 m) or less in order that each piece cut from a longer piece will have at least one of each of the required marks.

8.8.4 Custom products

For products manufactured to meet specific job specifications (custom products), the marking shall be permitted to contain information less than that specified in Section 8.8.2. However, custom products shall bear at least one mark containing a required identification. When long CLT products shipped to a job are to be cut later into several members for use in the structure, the frequency of marking required in Section 8.8.3 shall be followed.

8.8.5 Voiding marks

CLT products originally marked as conforming to this standard but subsequently rejected as not conforming thereto shall have any reference to the standard obliterated or voided by the manufacturer.

Note 15. This can be performed by blocking out the stamp with permanent black ink or light sanding.

9. QUALITY ASSURANCE

9.1 Objectives

This section is intended for use with CLT products that have qualified for trademarking under this standard. The purpose of this section is to assure product quality by detecting changes in properties that may adversely affect the CLT performance. In all cases, the criteria to which the CLT products are tested shall be provided in the Mill Specification or equivalent document.

9.2 Process Control

On-going evaluation of the process properties listed in this section shall be performed to confirm that the CLT quality remains in satisfactory compliance to the product specification requirements. Sampling methods and quality assurance testing shall be documented in an in-plant manufacturing standard and accepted by the approved agency. All processes and test records relevant to the production shall be retained based on the manufacturer's record retention policy and are subject to audit by the approved agency. Production shall be held pending results of the quality assurance testing on representative samples.

9.3 End, Face, and Edge Joints in Laminations

The lamination end joints, face joints, and edge joints (when applicable) shall be sampled and tested for on-going quality assurance in accordance with Table 3 of ANSI/AITC A190.1 and meet the strength (required for end joints only), wood failure, and durability requirements specified therein in the U.S., or shall be sampled and tested in accordance with Section 7 of CSA O122 and meet the strength (required for end joints only), wood failure, and durability requirements specified therein in Canada. Special considerations for face bonding of the CLT panel as a whole are provided in Sections 9.3.1 through 9.3.3 of this standard.

9.3.1 *Effective bonding area*

On-grade lumber shall be laid up to maintain an effective bonding area of not less than 80% on surfaces to be bonded for each bondline.

Note 16. To maintain an effective bond area, laminations in cross-plies may need to be oriented such that the bark and pith faces of adjacent pieces are generally alternated.

9.3.2 *Lamination grade limits*

Grade limits intended to limit the amount of lamination warp that will not be corrected upon application of pressure shall be qualified in accordance with Section 8.3 of this standard.

9.3.3 *Glue skip in the face bondline*

The average glue skip in a face bondline shall not exceed the level established to maintain the effective bonding area specified in Section 9.3.1. Glue skips are not assessed as delamination unless the inclusion of such skips does not invalidate the delamination requirements.

9.4 Finished Production Inspection

All production shall be inspected visually, and/or by measurements or testing for conformance to this standard with the following attributes:

(a) Dimensions (width, depth and length);

(b) Shape, including straightness and squareness;

(c) Type, quality and location of structural bond lines;

(d) Appearance classification;

(e) Layup, including lumber species and grades, placement, and orientation;

(f) Moisture content; and

(g) Application of the appropriate marks.

9.5 Minor Variations

A product is considered conforming to this standard when minor variations of a limited extent in non-critical locations exist, or when structural damage or defects have been repaired and, in the judgment of a qualified person, the product is structurally adequate for the use intended. The identity of the product and the nature of the minor variation shall be documented and provided to the designer of record upon request. A qualified person is one who is familiar with the job specifications and applicable design requirements and has first-hand knowledge of the manufacturing process.

ANNEX A. DESIGN PROPERTIES FOR ANSI/APA PRG 320 CLT (MANDATORY)

This Annex provides the allowable design properties for CLT grades listed in Table 1, which represent the production intended for use by the CLT manufacturers in North America and are based on the following layups:

- *E1: 1950f-1.7E Spruce-pine-fir MSR lumber in all parallel layers and No. 3 Spruce-pine-fir lumber in all perpendicular layers*
- *E2: 1650f-1.5E Douglas fir-Larch MSR lumber in all parallel layers and No. 3 Douglas fir-Larch lumber in all perpendicular layers*
- *E3: 1200f-1.2E Eastern Softwoods, Northern Species, or Western Woods MSR lumber in all parallel layers and No. 3 Eastern Softwoods, Northern Species, or Western Woods lumber in all perpendicular layers*
- *E4: 1950f-1.7E Southern pine MSR lumber in all parallel layers and No. 3 Southern pine lumber in all perpendicular layers*
- *V1: No. 2 Douglas fir-Larch lumber in all parallel layers and No. 3 Douglas fir-Larch lumber in all perpendicular layers*
- *V2: No. 1/No. 2 Spruce-pine-fir lumber in all parallel layers and No. 3 Spruce-pine-fir lumber in all perpendicular layers*
- *V3: No. 2 Southern pine lumber in all parallel layers and No. 3 Southern pine lumber in all perpendicular layers*

TABLE A1.
ALLOWABLE DESIGN PROPERTIES[a,b,c] FOR PRG 320 CLT (for use in the U.S.)

	Major Strength Direction						Minor Strength Direction					
CLT Grades	**$F_{b,0}$ (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)**
E1	1,950	1.7	1,375	1,800	135	45	500	1.2	250	650	135	45
E2	1,650	1.5	1,020	1,700	180	60	525	1.4	325	775	180	60
E3	1,200	1.2	600	1,400	110	35	350	0.9	150	475	110	35
E4	1,950	1.7	1,375	1,800	175	55	575	1.4	325	825	175	55
V1	900	1.6	575	1,350	180	60	525	1.4	325	775	180	60
V2	875	1.4	450	1,150	135	45	500	1.2	250	650	135	45
V3	975	1.6	550	1,450	175	55	575	1.4	325	825	175	55

For SI: 1 psi = 0.006895 MPa

(a) See Section 4 for symbols.

(b) Tabulated values are allowable design values and not permitted to be increased for the lumber size adjustment factor in accordance with the NDS. The design values shall be used in conjunction with the section properties provided by the CLT manufacturer based on the actual layup used in manufacturing the CLT panel (see Table A2).

(c) Custom CLT grades that are not listed in this table shall be permitted in accordance with Section 7.2.1

The allowable design capacities for these CLT grades with layups of 3, 5, and 7 layers are provided in Table A2. These capacities are deemed achievable by the Committee using the standard laminations tabulated in this standard. These capacities were derived analytically using the Shear Analogy Model[2] (the calculated moment capacities in the major strength direction were further multiplied by a factor of 0.85 for conservatism) and validated by testing. The lamination thicknesses are as tabulated. The allowable tensile, compressive, and shear capacities will be developed and added to future editions of this standard.

TABLE A2.
THE ALLOWABLE BENDING CAPACITIES[a,b,c] FOR CLT LISTED IN TABLE A1 (FOR USE IN THE U.S.)

		Lamination Thickness (in.) in CLT Layup							Major Strength Direction			Minor Strength Direction		
CLT Grade	CLT t (in.)	=	⊥	=	⊥	=	⊥	=	$F_bS_{eff,0}$ (lbf-ft/ft)	$EI_{eff,0}$ (10^6 lbf-in.^{2}/ft)	$GA_{eff,0}$ (10^6 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)
E1	4 1/8	1 3/8	1 3/8	1 3/8					4,525	115	0.46	160	3.1	0.61
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			10,400	440	0.92	1,370	81	1.2
	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	18,375	1,089	1.4	3,125	309	1.8
E2	4 1/8	1 3/8	1 3/8	1 3/8					3,825	102	0.53	165	3.6	0.56
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			8,825	389	1.1	1,430	95	1.1
	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	15,600	963	1.6	3,275	360	1.7
E3	4 1/8	1 3/8	1 3/8	1 3/8					2,800	81	0.35	110	2.3	0.44
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			6,400	311	0.69	955	61	0.87
	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	2,180	232	1.3
E4	4 1/8	1 3/8	1 3/8	1 3/8					4,525	115	0.53	180	3.6	0.63
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			10,425	441	1.1	1,570	95	1.3
	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	1,090	1.6	3,575	360	1.9
V1	4 1/8	1 3/8	1 3/8	1 3/8					2,090	108	0.53	165	3.6	0.59
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			4,800	415	1.1	1,430	95	1.2
	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	8,500	1,027	1.6	3,275	360	1.8
V2	4 1/8	1 3/8	1 3/8	1 3/8					2,030	95	0.46	160	3.1	0.52
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			4,675	363	0.91	1,370	81	1.0
	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	8,275	898	1.4	3,125	309	1.6
V3	4 1/8	1 3/8	1 3/8	1 3/8					2,270	108	0.53	180	3.6	0.59
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			5,200	415	1.1	1,570	95	1.2
	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	9,200	1,027	1.6	3,575	360	1.8

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

(a) See Section 4 for symbols.

(b) This table represents one of many possibilities that the CLT could be manufactured by varying lamination grades, thicknesses, orientations, and layer arrangements in the layup.

(c) Custom CLT grades that are not listed in this table shall be permitted in accordance with Section 7.2.1.

Note A1. The rounding rules in Table A2 are as follows:

F_bS (lbf-ft/ft) – Nearest 25 for values greater than 2,500, nearest 10 for values between 1,000 and 2,500, or nearest 5 otherwise

EI (lbf-in.^{2}/ft) and GA (lbf/ft) – Nearest 10^6 for values greater than 10^7, nearest 10^5 for values between 10^6 and 10^7, or nearest 10^4 otherwise

2 Gagnon, S. and M. Popovski. 2011. *Structural Design of Cross-Laminated Timber Elements.* In: Chapter 3, CLT Handbook. FPInnovations, Canada.

For use in Canada, the Limit States design properties are provided in Table A3 and the Limit States design resistances are shown in Table A4. The Limit States design resistances are not compatible with the allowable design capacities used in the U.S. Since there are no published specified strength and modulus of elasticity for Southern pine lumber in Canada, the CLT Grades E4 and V3 are not listed in Tables A3 and A4.

TABLE A3.
SPECIFIED STRENGTH AND MODULUS OF ELASTICITY[a,b,c] FOR PRG 320 CLT (for use in Canada)

	Major Strength Direction						Minor Strength Direction					
CLT Grades	$f_{b,0}$ (MPa)	E_0 (MPa)	$f_{t,0}$ (MPa)	$f_{c,0}$ (MPa)	$f_{v,0}$ (MPa)	$f_{s,0}$ (MPa)	$f_{b,90}$ (MPa)	E_{90} (MPa)	$f_{t,90}$ (MPa)	$f_{c,90}$ (MPa)	$f_{v,90}$ (MPa)	$f_{s,90}$ (MPa)
E1	28.2	11,700	15.4	19.3	1.5	0.50	7.0	9,000	3.2	9.0	1.5	0.50
E2	23.9	10,300	11.4	18.1	1.9	0.63	4.6	10,000	2.1	7.3	1.9	0.63
E3	17.4	8,300	6.7	15.1	1.3	0.43	4.5	6,500	2.0	5.2	1.3	0.43
V1	10.0	11,000	5.8	14.0	1.9	0.63	4.6	10,000	2.1	7.3	1.9	0.63
V2	11.8	9,500	5.5	11.5	1.5	0.50	7.0	9,000	3.2	9.0	1.5	0.50

For SI: 1 MPa = 145 psi

(a) See Section 4 for symbols.

(b) Tabulated values are Limit States design values and not permitted to be increased for the lumber size adjustment factor in accordance with CSA O86. The design values shall be used in conjunction with the section properties provided by the CLT manufacturer based on the actual layup used in manufacturing the CLT panel (see Table A4).

(c) Custom CLT grades that are not listed in this table shall be permitted in accordance with Section 7.2.1.

TABLE A4.
THE LSD BENDING RESISTANCES[a,b,c] FOR CLT LISTED IN TABLE A3 (for use in Canada)

		Lamination Thickness (mm) in CLT Layup							Major Strength Direction			Minor Strength Direction		
CLT Grade	CLT t (mm)	=	⊥	=	⊥	=	⊥	=	$f_bS_{eff,0}$ (10^6 N-mm/m)	$EI_{eff,0}$ (10^9 N-mm²/m)	$GA_{eff,0}$ (10^6 N/m)	$f_bS_{eff,90}$ (10^6 N-mm/m)	$EI_{eff,90}$ (10^9 N-mm²/m)	$GA_{eff,90}$ (10^6 N/m)
E1	105	35	35	35					42	1,088	7.3	1.4	32	9.1
	175	35	35	35	35	35			98	4,166	15	12	836	18
	245	35	35	35	35	35	35	35	172	10,306	22	28	3,183	27
E2	105	35	35	35					36	958	8.0	0.94	36	8.2
	175	35	35	35	35	35			83	3,674	16	8.1	929	16
	245	35	35	35	35	35	35	35	146	9,097	24	19	3,537	25
E3	105	35	35	35					26	772	5.3	0.92	23	6.4
	175	35	35	35	35	35			60	2,956	11	8.0	604	13
	245	35	35	35	35	35	35	35	106	7,313	16	18	2,299	19
V1	105	35	35	35					15	1,023	8.0	0.94	36	8.7
	175	35	35	35	35	35			35	3,922	16	8.1	929	17
	245	35	35	35	35	35	35	35	61	9,708	24	19	3,537	26
V2	105	35	35	35					18	884	7.2	1.4	32	7.5
	175	35	35	35	35	35			41	3,388	14	12	836	15
	245	35	35	35	35	35	35	35	72	8,388	22	28	3,183	23

For SI: 1 mm = 0.03937 in.; 1 m = 3.28 ft; 1 N = 0.2248 lbf

(a) See Section 4 for symbols.

(b) This table represents one of many possibilities that the CLT could be manufactured by varying lamination grades, thicknesses, orientations, and layer arrangements in the layup.

(c) Custom CLT grades that are not listed in this table shall be permitted in accordance with Section 7.2.1.

Note A2. The rounding rules in Table A4 are as follows:

$f_b S$ (N-mm/m) and GA (N/m) – Nearest 10^6 for values greater than 10^7, nearest 10^5 for values between 10^6 and 10^7, or nearest 10^4 otherwise.

EI (N-mm^2/m) – Nearest 10^9 for values greater than 10^{10}, nearest 10^8 for values between 10^9 and 10^{10}, or nearest 10^7 otherwise.

APPENDIX A. EXAMPLES OF CLT APPEARANCE CLASSIFICATIONS (NON-MANDATORY)

This appendix contains examples of CLT appearance classifications for reference only. These requirements are based on the appearance at the time of manufacturing. The actual CLT panel appearance requirements are recommended to be agreed upon between the buyer and the seller.

A1. Architectural Appearance Classification

An appearance classification normally suitable for applications where appearance is an important, but not overriding consideration. Specific characteristics of this classification are as follows:

- In exposed surfaces, all knot holes and voids measuring over 3/4 inch (19 mm) are filled with a wood-tone filler or clear wood inserts selected for similarity with the grain and color of the adjacent wood.
- The face layers exposed to view are free of loose knots and open knot holes are filled.
- Knot holes do not exceed 3/4 inch (19 mm) when measured in the direction of the lamination length with the exception that a void may be longer than 3/4 inch (19 mm) if its area is not greater than 1/2 in.^{2} (323 mm^2).
- Voids greater than 1/16 inch (1.6 mm) wide created by edge joints appearing on the face layers exposed to view are filled.
- Exposed surfaces are surfaced smooth with no misses permitted.

A2. Industrial Appearance Classification

An appearance classification normally suitable for use in concealed applications where appearance is not of primary concern. Specific characteristics of this grade are as follows:

- Voids appearing on the edges of laminations need not be filled.
- Loose knots and knot holes appearing on the face layers exposed to view are not filled.
- Members are surfaced on face layers only and the appearance requirements apply only to these layers.
- Occasional misses, low laminations or wane (limited to the lumber grade) are permitted on the surface layers and are not limited in length.

APPENDIX B. HISTORY OF STANDARD (NON-MANDATORY)

In March 2010, the APA Standards Committee on Standard for Performance-Rated Cross-Laminated Timber was formed to develop a national standard under the consensus processes accredited by the American National Standards Institute (ANSI). This national consensus standard, designated as ANSI/APA PRG 320, is developed based on broad input from around the world. It should be especially recognized that this standard incorporates draft standards that were developed by FPInnovations in Canada, as part of the joint effort between the U.S. and Canada in the development of a bi-national CLT standard. The first version of this standard was approved by ANSI for publication on December 20, 2011. Subsequent revisions resulted in this version of the standard.

The names of the ANSI/APA PRG 320 Committee members when this version of the standard is published are as shown below. The current list of the committee membership is available from the committee secretariat upon request.

Name	Affiliation	Notes
Chris Brandt	Weyerhaeuser Company	
Darryl Byle	Montana Sustainable Building Systems	
Kevin Cheung	Western Wood Products Association	
Mark Clark	Momentive	
Don DeVisser	West Coast Lumber Inspection Bureau	
Bruno Di Lenardo	Canadian Construction Materials Centre	
Julie Frappier	Nordic Engineered Wood	
Sylvain Gagnon	FPInnovations	
Bill Gareis	Ashland Inc.	
Ron Goff	American Institute of Timber Construction	
Werner Hofstätter	Canadian Timber Towers Ltd.	
Jon Howard	Rosboro LLC	
Crispin Howes	Halcrow Yolles	
Dave Kretschmann	USDA Forest Products Lab	
Frank Lam	University of British Columbia	
Ken Lau	Ainsworth Lumber Company	
William Love	Tembec Forest Products	
Conroy Lum	FPInnovations	
Robert Malczyk	Equilibrium Consulting Inc.	
Ted Marra	Kaiser Wood Products, Inc.	
David Moses	Moses Structural Engineers Inc.	
Crawford Murphy	MDS10 Architect and Sustainable CLT	
Scott Nyseth	StoneWood Design	
Al Rozek	NLGA	
Alexander Salenikovich	University of Laval	
Sheldon Shi	Mississippi State Univ.	
Robert Speed	NC Dept. of Insurance, Evaluation Services Section	
Kurt Stochlia	ICC-ES	
Ted Szabo	Alberta Innovates Bio-Solutions	
Brian Tolley	Akzo Nobel Coatings, Inc.	Vice Chair
Phil Vacca	Louisiana-Pacific Corp.	
Wolfgang Weirer	KLH GmbH	
Chris Whelan	Henkel Corporation	
Tom Williamson	T.Williamson-Timber Engineering LLC	Chair
B.J. Yeh	APA	Secretariat
Cory Zurell	Blackwell Bowick Partnership Ltd	

Inquiries or suggestions for improvement of this standard should be directed to:

Secretariat, ANSI/APA PRG 320
APA – The Engineered Wood Association
7011 South 19th Street
Tacoma, WA 98466
Internet address: www.apawood.org
e-mail address: help@apawood.org

ANSI/APA PRG 320-2012
Standard for Performance-Rated Cross-Laminated Timber

APA HEADQUARTERS
7011 So. 19th St. ▪ Tacoma, Washington 98466 ▪ (253) 565-6600 ▪ Fax: (253) 565-7265

www.apawood.org

PRODUCT SUPPORT HELP DESK
(253) 620-7400 ▪ help@apawood.org

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