Standard Specifications for

Structural Glued Laminated Timber

of Softwood Species

AITC 117-2004

AMERICAN INSTITUTE OF TIMBER CONSTRUCTION

CONTENTS

American Institute of Timber Construction

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ERRATA

March 1, 2005

Subsequent to the printing of AITC 117-2004, errors have been discovered on pages 13, 24, 25, 26, 30, 31, 32, and 44. Corrections have been made to those pages and are shown using underline/~~strikethrough~~ formatting.

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Adopted as Recommendations, March 1, 2004

Preface

The term *structural glued laminated timber* as used herein refers to an engineered, stress-rated product of a timber laminating plant, comprising assemblies of suitably selected and prepared wood laminations bonded together with adhesives. The grain of all laminations is approximately parallel longitudinally. Glued laminated timber is permitted to be comprised of pieces end joined to form any length, of pieces placed or bonded edge to edge to make any width, or of pieces bent to curved form during bonding.

These specifications supercede previously issued laminating specifications and supplements, including AITC 117-*Design* and AITC 117-*Manufacturing*. They represent the latest research available from the U.S. Forest Products Laboratory, various colleges and universities, and the American Institute of Timber Construction.

The first part of these specifications (**I.** *Design Requirements*) describes design values and adjustment factors for use in the design of structural glued laminated timber. The design values described herein are for use with the allowable stress design (ASD) methodology. For Load and Resistance Factor Design (LRFD), conversion formulas for design values are provided in Section 7.

Specific layup requirements and requirements for lumber, adhesives, and end joint performance are discussed in the second part of these specifications (**II.** *Manufacturing Requirements*). The production of structural glued laminated timber under these specifications shall also be in accordance with American National Standard ANSI/AITC A190.1 *Structural Glued Laminated Timber* (1).

Layups not listed in these specifications are permitted to be used provided that all other requirements of these specifications are met. Specific requirements for alternate layups are included in the third part of these specifications (**III**. *Alternate Layup Requirements*).

Structural glued laminated timber conforming to these specifications shall be produced by licensees of the American Institute of Timber Construction (AITC). Quality assurance for workmanship and materials shall be the responsibility of the manufacturer's quality control operations. The manufacturer's quality control systems shall be subject to periodic auditing by the American Institute of Timber Construction. Timbers conforming to these specifications shall be marked according to ANSI/AITC A190.1 (1).

I. Design Requirements

1. General

These specifications contain data relating to design values and adjustment factors for the design of structural glued laminated timber members. They are, however, intended to be neither a design manual nor an engineering textbook. Structural design of glued laminated timber members and their fastenings shall be in accordance with these specifications, the AITC Timber Construction Manual (2), and the National Design Specification® (NDS) for Wood Construction (3).

Structural glued laminated timbers are permitted to be made up a single grade of lumber or a combination of grades. Structural glued laminated timber combinations generally utilize higher grade lumber in the outer zones than in the core. Design values for structural glued laminated timbers are established according to the analysis procedures of ASTM D3737 (4) or through full scale tests in accordance with ASTM D198 (5) and analysis in accordance with ASTM D2915 (6) or ASTM D5457 (7).

1.1. Combination Symbols or Identification Numbers

Each structural glued laminated timber layup is assigned a combination symbol or a number. The combination symbol or number is used to distinguish one combination from another. Each layup is assigned design values based on ASTM D3737 or full scale tests. Design values for common layups are contained in Table A1 and Table 8.2. Table A1 contains design values for structural glued laminated timber combinations. Table 8.2. contains design values for uniform grade layups.

The combination symbols in Table A1 indicate the primary design bending stress and the grading system used for the lumber outer zones. For example, 24F-V4 indicates that the beam has a primary bending design value of 2400 psi and that the lumber in the outer zones was visually graded. 24F-E13 indicates that the bending design value is 2400 psi and the lumber in the outer zones was E-rated using a mechanical grading system. The number at the end of the combination symbol is an arbitrary number assigned to distinguish between different combinations.

The identification numbers for layups in Table 8.2. have been assigned for specification purposes. Each number corresponds to a specific grade of lumber used in a uniform grade layup.

1.2. Stress Classes

To simplify specification, combinations from Table A1 that have similar design stresses have been grouped into stress classes. These stress classes are recommended for specification purposes rather than specifying by combination symbol. Use of the stress class system allows manufacturers flexibility in choosing combinations that make efficient use of their available resources and simplifies the design process. These stress classes are shown in Table 8.1.

Stress classes are designated by primary bending stress and modulus of elasticity. To qualify for a stress class, combinations are required to have design values that meet or exceed all values listed for the stress class. Each combination qualifying for a stress class also qualifies for all lower stress classes.

Because the stress classes are not species group-specific, it is critical that the designer specify when a particular species is required for appearance reasons or other considerations. Some stress classes are not available in all species. In addition, Southern Pine and Western Species structural glued laminated timbers have different standard sizes, so these general species groups shall be specified at a minimum. Table A1 lists combinations included in each stress class.

1.3. Balanced or Unbalanced Layups

Structural glued laminated timbers are permitted to be laid up with lumber grades placed symmetrically or asymmetrically about the neutral axis of the member. Timbers with symmetric layups are referred to as “balanced” and have the same design values for positive and negative bending. Timbers with asymmetric layups are referred to as “unbalanced” and have higher design stresses for positive bending than for negative bending. Unbalanced layups are generally used for simple, single-span beams, while balanced layups are used for continuous or cantilevered beams. Unbalanced combinations are permitted to be used as continuous or cantilevered beams, provided that the stresses due to negative moment do not exceed the tabulated bending design value modified by applicable adjustment factors. The top side of unbalanced beams is required to be marked “TOP” by the manufacturer to eliminate confusion.

1.4. Allowable Stresses

Tabulated design stresses for structural glued laminated timber are based on standard conditions and must be modified for design use by applying applicable adjustment factors. The tabulated design stress multiplied by all applicable adjustment factors is referred to as the "allowable stress." The tabulated design values are discussed in Section 2, and the adjustment factors are discussed in Section 3.

2. Design Values

Design values for structural glued laminated timber are dependent on the orientation of the member in relation to the applied loads. Values designated with a subscript "x" are based on transverse loads applied perpendicular to the wide faces of the laminations, causing bending about the x-x axis. Values designated with a subscript "y" are based on transverse loads applied parallel to the wide faces of the laminations, causing bending about the y-y axis.

Design values are tabulated for bending (F_{bx}^{+}, F_{bx}^{-}, F_{by}), compression perpendicular to grain ($F_{c\perp x}$, $F_{c\perp y}$), shear (F_{vx}, F_{vy}), modulus of elasticity (E_x, E_y, E_{axial}), tension parallel to grain (F_t), and compression parallel to grain (F_c). Also tabulated are specific gravity values and species groups for use in connection design. Values are not tabulated for torsion, for modulus of rigidity, or for radial stresses in curved bending members, because these values can be determined from other tabulated design values.

2.1. Bending Design Values, F_{bx}^{+}, F_{bx}^{-}, F_{by}

Tabulated design values are provided for positive bending of horizontally laminated timbers (F_{bx}^{+}), negative bending of horizontally laminated timbers (F_{bx}^{-}), and bending of vertically laminated members (F_{by}). Horizontally laminated members have bending loads applied perpendicular to the wide faces of the laminations. Vertically laminated members have bending loads applied parallel to the wide faces of the laminations. Positive bending causes tensile stresses in the special tension laminations at the bottom of a beam. Negative bending causes compressive stresses in the special tension laminations at the bottom of a beam.

2.2. Compression Perpendicular to Grain Design Values, $F_{c\perp x}$, $F_{c\perp y}$

The use of multiple laminating grades results in different design values in compression perpendicular to grain for the top and bottom and for the side faces of a beam. One value is tabulated for use in bearing on the top or bottom of the beam and one value is tabulated for side bearing to simplify design.

The tabulated compression perpendicular to grain design values are based on a deformation limit of 0.04 in. obtained when testing in accordance with ASTM D143 (8). In special applications where deformation is critical, the use of a reduced compression perpendicular to grain design value may be appropriate. A compression perpendicular to grain design value based on a 0.02 in. deformation limit can be calculated as 73% of the tabulated value.

2.3. Shear Design Values, F_{vx}, F_{vy}

The tabulated shear design values, F_{vx}, are permitted to be used for prismatic members subject most load conditions. For non-prismatic members and for all members subject to impact or cyclic loads, the tabulated shear values shall be reduced by 28%. This reduction shall also apply to the design of members transferring shear through mechanical fasteners.

Prismatic members shall be defined as straight (or cambered) members with constant cross section. Non-prismatic members include, but are not limited to: arches, tapered beams, curved beams, and notched members.

The tabulated shear design values, F_{vy}, are applicable to members with four or more laminations. For members with three laminations, the tabulated value shall be reduced by 5%. For members with two laminations the tabulated value shall be reduced by 16%.

The tabulated shear design values permit minor amounts of checking (≤ 15% of beam width) without explicit consideration by the designer. AITC Technical Note 18 (9) provides guidelines for the analysis of severely checked beams.

2.4 Modulus of Elasticity Design Values, E_x, E_y, E_{axial}

Design values for modulus of elasticity are tabulated for bending about either axis and for axial deformation. In general, E_x and E_y should be used for calculation of deflection of beams and for stability calculations for columns and beams. E_{axial} is appropriate to use for extensional deformations such as for use in calculating deflection of trusses.

E_x and E_y are based on a span to depth ratio of approximately 21, including an adjustment for shear deflection. These values can be used for most designs without considering shear deflections explicitly. For span to depth ratios of 15 or less, deflections due to shear stresses should be considered. ASTM D2915 (6) presents one method of accounting for shear deformations.

2.5. Tension Parallel to Grain Design Value, F_t

A single design value is tabulated for tension parallel to grain for each combination or stress class.

2.6. Compression Parallel to Grain Design Value, F_c

A single design value is tabulated for compression parallel to grain for each combination or stress class.

2.7. Radial Compression Design Values, F_{rc}

The design value for radial compression, F_{rc}, shall be equal to the design value for compression perpendicular to grain, $F_{c\perp y}$.

2.8. Radial Tension Design Values, F_{rt}

The design value for radial tension, F_{rt}, shall be equal to 1/3 of the shear design value, F_{vx}, for non-prismatic members except for timbers manufactured from Western Species, which are prescriptively limited to 15 psi for loads other than wind or earthquake loads. For wind and earthquake loading of all species groups, the design value for radial tension shall be 1/3 of the shear design value for non-prismatic members. If the calculated radial tension stress (due to loads or load combinations not including wind or seismic loads) exceeds 15 psi for Western Species timbers, radial reinforcement shall be required. Design values for radial tension for radially reinforced members shall be limited to 1/3 of the shear design value for non-prismatic members. Radial reinforcement shall be designed in accordance with the Timber Construction Manual (2).

2.9. Torsion Design Values, F_{vt}

The torsion design value shall be taken as 2/3 of the shear design value, F_{vx}, for non-prismatic members.

2.10. Modulus of Rigidity Design Values, G

In lieu of specific data, the modulus of rigidity shall be taken as 1/16 of the modulus of elasticity for the lowest grade lamination used in the layup. If specific data are available, they shall be permitted to be used to determine the modulus of rigidity.

3. Adjustment of Design Values

Tabulated design values apply to members meeting the following conditions:

(a) Normal duration of load
(b) Dry service conditions
(c) Service temperatures below 100 ^{O}F
(d) Full lateral support
(e) Reference dimensions
(f) Span to depth ratio of L/d=21
(g) Straight members
(h) Not chemically treated

Design values shall be adjusted for all other conditions. Adjustment factors are discussed in Sections 3.1-3.13. The applicability of the various adjustment factors is shown in Table 3.0.

Table 3.0. *Applicability of Adjustment Factors*

			Load Duration Factor	Wet Service Factor	Temperature Factor	Beam Stability Factor	Volume Factor	Flat Use Factor	Curvature Factor	Stress Interaction Factor	Column Stability Factor	Shear Size Factor	Bearing Area Factor
F_b'	=	F_b	C_D	C_M	C_t	C_L	C_V	C_{fu}	C_c	C_I	-	-	-
F_t'	=	F_t	C_D	C_M	C_t	-	-	-	-	-	-	-	-
F_V'	=	F_V	C_D	C_M	C_t	-	-	-	-	-	-	C_H	-
$F_{c\perp}'$	=	$F_{c\perp}$	-	C_M	C_t	-	-	-	-	-	-	-	C_b
F_c'	=	F_c	C_D	C_M	C_t	-	-	-	-	-	C_P	-	-
E'	=	E	-	C_M	C_t	-	-	-	-	-	-	-	
F_{rt}'	=	F_{rt}	C_D	C_M	C_t	-	-	-	-	-	-	-	

3.1. Duration of Load Factor, C_D

The viscoelastic nature of wood allows it to carry greater loads for short duration than for long duration. Tabulated design values are based on normal load duration, which assumes a member is loaded to its full design capacity for a cumulative duration of 10 years (applied continuously or intermittently). For the condition of normal loading, the duration of load factor, C_D = 1.00. For other load durations, tabulated design values shall be adjusted according Table 3.1. For load combinations, the load duration factor for the shortest duration load in the combination is permitted to be applied to the entire load combination.

Table 3.1. *Frequently used load duration factors.*

Load Duration [1]	C_D	Typical Design Loads
Permanent	0.90	Dead Load
Ten Years	1.00	Occupancy Live Load (Normal)
Two Months	1.15	Snow Load
Seven Days	1.25	Construction Load, Roof Live Load
Ten Minutes	1.60	Wind/Earthquake Load
Impact [2]	2.00	Impact Load

1. Load duration factors shall not apply to modulus of elasticity, nor to compression perpendicular to grain design values based on a deformation limit.
2. Load duration factors greater than 1.6 shall not apply to structural glued laminated timbers pressure-treated with water-borne preservatives or fire-retardant chemicals. The impact load duration factor shall not apply to connections.

3.2. Wet Service Factor, C_M

Tabular design values for structural glued laminated timber are based on wood with a moisture content of less than 16%. When the moisture content of the glued laminated timber in service is expected to be 16% or greater, the applicable wet service factor shall be applied. Table 3.2 shows the wet service factors applicable to each design value.

Table 3.2. *Wet Service Factor, C_M*

Design Value	Wet Service Factor (C_M)
Bending, F_{bx}^{+}, F_{bx}^{-}, F_{by}	0.80
Tension parallel to grain, F_t	0.80
Shear, F_{vx}, F_{vy}	0.875
Compression perpendicular to grain, $F_{c\perp x}$, $F_{c\perp y}$	0.53
Compression parallel to grain, F_c	0.73
Modulus of Elasticity, E_x, E_y, E_{axial}	0.833
Radial Tension, F_{rt}	0.875
Radial Compression, F_{rc}	0.53
Modulus of Rigidity, G	0.833

3.3. Temperature Factor, C_t

Tabular design values are based on temperatures up to 100 ^{O}F. When in service temperatures are expected to exceed 100 ^{O}F for sustained exposures, the tabular design value shall be reduced by multiplying by the appropriate factor from Table 3.3.

Table 3.3. *Temperature Factor, C_t*

Design Value	In Service Moisture Condition	$T \leq 100\ ^{O}F$	$100\ ^{O}F \leq T \leq 125\ ^{O}F$	$125\ ^{O}F \leq T \leq 150\ ^{O}F$
F_t, E_x, E_y, E_{axial}	Wet or Dry	1.0	0.9	0.9
F_{bx}^{+}, F_{bx}^{-}, F_{by}, F_v, F_c, $F_{c\perp x}$, $F_{c\perp}$, F_{rt}, F_{rc},	Dry	1.0	0.8	0.7
F_{bx}^{+}, F_{bx}^{-}, F_{by}, F_v, F_c, $F_{c\perp x}$, $F_{c\perp}$, F_{rt}, F_{rc},	Wet	1.0	0.7	0.5

3.4. Beam Stability Factor, C_L

The tabular bending stresses are applicable to bending members that are fully laterally braced to prevent buckling of the member, or have depth less than or equal to their width. Full lateral bracing requires lateral support of the ends at points of bearing to prevent rotation and continuous support along the compression edge of the beam to prevent lateral displacement. When other conditions exist, the beam stability factor shall be calculated and applied as shown in the AITC Timber Construction Manual (2) and the NDS® (3). The beam stability factor shall not be applied cumulatively with the volume factor. The smaller factor shall apply.

3.5. Volume Factor, C_V

The tabular stresses for bending about the x-x axis, F_{bx}, are based on a member with a reference size of 5-1/8 in. wide, 12 in. deep, and 21 ft long. When a different size member exists, the tabular design value shall be multiplied by the volume factor, C_V, calculated as follows.

$$C_V = \left[\left(\frac{5.125in}{b}\right)\left(\frac{12in}{d}\right)\left(\frac{21ft}{L}\right)\right]^{\frac{1}{x}} \leq 1.0 \qquad \text{Equation 3.5.}$$

where:

C_V = volume factor
b = beam width (in.) For beams with multiple piece laminations (across width), b = width of widest piece used in the layup.
d = beam depth (in.)
L = length of beam between points of zero moment (ft)
x = 20 for Southern Pine
x = 10 for all other species

The volume factor shall not be applied cumulatively with the beam stability factor. The smaller factor shall apply.

3.6. Flat Use Factor, C_{fu}

The tabular stress for bending about the y-y axis, F_{by}, is based on a member with a reference depth of 12 in. For depths less than 12 in., F_{by} is permitted to be increased by multiplying by the flat use factor, C_{fu} for structural glued laminated timber (Equation 3.6.)

$$C_{fu} = \left(\frac{12in}{d}\right)^{\frac{1}{9}} \qquad \text{Equation 3.6.}$$

where:

C_{fu} = flat use factor
d = beam depth (in.) (measured parallel to wide face of laminations)

3.7. Curvature Factor, C_c

For the curved portion of members, the design stresses in bending, F_{bx}^{+}, F_{bx}^{-}, shall be reduced by multiplying by the curvature factor calculated by Equation 3.7.

$$C_c = 1 - 2000\left(\frac{t}{R}\right)^2 \qquad \text{Equation 3.7.}$$

where:

t = lamination thickness
R = radius of curvature

No curvature factor need be applied to the design value in the straight portion of a member, regardless of curvature elsewhere.

3.8. Stress Interaction Factor, C_I

For tapered bending members, consideration must be given to the stress interactions caused by the taper. The stress interaction factor shall be applied to the allowable bending stress, F_{bx}, as described in the AITC Timber Construction Manual.

3.9. Column Stability Factor, C_P

The tabular design value for compression parallel to grain, F_c, shall be multiplied by the column stability factor as calculated by methods in the AITC Timber Construction Manual and the NDS®.

3.10. Bearing Area Factor, C_b

For bearings less than 6 inches in length and not nearer than three inches to the end of the member, the design value for compression perpendicular to grain, $F_{c\perp}$, shall be permitted to be multiplied by the bearing area factor calculated with Equation 3.10.

$$C_b = \frac{l_b + 0.375in}{l_b} \qquad \text{Equation 3.10.}$$

where: l_b = bearing length measured parallel to grain

3.12. Preservative Pressure Treatment Factor, C_{pt}

The design values given herein are also applicable to structural glued laminated timbers that have been pressure treated by an approved preservative process in accordance with AITC 109 *Standard for Preservative Treatment of Structural Glued Laminated Timber* (10). Treatment processes and chemicals not included in AITC 109 may cause strength or stiffness loss in structural glued laminated timbers. Appropriate reduction factors for these processes and chemicals shall be obtained from the party providing the treatment.

3.13. Fire Retardant Treatment Factor, C_{rt}

The effect of fire retardant treatments on the strength of structural glued laminated timbers is dependent on the species and treatment combinations involved. Research indicates that bending strength may be reduced by 10-25%. Appropriate reduction factors for fire retardant treatment shall be obtained from the party providing the treatment. Because of the excellent fire performance characteristics of structural glued laminated timber, fire retardant treatments are typically not applied.

4. Dimensions and Shapes

American National Standard ANSI/AITC A190.1 (1) permits the use of any width or depth of structural glued laminated timber. The use of standard finished sizes constitutes recommended practice to the extent that other considerations will permit. The depth and width of the timber shall be as agreed upon by the buyer and seller. All members shall be sized in accordance with the width, depth, and length requirements of the structural design. Dimensional tolerances shall be in accordance with ANSI/AITC A190.1 (1). Shape shall be as agreed upon by buyer and seller.

4.1. Standard Sizes

Standard net finished widths for structural glued laminated timbers are as shown in Table 4.1.

Table 4.1. *Standard Net Finished Widths for Structural Glued Laminated Timber.*

Nominal Width of Laminations	Western Species Net Width (in.)	Southern Pine Net Width (in.)
3	2-1/8 or 2-1/2	2-1/8 or 2-1/2
4 [1]	3-1/8	3 or 3-1/8
6 [1]	5-1/8	5 or 5-1/8
8	6-3/4	6-3/4
10	8-3/4	8-1/2
12	10-3/4	10-1/2
14	12-1/4	12
16	14-1/4	14

1. Standard widths for structural glued laminated timber meeting the requirements of the Framing appearance grade are 3-1/2 in. for nominal 4 in. lamination width and 5-1/2 in. for nominal 6 in. lamination width

Standard depths are in multiples of the standard lamination thickness. Southern Pine laminations are typically surfaced to 1-3/8 in. thick , and Western Species laminations are typically surfaced to 1-1/2 in. thick. Laminations 3/4 in. thick are often used for curved members of both Southern Pine and Western Species. I-joist compatible depths are also available from some manufacturers.

4.2 Shape

Structural glued laminated timbers can be manufactured in a variety of shapes from straight beams to graceful curved arches. Members can also be manufactured with tapered or constant cross section. Laminated timbers that are tapered and/or curved shall be designed in accordance with the AITC Timber Construction Manual (2).

The ability to bend laminations to curved shape is dependent upon many factors relating to both wood properties and manufacturing techniques, therefore, the designer is encouraged to consult with the manufacturer prior to specifying. Two prime considerations are thickness of laminations (t) and bending radius (R).

The t/R ratio shall not exceed 1/100 for Southern Pine or 1/125 for other softwoods, where t is the actual lamination thickness and R is the radius of curvature. The recommended radii of curvature at the inside face of sharply curved members, such as tudor arches, are:

7 ft 0 in. for Southern Pine using a lamination thickness up to 3/4 in.
9 ft 4 in. for all other softwood species using a lamination thickness up to 7/8 in.

For less sharply curved members, the recommended radius of curvature at the inside face is:

27 ft 6 in. for all softwood species utilizing a lamination thickness from 1-1/4 in. to 1-5/8 in.

5. Appearance Grades

Appearance grades shall be specified in accordance with ANSI/AITC A190.1 (1) and AITC 110 *Standard Appearance Grades for Structural Glued Laminated Timber* (11), or as agreed upon between buyer and seller. The tabular design values are independent of the appearance grades.

Special surfacing, such as rough saw texturing reduces the cross section and affects the member capacity based on the reduced section properties. This reduced cross section shall be considered in design.

6. Connection Design

The design of fasteners and connections shall be in accordance with the 2001 or more recent *National Design Specification® (NDS) for Wood Construction* (3), with the exception that the provisions of NDS 2001 Appendix E shall be mandatory.

In addition, consideration shall be given to shrinkage or swelling of wood members occurring at connections due to moisture changes. AITC 104 (12) shows examples of recommended detailing practice.

6.1 Dowel-Type Fasteners

The design of dowel-type fasteners in accordance with the NDS® requires the specific gravity of the timber member for design calculations. In general, the specific gravity values in Table 6.1 are permitted to be used for the species groups listed. The specific gravities to be used for connection design for laminated timber combinations or stress classes are listed in Table 8.1. and Table A1.

Table 6.1. *Specific Gravity for Fastener Design*

Species or Species Group	Specific Gravity (G)
Southern Pine	0.55
Douglas Fir-Larch	0.50
Douglas Fir South	0.46
Alaska Cedar	0.46
Hem-Fir	0.43
Southern Pine (coarse grain)	0.43
Spruce-Pine-Fir	0.42
Eastern Spruce	0.41
Redwood	0.37
Western Cedars	0.36
Softwood Species	0.35

6.2 Split Rings and Shear Plate Connectors

Four specific gravity groupings have been developed for split ring and shear plate connector design. The specific gravity values corresponding to each group are shown in Table 6.2. The assigned specific gravities for each species for design of split ring and shear plate connectors shall be as shown in Table 6.1.

Table 6.2. *Groups for Split Ring and Shear Plate Connectors*

Specific Gravity Grouping	Specific Gravity, G
A	$G \geq 0.60$
B	$0.49 \leq G < 0.60$
C	$0.42 \leq G < 0.49$
D	$G < 0.42$

6.3. Pre-engineered Metal Connectors

Pre-engineered metal connectors are commercially available for use with structural glued laminated timber. These components shall be designed and installed in accordance with the manufacturer's requirements and applicable evaluation reports.

7. Load and Resistance Factor Design

The tabulated design values presented in these specifications are intended for use with Allowable Stress Design (ASD). Conversion of these design values is necessary if Load and Resistance Factor Design (LRFD) is used. LRFD design shall conform to AF&PA/ASCE Standard 16-95 (13), except that the load combinations shall conform with ASCE 7-02 (14). The design value adjustment factors used for ASD are also applicable for LRFD, with the exception of the Load Duration Factor. Factors applicable to only LRFD are shown, subsequently.

7.1. Format Conversion Factors, K_F

For use with the LRFD methodology, ASD tabulated values shall be converted by multiplication with the conversion factor, K_F. Conversion factors for each property are defined in Table 7.1.

Table 7.1. *Format Conversion Factors for LRFD*

Application	Property	K_F
Members	F_b, F_t, F_V, F_c, F_{rt}	$2.16/\phi$
	$F_{c\perp}$, F_{rc}	$1.875/\phi$
Connections	Z, W	$2.16/\phi$

For stability calculations, LRFD equations require the use of a 5th percentile modulus of elasticity, E_{05}. E_{05} shall be calculated using Equation 7.1.

$$E_{05} = 1.05E\left(1 - 1.645CoV_E\right) \qquad \text{Equation 7.1.}$$

where: E_{05} = 5th percentile modulus of elasticity
E = average modulus of elasticity from ASD tables
CoV_E = coefficient of variation for modulus of elasticity
= 0.10 for structural glued laminated timber with 6 or more laminations
= 0.15 for structural glued laminated timber with less than 6 laminations

7.2. Resistance Factors, ϕ

LRFD design values shall be multiplied by the appropriate resistance factor, ϕ, as specified in Table 7.2.

Table 7.2. *Resistance Factors for LRFD*

Application	Property	Symbol	Value
Members	F_b	ϕ_b	0.85
	F_t	ϕ_t	0.80
	F_v, F_{rt}	ϕ_V	0.75
	F_c, $F_{c\perp}$, F_{rc}	ϕ_c	0.90
	E_s	ϕ_s	0.85
Connections	Z, W	ϕ_z	0.65

7.3. Time Effect Factors, λ

LRFD design values shall be multiplied by the appropriate time effect factor based on the primary load in the load combination. Appropriate load combinations shall be as specified in the applicable building code. Load combinations from ASCE 7-02 are shown in Table 7.3 with corresponding time effect factors. The ASD Load Duration Factor shall not apply for LRFD.

Table 7.3. *Time Effect Factors for LRFD with ASCE 7-02 load combinations.*

Load Combination	Primary Load	λ
1.4(D+F)	D, F	0.6
1.2(D+F) + 1.6(L+H) + 0.5(L_r or S or R)	L (from storage) L (from occupancy) L (from impact [1]) H	0.7 0.8 1.25 0.6
1.2D + 1.6(L_r or S or R) + (L or 0.8W)	L_r, S, R	0.8
1.2D + 1.6W + L + 0.2S	W	1.0
1.2D + 1.0E + L +0.2S	E	1.0
0.9D + 1.6W + 1.6H	W	1.0
0.9D + 1.0E + 1.6H	E	1.0

1. Time effect factors greater than 1.0 shall not apply to connections or to structural members pressure-treated with water-borne preservatives or fire-retardant chemicals.

where: D = dead load
E = earthquake load
F = load due to fluids with well-defined pressures and maximum heights
H = load due to lateral earth pressure, ground water pressure, or pressure of bulk materials
L = live load
L_r = roof live load
R = rain load
S = snow load
W = wind load

8. Design Value Tables

The design values in Table 8.1 are applicable to members with 4 or more laminations and are intended primarily for members stressed in bending due to loads applied perpendicular to the wide faces of the laminations. Design values are included, however, for axial loads and bending loads applied parallel to the wide faces of the laminations. The values in Table 8.1 are for the industry recommended stress classes. Each stress class is representative of a group of combinations with similar design values. Design values for individual combinations are shown in Annex A, Table A1.

Table 8.2 contains design values for timbers with uniform grade layups. These layups are intended primarily for timbers loaded axially or in bending due to loads applied parallel to the wide faces of the laminations. Design values are included, however, for bending due to loads applied perpendicular to the wide face of the laminations. The layups included in Table 8.2 represent the most common uniform grade layups used. An expanded list of uniform grade layups is shown in Annex A, Table A2.

The design values in Tables 8.3 and A3 are applicable to stress classes and combinations that have been modified by secondary manufacturing or fabrication by removing material from the compression face to create a tapered beam. The design values in Table 8.3 and A3 shall replace the corresponding design values in Tables 8.1 and A1 for all such field-tapered beams. For members manufactured with taper in the laminating plant, the design values published in Tables 8.1 and A1 shall apply.

Table 8.1 Design Values for Structural Glued Laminated Softwood Timber

(Members stressed primarily in bending) (Tabulated design values are for normal load duration and dry service conditions. See Section 3 for a comprehensive description of design value adjustment factors.)

	Bending About X-X Axis Loaded Perpendicular to Wide Faces of Laminations					Bending About Y-Y Axis Loaded Parallel to Wide Faces of Laminations				Axially Loaded			Fasteners
	Extreme Fiber in Bending		Compression Perpendicular to Grain	Shear Parallel to Grain (Horizontal)	Modulus of Elasticity	Extreme Fiber in Bending	Compression Perpendicular to Grain	Shear Parallel to Grain (Horizontal)	Modulus of Elasticity	Tension Parallel to Grain	Compression Parallel to Grain	Modulus of Elasticity	Specific Gravity for Fastener Design
	Tension Zone Stressed in Tension (Positive Bending)	Compression Zone Stressed in Tension (Negative Bending)											
Stress Class	F_{bx}^{+} (psi)	F_{bx}^{-} (1) (psi)	$F_{c\perp x}$ (psi)	F_{vx} (4) (psi)	E_x (10^6 psi)	F_{by} (psi)	$F_{c\perp y}$ (psi)	F_{vy} (5) (psi)	E_y (10^6 psi)	F_t (psi)	F_c (psi)	E_{axial} (10^6 psi)	G
16F-1.3E	1600	925	315	195	1.3	800	315	170	1.1	675	925	1.2	0.42
20F-1.5E	2000	1100	425	210 (6)	1.5	800	315	185	1.2	725	925	1.3	0.42
24F-1.7E	2400	1450	500	210 (6)	1.7	1050	315	185	1.3	775	1000	1.4	0.42
24F-1.8E	2400	1450 (2)	650	265 (3)	1.8	1450	560	230 (3)	1.6	1100	1600	1.7	0.50 (10)
26F-1.9E (7)	2600	1950	650	265 (3)	1.9	1600	560	230 (3)	1.6	1150	1600	1.7	0.50 (10)
28F-2.1E SP (7)	2800	2300	~~740~~ 805	300	2.1 (9)	1600	650	260	1.7	1250	1750	1.7	0.55
30F-2.1E SP (7)(8)	3000	2400	~~740~~ 805	300	2.1 (9)	1750	650	260	1.7	1250	1750	1.7	0.55

(1) For balanced layups, F_{bx}^{-} shall be equal to F_{bx}^{+} for the stress class. Designer shall specify when balanced layup is required.

(2) Negative bending stress, F_{bx}^{-}, is permitted to be increased to 1850 psi for Douglas Fir and to 1950 psi for Southern Pine for specific combinations. Designer shall specify when these increased stresses are required.

(3) For structural glued laminated timber of **Southern Pine**, the basic shear design values, F_{vx} and F_{vy}, are permitted to be increased to **300 psi**, and **260 psi**, respectively.

(4) The design value for shear, F_{vx}, shall be decreased by multiplying by a factor of 0.72 for non-prismatic members, notched members, and for all members subject to impact or cyclic loading. The reduced design value shall be used for design of members at connections that transfer shear by mechanical fasteners. The reduced design value shall also be used for determination of design values for radial tension and torsion.

(5) Design values are for timbers with laminations made from a single piece of lumber across the width or multiple pieces that have been edge bonded. For timbers manufactured from multiple piece laminations (across width) that are not edge bonded, value shall be multiplied by 0.4 for members with 5, 7, or 9 laminations or by 0.5 for all other members. This reduction shall be cumulative with the adjustment in footnote (4).

(6) Certain Southern Pine combinations may contain lumber with wane. If lumber with wane is used, the design value for shear parallel to grain, F_{vx}, shall be multiplied by 0.67 if wane is allowed on both sides. If wane is limited to one side, F_{vx} shall be multiplied by 0.83. This reduction shall be cumulative with the adjustment in footnote (4).

(7) 26F, 28F, and 30F beams are not produced by all manufacturers, therefore, availability may be limited. Contact supplier or manufacturer for details.

(8) 30F combinations are restricted to a maximum 6 in. nominal width.

(9) For 28F and 30F members with more than 15 laminations, E_x = 2.0 million psi.

(10) For structural glued laminated timber of Southern Pine, specific gravity for fastener design is permitted to be increased to 0.55.

Design values in this table represent design values for groups of similar glued laminated timber combinations. Higher design values for some properties may be obtained by specifying a particular combination listed in ~~Appendix~~ Annex A. Design values are for members with 4 or more laminations. For 2 and 3 lamination members, see Table 8.2. Some stress classes are not available in all species. Contact manufacturer for availability.

Table 8.2 Design Values for Structural Glued Laminated Softwood Timber

(Members stressed primarily in axial tension or compression) (Tabulated design values are for normal load duration and dry service conditions. See Section 3 for a comprehensive description of design value adjustment factors.)

			All Loading		Axially Loaded			Bending about Y-Y Axis Loaded Parallel to Wide Faces of Laminations				Bending About X-X Axis Loaded Perpendicular to Wide Faces of Laminations	
					Tension Parallel to Grain	Compression Parallel to Grain		Bending			Shear Parallel to Grain[1][2]	Bending[4]	Shear Parallel to Grain[3]
Identification Number	Species	Grade	Modulus of Elasticity **E** (10^6 psi)	Compression Perpendicular to Grain $F_{c\perp}$ (psi)	2 or More Laminations F_t (psi)	4 or More Laminations F_c (psi)	2 or 3 Laminations F_c (psi)	4 or More Laminations F_{by} (psi)	3 Laminations F_{by} (psi)	2 Laminations F_{by} (psi)	F_{vy} (psi)	2 Laminations to 15 in. Deep[5] F_{bx} (psi)	F_{vx} (psi)
Visually Graded Western Species													
1	DF	L3	1.5	560	900	1550	1200	1450	1250	1000	230	1250	265
2	DF	L2	1.6	560	1250	1950	1600	1800	1600	1300	230	1700	265
3	DF	L2D	1.9	650	1450	2300	1850	2100	1850	1550	230	2000	265
5	DF	L1D	2.0	650	1600	2400	2100	2400	2100	1800	230	2200	265
22[6]	SW	L3	1.0	315	525	850	675	800	700	550	170	725	195
70	AC	L2	1.3	470	975	1450	1450	1400	1250	1000	230	1350	265
Visually Graded Southern Pine													
47	SP	N2M14	1.4	650	1200	1900	1150	1750	1550	1300	260	1400	300
48	SP	N2D14	1.7	740	1400	2200	1350	2000	1800	1500	260	1600	300
49	SP	N1M16	1.7	650	1350	2100	1450	1950	1750	1500	260	1800	300
50	SP	N1D14	1.9	740	1550	2300	1700	2300	2100	1750	260	2100	300

Footnotes to Table A2:

(1) For members with 2 or 3 laminations, the shear design value for transverse loads parallel to the wide faces of the laminations, F_{vy}, shall be reduced by multiplying by a factor of 0.84 or 0.95, respectively.

(2) The shear design value for transverse loads applied parallel to the wide faces of the laminations, F_{vy}, shall be multiplied by 0.4 for members with 5, 7, or 9 laminations manufactured from multiple piece laminations (across width) that are not edge bonded. The shear design value, F_{vy}, shall be multiplied by 0.5 for all other members manufactured from multiple piece laminations with unbonded edge joints. This reduction shall be cumulative with the adjustment in footnote (1).

(3) The design value for shear, F_{vx}, shall be decreased by multiplying by a factor of 0.72 for non-prismatic members, notched members, and for all members subject to impact or cyclic loading. The reduced design value shall be used for design of members at connections that transfer shear by mechanical fasteners. The reduced design value shall also be used for determination of design values for radial tension and torsion.

(4) Tabulated design values are for timbers without special tension laminations. If special tension laminations are used, the design value for bending, F_{bx}, shall be permitted to be increased by multiplying by 1.18. This factor shall not be applied cumulatively with the adjustment in footnote (5).

(5) For members greater than 15 in. deep and without special tension laminations, the bending design value, F_{bx}, shall be reduced by multiplying by a factor of 0.88. This factor shall not be applied cumulatively with the adjustment in footnote (4).

(6) When Western Cedars, Western Cedars (North), Western Woods, and Redwood (open grain) are used in combinations for Softwood Species (SW), the design value for modulus of elasticity shall be reduced by 100,000 psi. When Coast Sitka Spruce, Coast Species, Western White Pine, and Eastern White Pine are used in combinations for Softwood Species (SW) tabulated design values for shear parallel to grain, F_{vx} and F_{vy}, shall be reduced by 10 psi, before applying any other adjustments.

Table 8.3 - Design Values for Structural Glued Laminated Softwood Timber with Taper Cuts on Compression Face [1]

Stress Class	F_{bx}^{+} (psi)	E_x (psi)	$F_{c\perp x\ Top}$ (psi)
16F-1.3E	1050	1.2	315
20F-1.5E	1250	1.4	375
24F-1.7E	1250	1.4	375
24F-1.8E	2000	1.7	560
26F-1.9E	2000	1.7	560
28F-2.1E	2400	1.9	650
30F-2.1E	2400	1.9	650

(1) Design values are applicable to beams that have up to 2/3 of the depth on the compression side removed by taper cutting.

II. Manufacturing Requirements

1. General

Manufacture of structural glued laminated timber shall be in accordance with ANSI/AITC A190.1, *Structural Glued Laminated Timber* (1). These specifications outline specific manufacturing and layup requirements for the manufacture of structural glued laminated timber made from approved combinations of lumber grades or single grades of lumber.

1.1 Combinations

These specifications are applicable to layups with the grades and number of laminations as indicated in Tables B1 and B2 in Annex B. Other combinations of grades and species are permitted to be used provided their design values are determined following procedures allowed in ANSI/AITC A190.1 and outlined in these specifications in section *III. Alternate Layup Requirements*. Combinations other than those shown herein shall be approved by AITC prior to production.

1.2 Stress Classes

To simplify specification and allow for flexibility of manufacture, combinations that have similar design values have been grouped into stress classes. Section 1.2, “Stress Classes” under *I. Design Requirements* in these specifications contains further discussion of stress classes, and Section 11 “Marking” discusses stress class marking requirements.

2. Lumber

Lumber shall be either visually graded or E-rated as required for the laminating combinations. Structural laminating lumber shall be graded on the basis of the dressed size of the lumber. The knot sizes for structural laminating grades of Western species are based on a fraction of the dressed width of the piece of lumber. The knot sizes for structural joists and planks and structural light framing grades of all species are tabulated in applicable grading rules and the *AITC Grading Handbook* (15) on the basis of the nominal width.

2.1 Ripping Lumber

When lumber is ripped or re-sawn, it shall be graded on the basis of the size of each finished piece, not the full width of the lumber.

This requirement shall also apply to beams that are ripped after laminating. Plant quality control systems shall qualify and document an approved process for grading lumber for these “splitter” beams.

Where the finished width of the laminated timber is less than 85% of the dressed width of the lumber used for the laminations, the lumber shall be graded on the basis of the next smaller nominal width.

2.2 Grades and Lumber Requirements

AITC Grading Handbook for Laminating Lumber (15) summarizes the complete requirements for laminating grades of approved species and references approved grading rules. This handbook is included herein as Annex C.

2.3 Species Groups

Structural glued laminated timber production is separated into two general species groups-Western Species (WS) and Southern Pine (SP). The Western Species group is further subdivided into several species groups. These are Alaska Cedar (AC), Douglas Fir-Larch (DF), Douglas Fir South (DFS), Eastern Spruce (ES), Hem-Fir (HF), Softwood Species (SW), and Spruce Pine Fir (SPF).

Note: Softwood Species (SW) and Eastern Spruce (ES) are included under the general category of Western Species although Eastern Spruce and some Softwood Species are produced in other areas.
Southern Pine is made up of only one species group.

The softwood species groups used for laminating and the species in those groups that are included in these specifications are shown in Table 2.3.

Table 2.3. *Individual species included in species groups.*

Species Group	Symbol	Species that may be included in the group	Grading rules agency
Alaska Cedar	AC	Alaska Cedar,	WCLIB, WWPA
Redwood	CR	Redwood	RIS
Canadian Spruce Pine	CSP		NLGA
Douglas Fir-Larch	DF-L	Douglas Fir, Western Larch	WCLIB, WWPA
Douglas Fir South	DFS	Douglas Fir South	WWPA
Eastern Spruce	ES	Black Spruce, Red Spruce White Spruce	NELMA, NSLB
Hem-Fir	HF	California Red Fir, Grand Fir, Noble Fir, Pacific Silver Fir, Western Hemlock, White Fir	WCLIB, WWPA
Softwood Species (Western Woods plus others)	SW	Alpine Fir, Balsam Fir, Black Spruce, Douglas Fir, Douglas Fir South, Engelmann Spruce, Idaho White Pine, Jack Pine, Lodgepole Pine, Mountain Hemlock, Ponderosa Pine, Sugar Pine, Red Spruce, Western Larch, Western Red Cedar, White Spruce	WCLIB, WWPA
Southern Pine	SP	Loblolly Pine, Longleaf Pine, Shortleaf Pine, Slash Pine	SPIB
Spruce - Pine - Fir (South)	SPF	Balsam Fir, Black Spruce, Engelmann Spruce, Jack Pine, Lodgepole Pine, Red Spruce, White Spruce	NELMA, NSLB, WCLIB, WWPA

2.4 Substitutions

Lumber of higher grades of the same species is permitted to be substituted in all layups with some restrictions. Visually graded lumber shall not be permitted to be substituted for E-rated lumber. Substitutions of E-rated lumber grades for visual grades of lumber shall be approved by AITC Technical Services prior to making the substitution.

3. Adhesives

Adhesives shall comply with ANSI/AITC A190.1, and shall be qualified prior to use within a manufacturing facility. Qualification requirements are outlined in ANSI/AITC A190.1, and thoroughly defined in AITC 200, *Inspection Manual* (16) and AITC 405, *Standard for New Wet-Use Structural Adhesive Types* (17).

4. End Joints

4.1 General

End joints in glued laminated timber combinations are permitted to be plane scarf joints, finger joints or other types that are qualified in accordance with ANSI/AITC A190.1.

4.2 End Joint Qualification Stress Levels

End joints for laminations in the outer tension zone shall be qualified at a stress level equal to or greater than the combination nominal bending stress level. The QSL shall be determined according to ANSI/AITC A190.1.

5. Laminations

Individual laminations shall not exceed two inches in net thickness, except when gap-filling adhesives are used. Lamination dimensions shall be within the tolerances specified in ANSI/AITC A190.1.

6. Dimensions and Shapes

ANSI/AITC A190.1 permits the use of any width or depth of structural glued laminated timber. The use of standard finished sizes constitutes recommended practice to the extent that other considerations will permit. Shape shall be as agreed upon by buyer and seller.

6.1 Sizes

6.1.1 Custom Members

The depth and width of custom members shall be as agreed upon by buyer and seller. All structural glued laminated timber members shall be furnished in accordance with the width, depth, length, and other fabrications required by the design. Member dimensions shall be within the tolerances specified in ANSI/AITC A190.1.
The laminator is permitted to use different thicknesses of lumber to develop the specified depth provided the volume of the higher grades of lumber equals or exceeds that required by section 7.1.1.

6.1.2 Non-custom Members

While custom dimensions are always permitted for structural glued laminated timber members(as agreed upon by the buyer and seller), standard dimensions for non-custom members have been developed for ease of specifying as well as consistency of manufacture. These dimensions are fully described in AITC 113-01, *Standard for Dimensions of Structural Glued Laminated Timber* (18). Tolerances for these dimensions shall be as defined in ANSI/AITC A190.1.

6.2 Shapes

6.2.1 Custom Members

Structural glued laminated timber members shall be furnished in accordance with the cross section shape required by the design. Members shall also conform to the requirements for straight, tapered, cambered or curved form as required by the design. Measurement for squareness for those members with a rectangular cross section shall be made as outlined in 6.2.2.

6.2.2 Non-custom Members

Unless specifically agreed upon by both the buyer and seller, non-custom members shall be rectangular in cross section. Tolerances for squareness of rectangular cross sections shall be as defined in ANSI/AITC A190.1. Measurement shall be made by placing one side of a square along a top or bottom face and determining the offset from the other side of the square to the side of the member.

6.3 Radius of Curvature

The ability to bend laminations to curved shape is dependent upon many factors relating to both wood properties and manufacturing techniques. Two prime considerations are thickness of laminations (t) and bending radius (R). The t/R ratio shall not exceed 1/100 for Southern Pine or 1/125 for other softwoods, where t is the actual lamination thickness and R is the radius of curvature.

7. Layup of Members

7.1 Combinations

7.1.1 Determining Number of Laminations

The number of laminations to use in each zone in the layup shall be based on the percentage shown in Annex B, Tables B1 and B2. Percent values shall be applied to the total depth of the member. When the determined number of laminations results in a fractional number, the fractional number of laminations shall be rounded upward to the next whole number. For the inner tension and compression zones, the resulting excess of percentage resulting from rounding upward of the outer zone is permitted to be subtracted from the next inner zone requirements.

Where more than one thickness is used within a member and those lamination thicknesses vary by more than 3/16 in., the total thickness of each grade of lumber required in the inner and outer tension and compression zones shall be determined by using the thickest lamination in the member as the basic lamination thickness.

Example: When the thickest lamination used is 1-3/8 in. and 1.6 in. of L1 grade is required in a zone (based on multiplying the percentage required for that zone in the table by the depth of the member in inches), then a total thickness of at least 2-3/4 in. of L1 grade is required in that zone. In no case shall the special tension lamination requirements for bending members be less than 5 percent of the total depth of the member in inches.

For special tension laminations (5% of depth), the excess percentage resulting from rounding upward is permitted to be subtracted from the next inner zone.

Example: 10% L1 is required for the outer tension zone with special tension laminations. With a 20 lam beam, the 5% tension lam requirement is exactly one lamination. Then 5% is permitted to be subtracted from the L1 requirement leaving only 5% L1 left. One lamination fulfills this requirement.

7.1.2 Alternate Layups

Certain modifications of combinations are permitted. In certain combinations allowing the use of lumber with wane or coarse grain, higher design values are permitted for shear parallel to grain if these materials are excluded. Increased design values are permitted for compression perpendicular to grain when higher grades of lumber are substituted in the area loaded in bearing perpendicular to grain. Any such substitutions shall be clearly documented. Following are options that are permitted to be used based on alternate or modified combinations.

7.1.3 Grade Options

Substitution of laminations of the same species and of higher grades is permitted in accordance with section 2.4 under *II. Manufacturing Requirements* of these specifications. Full or partial length substitutions are permitted.

7.1.3.1 Wane

Certain combinations are permitted to contain wane. These combinations are for dry conditions of use only, except as allowed in ANSI/AITC A190.1. These combinations allow wane up to 1/6 the width of the member on each side of the member. When this is the case, the basic shear design value shall be reduced by 1/3. When wane is restricted to just one side of the member, the basic design shear value shall be reduced by 1/6. When wane material is used in these combinations, members shall be for industrial or framing appearance grades and for straight or cambered simple span members only.

When lumber with wane is excluded from these combinations, they are permitted to be used for curved members, wet-use conditions and all appearance grades. The shear value is also permitted to be the base shear value.

Selectively placed wane is permitted for use in glued laminated timber combinations without a corresponding reduction in shear design values based on the following set of rules. Combinations meeting these requirements are for dry conditions of use only, exept as allowed in ANSI/AITC A190.1.

1. Lumber with wane up to 1/6 of the finished member width and ½ of the lamination thickness shall be permitted on only one side of the member.
2. No wane shall be permitted within the central 40% of the depth of the cross section.
3. No wane shall be permitted in the outer laminations (top & bottom).
4. No wane shall be permitted in the 302 grade tension laminations.
5. No wane shall be permitted at the glue lines adjacent to the top or bottom laminations or at glue lines adjacent to 302 grade tension laminations.
6. Combinations utilizing wane shall be restricted to Framing or Industrial Appearance Grades.
7. Wane shall not be permitted at the interior edge joint of multi-piece laminations.
8. Combinations utilizing wane conforming to these rules shall be designated with a “W1” in the combination symbol (i.e. 24F-V1-W1). Appropriate stamps shall be obtained from AITC prior to production.
9. The preceding rules shall only apply to members of constant cross section. Wane shall not be permitted at any location in tapered members without a reduction of allowable shear stresses.

7.1.3.2 Coarse Grain Southern Pine

Where coarse grain Southern Pine is permitted in combinations, design values for shear parallel to grain (horizontal shear) are permitted to be increased by a factor of 1.43 if medium grain material is substituted for the coarse grain material.

7.2 Special Tension Laminations

7.2.1 General

In addition to the grade requirements tabulated for the outer tension zone, the grading requirements for 302 grade tension laminations shall be applicable to the outer 5 percent of the total depth of bending members. These tension lamination grade requirements are shown for each combination in the tables. For balanced combinations, 302 tension lamination requirements apply to both top and bottom of the bending member. Special tension laminations shall not be required for arches, compression members, or tension members.

7.2.2 Combinations without Special Tension Laminations

Combinations requiring special tension laminations are permitted to be manufactured without the special tension laminations provided the tabular design value for extreme fiber in bending about the x-x axis, F_{bx}, is multiplied by 0.75 for depths greater than 15 in. and 0.85 for depths less than or equal to 15 in. This reduction in tabular design values for bending does not apply to arches, compression and tension members, which do not require special tension laminations.

7.3 Tapered Members

Combination requirements, including 302 lamination requirements shall apply for every cross section along the entire length of a tapered member unless the shop drawings or instructions from the designer indicate otherwise.

7.4 Fire Resistive Construction

When bending members are specified to be one-hour fire resistive, they shall be manufactured to the same lay-up as tabulated except that a core lamination shall be removed, the tension zone moved inward and the equivalent of one additional nominal 2 in. thickness outer tension lamination added.

When bending members are specified to be one-and-one-half-hour or two-hour fire resistive, they shall be manufactured to the same lay-up as tabulated except that two (2) core laminations shall be removed, the tension zone moved inward and the equivalent of two (2) additional nominal 2 in. thickness outer tension laminations added.

Layups modified to meet these requirements shall be marked with “1-HOUR FIRE RATING” if one additional tension lamination is used or “2-HOUR FIRE RATING” if two additional tension laminations are used.

8. Radial Reinforcement

Installation of mechanical radial reinforcement shall be in accordance with AITC 404, *Standard for Radial Reinforcing Curved Glued Laminated Timber Members to Resist Radial Tension* (19).

8.1 Curved Beams

Mechanical radial reinforcement for curved beams, where required, shall be in accordance with the design drawings and/or shop details as approved by the designer.

8.2 Moisture Content

For dry conditions of use, the moisture content of the laminations prior to bonding shall not exceed 12% when mechanical radial reinforcement is used.

9. Appearance Grades

9.1 General

Appearance requirements shall be in accordance with ANSI/AITC A190.1 and AITC 110, *Standard Appearance Grades for Structural Glued Laminated Timber* (11) or as agreed upon by buyer and seller.

9.2 Special Surfacing

Special surfacing, such as rough saw texturing may reduce the cross section of a glulam. As size tolerances always apply to the finished product, over-sizing the glulam prior to final texturing may be required to meet size tolerances.

10. Inspection and Quality Control

The assurance that quality materials and workmanship are used in glulam members shall be vested in the day-to-day quality control operations of the manufacturing facility. The manufacturer's quality control system shall conform to ANSI/AITC A190.1 and AITC 200.

11. Marking

11.1 General

Marking of all structural glued laminated timber shall be in accordance with ANSI/AITC A190.1.

11.2 Orientation -- TOP Stamp

For custom members, straight or cambered bending members shall be stamped "TOP" on the top at both ends of the member according to ANSI/AITC A190.1. For non-custom members, the TOP stamp shall be on top of the member spaced at a maximum of 8 feet. Axially loaded members and bending members which are fabricated in such a manner that they cannot be installed upside down need not be marked with the TOP stamp. The stamp shall contain letters at least 2 in. in height.

11.3 Treated Members

For special marking requirements for preservatively treated members, see AITC 109, *Standard for Preservative Treatment of Structural Glued Laminated Timber*.

11.4 Special Design Properties

Whenever design properties for the layup differ from those tabulated in this Standard, the modified design values shall be stamped on the beam near enough to the AITC Quality Assurance mark so as to be obviously noticeable.

11.5 Urea

Members bonded with adhesive containing urea shall be stamped "Do not chemically treat" unless it meets the requirements of the exception to this rule described in ANSI/AITC A190.1.

12. Protection During Shipping and Field Handling

Sealers and wrapping shall be as specified. AITC 111 *Recommended Practice for Protection of Structural Glued Laminated Timber During Transit, Storage and Erection* (20) describes industry recommendations for protecting laminated timber members.

III. Alternate Layup Requirements

1. General

The development and use of alternate combinations allows for more efficient and innovative use of the lumber resource. Layups of structural glued laminated timber not listed in these specifications shall be permitted to be used provided the following provisions are met.

Alternate layups shall be approved by AITC prior to production. Alternate layups shall be given a unique designation following AITC protocols for assigning combination symbols or identification numbers. Manufacturing and design requirements from the previous sections shall apply.

2. Design Values

Design values for alternate layups shall be established by analysis in accordance with ASTM D3737 (4) or by full scale testing in accordance with ASTM D 198 (5) and analysis in accordance with ASTM D2915 (6) or ASTM D5457 (7). All design values shall be approved by AITC before use.

2.1. Design Values by Analysis Only

For combinations developed by analysis only, the design values shall be established according to ASTM D3737 (4). In addition, for horizontally laminated beams, the maximum outer fiber bending stress calculated according to transformed section analysis shall not exceed the nominal bending stress by more than 10% unless the end joints are qualified and maintained at a higher nominal stress level.

2.2. Design Values by Full-Scale Testing and Analysis

Design values shall be permitted to be established following the test procedures of ASTM D198 (5) and the analysis procedures of ASTM D2915 (6) or ASTM D5457 (7). Samples chosen for full scale testing shall be representative of production. Full scale beam tests shall be witnessed by a representative of AITC or a separate, independent party approved by AITC.

Design values for layups developed by testing and analysis at the expense of a single AITC member firm shall be proprietary to that member. Other members desiring to manufacture the same layup shall be required to perform similar full scale tests to justify the design values based on their production processes.

Design values developed by analysis in accordance with ASTM D3737, or by full scale testing and analysis at the expense of AITC, shall be made available for the use of all AITC licensed laminators upon request.

3. Quality Assurance

The production parameters and end joint QSL's from the initial qualification shall be the basis of the manufacturing facility's quality assurance requirements for alternate layups with design values established by full scale testing. Documentation of these requirements shall be maintained at the manufacturing facility and shall be available to AITC personnel.

4. Documentation

Documentation of the design values and layup requirements for alternate layups shall be maintained at AITC and at the manufacturing facility. This documentation shall be provided to the public by AITC upon request.

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Annex A

Expanded Design Value Tables for

Structural Glued Laminated Softwood Timber

Table A1 - Design Values for Structural Glued Laminated Softwood Timber Combinations [1]

(Members stressed primarily in bending) (Tabulated design values are for normal load duration and dry service conditions. See Section 3 for a comprehensive description of design value adjustment factors.)

		Bending About X-X Axis (Loaded Perpendicular to Wide Faces of Laminations)						Bending About Y-Y Axis (Loaded Parallel to Wide Faces of Laminations)				Axially Loaded			Fasteners	
		Extreme Fiber in Bending		Compression Perpendicular to Grain		Shear Parallel to Grain (Horizontal)	Modulus of Elasticity	Extreme Fiber in Bending	Compression Perpendicular to Grain	Shear Parallel to Grain (Horizontal)	Modulus of Elasticity	Tension Parallel to Grain	Compression Parallel to Grain	Modulus of Elasticity	Specific Gravity for Fastener Design	
		Tension Zone Stressed in Tension [2]	Compression Zone Stressed in Tension	Tension Face	Compression Face										Top or Bottom Face	Side Face
Combination Symbol	Species Outer/ Core	F_{bx}^{+} (psi)	F_{bx}^{-} (psi)	$F_{c\perp x}$ (psi)		F_{vx} [3] (psi)	E_x (10^6 psi)	F_{by} (psi)	$F_{c\perp y}$ (psi)	F_{vy} [4] (psi)	E_y (10^6 psi)	F_t (psi)	F_c (psi)	E_{axial} (10^6 psi)	G	
16F-1.3E		**1600**	**925**	**315**		**195**	**1.3**	**800**	**315**	**170**	**1.1**	**~~625~~ 675**	**~~725~~ 925**	**1.2**	**~~0.35~~ 0.42**	
16F-V3	DF/DF	1600	1150	560	560	265	1.5	1450	560	230	1.5	900	1450	1.6	0.5	0.5
16F-V6	DF/DF	1600	1600	560	560	265	1.5	1450	560	230	1.5	900	1550	1.6	0.5	0.5
16F-E2	HF/HF	1600	1050	375	375	215	1.3	1200	375	190	1.3	825	1200	1.4	0.43	0.43
16F-E3	DF/DF	1600	1200	560	560	215	1.6	1450	560	190	1.5	925	1600	1.6	0.5	0.5
16F-E6	DF/DF	1600	1600	560	560	265	1.6	1550	560	230	1.5	975	1600	1.6	0.5	0.5
16F-E7	HF/HF	1600	1600	375	375	215	1.4	1450	375	190	1.4	1000	1450	1.5	0.43	0.43
16F-V2	SP/SP	1600	1350	650	650	300	1.4	1450	650	260	1.4	975	1350	1.5	0.55	0.55
16F-V3	SP/SP	1600	1450	740	740	300	1.4	1450	650	260	1.4	925	1400	1.4	0.55	0.55
16F-V5	SP/SP	1600	1600	650	650	300	1.4	1750	650	260	1.4	1000	1500	1.5	0.55	0.55
16F-E1	SP/SP	1600	1250	650	650	300	1.6	1750	650	260	1.5	1050	1550	1.6	0.55	0.55
16F-E3	SP/SP	1600	1600	650	650	300	1.6	1750	650	260	1.5	1100	1600	1.6	0.55	0.55
20F-1.5E		**2000**	**1100**	**425**		**210**	**1.5**	**800**	**315**	**185**	**1.2**	**725**	**925**	**1.3**	**~~0.41~~ 0.42**	
20F-V3	DF/DF	2000	1450	650	560	265	1.6	1450	560	230	1.5	975	1550	1.6	0.5	0.5
20F-V7	DF/DF	2000	2000	650	650	265	1.6	1450	560	230	1.6	1000	1600	1.6	0.5	0.5
20F-V9	HF/HF	2000	2000	500	500	215	1.5	1350	375	190	1.4	975	1400	1.5	0.43	0.43
20F-V12	AC/AC	2000	1400	560	560	265	1.5	1250	470	230	1.4	900	1500	1.4	0.46	0.46
20F-V13	AC/AC	2000	2000	560	560	265	1.5	1250	470	230	1.4	925	1550	1.5	0.46	0.46
20F-E2	HF/HF	2000	1400	500	500	215	1.6	1200	375	190	1.4	925	1350	1.5	0.43	0.43
20F-E3	DF/DF	2000	1200	560	560	265	1.7	1450	560	230	1.6	1000	1600	1.7	0.5	0.5
20F-E6	DF/DF	2000	2000	560	560	265	1.7	1550	560	230	1.6	1100	1650	1.7	0.5	0.5
20F-E7	HF/HF	2000	2000	500	500	215	1.6	1450	375	190	1.4	1050	1450	1.5	0.43	0.43
20F-V2	SP/SP	2000	1550	740	650	300	1.5	1450	650	260	1.4	975	1350	1.5	0.55	0.55
20F-V3	SP/SP	2000	1450	650	650	300	1.5	1750	650	260	1.4	1050	1400	1.5	0.55	0.55
20F-V5	SP/SP	2000	2000	740	740	300	1.6	1450	650	260	1.4	1050	1500	1.5	0.55	0.55
20F-E1	SP/SP	2000	1250	650	650	300	1.7	1750	650	260	1.5	1050	1550	1.6	0.55	0.55
20F-E3	SP/SP	2000	2000	650	650	300	1.7	1900	650	260	1.5	1150	1650	1.6	0.55	0.55
24F-1.7E		**2400**	**1450**	**500**		**210**	**1.7**	**1050**	**~~375~~ 315**	**185**	**1.3**	**775**	**1000**	**1.4**	**~~0.43~~ 0.42**	
24F-V5	DF/HF	2400	1600	650	650	215	1.7	1200	375	190	1.5	1150	1450	1.6	0.5	0.43
24F-V10	DF/HF	2400	2400	650	650	215	1.8	1450	375	190	1.5	1100	1550	1.6	0.5	0.43
24F-E11	HF/HF	2400	2400	500	500	215	1.8	1550	375	190	1.5	1150	1550	1.6	0.43	0.43
24F-E15	HF/HF	2400	1600	500	500	215	1.8	1200	375	190	1.5	975	1500	1.6	0.43	0.43
24F-V1	SP/SP	2400	1750	740	650	300	1.7	1450	650	260	1.5	1100	1550	1.6	0.55	0.55
24F-V4 [5]	SP/SP	2400	1450	740	650	210	1.7	1050	470	185	1.3	875	1000	1.5	0.55	0.43
24F-V5	SP/SP	2400	2400	740	740	300	1.7	1750	650	260	1.5	1150	1650	1.6	0.55	0.55

Table A1 - Design Values for Structural Glued Laminated Softwood Timber Combinations [1]

(Members stressed primarily in bending) (Tabulated design values are for normal load duration and dry service conditions. See Section 3 for a comprehensive description of design value adjustment factors.)

		Bending About X-X Axis (Loaded Perpendicular to Wide Faces of Laminations)						**Bending About Y-Y Axis** (Loaded Parallel to Wide Faces of Laminations)				**Axially Loaded**			**Fasteners**	
		Extreme Fiber in Bending		Compression Perpendicular to Grain		Shear Parallel to Grain (Horizontal)	Modulus of Elasticity	Extreme Fiber in Bending	Compression Perpendicular to Grain	Shear Parallel to Grain (Horizontal)	Modulus of Elasticity	Tension Parallel to Grain	Compression Parallel to Grain	Modulus of Elasticity	Specific Gravity for Fastener Design	
		Tension Zone Stressed in Tension [2]	Compression Zone Stressed in Tension	Tension Face	Compression Face										Top or Bottom Face	Side Face
Combination Symbol	Species Outer/ Core	F_{bx}^{+} (psi)	F_{bx}^{-} (psi)	$F_{c\perp x}$ (psi)		F_{vx} [3] (psi)	E_x (10^6 psi)	F_{by} (psi)	$F_{c\perp y}$ (psi)	F_{vy} [4] (psi)	E_y (10^6 psi)	F_t (psi)	F_c (psi)	E_{axial} (10^6 psi)	G	
24F-1.8E		**2400**	**1450**	**650**		~~190~~ 265	**1.8**	**1450**	**560**	**230**	**1.6**	**1100**	**1600**	**1.7**	**0.5**	
24F-V4	DF/DF	2400	1850	650	650	265	1.8	1450	560	230	1.6	1100	1650	1.7	0.5	0.5
24F-V8	DF/DF	2400	2400	650	650	265	1.8	1450	560	230	1.6	1100	1650	1.7	0.5	0.5
24F-E4	DF/DF	2400	1450	650	650	265	1.8	1450	560	230	1.7	1100	1700	1.8	0.5	0.5
24F-E13	DF/DF	2400	2400	650	650	265	1.8	1750	560	230	1.7	1200	1700	1.8	0.5	0.5
24F-E18	DF/DF	2400	2400	650	650	265	1.9	1550	560	230	1.7	1100	1700	1.8	0.5	0.5
24F-V3	SP/SP	2400	1950	740	740	300	1.8	1750	650	260	1.6	1150	1650	1.7	0.55	0.55
24F-E1	SP/SP	2400	1450	~~740~~ 805	650	300	1.8	1750	650	260	1.6	1100	1600	1.7	0.55	0.55
24F-E4	SP/SP	2400	2400	~~740~~ 805	~~740~~ 805	300	1.9	2200	650	260	1.7	1450	1850	1.8	0.55	0.55
26F-1.9E [8]		**2600**	**1950**	**650**		**265**	**1.9**	**1600**	**560**	**230**	**1.6**	**1150**	**1600**	**1.7**	**0.5**	
26F-V1	DF/DF	2600	1950	650	650	265	2.0	1750	560	230	1.8	1300	1850	1.9	0.5	0.5
26F-V2	DF/DF	2600	2600	650	650	265	2.0	1750	560	230	1.8	1300	1850	1.9	0.5	0.5
26F-V1	SP/SP	2600	1950	740	740	300	1.8	1900	650	260	1.6	1150	1600	1.7	0.55	0.55
26F-V2	SP/SP	2600	2100	740	740	300	1.9	2200	740	260	1.8	1250	1650	1.9	0.55	0.55
26F-V3	SP/SP	2600	2100	740	740	300	1.9	2100	650	260	1.8	1200	1600	1.9	0.55	0.55
26F-V4	SP/SP	2600	2600	740	740	300	1.9	2100	650	260	1.8	1200	1600	1.9	0.55	0.55
28F-2.1E SP [8]		**2800**	**2300**	~~740~~ 805		**300**	**2.1 [10]**	**1600**	**650**	**260**	**1.7**	~~1300~~ 1250	~~1850~~ 1750	**1.7**	**0.55**	
28F-E1	SP/SP	2800	2300	~~740~~ 805	~~740~~ 805	300	2.1 [10]	1600	650	260	1.7	1300	1850	1.7	0.55	0.55
28F-E2	SP/SP	2800	2800	~~740~~ 805	~~740~~ 805	300	2.1 [10]	2000	650	260	1.7	1300	1850	1.7	0.55	0.55
30F-2.1E SP [8][9]		**3000**	**2400**	~~740~~ 805		**300**	**2.1 [10]**	**1750**	**650**	**260**	**1.7**	**1250**	**1750**	**1.7**	**0.55**	
30F-E1	SP/SP	3000	2400	~~740~~ 805	~~740~~ 805	300	2.1 [10]	1750	650	260	1.7	1250	1750	1.7	0.55	0.55
30F-E2	SP/SP	3000	3000	~~740~~ 805	~~740~~ 805	300	2.1 [10]	1750	650	260	1.7	1350	1750	1.7	0.55	0.55

Footnotes to Table A1:

1 The combinations in this table are applicable to members consisting of 4 or more laminations and are intended primarily for members stressed in bending due to loads applied perpendicular to the wide faces of the laminations. However, design values are tabulated for loading both perpendicular and parallel to the wide faces of the laminations. For combinations and design values applicable to members loaded primarily axially or parallel to the wide faces of the laminations, see Table A2. For members of 2 or 3 laminations, see Table A2.

2 The tabulated design values in this column, for bending about the X-X axis (F_{bx}), require the use of special tension laminations. If these special tension laminations are omitted, value shall be multiplied by 0.75 for members greater than or equal to 15 in. in depth or by 0.85 for members less than 15 in. in depth.

3 The design value for shear, F_{vx}, shall be decreased by multiplying by a factor of 0.72 for non-prismatic members, notched members, and for all members subject to impact or cyclic loading. The reduced design value shall be used for design of members at connections that transfer shear by mechanical fasteners. The reduced design value shall also be used for detrmination of design values for radial tension and torsion.

4 Design values are for timbers with laminations made from a single piece of lumber across the width or multiple pieces that have been edge bonded. For timber manufactured from multiple piece laminations (across width) that are not edge-bonded, value shall be multiplied by 0.4 for members with 5, 7, or 9 laminations or by 0.5 for all other members. This reduction shall be cumulative with the adjustment in footnote 3.

5 This combination may contain lumber with wane. If lumber with wane is used, the design value for shear parallel to grain, $F_{VX,}$ shall be multiplied by 0.67 if wane is allowed on both sides. If wane is limited to one side, F_{vx} shall be multiplied by 0.83. This reduction shall be cumulative with the adjustment in footnote 3.

8 26F, 28F, and 30F beams are not produced by all manufacturers, therefore, availability may be limited. Contact supplier or manufacturer for details.

9 30F combinations are restricted to a maximum 6 in. nominal width.

10 For 28F and 30F members with more than 15 laminations, E_x = 2.0 million psi.

Table A2 Design Values for Structural Glued Laminated Softwood Timber

(Members stressed primarily in axial tension or compression) (Tabulated design values are for normal load duration and dry service conditions. See Section 3 for a comprehensive description of design value adjustment factors.)

			All Loading		Axially Loaded			Bending about Y-Y Axis Loaded Parallel to Wide Faces of Laminations				Bending about X-X Axis Loaded Perpendicular to Wide Faces of Laminations	
					Tension Parallel to Grain	Compression Parallel to Grain		Bending			Shear Parallel to Grain[1][2]	Bending[4]	Shear Parallel to Grain[3]
Identification Number	Species	Grade	Modulus of Elasticity **E** (10^6 psi)	Compression Perpendicular to Grain $F_{c\perp}$ (psi)	2 or More Laminations F_t (psi)	4 or More Laminations F_c (psi)	2 or 3 Laminations F_c (psi)	4 or More Laminations F_{by} (psi)	3 Laminations F_{by} (psi)	2 Laminations F_{by} (psi)	F_{vy} (psi)	2 Laminations to 15 in. Deep[5] F_{bx} (psi)	F_{vx} (psi)
Visually Graded Western Species													
1	DF	L3	1.5	560	900	1550	1200	1450	1250	1000	230	1250	265
2	DF	L2	1.6	560	1250	1950	1600	1800	1600	1300	230	1700	265
3	DF	L2D	1.9	650	1450	2300	1850	2100	1850	1550	230	2000	265
4	DF	L1CL	1.9	590	1400	2100	1900	2200	2000	1650	230	1900	265
5	DF	L1D	2.0	650	1600	2400	2100	2400	2100	1800	230	2200	265
14	HF	L3	1.3	375	800	1100	975	1200	1050	850	190	1100	215
15	HF	L2	1.4	375	1050	1350	1300	1500	1350	1100	190	1450	215
16	HF	L1	1.6	375	1200	1500	1450	1750	1550	1300	190	1600	215
17	HF	L1D	1.7	500	1400	1750	1700	2000	1850	1550	190	1900	215
22[6]	SW	L3	1.0	315	525	850	675	800	700	550	170	725	195
69	AC	L3	1.2	470	725	1150	1100	1100	975	775	230	1000	265
70	AC	L2	1.3	470	975	1450	1450	1400	1250	1000	230	1350	265
71	AC	L1D	1.6	560	1250	1900	1900	1850	1650	1400	230	1700	265
72	AC	L1S	1.6	560	1250	1900	1900	1850	1650	1400	230	1900	265
E-Rated Western Species													
27	DF	1.9E2	1.8	560	900	1750	1200	1450	1250	1000	230	1250	265
28	DF	2.1E2	2.0	650	1100	2000	1400	1650	1450	1150	230	1500	265
29	DF	2.3E2	2.2	650	1250	2250	1550	1900	1650	1350	230	1700	265
30	DF	1.9E6	1.8	560	1550	2100	1700	2400	2400	2100	230	1800	265
31	DF	2.1E6	2.0	650	1800	2400	1950	2400	2400	2400	230	2100	265
32	DF	2.3E6	2.2	650	1800	2400	2200	2400	2400	2400	230	2400	265
62	DF	2.2E2	2.1	650	1150	1850	1500	1800	1550	1250	230	1800	265
63	DF	2.2E6	2.1	650	1950	2300	2000	2400	2400	2400	230	2200	265
33	HF	1.6E2	1.5	375	800	1050	950	1200	1050	850	190	1100	215
34	HF	1.9E2	1.8	500	900	1500	1200	1450	1250	1000	190	1300	215
35	HF	2.1E2	2.0	500	1100	1550	1400	1650	1450	1150	190	1850	215
36	HF	1.6E4	1.5	375	1200	1450	1350	2100	1900	1700	190	1400	215
37	HF	1.9E6	1.8	500	1550	1950	1700	2400	2400	2100	190	1800	215
38	HF	2.1E6	2.0	500	1800	2400	1950	2400	2400	2400	190	2100	215
39[6]	SW	1.6E2	1.5	315	800	1200	950	1200	1050	850	170	1100	195
40[6]	SW	1.9E2	1.8	315	900	1500	1200	1450	1250	1000	170	1250	195
41[6]	SW	2.1E2	2.0	315	1100	1750	1400	1650	1450	1150	170	1550	195
42[6]	SW	1.6E4	1.5	315	1200	1550	1350	2100	1900	1700	170	1400	195
43[6]	SW	1.9E6	1.8	315	1550	1950	1700	2400	2400	2100	170	1800	195
44[6]	SW	2.1E6	2.0	315	1800	2100	1950	2400	2400	2400	170	2100	195
Visually Graded Southern Pine													
47	SP	N2M14	1.4	650	1200	1900	1150	1750	1550	1300	260	1400	300
47 1:10	SP	N2M10	1.4	650	1150	1700	1150	1750	1550	1300	260	1400	300
47 1:8	SP	N2M	1.4	650	1000	1500	1150	1600	1550	1300	260	1350	300
48	SP	N2D14	1.7	740	1400	2200	1350	2000	1800	1500	260	1600	300
48 1:10	SP	N2D10	1.7	740	1350	2000	1350	2000	1800	1500	260	1600	300
48 1:8	SP	N2D	1.7	740	1150	1750	1350	1850	1800	1500	260	1600	300
49	SP	N1M16	1.7	650	1350	2100	1450	1950	1750	1500	260	1800	300
49 1:12	SP	N1M12	1.7	650	1300	1900	1450	1950	1750	1500	260	1750	300
49 1:10	SP	N1M	1.7	650	1150	1700	1450	1850	1750	1500	260	1550	300
50	SP	N1D14	1.9	740	1550	2300	1700	2300	2100	1750	260	2100	300
50 1:12	SP	N1D12	1.9	740	1550	2200	1700	2300	2100	1750	260	2100	300
50 1:10	SP	N1D	1.9	740	1350	2000	1700	2100	2100	1750	260	1800	300
E-Rated Southern Pine													
54	SP	2.1E2	2.0	~~740~~ 805	1100	2300	1400	1650	1450	1150	260	1500	300
55	SP	2.3E2	2.2	~~740~~ 805	1250	2400	1550	1900	1650	1350	260	1700	300
56	SP	1.9E6	1.8	650	1550	1850	1700	2400	2400	2100	260	1800	300
57	SP	2.1E6	2.0	~~740~~ 805	1800	2300	1950	2400	2400	2400	260	2100	300
58	SP	2.3E6	2.2	~~740~~ 805	1800	2400	2200	2400	2400	2400	260	2400	300

Footnotes to Table A2:

(1) For members with 2 or 3 laminations, the shear design value for transverse loads parallel to the wide faces of the laminations, F_{vy}, shall be reduced by multiplying by a factor of 0.84 or 0.95, respectively.

(2) The shear design value for transverse loads applied parallel to the wide faces of the laminations, F_{vy}, shall be multiplied by 0.4 for members with 5, 7, or 9 laminations manufactured from multiple piece laminations (across width) that are not edge bonded. The shear design value, F_{vy}, shall be multiplied by 0.5 for all other members manufactured from multiple piece laminations with unbonded edge joints. This reduction shall be cumulative with the adjustment in footnote (1).

(3) The design value for shear, F_{vx}, shall be decreased by multiplying by a factor of 0.72 for non-prismatic members, notched members, and for all members subject to impact or cyclic loading. The reduced design value shall be used for design of members at connections that transfer shear by mechanical fasteners. The reduced design value shall also be used for determination of design values for radial tension and torsion.

(4) Tabulated design values are for timbers without special tension laminations. If special tension laminations are used, the design value for bending, F_{bx}, shall be permitted to be increased by multiplying by 1.18. This factor shall not be applied cumulatively with the adjustment in footnote (5).

(5) For members greater than 15 in. deep and without special tension laminations, the bending design value, F_{bx}, shall be reduced by multiplying by a factor of 0.88. This factor shall not be applied cumulatively with the adjustment in footnote (4).

(6) When Western Cedars, Western Cedars (North), Western Woods, and Redwood (open grain) are used in combinations for Softwood Species (SW), the design value for modulus of elasticity shall be reduced by 100,000 psi. When Coast Sitka Spruce, Coast Species, Western White Pine, and Eastern White Pine are used in combinations for Softwood Species (SW) tabulated design values for shear parallel to grain, F_{vx} and F_{vy}, shall be reduced by 10 psi, before applying any other adjustments.

Table A3 - Design Values for Structural Glued Laminated Softwood Timber Combinations with Taper Cuts on the Compression Face [1]

Combination Symbol	Species Outer/ Core	F_{bx}^{+} (psi)	E_x (psi)	$F_{c\perp x\ Top}$ (psi)
16F-1.3E		**1050**	**1.2**	**315**
16F-V3	DF/DF	1500	1.5	560
16F-V6	DF/DF	1500	1.5	560
16F-E2	HF/HF	1350	1.4	375
16F-E3	DF/DF	1650	1.6	560
16F-E6	DF/DF	1900	1.6	560
16F-E7	HF/HF	1350	1.4	375
16F-V2	SP/SP	1450	1.5	650
16F-V3	SP/SP	1550	1.4	650
16F-V5	SP/SP	1550	1.5	650
16F-E1	SP/SP	1850	1.6	650
16F-E3	SP/SP	1950	1.6	650
20F-1.5E		**1250**	**1.4**	**375**
20F-V3	DF/DF	1900	1.6	560
20F-V7	DF/DF	1900	1.6	560
20F-V9	HF/HF	1650	1.5	375
20F-V12	AC/AC	1650	1.4	470
20F-V13	AC/AC	1650	1.4	470
20F-E2	HF/HF	1700	1.5	375
20F-E3	DF/DF	1900	1.6	560
20F-E6	DF/DF	1900	1.6	560
20F-E7	HF/HF	1700	1.5	375
20F-V2	SP/SP	1500	1.4	650
20F-V3	SP/SP	1700	1.5	650
20F-V5	SP/SP	1500	1.5	650
20F-E1	SP/SP	1950	1.6	650
20F-E3	SP/SP	1900	1.6	650
24F-1.7E		**1250**	**1.4**	**375**
24F-V5	DF/HF	1900	1.6	375
24F-V10	DF/HF	1900	1.6	375
24F-E2	HF/HF	1900	1.6	375
24F-E11	HF/HF	1900	1.6	375
24F-E15	HF/HF	1900	1.6	375
24F-V1	SP/SP	1800	1.6	650
24F-V4	SP/SP	1250	1.4	470
24F-V5	SP/SP	2100	1.7	650
24F-1.8E		**2100**	**1.7**	**560**
24F-V4	DF/DF	2100	1.7	560
24F-V8	DF/DF	2100	1.7	560
24F-E4	DF/DF	2100	1.7	560
24F-E13	DF/DF	2100	1.7	560
24F-E18	DF/DF	2100	1.7	560
24F-V3	SP/SP	2100	1.7	650
24F-E1	SP/SP	2100	1.7	650
24F-E4	SP/SP	2100	1.7	650
26F-1.9E		**2000**	**1.7**	**560**
26F-V1	DF/DF	2100	1.7	560
26F-V2	DF/DF	2100	1.7	560
26F-V1	SP/SP	2000	1.7	650
26F-V2	SP/SP	2400	1.8	740
26F-V3	SP/SP	2000	1.8	650
26F-V4	SP/SP	2000	1.8	650
28F-2.1E		**2400**	**1.9**	**650**
28F-E1	SP/SP	2400	1.9	650
28F-E2	SP/SP	2400	1.9	650
30F-2.1E		**2400**	**1.9**	**650**
30F-E1	SP/SP	2400	1.9	650
30F-E2	SP/SP	2400	1.9	650

1. Design values are applicable to beams that have up to 2/3 of the depth on the compression side removed by taper cutting.

AITC 117-2004

Annex B

Lay-up Requirements for

Structural Glued Laminated Softwood Timber

Table B1 - Lay-up Requirements for Structural Glued Laminated Softwood Timber Combinations

(Required 302 tension lamination grade is shown under applicable range of depths. Balanced layups require 302 laminations on top 5% and bottom 5%. Unbalanced layups require 302 laminations on bottom 5%.)

Visually Graded Western Species

16F-V3 WS (Unbalanced)

4 - 10 Lams			11 or More Lams		
--			302-20		
10%	L3 DF	--	10%	L3 DF	--
--	--	--	--		--
--	L3 DF	--	--	L3 DF	--
--	--	--	--		--
10%	L2D	--	10%	L3 DF	--

16F-V6 WS (Balanced)

4 - 10 Lams			11 or More Lams		
--			302-20		
10%	L2 DF	--	10%	L3 DF	--
--	--	--	--	--	--
--	L3 DF	--	--	L3 DF	--
--	--	--	--	--	--
10%	L2 DF	--	10%	L3 DF	--

20F-V3 WS (Unbalanced)

4 - 10 Lams			11 or More Lams		
302-20			302-20		
10%	L2 DF	--	5%	L2 DF	--
--	--	--	--	--	--
--	L3 DF	--	--	L3 DF	--
--	--	--	5%	L2 DF	--
10%	L2D DF	--	5%	L2D DF	--

20F-V3 WS (Alternate)

4 - 10 Lams		
--		
20%	L2 DF	--
--	--	--
--	L3 DF	--
20%	L2 DF	--
15%	L1Đ DF	--

20F-V7 WS (Balanced)

4 - 10 Lams			11 or More Lams		
302-20			302-20		
10%	L2D DF	--	5%	L2D DF	--
--	--	--	5%	L2 DF	--
--	L3 DF	--	--	L3 DF	--
--	--	--	5%	L2 DF	--
10%	L2D DF	--	5%	L2D DF	--

20F-V7 WS (Alternate)

4 - 7 Lams			8 - 10 Lams		
--			--		
10%	L1Đ DF	--	15%	L1Đ DF	--
--	--	--	--	--	--
--	L3 DF	--	--	L3 DF	--
--	--	--	--	--	--
10%	L1Đ DF	--	15%	L1Đ DF	--

20F-V9 WS (Balanced)

4 - 10 Lams			11 - 12 Lams			13 - 19 Lams			20 or More Lams		
302-20 (1:14)			302-22			302-22			302-24		
10%	L1D HF	--	10%	L1D HF	--	10%	L1D HF	--	10%	L1D HF	--
20%	L2 HF	--	20%	L2 HF	--	10%	L2 HF	--	10%	L2 HF	--
--	L3 HF	--	--	L3 HF	--	--	L3 HF	--	--	L3 HF	--
20%	L2 HF	--	20%	L2 HF	--	10%	L2 HF	--	10%	L2 HF	--
10%	L1D HF	--	10%	L1D HF	--	10%	L1D HF	--	10%	L1D HF	--

20F-V9 WS (Alternate)

4 - 10 Lams		
--		
10%	SSS HF	--
15%	L1D HF	--
--	L3 HF	--
15%	L1D HF	--
10%	SSS HF	--

20F-V12 WS (Unbalanced)

4 - 7 Lams			8 - 10 Lams			11 - 18 Lams			19 or More Lams		
302-20 (1:14)			302-20 (1:14)			302-24			302-26		
10%	L1D AC	--	10%	L1D AC	--	10%	L1D AC	--	10%	L1D AC	--
15%	L2 AC	--	15%	L2 AC	--	15%	L2 AC	--	15%	L2 AC	--
--	L3 AC	--	--	L3 AC	--	--	L3 AC	--	--	L3 AC	--
10%	L2 AC	--	10%	L2 AC	--	10%	L2 AC	--	10%	L2 AC	--
30%	L1D AC	--	35%	L1D AC	--	15%	L1S AC	--	15%	L1S AC	--

20F-V13 WS (Balanced)

4 - 7 Lams			8 - 10 Lams			11 or More Lams		
302-20 (1:16)			302-22			302-24		
15%	L1S AC	--	15%	L1S AC	--	10%	L1S AC	--
10%	L1D AC	--	10%	L1D AC	--	10%	L1D AC	--
--	L3 AC	--	--	L3 AC	--	--	L3 AC	--
10%	L1D AC	--	10%	L1D AC	--	10%	L1D AC	--
15%	L1S AC	--	15%	L1S AC	--	10%	L1S AC	--

24F-V4 WS (Unbalanced)

4 - 7 Lams			8 - 10 Lams			11 or More Lams		
302-20 (1:14)			302-22			302-24		
10%	L2D DF	--	10%	L2D DF	--	10%	L2D DF	--
10%	L2 DF	--	10%	L2 DF	--	10%	L2 DF	--
--	L3 DF	--	--	L3 DF	--	--	L3 DF	--
15%	L2 DF	--	15%	L2 DF	--	10%	L2 DF	--
15%	L1Đ DF	--	15%	L1Đ DF	--	10%	L1Đ DF	--

Table B1 - Lay-up Requirements for Structural Glued Laminated Softwood Timber Combinations

(Required 302 tension lamination grade is shown under applicable range of depths. Balanced layups require 302 laminations on top 5% and bottom 5%. Unbalanced layups require 302 laminations on bottom 5%.)

24F-V5 WS (Unbalanced)

4 - 7 Lams 302-20 (1:14)			8 - 10 Lams 302-22			11 or More Lams 302-24		
20%	L2D DF	--	20%	L2D DF	--	10%	L2D DF	--
20%	L2 HF	--	20%	L2 HF	--	10%	L2 HF	--
--	L3 HF	--	--	L3 HF	--	--	L3 HF	--
20%	L1 HF	--	20%	L1 HF	--	20%	L1 HF	--
20%	L1Đ DF	--	20%	L1Đ DF	--	15%	L1Đ DF	--

24F-V8 WS (Balanced)

4 - 7 Lams 302-20 (1:14)			8 - 10 Lams 302-22			11 or More Lams 302-24		
10%	L1Đ DF	--	10%	L1Đ DF	--	10%	L1Đ DF	--
10%	L2 DF	--	10%	L2D DF	--	5%	L2 DF	--
--	L3 DF	--	--	L3 DF	--	--	L3 DF	--
10%	L2 DF	--	10%	L2D DF	--	5%	L2 DF	--
10%	L1Đ DF	--	10%	L1Đ DF	--	10%	L1Đ DF	--

24F-V10 WS (Balanced)

4 - 7 Lams 302-20 (1:14)			8 - 10 Lams 302-22			11 or More Lams 302-24		
20%	L1Đ DF	--	20%	L1Đ DF	--	15%	L1Đ DF	--
10%	L2 HF	--	10%	L2 HF	--	15%	L2 HF	--
--	L3 HF	--	--	L3 HF	--	--	L3 HF	--
10%	L2 HF	--	10%	L2 HF	--	15%	L2 HF	--
20%	L1Đ DF	--	20%	L1Đ DF	--	15%	L1Đ DF	--

26F-V1 WS (Unbalanced)

4 - 7 Lams 302-22			8 - 10 Lams 302-24			11 or More Lams 302-26		
25%	L1Đ DF	--	25%	L1Đ DF	--	25%	L1Đ DF	--
5%	L2D DF	--	5%	L2D DF	--	5%	L2D DF	--
--	L3 DF	--	--	L3 DF	--	--	L3 DF	--
5%	L2D DF	--	5%	L2D DF	--	5%	L2D DF	--
25%	L1Đ DF	--	25%	L1Đ DF	--	25%	L1Đ DF	--

26F-V2 WS (Balanced)

4 - 7 Lams 302-22			8 - 10 Lams 302-24			11 or More Lams 302-26		
25%	L1Đ DF	--	25%	L1Đ DF	--	25%	L1Đ DF	--
5%	L2D DF	--	5%	L2D DF	--	5%	L2D DF	--
--	L3 DF	--	--	L3 DF	--	--	L3 DF	--
5%	L2D DF	--	5%	L2D DF	--	5%	L2D DF	--
25%	L1Đ DF	--	25%	L1Đ DF	--	25%	L1Đ DF	--

E-rated Western Species

16F-E2 WS (Unbalanced)

4 - 10 Lams 302-20			11 or More Lams 302-20		
10%	1.6E2 HF	--	10%	1.6E2 HF	--
--	--	--	--		--
--	L3 HF	--	--	L3 HF	--
--	--	--	5%	1.6E2 HF	--
10%	1.6E4 HF	--	5%	1.6E4 HF	--

16F-E2 WS (Alternate)

4 - 7 Lams --			8 - 10 Lams --		
10%	1.9E2 HF	--	20%	1.6E2 HF	--
--	--	--	--	--	--
--	L3 HF	--	--	L3 HF	--
--	--	--	--	--	--
10%	1.9E6 HF	--	30%	1.6E4 HF	--

16F-E3 WS (Unbalanced)

4 - 10 Lams --			11 or More Lams 302-20		
10%	1.9E2 DF	--	5%	1.9E2 DF	--
--	--	--	--	--	--
--	L3 DF	--	--	L3 DF	--
--	--	--	--	--	--
10%	1.9E6 DF	--	5%	1.9E6 DF	--

16F-E6 WS (Balanced)

4 - 10 Lams --			11 or More Lams 302-20		
10%	1.9E6 DF	--	5%	1.9E6 DF	--
--	--	--	--	--	--
--	L3 DF	--	--	L3 DF	--
--	--	--	--	--	--
10%	1.9E6 DF	--	5%	1.9E6 DF	--

16F-E7 WS (Balanced)

4 or More Lams 302-20		
10%	1.6E4 HF	--
--	--	--
--	L3 HF	--
--	--	--
10%	1.6E4 HF	--

16F-E7 WS (Alternate)

4 - 7 Lams --			8 - 10 Lams --		
10%	1.9E6 HF	--	30%	1.6E4 HF	--
--	--	--	--	--	--
--	L3 HF	--	--	L3 HF	--
--	--	--	--	--	--
10%	1.9E6 HF	--	30%	1.6E4 HF	--

Table B1 - Lay-up Requirements for Structural Glued Laminated Softwood Timber Combinations

(Required 302 tension lamination grade is shown under applicable range of depths. Balanced layups require 302 laminations on top 5% and bottom 5%. Unbalanced layups require 302 laminations on bottom 5%.)

20F-E2 WS (Unbalanced)

4 - 7 Lams 302-20			8 - 10 Lams 302-22			11 or More Lams 302-22		
10%	1.9E2 HF	--	10%	1.9E2 HF	--	20%	1.9E2 HF	--
--	--	--	--	--	--	--	--	--
--	L3 HF	--	--	L3 HF	--	--	L3 HF	--
15%	1.6E4 HF	--	10%	1.6E4 HF	--	--	--	--
10%	1.9E6 HF	--	10%	1.9E6 HF	--	20%	1.9E6 HF	--

20F-E2 WS (Alternate)

4 - 10 Lams --		
10%	1.9E2 HF	--
--	--	--
--	L3 HF	--
10%	1.9E6 HF	--
10%	2.1E6 HF	--

20F-E3 WS (Unbalanced)

4 - 10 Lams 302-20			11 - 13 Lams 302-22			14 or More Lams 302-22		
10%	1.9E2 DF	--	15%	1.9E2 DF	--	15%	1.9E2 DF	--
--	--	--	--	--	--	--	--	--
--	L3 DF	--	--	L3 DF	--	--	L3 DF	--
--	--	--	--	--	--	--	--	--
20%	1.9E6 DF	--	20%	1.9E6 DF	--	15%	1.9E6 DF	--

20F-E3 WS (Alternate)

4 - 10 Lams --		
20%	2.1E2 DF	--
10%	1.9E2 DF	--
--	L3 DF	--
10%	1.9E6 DF	--
20%	2.1E6 DF	--

20F-E6 WS (Balanced)

4 - 10 Lams 302-20			11 - 13 Lams 302-22			14 or More Lams 302-22		
20%	1.9E6 DF	--	20%	1.9E6 DF	--	15%	1.9E6 DF	--
--	--	--	--	--	--	--	--	--
--	L3 DF	--	--	L3 DF	--	--	L3 DF	--
--	--	--	--	--	--	--	--	--
20%	1.9E6 DF	--	20%	1.9E6 DF	--	15%	1.9E6 DF	--

20F-E6 WS (Alternate)

4 - 10 Lams --		
20%	2.1E6 DF	--
10%	1.9E6 DF	--
--	L3 DF	--
10%	1.9E6 DF	--
20%	2.1E6 DF	--

20F-E7 WS (Balanced)

4 - 7 Lams 302-20			8 - 10 Lams 302-22			11 or More Lams 302-22		
10%	1.9E6 HF	--	10%	1.9E6 HF	--	20%	1.9E6 HF	--
15%	1.6E4 HF	--	10%	1.6E4 HF	--	--	--	--
--	L3 HF	--	--	L3 HF	--	--	L3 HF	--
15%	1.6E4 HF	--	10%	1.6E4 HF	--	--	--	--
10%	1.9E6 HF	--	10%	1.9E6 HF	--	20%	1.9E6 HF	--

20F-E7 WS (Alternate)

4 - 10 Lams 302-20		
10%	2.1E6 HF	--
10%	1.9E6 HF	--
--	L3 HF	--
10%	1.9E6 HF	--
10%	2.1E6 HF	--

24F-E4 WS (Unbalanced)

4 - 10 Lams 302-20			11 - 13 Lams 302-22			14 - 15 Lams 302-22			16 or More Lams 302-24		
20%	2.1E2 DF	--	10%	2.1E2 DF	--	10%	2.1E2 DF	--	10%	2.1E2 DF	--
20%	1.9E2 DF	--	20%	1.9E2 DF	--	15%	1.9E2 DF	--	10%	1.9E2 DF	--
--	L3 DF	--	--	L3 DF	--	--	L3 DF	--	--	L3 DF	--
20%	1.9E6 DF	--	30%	1.9E6 DF	--	15%	1.9E6 DF	--	10%	1.9E6 DF	--
20%	2.1E6 DF	--	10%	2.1E6 DF	--	10%	2.1E6 DF	--	10%	2.1E6 DF	--

24F-E11 WS (Balanced)

4 - 8 Lams 302-20			9 - 13 Lams 302-22			14 or More Lams 302-24		
10%	2.1E6 HF	--	10%	2.1E6 HF	--	10%	2.1E6 HF	--
10%	1.9E6 HF	--	10%	1.9E6 HF	--	10%	1.9E6 HF	--
--	L3 HF	--	--	L3 HF	--	--	L3 HF	--
10%	1.9E6 HF	--	10%	1.9E6 HF	--	10%	1.9E6 HF	--
10%	2.1E6 HF	--	10%	2.1E6 HF	--	10%	2.1E6 HF	--

24F-E13 WS (Balanced)

4 - 10 Lams 302-22			11 - 13 Lams 302-24			14 - 15 Lams 302-24			16 or More Lams 302-24		
20%	2.1E6 DF	--	10%	2.1E6 DF	--	10%	2.1E6 DF	--	10%	2.1E6 DF	--
20%	1.9E6 DF	--	30%	1.9E6 DF	--	15%	1.9E6 DF	--	10%	1.9E6 DF	--
--	L3 DF	--	--	L3 DF	--	--	L3 DF	--	--	L3 DF	--
20%	1.9E6 DF	--	30%	1.9E6 DF	--	15%	1.9E6 DF	--	10%	1.9E6 DF	--
20%	2.1E6 DF	--	10%	2.1E6 DF	--	10%	2.1E6 DF	--	10%	2.1E6 DF	--

Table B1 - Lay-up Requirements for Structural Glued Laminated Softwood Timber Combinations

(Required 302 tension lamination grade is shown under applicable range of depths. Balanced layups require 302 laminations on top 5% and bottom 5%. Unbalanced layups require 302 laminations on bottom 5%.)

24F-E15 WS (Unbalanced)

4 - 7 Lams 302-20			8 - 10 Lams 302-22			11 - 14 Lams 302-24			15 - 19 Lams 302-24			20 or More Lams 302-24		
10%	2.1E2 HF	--	10%	2.1E2 HF	--	10%	1.9E2 HF	--	10%	2.1E2 HF	--	10%	2.1E2 HF	--
10%	1.6E4 HF	--	15%	1.6E4 HF	--	10%	1.6E4 HF	--	10%	1.6E4 HF	--	15%	1.6E4 HF	--
--	L3 HF	--	--	L3 HF	--	--	L3 HF	--	--	L3 HF	--	--	L3 HF	--
10%	1.6E4 HF	--	10%	1.9E2 HF	--	10%	1.9E2 HF	--	10%	1.9E2 HF	--	10%	1.9E2 HF	--
10%	2.1E6 HF	--	10%	2.1E6 HF	--	10%	2.1E3 HF	--	10%	2.1E3 HF	--	10%	2.1E3 HF	--

24F-E18 WS (Balanced)

4 - 8 Lams 302-20			9 - 11 Lams 302-22			12 - 15 Lams 302-22			16 or More Lams 302-22		
10%	2.1E6 DF	--	10%	2.1E6 DF	--	10%	2.1E3 DF	--	10%	2.1E3 DF	--
--	--	--	10%	1.9E6 DF	--	5%	1.9E2 DF	--	10%	1.9E2 DF	--
--	L3 DF	--	--	L3 DF	--	--	L3 DF	--	--	L3 DF	--
--	--	--	10%	1.9E6 DF	--	5%	1.9E2 DF	--	10%	1.9E2 DF	--
10%	2.1E6 DF	--	10%	2.1E6 DF	--	10%	2.1E3 DF	--	10%	2.1E3 DF	--

Visually Graded Southern Pine

16F-V2 SP (Unbalanced)

4 or More Lams 302-20		
10%	N2M	--
--	--	--
--	N2M	--
--	--	--
5%	N2M	1:10

16F-V2 SP (Alternate)

4 - 8 Lams --			9 - 10 lams --		
10%	N2M	--	10%	N2M	--
--	--	--	--	--	--
--	N3M	1:8	--	N3M	1:8
10%	N2M	--	10%	N2M	--
10%	N1D	1:12	10%	N2D	1:12

16F-V3 SP (Unbalanced)

4 - 10 Lams 302-20			11 or More Lams 302-20		
10%	N2D	--	5%	N2D	--
--	--	--	--	--	--
--	N3M	1:8	--	N3M	1:8
--	--	--	--	--	--
10%	N2D	--	5%	N2D	1:10

16F-V3 SP (Alternate)

4 - 8 Lams --			9 - 10 lams --		
10%	N2D	--	10%	N2D	--
--	--	--	--	--	--
--	N2M	1:8	--	N2M	1:8
25%	N2D	--	5%	N2D	--
5%	N2D	1:10	5%	N2D	1:10

16F-V5 SP (Balanced)

4 or More Lams 302-20		
10%	N2M	1:10
--	--	--
--	N2M	--
--	--	--
10%	N2M	1:10

16F-V5 SP (Alternate)

4 - 8 Lams --			9 - 10 lams --		
5%	N2D	1:10	5%	N2D	1:10
25%	N2D	--	5%	N2D	--
--	N2M	1:8	--	N2M	1:8
25%	N2D	--	5%	N2D	--
5%	N2D	1:10	5%	N2D	1:10

20F-V2 SP (Unbalanced)

4 - 10 Lams 302-20			11 or More Lams 302-20		
10%	N2D	--	15%	N2D	--
--	--	--	--	--	--
--	N3M	1:8	--	N3M	1:8
10%	N2M	--	5%	N2M	1:10
10%	N1D	1:12	5%	N2D	1:12

20F-V2 SP (Alternate)

4 - 8 Lams --			9 - 10 lams --		
10%	N1D	--	10%	N1M	1:14
10%	N2M	--	15%	N2M	--
--	N3M	1:8	--	N3M	1:8
10%	N2M	--	10%	N2M	--
20%	N1D	--	20%	N1D	1:12

Table B1 - Lay-up Requirements for Structural Glued Laminated Softwood Timber Combinations

(Required 302 tension lamination grade is shown under applicable range of depths. Balanced layups require 302 laminations on top 5% and bottom 5%. Unbalanced layups require 302 laminations on bottom 5%.)

20F-V3 SP (Unbalanced)

4 - 10 Lams 302-20			11 - 12 Lams 302-20			13 or More Lams 302-20		
5%	N2M	--	5%	N2M	--	5%	N2M	--
--	--	--	--	--	--	--	--	--
--	N2M	--	--	N2M	--	--	N2M	--
5%	N1D	--	--	--	--	5%	N2M	1:10
5%	N1D	1:12	5%	N2D	1:12	5%	N2M	1:12

20F-V3 SP (Alternate)

4 - 8 Lams --			9 - 10 Lams --		
10%	N2D	--	10%	N2D	--
--	--	--	--	--	--
--	N2M	--	--	N2M	--
--	--	--	15%	N1D	--
25%	N1D	--	5%	N1D	1:12

20F-V5 SP (Balanced)

4 - 8 Lams 302-20			9 - 10 Lams 302-20			11 or More Lams 302-20		
10%	N1D	--	5%	N2D	1:10	10%	N2D	1:12
10%	N2M	--	15%	N2D	--	5%	N2D	--
--	N3M	1:8	--	N3M	1:8	--	N3M	1:8
10%	N2M	--	15%	N2D		5%	N2D	
10%	N1D	--	5%	N2D	1:10	10%	N2D	1:12

20F-V5 SP (Alternate)

4 - 8 Lams --			9 - 10 Lams --		
10%	N1D	--	10%	N1D	1:12
10%	N2D	--	10%	N2D	--
--	N3M	1:8	--	N3M	1:8
10%	N2D	--	10%	N2D	--
10%	N1D	--	10%	N1D	1:12

24F-V1 SP (Unbalanced)

4 - 8 Lams 302-20 (1:14)			9 - 10 lams 302-22			11 or More Lams 302-24		
10%	N1D	--	5%	N1M	1:12	15%	N1M	1:12
--	--	--	10%	N1M	--	--	--	--
10%	N2D	--	15%	N2M	--	15%	N2M	--
--	N3M	1:8	--	N3M	1:8	--	N3M	1:8
15%	N2D	--	15%	N2M	--	15%	N2M	--
5%	N1D	--	10%	N1D	--	10%	N1D	1:12
5%	N1D	1:14	5%	N1D	1:14	5%	N1D	1:16

24F-V3 SP (Unbalanced)

4 - 8 Lams 302-20 1:14			9 - 10 lams 302-22			11 or More Lams 302-24		
10%	N1D	--	10%	N1D	--	10%	N1D	--
10%	N2D	--	10%	N2D	--	10%	N2D	--
--	N2M	--	--	N2M	--	--	N2M	--
15%	N2D	--	15%	N2D	--	15%	N2D	--
5%	N1D	--	5%	N1D	1:12	5%	N1D	1:12
5%	N1D	1:14	5%	N1D	1:14	5%	N1D	1:14

24F-V4 SP (Unbalanced)

4 - 5 Lams 302-20 (1:14)			6 - 8 Lams 302-20 (1:14)			9 - 10 Lams 302-22			11 or More Lams 302-24		
5%	N1M	1:12	5%	N1M	1:14	5%	N1M	1:12	5%	N1M	1:14
10%	N1M	--	5%	N1M	--	5%	N1M	--	5%	N1M	1:12
--	--	--	--	--	--	--	--	--	5%	N1M	--
15%	N2M	--	15%	N2M	--	15%	N2M	--	10%	N2M	--
--	N3C	1:8	--	N3C	1:8	--	N3C	1:8	--	N3C	1:8
10%	N2M	--	15%	N2M	--	15%	N2M	--	20%	N2M	--
--	--	--	--	--	--	--	--	--	5%	N1D	--
30%	N1D	--	20%	N1D	--	20%	N1D	--	10%	N1D	1:14

24F-V5 SP (Balanced)

4 - 8 Lams 302-20 (1:14)			9 - 10 Lams 302-22			11 or More Lams 302-24		
10%	N1D	--	10%	N1D	--	10%	N1D	1:12
10%	N2D	--	5%	N2D	--	5%	N2D	1:10
--	N2M	--	--	N2M	--	--	N2M	--
10%	N2D	--	5%	N2D	--	5%	N2D	1:10
10%	N1D	--	10%	N1D	--	10%	N1D	1:12

26F-V1 SP (Unbalanced)

7 - 8 Lams 302-22			9 - 10 Lams 302-24			11 or More Lams 302-26		
20%	N1D	--	5%	N1D	1:12	5%	N1D	1:12
--	--	--	15%	N1D	--	5%	N1D	--
--	--	--	--	--	--	10%	N2D	--
--	N1M	--	--	N2D	--	--	N2M	--
--	--	--	--	--	--	15%	N2D	1:10
25%	N1D	--	25%	N1D	--	10%	N1D	1:14

26F-V2 SP (Unbalanced)

7 - 8 Lams 302-22			9 - 10 Lams 302-24			11 or More Lams 302-26		
20%	N1D	--	5%	N1D	1:12	5%	N1D	1:12
--	--	--	15%	N1D	--	20%	N1D	--
--	N2D	--	--	N2D	--	--	N2D	--
15%	N1D	--	15%	N1D	--	15%	N1D	--
10%	N1D	1:12	10%	N1D	1:12	10%	N1D	1:12

Table B1 - Lay-up Requirements for Structural Glued Laminated Softwood Timber Combinations

(Required 302 tension lamination grade is shown under applicable range of depths. Balanced layups require 302 laminations on top 5% and bottom 5%. Unbalanced layups require 302 laminations on bottom 5%.)

26F-V3 SP (Unbalanced)

7 - 8 Lams 302-22			9 - 10 Lams 302-24			11 or More Lams 302-26		
20%	N1D	--	5%	N1D	1:12	5%	N1D	1:12
--	--	--	15%	N1D	--	20%	N1D	--
--	N1M	--	--	N1M	--	--	N1M	--
15%	N1D	--	15%	N1D	--	15%	N1D	--
10%	N1D	1:12	10%	N1D	1:12	10%	N1D	1:12

26F-V4 SP (Balanced)

7 - 8 Lams 302-22			9 - 10 Lams 302-24			11 or More Lams 302-26		
10%	N1D	1:12	10%	N1D	1:12	10%	N1D	1:12
15%	N1D	--	15%	N1D	--	15%	N1D	--
--	N1M	--	--	N1M	--	--	N1M	--
15%	N1D	--	15%	N1D	--	15%	N1D	--
10%	N1D	1:12	10%	N1D	1:12	10%	N1D	1:12

26F-V5 SP (Balanced)

7 - 8 Lams 302-22			9 - 10 Lams 302-24			11 or More Lams 302-26		
10%	N1D	1:12	10%	N1D	1:12	10%	N1D	1:12
15%	N1D	--	15%	N1D	--	15%	N1D	--
--	N2D	--	--	N2D	--	--	N2D	--
15%	N1D	--	15%	N1D	--	15%	N1D	--
10%	N1D	1:12	10%	N1D	1:12	10%	N1D	1:12

E-rated Southern Pine

16F-E1 SP (Unbalanced)

4 - 10 Lams 302-20			11 or More Lams 302-20		
10%	1.9E2	--	5%	1.9E2	--
--	--	--	--	--	--
--	N2M	--	--	N2M	--
--	--	--	--	--	--
10%	1.9E6	--	10%	1.9E6	--

16F-E1 SP (Alternate)

4 - 10 Lams --		
10%	1.9E2	--
--	--	--
--	N2M	--
--	--	--
10%	2.1E6	--

16F-E3 SP (Balanced)

4 or More Lams --		
10%	1.9E6	--
--	--	--
--	N2M	--
--	--	--
10%	1.9E6	--

20F-E1 SP (Unbalanced)

4 - 8 Lams 302-20			9 - 10 Lams 302-20			11 - 13 Lams 302-20			14 or More Lams 302-20		
10%	1.9E2	--	10%	1.9E2	--	5%	1.9E2	--	15%	1.9E2	--
--	--	--	--	--	--	--	--	--	--	--	--
--	N2M	--	--	N2M	--	--	N2M	--	--	N2M	--
--	--	--	10%	1.9E6	--	5%	1.9E6	--	--	--	--
10%	2.1E6	--	10%	2.1E6	--	5%	2.1E6	--	15%	1.9E6	--

20F-E1 SP (Alternate)

4 - 8 Lams --			9 - 10 Lams --		
10%	2.1E2	--	10%	2.1E2	--
--	--	--	--	--	--
--	N2M	--	--	N2M	--
--	--	--	15%	1.9E6	--
25%	2.1E6	--	15%	2.1E6	--

20F-E3 SP (Balanced)

4 - 10 Lams 302-20			11 - 14 Lams 302-20			15 or More Lams 302-20		
20%	1.9E6	--	5%	2.1E6	--	15%	1.9E6	--
--	--	--	5%	1.9E6	--	--	--	--
--	N2M	--		N2M	--	--	N2M	--
--	--	--	5%	1.9E6	--	--	--	--
20%	1.9E6	--	5%	2.1E6	--	15%	1.9E6	--

20F-E3 SP (Alternate)

4 - 8 Lams --			9 - 10 Lams --		
25%	2.1E6	--	10%	2.1E6	--
10%	1.9E6	--	10%	1.9E6	--
--	N2M	--	--	N2M	--
10%	1.9E6	--	10%	1.9E6	--
25%	2.1E6	--	10%	2.1E6	--

Table B1 - Lay-up Requirements for Structural Glued Laminated Softwood Timber Combinations

(Required 302 tension lamination grade is shown under applicable range of depths. Balanced layups require 302 laminations on top 5% and bottom 5%. Unbalanced layups require 302 laminations on bottom 5%.)

24F-E1 SP (Unbalanced)

4 - 8 Lams 302-20			9 - 10 Lams 302-22			11 or More Lams 302-24		
10%	2.1E2	--	10%	2.1E2	--	20%	1.9E2	--
--	--	--	--	--	--	--	--	--
--	N2M	--	--	N2M	--	--	N2M	--
25%	1.9E6	--	20%	1.9E6	--	10%	1.9E6	--
10%	2.1E6	--	10%	2.1E6	--	10%	2.1E6	--

24F-E4 SP (Balanced)

4 - 8 Lams 302-20			9 - 10 Lams 302-22			11 or More Lams 302-24		
20%	2.1E6	--	20%	2.1E6	--	20%	2.1E6	--
10%	1.9E6	--	10%	1.9E6	--	10%	1.9E6	--
--	N2M	--	--	N2M	--	--	N2M	--
10%	1.9E6	--	10%	1.9E6	--	10%	1.9E6	--
20%	2.1E6	--	20%	2.1E6	--	20%	2.1E6	--

28F-E1 SP (Unbalanced)

4 - 10 Lams 302-28			11 or More Lams 302-30		
10%	N1D 2.3E	1:12	10%	N1D 2.3E	1:12
10%	N1D 2.0E	--	15%	N1D 2.0E	--
--	N2M	--	--	N2M	--
10%	N1D 2.0E	--	15%	N1D 2.0E	--
10%	N1D 2.3E	--	5%	N1D 2.3E	--
10%	2.3E3	1:14	5%	2.3E5	1:16

28F-E2 SP (Balanced)

4 - 10 Lams 302-28			11 or More Lams 302-30		
10%	2.3E3	1:14	5%	2.3E5	1:16
10%	N1D 2.3E	--	5%	N1D 2.3E	--
10%	N1D 2.0E	--	15%	N1D 2.0E	--
--	N2M	--	--	N2M	--
10%	N1D 2.0E	--	15%	N1D 2.0E	--
10%	N1D 2.3E	--	5%	N1D 2.3E	--
10%	2.3E3	1:14	5%	2.3E5	1:16

30F-E1 SP (Unbalanced)

4 - 10 Lams 302-28			11 or More Lams 302-30		
10%	N1D 2.3E	--	15%	N1D 2.3E	--
20%	N1D 2.0E	--	15%	N1D 2.0E	--
--	N2M	--	--	N2M	--
10%	N1D 2.0E	--	15%	N1D 2.0E	--
10%	N1D 2.3E	--	5%	N1D 2.3E	--
10%	2.3E3	1:12	5%	2.3E5	1:16

30F-E2 SP (Balanced)

4 - 10 Lams 302-28			11 or More Lams 302-30		
10%	2.3E3	1:12	5%	2.3E5	1:16
10%	N1D 2.3E	--	5%	N1D 2.3E	--
10%	N1D 2.0E	--	15%	N1D 2.0E	--
--	N2M	--	--	N2M	--
10%	N1D 2.0E	--	15%	N1D 2.0E	--
10%	N1D 2.3E	--	5%	N1D 2.3E	--
10%	2.3E3	1:12	5%	2.3E5	1:16

California Redwood

16F-V1 CR (Balanced)

4 - 7 Lams 302-20			8 - 10 Lams 302-22			11 or More Lams 302-24		
30%	L1 or L2	1:16	25%	L1 or L2	1:16	25%	L1 or L2	1:18
--	--	--	5%	L3	--	5%	L3	--
--	L4 or L5	--	--	L4 or L5	--	--	L4 or L5	--
--	--	--	5%	L3	--	5%	L3	--
30%	L1 or L2	1:16	25%	L1 or L2	1:16	25%	L1 or L2	1:18

TABLE B2 – Layup Requirements for Uniform Grade Members

(Layups shall require 302 tension laminations on top 5% and bottom 5% only when specified.)

Combination Symbol (QSL)	Grade/ Species	Tension Laminations (if Required) by Bending Member Depth			Combination Symbol (QSL)	Grade/ Species	Tension Laminations (if Required) by Bending Member Depth		
		4 lams to < 12 in.	12 in. to 15 in.	> 15 in.			4 lams to < 12 in.	12 in. to 15 in.	> 15 in.
Visually Graded Western Species					**E-Rated Western Species**				
1 (20F)	L3 DF	302-20	302-20	302-20	27 (20F)	1.9E2 DF	302-20	302-20	302-20
2 (22F)	L2 DF	302-20	302-20	302-20	28 (20F)	2.1E2 DF	302-20	302-20	302-20
3 (24F)	L2D DF	302-20	302-22	302-24	29 (20F)	2.3E2 DF	302-20	302-20	302-20
4 (24F)	L1CL DF	302-20	302-20	302-22	30 (20F)	1.9E6 DF	302-20	302-20	302-22
5 (24F)	L1 DF	302-20	302-22	302-24	31 (20F)	2.1E6 DF	302-20	302-22	302-24
14 (18F)	L3 HF	302-20	302-20	302-20	32 (20F)	2.3E6 DF	302-20	302-22	302-24
15 (22F)	L2 HF	302-20	302-20	302-20	62 (20F)	2.2E2 DF	302-20	302-20	302-20
16 (22F)	L1 HF	302-20	302-22	302-24	63 (20F)	2.2E6 DF	302-20	302-22	302-24
17 (24F)	L1D HF	302-20	302-22	302-24	33 (20F)	1.6E2 HF	302-20	302-20	302-20
22 (16F)	L3 SW	302-20	302-20	302-20	34 (20F)	1.9E2 HF	302-20	302-20	302-20
69 (16F)	L3 AC	302-20	302-20	302-20	35 (20F)	2.1E2 HF	302-20	302-20	302-20
70 (20F)	L2 AC	302-20	302-20	302-20	36 (20F)	1.6E4 HF	302-20	302-20	302-20
71 (22F)	L1D AC	302-20	302-22	302-24	37 (20F)	1.9E6 HF	302-20	302-20	302-22
					38 (20F)	2.1E6 HF	302-20	302-22	302-24
					39 (20F)	1.6E2 SW	302-20	302-20	302-20
					40 (20F)	1.9E2 SW	302-20	302-20	302-20
					41 (20F)	2.1E2 SW	302-20	302-20	302-20
					42 (20F)	1.6E4 SW	302-20	302-20	302-20
					43 (20F)	1.9E6 SW	302-20	302-20	302-22
					44 (20F)	2.1E6 SW	302-20	302-22	302-24
Visually Graded - Southern Pine					**E-Rated Southern Pine**				
47 (20F)	N2M12 SP	302-20	302-20	302-20	53 (20F)	1.9E2 SP	302-20	302-20	302-20
48 (20F)	N2D12 SP	302-20	302-20	302-20	54 (20F)	2.1E2 SP	302-20	302-20	302-20
49 (20F)	N1M16 SP	302-20	302-20	302-22	55 (20F)	2.3E2 SP	302-20	302-20	302-20
50 (20F)	N1D14 SP	302-20	302-22	302-24	56 (20F)	1.9E6 SP	302-20	302-20	302-22
					57 (20F)	2.1E6 SP	302-20	302-22	302-24
					58 (20F)	2.3E6 SP	302-20	302-22	302-24

AITC 117-2004

Annex C

AITC Grading Handbook

for Laminating Lumber

AITC Grading Handbook for Laminating Lumber

This Grading Handbook is intended as a guide for use in grading lumber for the manufacture of structural glued laminated timber. Some manufacturing information has been included as reference for the graders, but this Handbook is not intended to be a substitute for other AITC publications.

1. Introduction

Lumber shall be either visually graded or mechanically graded as required for the laminating combinations. Structural laminating lumber shall be graded on the basis of the dressed size of the lumber. The knot sizes for structural laminating grades of Western species are based on a fraction of the dressed width of the piece of lumber. The knot sizes for structural joists and planks grades and structural light framing grades of all species are tabulated on the basis of the nominal width. When lumber is graded before being ripped or resawn, it shall be graded on the basis of the ripped or resawn size. Otherwise it shall be graded after being ripped or resawn. Where the finished width of the laminated timber is less than 85% of the dressed width of the lumber used for the laminations, the lumber shall be graded on the basis of the next smaller nominal width.

2. Definitions/Measurement of Characteristics

2.1. Moisture Content

The weight of the water in wood expressed in percentage of the weight of the oven-dry wood.

2.2. Knots

A portion of a branch or limb that has become incorporated in a piece of lumber.

Knots are permitted to be sound, unsound, or not firmly fixed. A knot shall be measured by the area of the cross section it occupies. For all lumber, knots shall be limited in size and spaced as described for specific grades herein.

2.2.1. Edge knot

A knot located at the edge of the face in a piece of lumber. A wide face knot overlapping part of the edge shall be considered an edge knot if it occupies more than 1/2 the thickness.

2.3. Knotholes

The hole left when a “loose” knot falls or is forced from the lumber.

2.4. Slope of Grain

The deviation of the line of fibers from a straight line parallel to the sides of the piece.

2.5. Splits

A separation of the wood through the piece to the opposite surface or to an adjoining surface due to the tearing apart of the wood cells.

2.6. Shakes

A lengthwise separation of the wood which occurs between or through the rings of annual growth.

2.7. Checks

A separation of the wood normally occurring across or through the rings of annual growth and usually as a result of seasoning.

2.8. Warp

Any deviation from a true or plane surface, including bow, crook and cup or any combination thereof.

2.8.1. Bow

A deviation flatwise from a straight line drawn from end to end of a piece.

2.8.2. Crook

A deviation edgewise from a straight line drawn from end to end of a piece.

2.8.3. Cup

A deviation in the face of a piece from a straight line drawn from edge to edge of a piece.

2.9. Skip

An un-surfaced area on dressed lumber.

2.10. Torn Grain

A manufacturing imperfection in the surface of a piece where wood has been torn or broken out by surfacing.

2.11. Raised Grain

A condition of the surface of dressed lumber in which the hard latewood is raised above the surface of the softer earlywood, but not torn loose from it.

2.12. Wane

Bark or lack of wood from any cause except eased edges, on the edge or corner of a piece of lumber.

2.13. Decay

A disintegration of the wood substance due to action of wood-destroying fungi, and is also known as dote or rot.

2.13.1. White Speck

A form of decay identified by small white or brown pits or spots in wood caused by fungi. It develops in the living tree and does not develop further in wood in service.

2.13.2. Honeycomb

A form of decay similar to white speck but the pockets are larger.

2.14. Compression Wood

Abnormal wood formed on the underside of leaning and crooked coniferous trees. It is characterized, aside from its distinguishing color by being hard and brittle. It is identified by its relatively wide, usually eccentric annual rings, relatively large amount of latewood (sometimes more than 50% of the width of the annual rings in which it occurs), and its lack of demarcation between earlywood and latewood in the same annual rings.

2.15. Springwood or Earlywood

The less dense, larger-celled part of the growth layer formed first during the annual growth cycle.

2.16. Summerwood or Latewood

The more dense, smaller-celled, later-formed part of a growth ring.

2.17. Growth Rate

A characteristic used to estimate specific gravity from the number of growth rings per inch along with the amount of summerwood.

3. General Requirements

3.1. Moisture Content

Moisture content shall not exceed 16%. Moisture content determinations shall be based on ASTM D4442 or D4444. In-line moisture meters used for lumber segregation shall be calibrated using one of these standards.

The range of average moisture contents of pieces of lumber to be assembled into a single timber shall not exceed 5 percentage points if the average moisture content of any piece exceeds 12%. The moisture content of a piece of lumber shall be the average moisture content throughout the cross section and along the length of the piece.

Exception: when it is known that the in use equilibrium moisture content of the laminated timber will be 16% or more, the moisture content of laminations at the time of bonding shall not exceed 20%. All bonding procedures for lumber with moisture content above 16% shall be qualified according to the requirements of ANSI/AITC A190.1. These qualification tests shall be performed using lumber with the maximum moisture content to be qualified (not to exceed 20%).

3.2. Surfacing and Cleanliness

At the time of bonding, variations in thickness across the width of a lamination shall not exceed plus or minus 0.008 in. The variation in thickness along the length of an individual piece of lumber or the lamination shall not exceed plus or minus 0.012 in. The thickness variation shall occur randomly across the width and along the length such that the cumulative effect does not contribute to side-to-side depth variations greater than allowed in ANSI/AITC A190.1. All

bonding surfaces including face, edge and end joints shall be smooth 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 mating surfaces. All bonding surfaces shall be free from dust, foreign matter, and exudation which are detrimental to satisfactory bonding.

When lumber will not be resurfaced prior to laminating, the grading process must contain adequate checks to assure that pieces not conforming to the tolerances stated above are excluded.

When lumber will be resurfaced after grading, pieces which will not, after being surfaced, conform to the tolerances stated above, shall be excluded.

3.3. Knots

Knots shall be permitted to be sound, unsound, or not firmly fixed.

3.3.1. In or near end joints

Knots or knotholes in plane scarf joints shall be limited to those permitted for the lumber grade. In no case shall they exceed 1/4 the nominal width of the piece in laminations occupying the outer 10% on each side of bending members and in any lamination of tension members.

Finger joints shall not contain knots.

In bending members, knots exceeding 3/8 in. diameter shall not be permitted within 2 knot diameters or 6 in., whichever is less, of finger joints in the inner and outer tension zones (in no case less than 10% of the depth of bending members). Knots over 1/2 in. diameter shall not be permitted within one knot diameter of finger joints in the balance of the laminations.

In tension members, knots larger than 3/8 in. shall not be permitted within 2 knot diameters or 6 in., whichever is less, of finger joints in any lamination.

In compression members, knots larger than 3/4 in. shall not be permitted within one knot diameter of finger joints.

Measurement of knot diameter for spacing near end joints shall be parallel to the longitudinal axis of the piece of lumber. The distance of knots from finger joints shall be measured from the edge of the knot nearest the joint to the closest part of the joint.

NOTE: The grader must consider the end trim plus the length of the fingers, when determining if a knot will be in, or too close to, a finger joint.

3.4. Knotholes

Knotholes shall be permitted to be the same size as knots permitted in the grade. Other holes shall be permitted if no larger than the allowable knothole.

3.5. Splits and Shakes

Splits and shakes shall be permitted in all grades if extending from wide faces into the thickness of the piece at an angle of 45° or more from the wide face.

3.6. Checks

Seasoning checks shall be permitted.

3.7. Warp

Warp (including bow, crook and cup) shall not be so great that they will not be straightened out by pressure in bonding. Light crook shall be permitted.

3.8. Pitch Pockets and Streaks

Medium scattered pitch or bark pockets are permitted in all grades. Pitch streaks shall not exceed 1/6 of the width.

3.9. Torn Grain

Torn grain up to 1/16 in. shall be permitted with some occasional allowance for up to 1/8 in.

3.10. Wane

Light wane which will be removed by resurfacing and therefore not be present in the finished timber shall be permitted at the time of grading. For specific combinations, wane not exceeding 1/6 the width on one or both edges of the wide

face of a lamination, as permitted by the layup, shall be permitted in designated grades except that the outer laminations, shall be free of wane.

3.11. Slope of Grain

Slope of grain of visually graded lumber shall be limited in the full length of each lamination according to the appropriate grade and shall be measured over a distance sufficiently great to determine the general slope, disregarding local deviations, except as noted for special tension laminations.

3.12. Decay

Decay shall not be permitted, except that firm white speck in limited form may be allowed in some laminating grades as defined herein.

3.13. Timber Breaks

Timber breaks shall not be permitted.

3.14. Compression Wood

Compression wood in recognizable form shall be restricted in tension laminations up to 5% of the cross section if neither damaging nor containing timber breaks. Other lamination grades have specific allowances per grade.

3.15. Saw Kerfs

Saw kerfs shall not be allowed in the outer five percent of the member depth. Other zones shall be permitted to have saw kerfs equal to or less than one-half of the allowable knot size for the grade.

3.16. Growth Rate

Density of all species, if visually determined, shall be graded according to the following:

- Dense (D): Dense lumber shall average not less than 6 annual rings per inch and 1/3 or more summerwood. Pieces averaging less than 6 annual rings per inch but not less than 4 are accepted as dense if averaging 1/2 or more summerwood.
- Close (CL): DF-L only. Close grain lumber shall have a minimum average of 6 but no more than 30 annual rings per inch with no restriction on the percentage of summerwood. Pieces averaging 5 rings shall be accepted as close grain if averaging 1/3 or more summerwood.
- Medium: Medium grain lumber shall have 4 or more annual rings per inch. In Douglas Fir, pieces averaging less than 4 rings per inch are accepted if averaging 1/3 or more summerwood. Medium grain is not defined in the current SPIB Standard Grading Rules, but is required for some laminating grades of Southern Pine.
- Coarse (C): SP only. Coarse grain is that which fails to meet the requirements for medium grain. Coarse grain is not defined in the current SPIB Standard Grading Rules, but is permitted for some laminating grades of Southern Pine.

4. Visual Grades

4.1. General Requirements

4.1.1. Knots

The knot sizes for structural laminating grades of Western Species are based on a fraction of the dressed width of the piece of lumber. The knot sizes for structural joists and planks and structural light framing grades of all species are tabulated on the basis of the nominal width.

Knots shall be well spaced. Well spaced means that the sum of all knots in any 6 in. of length of a piece shall not exceed twice the size of the largest knot permitted, and more than one knot of the maximum permissible size shall not be in the same 6 in. of length. Tension laminations shall be excluded from this rule due to more restrictive spacing requirements.

4.1.2. Slope of Grain

Slope of grain of visually graded lumber shall be limited in the full length of each lamination and shall be measured over a distance sufficiently great to determine the general slope, disregarding local deviations, except as noted for special tension laminations.

4.1.3. Density or Growth Rate

Growth rate shall be verified on both ends of visually graded tension laminations. In other visual grades, growth rate is permitted to be assessed by looking at one end of the piece only, except as noted for special tension laminations.

4.1.4. Specific Gravity of Species

Density or growth rate shall be permitted to be determined by weight using the method described in Section 7. When weight is used to establish growth rate, grades requiring dense rate of growth shall have a specific gravity above the near average specific gravity for the species as shown in the table below.

Species	Near Avg. SG @ 12% MC
AC	0.42
DF-L	0.46
DF-S	0.50
HF	0.39
SP	0.49
SPF	0.35
SW	0.32

4.2. Laminating Grades

4.2.1. General

In general, laminating grades are designated with an "L", with the exception of Southern Pine (which uses "N"). The grade follows, then the density designation. Grades without density designations are considered Medium. Example: L1D is laminating grade 1, Dense.

4.2.2. Grade Specific Requirements

In addition to the General Requirements outlined in Section 3, and the General Requirements for Visual Grades in Section 4.1, the following requirements apply by grade:

4.2.2.1. L1D

- Density: Dense.
  - *Exception*: "L1" for Douglas Fir-Larch/Douglas Fir South is considered dense. No density designation as per 4.2.2 is required.
- Knot Size: Knots shall not occupy more than 1/4 of the cross-section.
- Slope of Grain: The basic slope of grain shall not exceed 1:14 for the full length of the piece.

4.2.2.1.a L1

- Density: Medium (except Douglas Fir-Larch/Douglas Fir South, which is dense).
- Knot Size: Knots shall not occupy more than 1/4 of the cross-section.
- Slope of Grain: The basic slope of grain shall not exceed 1:14 for the full length of the piece.

4.2.2.2. L1CL

- Density: Close.
- Knot Size: Knots shall not occupy more than 1/4 of the cross-section.
- Slope of Grain: The basic slope of grain shall not exceed 1:12 for the full length of the piece.

4.2.2.3. L2D

- Density: Dense.
- Knot Size: Knots shall not occupy more than 1/3 of the cross-section.
- Slope of Grain: The basic slope of grain shall not exceed 1:12 for the full length of the piece.
- White Speck: Firm white specks are permitted. A combination of white speck and a knot in the same cross-section shall not occupy more than 1/3 the width or equivalent.

4.2.2.4. L2

- Density: Medium.
- Knot Size: Knots shall not occupy more than 1/3 of the cross-section.
- Slope of Grain: The basic slope of grain shall not exceed 1:12 for the full length of the piece.
- White Speck: Firm white specks are permitted. A combination of white speck and a knot in the same cross-section shall not occupy more than 1/3 the width or equivalent.

4.2.2.5. L3

- Density: Medium.
- Knot Size: Knots shall not occupy more than 1/2 of the cross-section.
- Slope of Grain: The basic slope of grain shall not exceed 1:8 for the full length of the piece.
- White Speck: Firm white specks are permitted. A combination of white speck and a knot in the same cross-section shall not occupy more than 1/2 the width or equivalent.

4.3. Species Specific Requirements – Douglas Fir-Larch/Douglas-Fir South

Reference herein to Douglas Fir-Larch shall apply to Douglas Fir and Western Larch grown within the states of Wyoming, Montana, Idaho, Washington, Oregon and California, because the design values shown are based on a statistical analysis of the growth characteristics of the lumber from these sources.

Reference herein to Douglas Fir South shall apply to Douglas Fir grown within the states of Arizona, Colorado, Nevada, New Mexico and Utah because the design values shown are based on a statistical analysis of the growth characteristics of the lumber from these sources.

4.4. Species Specific Requirements – Hem-Fir

Reference herein to Hem-Fir species shall apply to any one or any combination of the following species: Western Hemlock, Pacific Silver Fir, Noble Fir, Grand Fir, California Red Fir and White Fir, including Hem-Fir grown in Canada.

In addition to the General Requirements outlined in Section 3, and the General Requirements for Visual Grades in Section 4.1 and 4.2, the following requirements apply for additional grades:

4.4.1. SSS

- Density: Dense by weight measurement only.
- Knot Size: Knots shall not occupy more than 1/10 of the cross-section.
- Slope of Grain: The basic slope of grain shall not exceed 1:18 for the full length of the piece.

4.5. Species Specific Requirements – Soft Woods

Reference herein to these species (SW) shall apply to any of the Softwood Species grown in the United States and Canada having an assigned modulus of elasticity (E) of 1,000,000 psi or more and design values in shear of 135 psi or more for No. 3 structural joists and planks grade based on 19% moisture content. The Softwood Species are those listed in *Standard Grading Rules for Western Lumber* (21) of the Western Wood Products Association, the *Standard Grading Rules for West Coast Lumber* (22) of the West Coast Lumber Inspection Bureau, *Standard Specifications for Grades of California Redwood Lumber* (23) of the Redwood Inspection Service, *Standard Grading Rules for Northeastern Lumber* (24) of the Northeastern Lumber Manufacturers Association or the *Standard Grading Rules for Canadian Lumber* (25) of the National Lumber Grades Authority (a Canadian agency).

4.6. Species Specific Requirements – Southern Pine

Reference herein to “Southern Pine” shall apply to the four major species of Southern pines: Loblolly, Longleaf, Shortleaf and Slash, as defined in the *Southern Pine Inspection Bureau Grading Rules* (26) of the Southern Pine Inspection Bureau (SPIB).

Note on slope of grain: The slope of grain for each grade is the maximum slope of grain allowed for the grade. Lamination requirements for the specified layup may be more restrictive than the basic slope of grain permitted by the grade. Where applicable, the more restrictive requirements apply. AITC 117 specifies slope of grain requirements for a particular lamination.

4.6.1. N1D

In addition to the General Requirements outlined in Section 3, and the General Requirements for Visual Grades in Section 4.1, the following requirements apply by grade:

- Density: Dense.
- Slope of Grain: The basic slope of grain shall not exceed 1:10 for the full length of the piece.
- Knot Size:

Width	4”	6”	8”	10”	12”
Edge Knot	1	1-1/2	2	2-1/2	3
Centerline Knot	1-1/2	2-1/4	2-3/4	3-1/4	3-3/4

4.6.2. N1M

In addition to the General Requirements outlined in Section 3, and the General Requirements for Visual Grades in Section 4.1, the following requirements apply by grade:

- Density: Medium.
- Slope of Grain: The basic slope of grain shall not exceed 1:10 for the full length of the piece.
- Knot Size:

Width	4”	6”	8”	10”	12”
Edge Knot	1	1-1/2	2	2-1/2	3
Centerline Knot	1-1/2	2-1/4	2-3/4	3-1/4	3-3/4

4.6.3. N2D

In addition to the General Requirements outlined in Section 3, and the General Requirements for Visual Grades in Section 4.1, the following requirements apply by grade:

- Density: Dense.
- Slope of Grain: The basic slope of grain shall not exceed 1:8 for the full length of the piece.
- Knot Size:

Width	4”	6”	8”	10”	12”
Edge Knot	1-1/4	1-7/8	2-1/2	3-1/4	3-3/4
Centerline Knot	2	2-7/8	3-1/2	4-1/4	4-3/4

4.6.4. N2M

In addition to the General Requirements outlined in Section 3, and the General Requirements for Visual Grades in Section 4.1, the following requirements apply by grade:

- Density: Medium.
- Slope of Grain: The basic slope of grain shall not exceed 1:8 for the full length of the piece.
- Knot Size:

Width	4”	6”	8”	10”	12”
Edge Knot	1-1/4	1-7/8	2-1/2	3-1/4	3-3/4
Centerline Knot	2	2-7/8	3-1/2	4-1/4	4-3/4

4.6.5. N3M

In addition to the General Requirements outlined in Section 3, and the General Requirements for Visual Grades in Section 4.1, the following requirements apply by grade:

- Density: Medium.
- Slope of Grain: The basic slope of grain shall not exceed 1:8 for the full length of the piece.

- Knot Size:

Width	4”	6”	8”	10”	12”
Edge Knot	1-3/4	2-3/4	3-1/2	4-1/2	5-1/2
Centerline Knot	2-1/2	3-3/4	4-1/2	5-1/2	6-1/2

4.6.6. N3C

In addition to the General Requirements outlined in Section 3, and the General Requirements for Visual Grades in Section 4.1, the following requirements apply by grade:

- Density: Coarse.
- Slope of Grain: The basic slope of grain shall not exceed 1:4 for the full length of the piece.
- Knot Size:

Width	4”	6”	8”	10”	12”
Edge Knot	1-3/4	2-3/4	3-1/2	4-1/2	5-1/2
Centerline Knot	2-1/2	3-3/4	4-1/2	5-1/2	6-1/2

4.7. Grade Specific Requirements – Alaska Cedar

Reference herein to this species shall apply to Alaska Cedar grown in the United States or Canada.

In addition to the General Requirements outlined in Section 3, and the General Requirements for Visual Grades in Section 4.1 and 4.2, the following additional requirements/exceptions apply by grade:

4.7.1. L1S

- Density: Dense.
- Knot Size: Knots shall not occupy more than 1/4 of the cross-section. A cross section shall be defined as any one-foot length.
- Slope of Grain: The basic slope of grain shall not exceed 1:14 for the full length of the piece.

4.7.2. L1D

- Slope of Grain: The basic slope of grain shall not exceed 1:12 for the full length of the piece.

4.8. Grade Specific Requirements – California Redwood

Reference to this species herein applies Redwood manufactured from timber grown within the Northern California coastal area as defined in the *Standard Specifications for Grades of California Redwood Lumber* (23) of the Redwood Inspection Service. The design values shown herein are based on a statistical analysis of the growth characteristics of the lumber from this source.

Laminating lumber shall be of Redwood graded in accordance with the *Standard Specifications for Grades of California Redwood Lumber* (23) of the Redwood Inspection Service.

There are five structural laminating grades of Redwood used for laminating purposes: "L1", clear all heart laminating; "L2", clear laminating; "L3", select heart laminating; "L4", construction heart laminating and "L5", construction laminating. See the above referenced standard for grading rules and specific requirements.

5. E-rated Grades (Other than 302-Tension Laminations)

5.1. General

E-rated laminating lumber is lumber that has been selected by nondestructive measurement and by visual inspection for compliance with the grade stiffness and manufacturing requirements of Section 3. An E-rated laminating lumber grade includes pieces with edge characteristics (knots, knotholes, burls, distorted grain) up to the maximum size allowed for use with the grade in any laminated timber lay-up combination. E-rated lumber has additional visual restrictions for portions of the lumber not evaluated for stiffness.

5.2. Long-Span E (MOE)

Long-span E or MOE as defined herein shall be used as the standard nomenclature for specifying E values of E-rated laminating lumber.

5.2.1. Definition

Long-span E is defined as the Modulus of Elasticity (MOE) calculated from deflection measured in a flat-wise static bending test of lumber with center point loading and a span-depth ratio (l/d) of approximately 100.

5.2.2. Measurement

Long-span E shall be measured by the procedures of AITC Test T116.

5.2.3. Lumber Production

E-rated laminating lumber shall be permitted to be produced with a system that measures MOE by means other than direct long-span E measurement. Production equipment used to measure MOE shall be calibrated to produce E-rated laminating lumber grades meeting the long-span E requirements of those grades. For purposes of calibration, long-span E shall be measured by the procedures of AITC Test T116.

5.3. E-Rated Laminating Lumber Specifications

5.3.1. Grade Names

E-rated laminating lumber grades shall be designated by the mean MOE of the grade, which is the mean long-span E requirement of the grade, the word "LAM", and the denominator of allowable edge knot fraction. For example, a grade with a mean long-span E requirement of 1,900,000 psi and an allowable 1/3 edge characteristic will be named "1.9E LAM-3". (For reasons of spacing on a grade stamp, this is permitted to be shortened to 1.9E-3 on a stamp.)

5.3.2. E Specifications for E-rated Lumber for Qualification

5.3.2.1. Mean long-span E

If the sample size is less than 125, the mean long-span E of the lumber shall equal or exceed the specified grade mean MOE. Alternatively, if the sample size equals or exceeds 40, the mean long-span E of the sample, E_t, shall meet the following criteria:

$$E_t \geq E_s - 1.303 \; S_t / \sqrt{n_t}$$

where:

S_t = the estimated population standard deviation

$S_t = (E_t - E_{st}) / 1.684$

n_t = sample size (≥ 40)

E_t = mean long-span E of the sample

E_s = grade long-span E

E_{st} = 5th percentile long-span E calculated from the test data

5.3.2.2. MOE Distribution

The distribution of MOE values within an E-rated lumber grade shall be such that the 5th percentile value shall be equal to or greater than the grade 5th percentile values as shown in the table below.

LONG-SPAN E SPECIFICATIONS		
GRADE	MEAN	5TH PERCENTILE
2.6E LAM	2.6	2.26
2.5E LAM	2.5	2.16
2.4E LAM	2.4	2.06
2.3E LAM	2.3	1.96
2.2E LAM	2.2	1.86
2.1E LAM	2.1	1.77
2.0E LAM	2.0	1.67
1.9E LAM	1.9	1.58
1.8E LAM	1.8	1.48
1.7E LAM	1.7	1.39
1.6E LAM	1.6	1.30
1.5E LAM	1.5	1.21

5.3.3. Visual Limitations

5.3.3.1. Edge Characteristics

Characteristics such as knots, knotholes, burls, and distorted grain occurring at the edges of the wide faces shall be measured and limited to a fraction of the cross section in conformance with American Lumber Standards--approved procedures in the following categories:

Edge Characteristics	Codes
1/6	6
1/4	4
1/3	3
1/2	2

5.3.3.2. Untested Portions

Portions of the lumber not tested by the E-rating device shall conform to the following visual limitations:

- Non-Edge Knots equal to the largest non-edge knots in the tested portion of the piece or the next larger edge knot, whichever is greater.
- Cross-Section Knots: Displacement of all knots in the same cross section shall not exceed the size of the permitted non-edge knot.
- Slope of Grain the general slope of grain in the untested portion shall not be steeper than:

Slope	Edge Characteristic
1 in 12	≤ 1/6
1 in 10	> 1/6 to ≤1/4
1 in 8	> 1/4

5.4. Production Quality Control

5.4.1. Supervision

Quality control of E-rated laminating lumber shall be under the supervision of an accredited third party inspection agency.

5.4.2. Quality Control

5.4.2.1. Formal Quality Control Program Required

A formal quality control program shall be maintained at the production facility to provide conformance to grade specifications on a continuous basis. The quality control program shall be approved by an accredited third party inspection agency.

5.4.2.2. E-rated Grade Edge Characteristics

The edge characteristic restrictions applied for lay-up shall not be required to be considered when establishing the MOE criteria for quality control of an E-rated laminating lumber grade or when evaluating a given lot of E-rated laminating lumber for conformance to the E specifications of the grade of the lot.

5.4.2.3. Quality Control Records

Quality control records shall be maintained at the lumber production facility, for a minimum of five (5) years.

5.5. Reinspection of Individual Lots for Conformance to Specifications

5.5.1. Test Method and Evaluation

The procedures of AITC Test T124 shall be used for testing and evaluating individual lots of E-rated laminating lumber for conformance to grade specifications.

5.5.2. Disposition of Nonconforming Lots

5.5.2.1. Regrade

The lumber shall be permitted to be regraded by testing all of the pieces in the lot in accordance with the long-span E testing procedures of AITC Test T116 and eliminating low E pieces from the lot so that the specifications for mean and lower 5th percentile E values of the E-rated grade are met. If the lumber is regraded by commercial testing devices other than a long-span E measuring device, conformance to grade specifications shall be verified by AITC Test T124.

5.5.2.2. Assign a Lower Grade Level

The lumber shall be permitted to be used at a lower E-rated grade level for which the lot was qualified by the test results.

6. Special Tension Lamination Grades

6.1. General

There are six (6) grades of tension laminations, 302-20, 302-22, 302-24, 302-26, 302-28 and 302-30. The following general restrictions and limiting provision apply to all grades and sizes of lumber graded as tension laminations:

6.1.1. Cross Section

A one-foot length of a lamination shall be considered as a cross section.

6.1.2. Density

Growth rate requirements shall apply to the full length of the piece. All tension laminations shall be required to be dense. Each piece shall have a specific gravity greater than the near average specific gravity for the species. See section 4.1.4 for the near average specific gravity by species.

Exception: Certain exceptions apply as shown in the Alternate Rules for each grade below.

6.2. 302-20

6.2.1. Primary Rules (All Species)

6.2.1.1. General

In addition to the basic requirements of the grades tabulated in these specifications, the following limitations shall apply to all 302-20 grades under the primary rules of grading:

- Knots shall not occupy more than 1/4 of the width in any cross section.
- The general slope of grain shall not be steeper than 1:12. Where more restrictive slope of grain is required by the laminating combinations, the more restrictive slope of grain shall apply.

- Any cross section shall have at least 50 percent clear wood free of strength-reducing characteristics with a slope of grain no steeper than 1:12. (Knots plus associated localized cross grain, knots plus associated localized cross grain plus localized cross grain not associated with a knot, or localized cross grain not associated with a knot are permitted to occupy up to 1/2 of the cross section.)

6.2.1.2. Visually Graded Combinations

In addition to the provisions in 6.2.1.1, the following applies to visually graded combinations:

- Pieces containing wide-ringed or lightweight pith associated wood at the ends of the piece occupying over 1/8 of the cross section shall be excluded. (The next inch of wood outside the area of the pith associated wood shall be dense. The line along which measurement of this inch is made shall correspond to the line used in the standard grading rules for rate of growth and percentage of summerwood. If a distance of one inch is not available along this line, the measurement will be made over such lesser portion as exists.)

6.2.1.3. E-Rated Combinations.

In addition to the provisions in 6.2.1.1, the following applies to E-rated combinations:

- Laminations for E-rated combinations shall be visually graded and E-rated in accordance with all of the requirements for the E-rated grade shown for the outer tension laminations.
- Pieces containing wide-ringed or lightweight pith associated wood at the ends of the piece occupying over 1/8 of the cross section shall be excluded. All wood not included as pith-associated wood shall be at least medium grain rate of growth.

6.2.2. Alternate Rules

6.2.2.1. Douglas Fir-Larch

Exceptions to provisions in 6.2.1 are allowed for Douglas Fir-Larch, 302-20 tension laminations as follows. Provisions not listed here are not excepted:

- Knots shall not exceed the size listed in the following chart:

Nominal width, in.	4	6	8	10	12
Knot size, in.	3/8	1/2	3/4	7/8	1

- Any cross section shall have at least 3/4 clear wood free of strength-reducing characteristics. (Knots plus associated localized cross grain, knots plus associated localized cross grain plus localized cross grain not associated with a knot, or localized cross grain not associated with a knot is permitted to occupy up to 1/4 of the cross section.)
- Slope of grain shall not be steeper than 1:10
- Pieces shall have a specific gravity of 0.45 or above based on oven-dried weight and volume at 12% moisture content.
- **End Joint Qualification:** Manufacturers using these alternative tension lamination provisions shall qualify their end joint by testing 30 end joints containing the maximum slope of grain to be used in the plant for this grade up to 1:10. Test procedures and criteria for acceptance of this test are as contained in AITC Test T119.

6.2.2.2. E-Rated

The following are alternative provisions for E-rated tension laminations. Laminations shall be visually graded and E-rated in accordance with all of the requirements for the E-rated grade shown for the outer tension laminations, except where specifically modified in this section. Lumber shall be from an E-rating system which employs continuously measured lowest point modulus of elasticity. In addition to these basic requirements the following limitations shall apply:

- Centerline knots shall not occupy more than 1/4 of the cross section.
- Edge knots are limited to that allowed by the E-rated grade.
- *Special Provisions For Ends of Piece*. In addition to the visual requirements above, the untested portion(s) of each piece shall be visually graded to meet the following:

- The untested portion(s) of the piece shall have the same general character as the remainder of the piece.
- The general slope of grain shall not be steeper than 1:12.
- Any cross section shall have at least 1/2 clear wood free of strength reducing characteristics.

- **Testing Provisions:** When this alternative provision is used the lumber shall be tested and qualified in accordance with AITC Test T123. Criteria for acceptance shall be that the 5th percentile with 75% confidence determined by AITC Test T123 shall equal or exceed 3,340 psi.
- *Application*. Tension laminations qualified under this alternate provision are permitted to be used for all visually graded combinations without regard to the long span E provided the compression perpendicular to grain design values are satisfied.

6.3. 302-22

6.3.1. Primary Rules (All Species)

6.3.1.1. General

In addition to the basic requirements of the grades tabulated in these specifications, the following limitations shall apply to all 302-22 grades under the primary rules of grading:

- Knots shall not occupy more than 1/4 of the width in any cross section.
- Any cross section shall have at least 60% clear wood free of strength-reducing characteristics with a slope of grain no steeper than 1:16. (Knots plus associated localized cross grain, or knots plus associated localized cross grain plus associated cross grain not associated with a knot, or localized cross grain not associated with a knot is permitted to occupy up to 40% of the cross section.)
- The general slope of grain shall not be steeper than 1:16. Where more restrictive slope of grain is required by the laminating combinations, the more restrictive slope of grain shall apply.

6.3.1.2. Visually Graded Combinations

In addition to the provisions in 6.3.1.1, the following applies to visually graded combinations:

- Pieces containing wide-ringed or lightweight pith associated wood at the ends of the piece occupying over 1/8 of the cross section shall be excluded. (The next inch of wood outside the area of the pith-associated wood shall meet the growth rate requirements of the grade, including "dense" when dense laminations are required. The line along which measurement of this inch is made shall correspond to the line used in the standard grading rules for rate of growth and percentage of summerwood. If a distance of one inch is not available along this line, the measurement will be made over such lesser portion as exists.)

6.3.1.3. E-Rated Combinations

In addition to the provisions in 6.3.1.1, the following applies to E-rated combinations:

- Laminations shall be visually graded and E-rated in accordance with all of the requirements for the E-rated grade shown for the outer tension laminations.
- Pieces containing wide-ringed or lightweight pith associated wood at the ends of the piece occupying over 1/8 of the cross section shall be excluded. All wood not included as pith associated wood shall be of at least medium grain rate of growth.

6.3.2. Alternate rules

6.3.2.1. Douglas Fir-Larch

Exception to provisions in 6.3.1 are allowed for Douglas Fir-Larch, 302-22 tension laminations as follows. Provisions not listed here are not excepted:

- Knots shall not exceed the size listed in the following chart:

Nominal width, in.	4	6	8	10	12
Knot size, in.	3/8	1/2	3/4	7/8	1

- Any cross section shall have at least 3/4 clear wood free of strength-reducing characteristics. (Knots plus associated localized cross grain, knots plus associated localized cross grain plus localized cross grain not

associated with a knot, or localized cross grain not associated with a knot is permitted to occupy up to 1/4 of the cross section.)

- Slope of grain shall not be steeper than 1:16.
- Growth rate requirements shall apply to the full length of the piece. Douglas Fir-Larch tension laminations are required to have at least an average of six annual rings per inch. Pieces shall have a specific gravity of 0.35 or above based on oven-dried weight and volume of 12% moisture content. (This tension lamination provides a compression perpendicular to grain design value of 590 psi. Where required to have 650 psi compression perpendicular to grain design value, at least one dense two inch nominal thickness lamination is required in the bearing area.)
- **End Joint Qualification:** Manufacturers using these alternative tension lamination provisions shall qualify their end joint by testing 30 end joints containing the maximum slope of grain to be used in the plant for this grade up to 1:16. Test procedures and criteria for acceptance of this test are as contained in AITC Test T119.

6.3.2.2. Douglas Fir-Larch

Exceptions to provisions in 6.3.1 are allowed for Douglas Fir-Larch, 302-22 tension laminations as follows. Provisions not listed here are not excepted:

- Knots shall not exceed the size listed in the following chart:

Nominal width, in.	4	6	8	10	12
Knot size, in.	3/8	1/2	3/4	7/8	1

- Any cross section shall have at least 3/4 clear wood free of strength-reducing characteristics. (Knots plus associated localized cross grain, knots plus associated localized cross grain plus localized cross grain not associated with a knot, or localized cross grain not associated with a knot is permitted to occupy up to 1/4 of the cross section.)
- Slope of grain shall not be steeper than 1:12.
- Growth rate requirements shall apply to the full length of the piece. Douglas Fir-Larch tension laminations are required to have at least an average of 6 annual rings per inch. (This tension lamination provides a compression perpendicular to grain design value of 590 psi. Where required to have 650 psi compression perpendicular to grain design value, at least one dense two inch nominal thickness lamination is required in the bearing area.)
- The long-span modulus of elasticity shall not be less than 1,700,000 psi.
- **End Joint Qualification:** Manufacturers using these alternative tension lamination provisions shall qualify their end joint by testing 30 end joints containing the maximum slope of grain to be used in the plant for this grade up to 1:12. Test procedures and criteria for acceptance of this test are as contained in AITC Test T119.

6.3.2.3. E-rated

The following are alternative provisions for E-rated tension laminations. Laminations shall be visually graded and E-rated in accordance with all of the requirements for the E-rated grade shown for the outer tension lamination, except where specifically modified in this section. Lumber shall be from a E-rating system which employs continuously measured lowest point modulus of elasticity. In addition to these basic requirements the following limitations shall apply:

- Centerline knots shall not occupy more than 1/4 of the cross section.
- Edge knots are limited to that allowed by the E-rated grade.
- *Special Provisions For Ends of Piece*. In addition to the visual requirements above, the untested portion(s) of each piece shall be visually graded to meet the following:
    - The untested portion(s) of the piece shall have the same general character as the remainder of the piece.
    - The general slope of grain shall not be steeper than 1:12.
    - Any cross section shall have at least 60% clear wood free of strength reducing characteristics.

- **Testing Provisions:** When this alternative provision is used the lumber shall be tested and qualified in accordance with AITC Test T123. Criteria for acceptance shall be that the 5th percentile with 75% confidence determined by AITC Test T123 shall equal or exceed 3,670 psi.
- *Application*: Tension laminations qualified under this alternate provision are permitted to be used for all visually graded combinations without regard to the long span E provided the compression perpendicular to grain design values are satisfied.

6.4. 302-24

6.4.1. Primary rules

6.4.1.1. General

In addition to the basic requirements of the grades tabulated in these specifications, the following limitations shall apply to all 302-24 grades under the primary rules of grading:

- Knots shall not occupy more than 1/5 of the width in any cross section.
- Any cross section shall have at least 2/3 clear wood free of strength-reducing characteristics with a slope of grain no steeper than 1:16. (Knots plus associated localized cross grain, knots plus associated localized cross grain plus localized cross grain not associated with a knot, or localized cross grain not associated with a knot is permitted to occupy up to 1/3 of the cross section.)
- Maximum size single strength-reducing characteristics when not in the same horizontal projection shall be at least two feet apart measured center to center.
- The general slope of grain shall not be steeper than 1:16. Where more restrictive slope of grain is required by the laminating combinations, the more restrictive slope of grain shall apply.

6.4.1.2. Visually Graded Combinations.

In addition to the provisions in 6.4.1.1, the following applies to visually graded combinations:

- Pieces containing wide-ringed or lightweight pith-associated wood at the ends of the piece occupying over 1/8 of the cross section shall be excluded. (The next inch of wood outside the area of the pith-associated wood shall meet the growth rate requirements of the grade, including "dense" when dense laminations are required. The line along which measurement of this inch is made shall correspond to the line used in the standard grading rules for rate of growth and percentage of summerwood. If a distance of one inch is not available along this line, the measurement will be made over such lesser portion as exists.)

6.4.1.3. E-Rated Combinations.

In addition to the provisions in 6.4.1.1, the following applies to E-rated combinations:

- Laminations shall be visually graded and E-rated in accordance with all of the requirements for the E-rated grade shown for the outer tension lamination.
- Pieces containing wide-ringed or lightweight pith associated wood at the ends of the piece occupying over 1/8 of the cross section shall be excluded. All wood not included as pith-associated wood shall be at least medium grain rate of growth.

6.4.2. Alternate rules

6.4.2.1. Douglas Fir-Larch

Exception to provisions in 6.4.1 are allowed for Douglas Fir-Larch, 302-24 tension laminations as follows. Provisions not listed here are not excepted:

- Knots shall not exceed the size listed in the following chart:

Nominal width, in.	4	6	8	10	12
Knot size, in.	3/8	1/2	3/4	7/8	1

- Any cross section shall have at least 3/4 clear wood free of strength-reducing characteristics. (Knots plus associated localized cross grain, knots plus associated localized cross grain plus localized cross grain not

associated with a knot, or localized cross grain not associated with a knot is permitted to occupy up to 1/4 of the cross section.)

- Maximum size single strength-reducing characteristics when not in the same horizontal projection shall be as least 2 ft apart measured center to center.
- Slope of grain shall not be steeper than 1:12.
- The long-span modulus of elasticity shall not be less than 1,800,000 psi.
- **End Joint Qualification:** Manufacturers using these alternative tension lamination provisions shall qualify their end joint by testing 30 end joints containing the maximum slope of grain to be used in the plant for this grade up to 1:12. Test procedures and criteria for acceptance of this test are as contained in AITC Test T119.

6.4.2.2. E-rated

The following are alternative provisions for E-rated tension laminations. Laminations shall be visually graded and E-rated in accordance with all of the requirements for the E-rated grade shown for the outer tension lamination, except where specifically modified in this section. Lumber shall be from a E-rating system which employs continuously measured lowest point modulus of elasticity. In addition to these basic requirements the following limitations shall apply:

- Centerline knots shall not occupy more than 1/5 of the cross section.
- Maximum size single strength-reducing characteristics when not in the same horizontal projection shall be at least two feet apart measured center to center.
- Edge knots are limited to that allowed by the E-rated grade.
- *Special Provisions For Ends of Piece*. In addition to the visual requirements above, the untested portion(s) of each piece shall be visually graded to meet the following:
    - The untested portion(s) of the piece shall have the same general character as the remainder of the piece.
    - The general slope of grain shall not be steeper than 1:12.
    - Any cross section shall have at least 2/3 clear wood free of strength reducing characteristics.
- **Testing Provisions:** When this alternative provision is used the lumber shall be tested and qualified in accordance with AITC Test T123. Criteria for acceptance shall be that the 5th percentile with 75% confidence determined by AITC Test T123 shall equal or exceed 4,000 psi.
- **End Joint Qualification:** Manufacturers using these alternative tension lamination provisions shall qualify their end joint by testing 30 end joints containing the maximum slope of grain to be used in the plant for this grade up to 1:12. Test procedures and criteria for acceptance of this test are as contained in AITC Test T119.
- *Application***:** Tension laminations qualified under this alternate provision are permitted to be used for all visually graded combinations without regard to the long span E provided the compression perpendicular to grain design values are satisfied.

6.5. 302-26

6.5.1. Primary rules

In addition to the basic requirements of the 302-24 lamination grade as tabulated in section 6.4, the following limitations shall apply:

- Any cross section containing an edge knot shall have 80% clear and straight-grained wood.

6.6. 302-28

6.6.1. Primary rules

In addition to the basic requirements of the 302-24 lamination grade as tabulated in section 6.4, the following limitations shall apply:

- Average Long Span E for the grade shall be 2.3 million psi with no piece less than 1.96 million psi and shall be verified through daily quality control.

6.7. 302-30

6.7.1. Primary Rules

In addition to the basic requirements of the 302-26 lamination grade as tabulated in section 6.4, the following limitations shall apply:

- Average Long Span E for the grade shall be 2.3 million psi with no piece less than 1.96 million psi and shall be verified through daily quality control.

6.8. Alternate Rules by Species

6.8.1. Southern Pine

Exception to provisions in 6.2, 6.3 and 6.4 are allowed for southern pine as follows. Provisions not listed here are not excepted:

- Knots shall not exceed the size listed in the following chart:

Nominal width, in.	4	6	8	10	12
Knot size, in.	3/8	1/2	3/4	7/8	1

- Any cross section shall have at least 3/4 clear wood free of strength-reducing characteristics. (Knots plus associated localized cross grain, or knots plus associated localized cross grain not associated with a knot, or localized cross grain not associated with a knot is permitted to occupy up to 1/4 of the cross section.)
- Slope of grain shall be no steeper than 1:10 for 302-20 and 1:12 for 302-22 and 302-24.
- **End Joint Qualification:** Manufacturers using these alternative tension lamination provisions shall qualify their end joint by testing 30 end joints containing the maximum slope of grain to be used in the plant for this grade up the maximum allowable for said grade. Test procedures and criteria for acceptance of this test are as contained in AITC Test T119.

6.8.2. E-Rated Hem Fir

The following are alternative provisions to those included in Sections 6.1, 6.2 and 6.3 for E-rated Hem-Fir tension laminations:

- Laminations shall be visually graded and E-rated in accordance with all of the requirements for the E-rated grade tabulated in these specifications for the outer tension lamination except where specifically modified in this section.
- Laminations shall conform to WCLIB Standard No. 17, paragraph 101-c except that the 3 in. cutout provision does not apply.
- The knot size permitted for all widths is a small knot (3/4 in. diameter). The number of 3/4 in. knots permitted is proportionate to the size of the piece of lumber in accordance with paragraph 101-c of WCLIB Standard No. 17.
- The 1/6th edge knot characteristic restriction shall be applied to nominal 4 in. wide lumber. For 302-24, 2.0E-1/6 grade is required, for 302-22, 1.8E-1/6 grade is required and for 302-20, 1.5E-1/4 grade is required.
- Any cross section shall have at least 2/3 clear wood free of strength-reducing characteristics (Knots plus associated localized cross grain, knots plus associated localized cross grain plus localized cross grain not associated with a knot, or localized cross grain not associated with a knot is permitted to occupy up to 1/3 of the cross section.)
- Slope of grain shall be no steeper than 1:12.
- For 302-24 grade, maximum size single strength-reducing characteristics when not in the same horizontal projection shall be at least two feet apart measured center to center.
- *Special Provisions for Ends of Piece*. The untested portion of each end of each piece shall be visually graded to meet the following:
    - The ends of the piece shall have the same general character as the remainder of the piece.
    - Any cross section shall have at least 1/2, 3/5 or 2/3 clear wood free of strength-reducing characteristics for 302-20, 302-22 or 302-24 respectively. (Knots plus associated localized cross grain, knots plus associated localized cross grain plus localized cross grain not associated with a knot, or localized cross

grain not associated with a knot is permitted to occupy up to 1/2, 2/5 or 1/3 of the cross section for 302-20, 302-22 and 302-24 respectively.)

- **End Joint Qualification:** Manufacturers using these alternative tension lamination provisions shall qualify their end joint by testing 30 end joints containing the maximum slope of grain to be used in the plant for this grade up to 1:12. Test procedures and criteria for acceptance of this test are as contained in AITC Test T119.
- **Testing Provisions.** The provisions for end joint qualification for clear wood at a cross section and general slope of grain is permitted to be eliminated if a test is conducted in accordance with AITC Test T123 to verify the strength of lumber from the E-rating system which employs continuously measured lowest point modulus of elasticity. Criteria for acceptance shall be that the 5th percentile with 75% confidence determined by AITC Test T123 shall equal or exceed the following values:

Grade	Test Value 5th Percentile, psi
302-24	4,000
302-22	3,670
302-20	3,340

6.9. C-14: Alternate Provision for Machine Graded Tension Laminations

6.9.1. General

This alternate provision covers lumber mechanically graded under the provisions of the American Lumber Standard (ALS). These grades shall be qualified and quality controlled by test for strength and stiffness by an agency qualified by ALS. These grades include machine stress-rated lumber (MSR) and machine-evaluated lumber (MEL). Machine graded lumber is lumber manufactured with the use of grading methodologies that include the use of machines for identifying mechanical properties in the grading process. This alternate provision shall be applied to lumber from each machine grading facility and grading system seeking qualification for production of tension laminations to be used on structural glued laminated timber with grades equivalent to the 302-20, 302-22 and 302-24 grades required. Machine graded lumber to be used under this alternate shall meet specific product descriptions as defined in the various standards. Qualification records shall be maintained at the facility where carried out and shall be available for review by the AITC Inspection Bureau.

Lumber to be qualified for tension laminations under this alternate provision shall be manufactured by a facility qualified to produce machine graded lumber under the supervision of a grading agency accredited by the American Lumber Standards Committee. This grading practice shall meet the quality control provision of such a grading agency and include quality control for tensile strength and long-span E properties.

6.9.2. Visual grading

The general visual requirements for machine graded lumber plus any additional visual limitations required by the supervisory grading agency for qualification under the provisions shall apply. In addition, the general lumber requirements contained in Section 3 of these rules shall apply.

6.9.3. Special Visual Grading Requirements.

The supervisory grading agency shall provide appropriate visual limitations applicable to those portions of pieces not subjected to machine grading which will assure that the tensile strength requirements of the grade are maintained. For this purpose, these rules are permitted to be those applied in sections 6.2, 6.3 and 6.4 to obtain grades equivalent to 302-20, 302-22 and 302-24.

6.9.4. Quality Control.

The quality control requirements of this alternate tension lamination material are the responsibility of the lumber producer under the supervision of a grading agency accredited by the American Lumber Standards Committee. Records for the respective quality control responsibilities shall be maintained at the facility where carried out and shall be available for periodic review by the grading agency and the AITC Inspection Bureau.

If the lumber is supplied to the laminator as meeting the requirements of Section 2, 6.7.1 and 6.7.2, all mechanical and visual inspection and quality control requirements shall be the responsibility of the machine grading facility.

If lumber is supplied to the laminator as meeting only the mechanical and visual stress grading criteria of 6.7.1, those inspection and quality control requirements shall be the responsibility of the machine grading facility; however, the laminator shall be responsible for the additional visual grading required to meet the laminating criteria of this standard.

6.9.5. Identification.

Each piece of machine graded lumber used under this alternative provision shall be grade stamped with the appropriate stamp of the supervisory grading agency.

6.9.6. Changes in Practice.

If, in the judgment of the AITC Inspection Bureau, significant changes are made in the visual or machine grading practice, the qualification prescribed herein shall be invalid and shall be re-qualified.

6.9.7. Testing Provisions.

When this alternative provision is used, the lumber shall be qualified for tensile strength and long-span E using a sample size of not less than 102 pieces. The testing procedures of AITC Test T123 shall be used for testing tensile properties. The testing procedures of AITC Test T116 shall be used for testing long-span E.

6.9.8. Criteria For Acceptance:

6.9.8.1. Tensile Strength Qualification.

For qualification for a tension lamination grade the 5th percentile tensile strength estimated with 75 percent confidence shall equal or exceed the values calculated as follows:

Grade	Test Value 5th Percentile, psi
302-24	4,000
302-22	3,670
302-20	3,340

Tension laminations for beams 6 inches or less in width and greater than 15 inches in depth shall meet or exceed 1.67 times the beam design value in bending, F_{bx}.

The values established in this way are then adjusted for lamination width by multiplying by the factors of 0.95, 0.90 and 0.84 for nominal 8, 10 and 12 inch widths respectively. These values are then reduced for beams of lesser depth by multiplying by factors of 0.90 for beams 12 inches to 15 inches in depth and 0.80 for beams less than 12 inches in depth.

6.9.8.2. End Joint Qualification.

Manufacturers using tension laminations qualified under this alternative provision shall qualify their end joints by following procedures in AITC Test T119 by testing 30 end joints in tension made from representative lumber from the machine grading system.

6.9.9. Application.

Tension laminations qualified under this alternative provision are permitted to be used for all visually graded and E-rated combinations provided the average long-span E of the laminations is at least equal to the average long-span E of the grade of lumber for which it is being substituted and the compression perpendicular to grain design values are satisfied.

6.9.10. Reinspection and Testing of Individual Lots for Conformance to Specifications.

The procedures of the grading agency supervising the production of the lumber shall be used for re-inspecting individual lots for conformance to specifications.

6.9.11. Records

The grading agency tha**t** supervises qualification to the provisions of C14 shall report a summary of the qualification results to the AITC Inspection Bureau.

7. Method for Determination of Specific Gravity

7.1. General

Measuring specific gravity of a piece of lumber shall be permitted to be used to determine density for all softwood species used for laminating, and shall be required to be used for dense Hem-Fir, since ring count and percent summerwood do not provide a reliable measure of density for Hem-Fir.

In determining specific gravity, lumber shall be weighed and a weight per volume shall be calculated. From this number the specific gravity shall be calculated.

In weighing lumber to determine specific gravity, several factors shall be taken into account: moisture content of the lumber; width, thickness and length; and accuracy of the measurements.

7.2. Moisture Content

The moisture content of lumber at the time of weighing shall be taken into account in determining whether or not a piece meets the minimum weight requirements for the species. The range of moisture content of lumber used for laminating is relatively small. However, in the preparation of charts to use in production, the minimum weights for 8%, 12% and 16% moisture content are recommended. Minimum weights for intermediate moisture contents may be interpolated.

Moisture contents shall be measured with a moisture meter calibrated for the species being tested.

7.3. Size

The thickness and width of lumber shall be maintained according to ANSI/AITC A190.1 tolerances, and measured to the nearest 0.01 in. at the time of weighing. Length shall be measured to the nearest 1/8 in.

7.4. Method of Weighing

Any method of weighing the nearest 0.01 lb. Is satisfactory.

7.5. Calculation of Specific Gravity

Calculation of specific gravity shall be normalized to 12% moisture content in order to compare it to the required levels. Therefore, the moisture content of the piece being measured shall be accurately measured and recorded. (Formulas were derived from equations in the Wood Handbook, 1999.)

First, the unit weight of the material shall be determined.

Start by calculating the volume of material measured:

$$V = \frac{w \cdot d \cdot l}{1728 in^3 / ft^3}$$

Where:

V = volume of lumber in ($ft^{3)}$

w = actual width of the lumber (in)

d = actual thickness of the lumber (in)

l = actual length of the lumber (in)

Then calculate the unit weight:

$$\rho = \frac{W}{V}$$

Where:

ρ = unit weight of lumber measured (lbs/ft^3)

W = measured weight of the piece (lbs)

From this the specific gravity of the piece can be calculated at its moisture content:

$$G_m = \frac{\rho}{62.4\,lbs/\,ft^3\left(1-\frac{M}{100}\right)}$$

Where:

G_m = specific gravity at moisture content M

M = measured moisture content (as percent)

With this the basic specific gravity of the piece can be calculated:

$$G_b = \frac{G_m}{1+\left[0.265\left(\frac{30-M}{30}\right)G_m\right]}$$

Where:

G_b = basic specific gravity

Finally the specific gravity at 12% moisture content can be calculated:

$$G_{12\%} = \frac{G_b}{1-0.159G_b}$$

If this number is larger than the required specific gravity, the piece passes.

Example: A DF-L 12 ft. 2x6 with a moisture content of 16% is weighed at 20.5 lbs. The average specific gravity for DF-L (see Section 4.1.4) is 0.46. Is this piece dense?

$$V = \frac{1.5in.\cdot 5.5in.\cdot 144in.}{1728\,in^3/\,ft^3} = 0.69\,ft^3$$

$$\rho = \frac{20.5lbs}{0.69\,ft^3} = 29.7\,lbs/\,ft^3$$

$$G_m = \frac{29.7\,lbs/\,ft^3}{62.4\,lbs/\,ft^3\left(1-\frac{16}{100}\right)} = 0.41$$

$$G_b = \frac{0.41}{1+\left[0.265\left(\frac{30-16}{30}\right)0.41\right]} = 0.39$$

$$G_{12\%} = \frac{0.39}{1-(0.159\cdot 0.39)} = 0.42$$

0.42 < 0.45 therefore the piece is *not* dense.

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