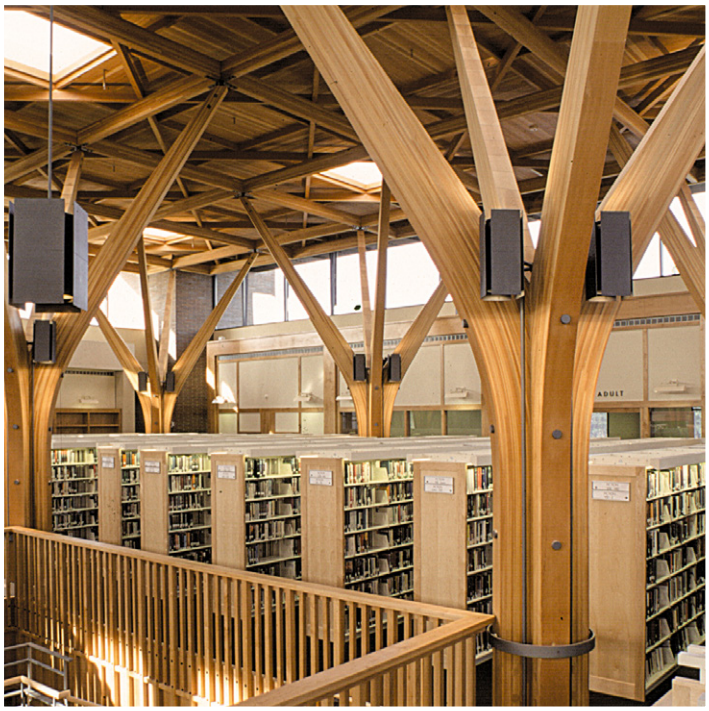
ANSI 117-2010

AMERICAN NATIONAL STANDARD

Standard Specification for Structural Glued Laminated Timber of Softwood Species



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APA – The Engineered Wood Association

Approved August 25, 2010
American National Standards Institute

FOREWORD (This Foreword is not a part of American National Standard ANSI 117-2010)

This Standard is an American National Standard previously designated as AITC 117-2010. It contains information for the design of structural glued laminated timber (glulam) members.

Development of consensus for this Standard was accomplished by the *Procedures for Development of American Institute of Timber Construction Consensus Standards,* approved May 18, 2007 by the American National Standards Institute (ANSI).

Since January 1, 2013, *APA – The Engineered Wood Association* has assumed the Secretariat responsibilities for this Standard and re-designated it as ANSI 117-2010. The maintenance of this Standard follows the *Operating Procedures for Development of Consensus Standards of APA – The Engineered Wood Association,* approved by ANSI.

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

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STANDARD SPECIFICATION FOR STRUCTURAL GLUED LAMINATED TIMBER OF SOFTWOOD SPECIES

PREFACE

The term *structural glued laminated timber* (glulam) 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. Glulam 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.

This Specification contains values for the design of structural glued laminated timber members. It is, 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 the National Design Specification® (NDS®) for Wood Construction.

Section 1 of this Specification (*Basic Requirements*) identifies characteristics of importance to the use of structural glued laminated timber and provides general information useful to the manufacturer and designer.

Section 2 (*Reference Design Values*) provides and describes reference design values for use in the design of structural glued laminated timber. The reference design values require adjustment by procedures detailed in the NDS.® 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 the NDS.®

Specific lay-up requirements are provided in Section 3 of this Specification (*Lay-up Requirements*). The production of structural glued laminated timber under this Specification shall be in accordance with American National Standard ANSI A190.1 *Structural Glued Laminated Timber* (4).

Combinations not listed in this Specification are permitted to be used provided that all other requirements of this Specification are met. Specific requirements for alternate combinations are included in Section 4 of this Specification (*Alternate Combinations*).

1. BASIC REQUIREMENTS

1.1 General

Structural glued laminated timber conforming to this Specification shall be produced in laminating plants audited and licensed by an accredited inspection agency meeting the requirements of ANSI A190.1 (4). 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 accredited inspection agency. Timbers conforming to this Specification shall be marked according to ANSI A190.1 (4).

Structural glued laminated timbers are permitted to be made up of a single grade of lumber or multiple grades placed with specific quantities in specific zones within the cross-section. Structural glued laminated timber combinations generally utilize higher grade lumber in the outer zones than in the center of the beam or core. Design values for structural glued laminated timbers are established according to the analysis procedures of ASTM D3737 (7) or through full scale tests in accordance with ASTM D7341 (8) and analysis in accordance with ASTM D2915 (6).

1.2 Species

Structural glued laminated timber can be manufactured from any suitable wood species. Wood species with similar properties are grouped for convenience. Design properties and lay-up information are included in this Specification for structural glued laminated timbers of the following species groups:

Species Group	Symbol	Species that may be included in the group
Alaska Cedar	AC	Alaska Cedar
Douglas Fir-Larch	DF	Douglas Fir, Western Larch
Eastern Spruce	ES	Black Spruce, Red Spruce, White Spruce
Hem-Fir	HF	California Red Fir, Grand Fir, Noble Fir, Pacific Silver Fir, Western Hemlock, White Fir
Port-Orford Cedar	POC	Port-Orford Cedar
Softwood Species	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
Southern Pine	SP	Loblolly Pine, Longleaf Pine, Shortleaf Pine, Slash Pine
Spruce-Pine-Fir	SPF	Alpine Fir, Balsam Fir, Black Spruce, Engelmann Spruce, Jack Pine, Lodgepole Pine, Norway Pine, Red Spruce, Sitka Spruce, White Spruce

Other species or species groups are permitted to be used in accordance with ANSI A190.1 (4).

1.3 Combination Symbols

Each structural glued laminated timber lay-up is assigned a combination symbol. The combination symbol is used to identify a combination and to distinguish one combination from another. Each combination is assigned design values based on ASTM D3737 (7) or full scale tests in accordance with ASTM D7341 (8). Design values for combinations are tabulated in Annex A. Lay-up requirements for combinations are tabulated in Annex B.

The combination symbols in Table A1-Expanded indicate the primary design bending stress and the grading system used for the lumber in the outer zones. For example, 24F-V4 indicates that the beam has a primary bending design value of 2400 psi (16.6 MPa) and that the lumber in the outer zones was visually graded. 24F-E13 indicates that the bending design value is 2400 psi (16.6 MPa) and the lumber in the outer zones was

E-rated using a mechanical grading system in addition to visual requirements. The number at the end of the combination symbol (13 in this example) is a number assigned to distinguish between different combinations. The species group(s) used in the beam is also included as part of the combination symbol. The first species group listed corresponds to the laminations in the outer zones of the lay-up, and the subsequent species group is for the laminations used in the interior zones.

The combination symbols for lay-ups in Table A2 are numbers which have been assigned for specification purposes. Each combination symbol corresponds to a specific grade of lumber used in a uniform grade lay-up.

1.4 Stress Classes

To simplify specification, combinations from Table A1-Expanded with 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 A1.

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. Table A1-Expanded lists combinations included in each stress class.

1.5 Balanced or Unbalanced Lay-ups

Structural glued laminated timbers are permitted to be manufactured with lumber grades placed symmetrically or asymmetrically about the neutral axis of the member. Timbers with symmetric lay-ups are referred to as "balanced" and have the same design values for positive and negative bending. Timbers with asymmetric lay-ups are referred to as "unbalanced" and have higher design stresses for positive bending than for negative bending. Unbalanced lay-ups are generally used for simple, single-span beams, while balanced lay-ups 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 straight or cambered beams is required to be marked "TOP" by the manufacturer to facilitate proper installation.

1.6 Adjusted Design Stresses

Reference design stresses for structural glued laminated timber are based on standard conditions and must be modified for expected end-use conditions by applying adjustment factors from the NDS.® The reference design stress multiplied by all applicable adjustment factors is referred to as the "adjusted design stress." The reference design values are discussed in Section 2.

1.7 Standard Sizes

American National Standard ANSI A190.1 (4) 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 A190.1 (4).

Standard net finished widths for structural glued laminated timbers are as shown in Table 1.7.

TABLE 1.7

STANDARD NET FINISHED WIDTHS FOR STRUCTURAL GLUED LAMINATED TIMBER.

Nominal Width of Laminations	Softwoods other than Southern Pine Net Width (in.)	Southern Pine Net Width (in.)
3	2-1/8 (55 mm) or 2-1/2 (65 mm)	2-1/8 (55 mm) or 2-1/2 (65 mm)
4[a]	3-1/8 (80 mm)	3 (75 mm) or 3-1/8 (80 mm)
6[a]	5-1/8 (130 mm)	5 (125 mm) or 5-1/8 (130 mm)
8	6-3/4 (170 mm)	6-3/4 (170 mm)
10	8-3/4 (220 mm)	8-1/2 (215 mm)
12	10-3/4 (275 mm)	10-1/2 (265 mm)
14	12-1/4 (310 mm)	12 (305 mm)
16	14-1/4 (360 mm)	14 (355 mm)

(a) Standard widths for structural glued laminated timber meeting the requirements of the Framing appearance grade are 3-1/2 in. (89 mm) for nominal 4 in. lamination width and 5-1/2 in. (140 mm) 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. (35 mm) thick, and laminations of other softwood species are typically surfaced to 1-1/2 in. (38 mm) thick. Laminations 3/4 in. (19 mm) thick are often used for curved members of both Southern Pine and Western Species. Depths matching standard I-joist depths are also available from many manufacturers.

1.8 Shapes

Structural glued laminated timbers can be manufactured in a variety of shapes from straight beams to curved arches. Members can also be manufactured with tapered or constant cross section.

1.8.1 For curved members manufactured with nominal 2 in. thickness laminations, the minimum radius of curvature (at the inside face) is 18 ft for Southern Pine and 27 ft 6 in. for other softwood species.

1.8.2 For tudor arches and other tightly curved members manufactured with nominal 1 in. thickness laminations, minimum radii of curvature (at the inside face) are:

7 ft 0 in.* for Southern Pine

9 ft 4 in.* for all other softwood species

*The manufacture of curved members with radii shorter than these requires standard thickness laminations to be planed to a thinner dimension resulting in more waste and less efficient use of materials. It is recommended that the designer contact the laminator prior to specifying radii shorter than those listed above. For thin laminations, the radius shall not be less than 100 times the lamination thickness for Southern Pine or 125 times the lamination thickness for other softwoods.

1.9 Appearance Grades

Appearance grades shall be specified in accordance with ANSI A190.1 (4) or as agreed upon between buyer and seller. The reference design values are independent of the appearance grades.

Special surfacing, such as rough saw texturing, may reduce the cross section and may affect the member capacity based on the reduced section properties. The reduced cross section (if applicable) shall be considered in design.

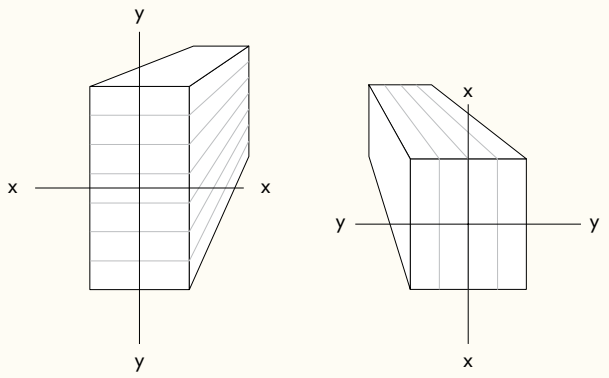
2. REFERENCE DESIGN VALUES

2.1 General

Design values for structural glued laminated timber are dependent on the orientation of the member relative 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 (Figure 2.1-1). 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 (Figure 2.1-1).

FIGURE 2.1-1

AXIS ORIENTATIONS



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), 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.

2.2 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 at the bottom of a beam. Negative bending causes compressive stresses at the bottom of a beam.

2.3 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. (1 mm) obtained when tested in accordance with ASTM D143 (5). A compression perpendicular to grain design value based on a 0.02 in. (0.5 mm) deformation limit can be estimated as 73% of the tabulated value.

2.4 Shear Design Values, F_{vx}, F_{vy}

The tabulated shear design values, F_{vx} and F_{vy}, are permitted to be used for prismatic members subjected to most load conditions. For non-prismatic members and for all members subject to impact or cyclic loads, the reference shear values shall be 72% of the tabulated values. The reduced value shall also apply to the design of members to resist shear from 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 reference design value shall be 95% of the tabulated value. For members with two laminations the reference design value shall be 84% of the tabulated value.

The tabulated shear design values permit minor amounts of checking (≤ 15% of beam width) without explicit consideration by the designer. An accredited inspection agency will typically provide guidelines for the analysis of severely checked beams.

2.5 Modulus of Elasticity Design Values, E_x, E_y, $E_{x\,min}$, $E_{y\,min}$, E_{axial}

Design values for modulus of elasticity are tabulated for bending about either axis. In general, E_x and E_y are used for calculation of deflection of members, and $E_{x\,min}$ and $E_{y\,min}$ are used for stability calculations for columns and beams. For the calculation of extensional deformations, the axial modulus of elasticity, can be estimated as $E_{axial} = 1.05E_y$, such as for use in calculating deflection of trusses.

$E_{x\,min}$ and $E_{y\,min}$ are calculated using the following formula:

$$E_{min} = \frac{E[1 - 1.645(CoV_E)][1.05]}{1.66} = \frac{E[1 - 1.645(0.10)][1.05]}{1.66} = 0.528E$$

where: E_{min} = $E_{x\,min}$ or $E_{y\,min}$ as appropriate
E = E_x or E_y as appropriate
CoV_E = coefficient of variation for modulus of elasticity

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 less than 14, deflections due to shear stresses should be considered. ASTM D2915 (6) presents one method of accounting for shear deformations.

2.6 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.

2.7 Compression Parallel to Grain Design Value, F_c

A single design value is tabulated for compression parallel to grain for each optimized combination or stress class. Uniform grade combinations have separate values tabulated for members with 2 or 3 laminations and for members with 4 or more laminations.

2.8 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 of the side faces, $F_{c\perp y}$.

2.9 Radial Tension Design Values, F_{rt}

For Southern Pine, the design value for radial tension (tension perpendicular to the longitudinal axis of a curved member), F_{rt}, shall be equal to 1/3 of the shear design value, F_{vx}, for non-prismatic members. Radial reinforcement shall not be required.

For all other softwood species, the reference design value for radial tension shall be limited to 15 psi (100 kPa) for loads other than wind or earthquake loads. If the calculated radial tension stress (due to loads or load combinations not including wind or seismic loads) exceeds 15 psi (100 kPa) multiplied by appropriate adjustment factors, 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 (3). For wind and earthquake loading, the design value for radial tension shall be 1/3 of the shear design value for non-prismatic members.

Loading type	Softwood species other than Southern Pine	Southern Pine
Wind or seismic	1/3 of F_{vx} for non-prismatic members	1/3 of F_{vx} for non-prismatic members
Other loading	15 psi[a]	1/3 of F_{vx} for non-prismatic members

(a) If the calculated radial tension stress (due to loads or load combinations not including wind or seismic loads) exceeds 15 psi (100 kPa) multiplied by appropriate adjustment factors, 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 (3).

2.10 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.

2.11 Modulus of Rigidity

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 lay-up. If data are available, they shall be permitted to be used to determine the modulus of rigidity.

2.12 Reference Design Value Tables

The design values in Table A1 and Table A1-Expanded are applicable to members with 4 or more laminations and are intended primarily for members stressed in bending about the x-x axis (Figure 2.1-1). Design values are included, however, for axial stresses and stresses from bending about the y-y axis (Figure 2.1-1). The values in Table A1 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 Table A1-Expanded.

Table A2 contains design values for timbers with uniform grade lay-ups. These combinations are intended primarily for timbers loaded axially or in bending about the y-y axis (Figure 2.1-1). Design values are included, however, for bending about the x-x axis (Figure 2.1-1).

The design values in Table 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 A3 shall replace the corresponding design values in Table A1 or Table A1-Expanded for all such field-tapered beams. For members manufactured with taper in the laminating plant with compression zone grade requirements maintained, the design values published in Table A1 shall apply.

3. LAY-UP REQUIREMENTS

3.1 Lumber Grades

Lumber grades shall be in accordance with Section 4.3 – *Lumber for Laminating* of ANSI A190.1 (4). *AITC Grading Handbook for Laminating Lumber* (1) summarizes the requirements for laminating grades of approved species and references approved grading rules.

3.2 Substitutions

Lumber of higher grades of the same species is permitted to be substituted in all lay-ups 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 the laminator's accredited inspection agency prior to making the substitution. Full or partial length substitutions are permitted.

3.3 Determining Number of Laminations in Each Zone

The number of laminations to use in each zone in the lay-up shall be calculated based on the percentages shown in Tables B1 and B2. Percent values shall be multiplied by the total depth of the member. The required number of laminations shall be determined starting with the outer zones and working inward. When the calculated 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 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.

Example: The tension zone of a hypothetical 16 lamination beam requires 5% 302-24, 15% L1, and 10% L2. The number of 302-24 laminations is determined by: 16 x 0.05 = 0.8 (rounded up to 1). The number of L1 laminations is: 16 x 0.15 – (1 – 0.8) = 2.4 – 0.2 = 2.2 lams (round up to 3). The number of L2 lams is 16 x 0.1 – (3 – 2.2) = 1.6 – 0.8 = 0.8 (rounded up to 1).

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. (35 mm) and 1.6 in. (41 mm) 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. (70 mm) of L1 grade is required in that zone.

3.4 Wane

Certain combinations are permitted to contain wane. These combinations are for dry conditions of use only, except as allowed in ANSI A190.1 (4). 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 prismatic members only.

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, except as allowed in ANSI A190.1 (4). When wane material is used in these combinations, members shall be for industrial or framing appearance grades and for prismatic members only.

1. Lumber with wane up to 1/6 of the finished member width and 1/2 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. Wane shall not be permitted at the interior edge joint of multi-piece laminations.
7. 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 the laminator's accredited inspection agency prior to production.

3.5 Tension Laminations

3.5.1 General

The flexural design values for most combinations listed in Table A1 require the use of specially graded tension laminations in the outer 5% of beam depth on the tension side(s). These special grades are designated as "302- tension laminations" and commonly referred to as "special tension laminations."

3.5.2 Combinations without 302 Tension Laminations

Combinations requiring 302 tension laminations are permitted to be manufactured without the 302 tension lamination grade requirements 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. (380 mm) or by 0.85 for depths less than or equal to 15 in. (380 mm). When the 302 tension laminations specified in Table B1 are omitted in visually graded lay-ups that normally require 302 tension laminations, they shall be replaced by dense laminations with a maximum slope of grain of 1:14 with knots and other strength-reducing characteristics meeting the requirements of L1 or No. 1, based on the normal lamination grading requirements used for the species.

3.5.3 Arches

302 tension laminations shall not be required for arches.

3.6 Tapered Members

Combination requirements, including 302 tension lamination requirements shall apply for every cross section along the entire length of tapered beams (Figure 3.6-1) unless the shop drawings or instructions from the designer indicate otherwise. Tudor arches (Figure 3.6-2) shall be laid up in accordance with AITC 200 (2), unless specified otherwise.

FIGURE 3.6-1

TAPERED BEAMS

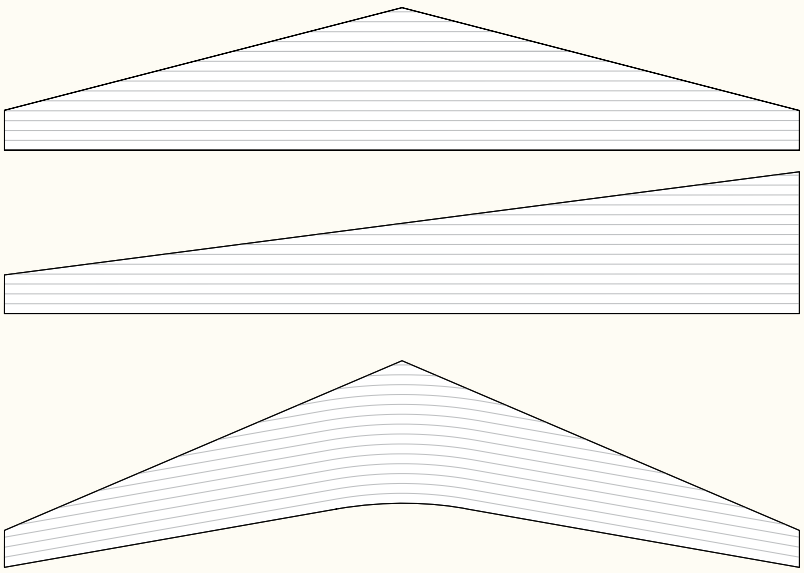
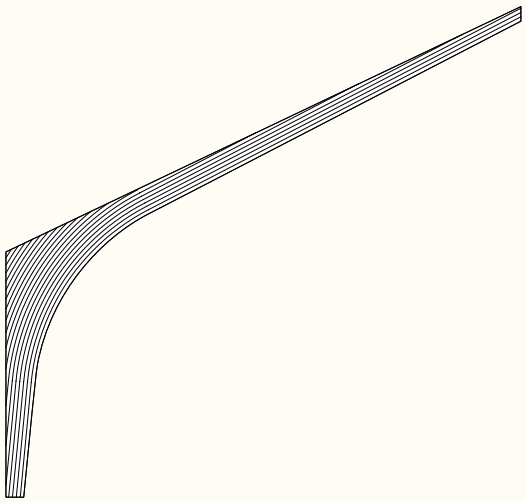


FIGURE 3.6-2

TUDOR ARCH



3.7 Fire Resistive Construction

When bending members are specified to be one-hour fire resistive, they shall be manufactured to the specified 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 core laminations shall be removed, the tension zone moved inward and the equivalent of two additional nominal 2 in. thickness outer tension laminations added.

For members designed for fire exposure on four sides, both the top and bottom of the lay-up shall be modified to meet these requirements. For lay-ups designed for fire exposure on three sides, only the bottom shall require modification.

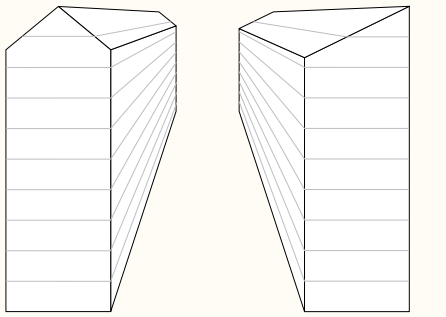
Lay-ups modified to meet these requirements shall be marked with "1-HOUR FIRE RATING" if one additional tension lamination is used or "2-HOUR FIRE RATING" if two additional tension laminations are used. Additionally, balanced lay-ups designed and manufactured for three-sided fire exposure shall be marked with "TOP" on the appropriate face to ensure proper orientation in the structure.

3.8 Cross Sections with Bevel Cuts on Compression Face

Beams manufactured with a bevel cut (or cuts) on the compression face (Figure 3.8-1) shall be laid up so that the grade of laminations in the outer compression zone is maintained through the entire depth of the bevel cut. Where necessary, core laminations shall be removed and additional compression laminations shall be added to meet this requirement.

FIGURE 3.8-1

BEVEL CUT IN OUTER COMPRESSION ZONES



3.9 Non-Standard Depths

For beams with non-standard depths, (i.e., I-joist compatible depths, etc.), grade requirements of the combination shall be maintained throughout the depth of the lay-up.

For unbalanced lay-ups, any of three options shall be permitted to be used:

(1) All laminations are permitted to be planed to a constant thickness.
(2) One or more core laminations are permitted to be planed to a thinner dimension.
(3) A core lamination is permitted to be removed with one extra compression lamination added with the excess material removed from the compression side after laminating.

For balanced lay-ups, either Option (1) or Option (2) shall be used.

4. ALTERNATE COMBINATIONS

4.1 General

The development and use of alternate combinations allows for more efficient and innovative use of the lumber resource. Combinations not listed in this Specification shall be permitted to be used, subject to the provisions of this Section.

Alternate lay-ups shall be approved by the laminator's accredited inspection agency prior to production. Alternate combinations shall be given a unique designation following industry protocols for assigning combination symbols.

4.2 Design Values

Design values for alternate lay-ups shall be established by analysis in accordance with ASTM D3737 (7) or by full-scale testing in accordance with ASTM D7341 (8) and analysis in accordance with ASTM D2915 (6). All design values shall be approved by the laminator's accredited inspection agency before use.

4.2.1 Design Values by Analysis Only

For combinations developed by analysis only, the design values shall be established according to ASTM D3737 (7). 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 qualification stress level (QSL).

4.2.2 Design Values by Full-Scale Testing and Analysis

Design values shall be permitted to be established following the procedures of ASTM D7341 (8) and ASTM D2915 (6). Samples chosen for full-scale testing shall be representative of production. Full scale beam tests shall be conducted by an accredited testing lab or witnessed by a representative of an accredited inspection agency.

4.3 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 lay-ups with design values established by full-scale testing. Documentation of these requirements shall be maintained at the manufacturing facility and shall be available to the laminator's accredited inspection agency. Periodic evaluation shall be conducted as required by ASTM D7341 (8) to ensure that test-based design values are maintained over time.

4.4 Documentation

Documentation of the design values and lay-up requirements for alternate lay-ups shall be maintained by the accredited inspection agency and by the laminator. This documentation shall be available to the public upon request.

ANNEX A
DESIGN VALUE TABLES FOR STRUCTURAL GLUED LAMINATED SOFTWOOD TIMBER

TABLE A1

REFERENCE 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.)

	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	Modulus of Elasticity		Extreme Fiber in Bending	Compression Perpendicular to Grain	Shear Parallel to Grain	Modulus of Elasticity		Tension Parallel to Grain	Compression Parallel to Grain	Specific Gravity for Fastener Design
	Bottom of Beam Stressed in Tension (Positive Bending)	Top of Beam Stressed in Tension (Negative Bending)			For Deflection Calculations	For Stability Calculations				For Deflection Calculations	For Stability Calculations			
Stress Class	F_{bx}^{+} (psi)	F_{bx}^{-} (1) (psi)	$F_{c\perp x}$ (psi)	F_{vx} (4) (psi)	E_x (10^6 psi)	$E_{x\,min}$ (10^6 psi)	F_{by} (psi)	$F_{c\perp y}$ (psi)	F_{vy} (5) (psi)	E_y (10^6 psi)	$E_{y\,min}$ (10^6 psi)	F_t (psi)	F_c (psi)	G
16F-1.3E	1600	925	315	195	1.3	0.69	800	315	170	1.1	0.58	675	925	0.41
20F-1.5E	2000	1100	425	195 (6)	1.5	0.79	800	315	170	1.2	0.63	725	925	0.41
24F-1.7E	2400	1450	500	210 (6)	1.7	0.90	1050	315	185	1.3	0.69	775	1000	0.42
24F-1.8E	2400	1450 (2)	650	265 (3)	1.8	0.95	1450	560	230 (3)	1.6	0.85	1100	1600	0.50 (10)
26F-1.9E (7)	2600	1950	650	265 (3)	1.9	1.00	1600	560	230 (3)	1.6	0.85	1150	1600	0.50 (10)
28F-2.1E SP (7)	2800	2300	805	300	2.1 (9)	1.09	1600	650	260	1.7	0.90	1250	1750	0.55
30F-2.1E SP (7)(8)	3000	2400	805	300	2.1 (9)	1.09	1750	650	260	1.7	0.90	1250	1750	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 values for shear, F_{vx} and F_{vy}, 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 unless the manufacturer has qualified for wider widths based on full-scale tests subject to approval by an accredited inspection agency.
(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.

Stress classes represent groups of similar glued laminated timber combinations. Values for individual combinations are included in Table A1 - Expanded. Design values are for members with 4 or more laminations. For 2 and 3 lamination members, see Table A2. Some stress classes are not available in all species. Contact manufacturer for availability.

TABLE A1–EXPANDED

REFERENCE 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.)

		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	Modulus of Elasticity		Extreme Fiber in Bending	Compression Perpendicular to Grain	Shear Parallel to Grain	Modulus of Elasticity		Tension Parallel to Grain	Compression Parallel to Grain	Specific Gravity for Fastener Design	
		Bottom of beam Stressed in tension (Positive Bending)	Top of Beam Stressed in Tension (Negative Bending)	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} [2] (psi)	E_x (10^6 psi)	$E_{x\,min}$ (10^6 psi)	F_{by} (psi)	$F_{c\perp y}$ (psi)	F_{vy} [3] (psi)	E_y (10^6 psi)	$E_{y\,min}$ (10^6 psi)	F_t (psi)	F_c (psi)	G	
16F-1.3E		**1600**	**925**	**315**		**195**	**1.3**	**0.69**	**800**	**315**	**170**	**1.1**	**0.58**	**675**	**925**	**0.41**	
16F-V3	DF/DF	1600	1250	560	560	265	1.5	0.79	1450	560	230	1.5	0.79	975	1500	0.5	0.5
16F-V6	DF/DF	1600	1600	560	560	265	1.6	0.85	1450	560	230	1.5	0.79	1000	1600	0.5	0.5
16F-E2	HF/HF	1600	1050	375	375	215	1.4	0.74	1200	375	190	1.3	0.69	825	1150	0.43	0.43
16F-E3	DF/DF	1600	1200	560	560	265	1.6	0.85	1400	560	230	1.5	0.79	975	1600	0.5	0.5
16F-E6	DF/DF	1600	1600	560	560	265	1.6	0.85	1550	560	230	1.5	0.79	1000	1600	0.5	0.5
16F-E7	HF/HF	1600	1600	375	375	215	1.4	0.74	1350	375	190	1.3	0.74	875	1250	0.43	0.43
16F-V2	SP/SP	1600	1400	740	650	300	1.5	0.79	1450	650	260	1.4	0.74	1000	1300	0.55	0.55
16F-V3	SP/SP	1600	1450	740	740	300	1.4	0.74	1450	650	260	1.4	0.74	975	1400	0.55	0.55
16F-V5	SP/SP	1600	1600	650	650	300	1.6	0.85	1600	650	260	1.5	0.79	1000	1550	0.55	0.55
16F-E1	SP/SP	1600	1250	650	650	300	1.6	0.85	1400	650	260	1.6	0.85	1050	1550	0.55	0.55
16F-E3	SP/SP	1600	1600	650	650	300	1.7	0.90	1650	650	260	1.6	0.85	1100	1550	0.55	0.55
20F-1.5E		**2000**	**1100**	**425**		**195**	**1.5**	**0.79**	**800**	**315**	**170**	**1.2**	**0.63**	**725**	**925**	**0.41**	
20F-V3	DF/DF	2000	1450	650	560	265	1.6	0.85	1450	560	230	1.5	0.79	1000	1550	0.5	0.5
20F-V7	DF/DF	2000	2000	650	650	265	1.6	0.85	1450	560	230	1.6	0.85	1050	1600	0.5	0.5
20F-V12	AC/AC	2000	1400	560	560	265	1.5	0.79	1250	470	230	1.4	0.74	925	1500	0.46	0.46
20F-V13	AC/AC	2000	2000	560	560	265	1.5	0.79	1250	470	230	1.4	0.74	950	1550	0.46	0.46
20F-V14	POC/POC	2000	1450	560	560	265	1.5	0.79	1300	470	230	1.4	0.74	900	1600	0.46	0.46
20F-V15	POC/POC	2000	2000	560	560	265	1.5	0.79	1300	470	230	1.4	0.74	900	1600	0.46	0.46
20F-E2	HF/HF	2000	1400	500	500	215	1.6	0.85	1200	375	190	1.4	0.74	925	1350	0.43	0.43
20F-E3	DF/DF	2000	1200	560	560	265	1.7	0.90	1400	560	230	1.6	0.85	1050	1600	0.5	0.5
20F-E6	DF/DF	2000	2000	560	560	265	1.7	0.90	1550	560	230	1.6	0.85	1150	1650	0.5	0.5
20F-E7	HF/HF	2000	2000	500	500	215	1.6	0.85	1450	375	190	1.4	0.74	1050	1450	0.43	0.43
20F-E8	ES/ES	2000	1300	450	450	200	1.5	0.79	1000	315	175	1.4	0.74	825	1100	0.41	0.41
24F-E/SPF1	SPF/SPF	2400	2400	560	560	215	1.6	0.85	1150	470	190	1.6	0.85	1150	2000	0.42	0.42
24F-E/SPF3	SPF/SPF	2400	1550	560	650	215	1.6	0.85	1200	470	195	1.5	0.79	900	1750	0.42	0.42
20F-V2	SP/SP	2000	1550	740	650	300	1.5	0.79	1450	650	260	1.4	0.74	1000	1400	0.55	0.55
20F-V3	SP/SP	2000	1450	650	650	300	1.5	0.79	1600	650	260	1.5	0.79	1000	1400	0.55	0.55
20F-V5	SP/SP	2000	2000	740	740	300	1.6	0.85	1450	650	260	1.4	0.74	1050	1500	0.55	0.55
20F-E1	SP/SP	2000	1300	650	650	300	1.7	0.90	1400	650	260	1.6	0.85	1050	1550	0.55	0.55
20F-E3	SP/SP	2000	2000	650	650	300	1.7	0.90	1700	650	260	1.6	0.85	1150	1600	0.55	0.55
24F-1.7E		**2400**	**1450**	**500**		**210**	**1.7**	**0.90**	**1050**	**315**	**185**	**1.3**	**0.69**	**775**	**1000**	**0.42**	
24F-V5	DF/HF	2400	1600	650	650	215	1.7	0.90	1350	375	200	1.5	0.79	1100	1450	0.5	0.43
24F-V10	DF/HF	2400	2400	650	650	215	1.8	0.95	1450	375	200	1.5	0.79	1150	1550	0.5	0.43
24F-E11	HF/HF	2400	2400	500	500	215	1.8	0.95	1550	375	190	1.5	0.79	1150	1550	0.43	0.43
24F-E15	HF/HF	2400	1600	500	500	215	1.8 1.7	0.95	1200	375	190	1.5	0.79	975	1500	0.43	0.43
24F-V1	SP/SP	2400	1750	740	650	300	1.7	0.90	1450	650	260	1.5	0.79	1100	1500	0.55	0.55
24F-V4 [4]	SP/SP	2400	1650	740	650	210	1.7	0.90	1350	470	230	1.5	0.79	975	1350	0.55	0.43
24F-V5	SP/SP	2400	2400	740	740	300	1.7	0.90	1700	650	260	1.6	0.85	1150	1600	0.55	0.55

TABLE A1–EXPANDED (Continued)

REFERENCE 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.)

		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	Modulus of Elasticity	Extreme Fiber in Bending	Compression Perpendicular to Grain	Shear Parallel to Grain	Modulus of Elasticity		Tension Parallel to Grain	Compression Parallel to Grain	Specific Gravity for Fastener Design	
		Bottom of beam Stressed in tension (Positive Bending)	Top of Beam Stressed in Tension (Negative Bending)	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} [2] (psi)	E_x (10^6 psi)	$E_{x\,min}$ (10^6 psi)	F_{by} (psi)	$F_{c\perp y}$ (psi)	F_{vy} [3] (psi)	E_y (10^6 psi)	$E_{y\,min}$ (10^6 psi)	F_t (psi)	F_c (psi)	G	
24F-1.8E		**2400**	**1450**	**650**		**265**	**1.8**	**0.95**	**1450**	**560**	**230**	**1.6**	**0.85**	**1100**	**1600**	**0.5**	
24F-V4	DF/DF	2400	1850	650	650	265	1.8	0.95	1450	560	230	1.6	0.85	1100	1650	0.5	0.5
24F-V8	DF/DF	2400	2400	650	650	265	1.8	0.95	1550	560	230	1.6	0.85	1100	1650	0.5	0.5
24F-E4	DF/DF	2400	1450	650	650	265	1.8	0.95	1400	560	230	1.7	0.90	1100	1700	0.5	0.5
24F-E13	DF/DF	2400	2400	650	650	265	1.8	0.95	1750	560	230	1.7	0.90	1250	1700	0.5	0.5
24F-E18	DF/DF	2400	2400	650	650	265	1.8	0.95	1550	560	230	1.7	0.90	975	1700	0.5	0.5
24F-V3	SP/SP	2400	2000	740	740	300	1.8	0.95	1700	650	260	1.6	0.85	1150	1650	0.55	0.55
24F-V8	SP/SP	2400	2400	740	740	300	1.8	0.95	1700	650	260	1.6	0.85	1150	1650	0.55	0.55
24F-E1	SP/SP	2400	1450	805	650	300	1.8	0.95	1550	650	260	1.7	0.90	1150	1600	0.55	0.55
24F-E4	SP/SP	2400	2400	805	805	300	1.9	1.00	1850	650	260	1.8	0.95	1450	1750	0.55	0.55
26F-1.9E [5]		**2600**	**1950**	**650**		**265**	**1.9**	**1.00**	**1600**	**560**	**230**	**1.6**	**0.85**	**1150**	**1600**	**0.5**	
26F-V1	DF/DF	2600	1950	650	650	265	2.0	1.06	1850	560	230	1.8	0.95	1350	1850	0.5	0.5
26F-V2	DF/DF	2600	2600	650	650	265	2.0	1.06	1850	560	230	1.8	0.95	1350	1850	0.5	0.5
26F-V1	SP/SP	2600	2000	740	740	300	1.8	0.95	1700	650	260	1.6	0.85	1150	1600	0.55	0.55
26F-V2	SP/SP	2600	2100	740	740	300	1.9	1.00	1950	740	260	1.8	0.95	1300	1850	0.55	0.55
26F-V3	SP/SP	2600	2100	740	740	300	1.9	1.00	1950	650	260	1.8	0.95	1250	1800	0.55	0.55
26F-V4	SP/SP	2600	2600	740	740	300	1.9	1.00	1700	650	260	1.8	0.95	1200	1600	0.55	0.55
26F-V5	SP/SP	2600	2600	740	740	300	1.9	1.00	1950	650	260	1.8	0.95	1300	1850	0.55	0.55
28F-2.1E SP [5]		**2800**	**2300**	**805**		**300**	**2.1 [7]**	**1.09**	**1600**	**650**	**260**	**1.7**	**0.90**	**1250**	**1750**	**0.55**	
28F-E1	SP/SP	2800	2300	805	805	300	2.1 [7]	1.09	1600	650	260	1.7	0.90	1300	1850	0.55	0.55
28F-E2	SP/SP	2800	2800	805	805	300	2.1 [7]	1.09	2000	650	260	1.7	0.90	1300	1850	0.55	0.55
30F-2.1E SP [5][6]		**3000**	**2400**	**805**		**300**	**2.1 [7]**	**1.09**	**1750**	**650**	**260**	**1.7**	**0.90**	**1250**	**1750**	**0.55**	
30F-E1	SP/SP	3000	2400	805	805	300	2.1 [7]	1.09	1750	650	260	1.7	0.90	1250	1750	0.55	0.55
30F-E2	SP/SP	3000	3000	805	805	300	2.1 [7]	1.09	1750	650	260	1.7	0.90	1350	1750	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 design values for shear, F_{vx} and F_{vy}, 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.

3 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.

4 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.

5 26F, 28F, and 30F beams are not produced by all manufacturers, therefore, availability may be limited. Contact supplier or manufacturer for details.

6 30F combinations are restricted to a maximum 6 in. nominal width unless the manufacturer has qualified for wider widths based on full-scale tests subject to approval by an accredited inspection agency.

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

TABLE A2

REFERENCE 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.)

Combination Symbol	Species	Grade	All Loading: Modulus of Elasticity E (10^6 psi)	All Loading: Modulus of Elasticity E_{min} (10^6 psi)	All Loading: Compression Perpendicular to Grain $F_{c\perp}$ (psi)	Axially Loaded: Tension Parallel to Grain, 2 or More Laminations F_t (psi)	Axially Loaded: Compression Parallel to Grain, 4 or More Laminations F_c (psi)	Axially Loaded: Compression Parallel to Grain, 2 or 3 Laminations F_c (psi)	Bending about Y-Y Axis, Loaded Parallel to Wide Faces of Laminations: Bending, 4 or More Laminations F_{by} (psi)	Bending about Y-Y Axis, Loaded Parallel to Wide Faces of Laminations: Bending, 3 Laminations F_{by} (psi)	Bending about Y-Y Axis, Loaded Parallel to Wide Faces of Laminations: Bending, 2 Laminations F_{by} (psi)	Bending about Y-Y Axis, Loaded Parallel to Wide Faces of Laminations: Shear Parallel to Grain[1][2] F_{vy} (psi)	Bending About X-X Axis, Loaded Perpendicular to Wide Faces of Laminations: Bending, 2 Laminations to 15 in. Deep[4] F_{bx} (psi)	Bending About X-X Axis, Loaded Perpendicular to Wide Faces of Laminations: Shear Parallel to Grain[3] F_{vx} (psi)
Visually Graded Western Species														
1	DF	L3	1.5	0.79	560	950	1550	1250	1450	1250	1000	230	1250	265
2	DF	L2	1.6	0.85	560	1250	1950	1600	1800	1600	1300	230	1700	265
3	DF	L2D	1.9	1.00	650	1450	2300	1900	2100	1850	1550	230	2000	265
4	DF	L1CL	1.9	1.00	590	1400	2100	1950	2200	2000	1650	230	2100	265
5	DF	L1	2.0	1.06	650	1650	2400	2100	2400	2100	1800	230	2200	265
14	HF	L3	1.3	0.69	375	800	1100	1050	1200	1050	850	190	1100	215
15	HF	L2	1.4	0.74	375	1050	1350	1350	1500	1350	1100	190	1450	215
16	HF	L1	1.6	0.85	375	1200	1500	1500	1750	1550	1300	190	1600	215
17	HF	L1D	1.7	0.90	500	1400	1750	1750	2000	1850	1550	190	1900	215
22[5]	SW	L3	1.0	0.53	315	525	850	725	800	700	575	170	725	195
69	AC	L3	1.2	0.63	470	725	1150	1100	1100	975	775	230	1000	265
70	AC	L2	1.3	0.69	470	975	1450	1450	1400	1250	1000	230	1350	265
71	AC	L1D	1.6	0.85	560	1250	1900	1900	1850	1650	1400	230	1750	265
72	AC	L1S	1.6	0.85	560	1250	1900	1900	1850	1650	1400	230	1900	265
73	POC	L3	1.3	0.69	470	775	1500	1200	1200	1050	825	230	1050	265
74	POC	L2	1.4	0.74	470	1050	1900	1550	1450	1300	1100	230	1400	265
75	POC	L1D	1.7	0.90	560	1350	2300	2050	1950	1750	1500	230	1850	265
Visually Graded Southern Pine														
47	SP	N2M12	1.4	0.74	650	1200	1900	1150	1750	1550	1300	260	1400	300
47 1:10	SP	N2M10	1.4	0.74	650	1150	1700	1150	1750	1550	1300	260	1400	300
47 1:8	SP	N2M	1.4	0.74	650	1000	1500	1150	1600	1550	1300	260	1400	300
48	SP	N2D12	1.7	0.90	740	1400	2200	1350	2000	1800	1500	260	1600	300
48 1:10	SP	N2D10	1.7	0.90	740	1350	2000	1350	2000	1800	1500	260	1600	300
48 1:8	SP	N2D	1.7	0.90	740	1150	1750	1350	1850	1800	1500	260	1600	300
49	SP	N1M16	1.7	0.90	650	1350	2100	1450	1950	1750	1500	260	1800	300
49 1:14	SP	N1M14	1.7	0.90	650	1350	2000	1450	1950	1750	1500	260	1800	300
49 1:12	SP	N1M12	1.7	0.90	650	1300	1900	1450	1950	1750	1500	260	1800	300
49 1:10	SP	N1M	1.7	0.90	650	1150	1700	1450	1850	1750	1500	260	1800	300
50	SP	N1D14	1.9	1.00	740	1550	2300	1700	2300	2100	1750	260	2100	300
50 1:12	SP	N1D12	1.9	1.00	740	1500	2200	1700	2300	2100	1750	260	2100	300
50 1:10	SP	N1D	1.9	1.00	740	1350	2000	1700	2100	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 values for shear, F_{vx} and F_{vy}, 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) For members greater than 15 in. deep, the bending design value, F_{bx}, shall be reduced by multiplying by a factor of 0.88.

(5) 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

REFERENCE DESIGN VALUES FOR STRUCTURAL GLUED LAMINATED SOFTWOOD TIMBER COMBINATIONS WITH TAPER CUTS (FIGURE 3.6-1) ON THE COMPRESSION FACE[1][2]

Combination Symbol	Species Outer/ Core	F_{bx}^{+} (psi)	E_x (10^6 psi)	$E_{x\,min}$ (10^6 psi)	$F_{c\perp x\ Top}$ (psi)	F_{vx}[3] (psi)
16F-1.3E		**1050**	**1.2**	**0.63**	**315**	**140**
16F-V3	DF/DF	1600	1.5	0.79	560	190
16F-V6	DF/DF	1600	1.5	0.79	560	190
16F-E2	HF/HF	1350	1.4	0.74	375	155
16F-E3	DF/DF	1600	1.6	0.85	560	190
16F-E6	DF/DF	1600	1.6	0.85	560	190
16F-E7	HF/HF	1350	1.4	0.74	375	155
16F-V2	SP/SP	1450	1.5	0.79	650	215
16F-V3	SP/SP	1550	1.4	0.74	650	215
16F-V5	SP/SP	1550	1.5	0.79	650	215
16F-E1	SP/SP	1600	1.6	0.85	650	215
16F-E3	SP/SP	1600	1.6	0.85	650	215
20F-1.5E		**1250**	**1.4**	**0.74**	**375**	**150**
20F-V3	DF/DF	1900	1.6	0.85	560	190
20F-V7	DF/DF	1900	1.6	0.85	560	190
20F-V12	AC/AC	1650	1.4	0.74	470	190
20F-V13	AC/AC	1650	1.4	0.74	470	190
20F-E2	HF/HF	1700	1.5	0.79	375	155
20F-E3	DF/DF	1900	1.6	0.85	560	190
20F-E6	DF/DF	1900	1.6	0.85	560	190
20F-E7	HF/HF	1700	1.5	0.79	375	155
20F-V2	SP/SP	1500	1.4	0.74	650	215
20F-V3	SP/SP	1700	1.5	0.79	650	215
20F-V5	SP/SP	1500	1.5	0.79	650	215
20F-E1	SP/SP	1950	1.6	0.85	650	215
20F-E3	SP/SP	1900	1.6	0.85	650	215
24F-1.7E		**1250**	**1.4**	**0.74**	**375**	**150**
24F-V5	DF/HF	1900	1.6	0.85	375	190
24F-V10	DF/HF	1900	1.6	0.85	375	155
24F-E2	HF/HF	1900	1.6	0.85	375	155
24F-E11	HF/HF	1900	1.6	0.85	375	155
24F-E15	HF/HF	1900	1.6	0.85	375	155
24F-V1	SP/SP	1800	1.6	0.85	650	215
24F-V4	SP/SP	1250	1.4	0.74	470	215
24F-V5	SP/SP	2100	1.7	0.90	650	215
24F-1.8E		**2000**	**1.7**	**0.90**	**560**	**190**
24F-V4	DF/DF	2100	1.7	0.90	560	190
24F-V8	DF/DF	2100	1.7	0.90	560	190
24F-E4	DF/DF	2100	1.7	0.90	560	190
24F-E13	DF/DF	2100	1.7	0.90	560	190
24F-E18	DF/DF	2100	1.7	0.90	560	190
24F-V3	SP/SP	2100	1.7	0.90	650	215
24F-V8	SP/SP	2100	1.7	0.90	650	215
24F-E1	SP/SP	2100	1.7	0.90	650	215
24F-E4	SP/SP	2100	1.7	0.90	650	215
26F-1.9E		**2000**	**1.7**	**0.90**	**560**	**190**
26F-V1	DF/DF	2100	1.7	0.90	560	190
26F-V2	DF/DF	2100	1.7	0.90	560	190
26F-V1	SP/SP	2000	1.7	0.90	650	215
26F-V2	SP/SP	2400	1.8	0.95	740	215
26F-V3	SP/SP	2000	1.8	0.95	650	215
26F-V4	SP/SP	2000	1.8	0.95	650	215
26F-V5	SP/SP	2000	1.8	0.95	740	215
28F-2.1E		**2400**	**1.9**	**1.00**	**650**	**215**
28F-E1	SP/SP	2400	1.9	1.00	650	215
28F-E2	SP/SP	2400	1.9	1.00	650	215
30F-2.1E		**2400**	**1.9**	**1.00**	**650**	**215**
30F-E1	SP/SP	2400	1.9	1.00	650	215
30F-E2	SP/SP	2400	1.9	1.00	650	215

1. Design values are applicable to beams that have up to 2/3 of the depth on the compression side removed by taper cutting.
2. Tabulated design values apply only to tapered portion of member
3. Shear design value has been reduced for non-prismatic members

ANNEX B
LAY-UP REQUIREMENTS FOR STRUCTURAL GLUED LAMINATED SOFTWOOD TIMBER

TABLE B1

LAY-UP REQUIREMENTS FOR STRUCTURAL GLUED LAMINATED SOFTWOOD TIMBER COMBINATIONS

Visually Graded Western Species

16F-V3 DF (Unbalanced)

4 - 10 Lams			11 or More Lams		
5%	L3 DF	--	10%	L3 DF	--
--	--	--	--	--	--
--	L3 DF	--	--	L3 DF	--
--	--	--	5%	L2 DF	--
5%	L2 DF	--	5%	L1 DF	--

16F-V6 DF (Balanced)

4 - 10 Lams			11 or More Lams		
5%	L2 DF	--	5%	L1 DF	--
--	--	--	5%	L2 DF	--
--	L3 DF	--	--	L3 DF	--
--	--	--	5%	L2 DF	--
5%	L2 DF	--	5%	L1 DF	--

20F-V3 DF (Unbalanced)

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

20F-V3 DF (Alternate)

4 - 10 Lams		
20%	L2 DF	--
--	--	--
--	L3 DF	--
20%	L2 DF	--
15%	L1 DF	--

20F-V7 DF (Balanced)

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

20F-V7 DF (Alternate)

4 - 7 Lams			8 - 10 Lams		
10%	L1 DF	--	15%	L1 DF	--
--	--	--	--	--	--
--	L3 DF	--	--	L3 DF	--
--	--	--	--	--	--
10%	L1 DF	--	15%	L1 DF	--

20F-V12 AC (Unbalanced)

4 - 7 Lams			8 - 10 Lams			11 - 18 Lams			19 or More Lams		
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	--
25%	L1D AC	--	30%	L1D AC	--	10%	L1S AC	--	10%	L1S AC	--
5%	302-20 AC	1:14	5%	302-20 AC	1:14	5%	302-24 AC	--	5%	302-26 AC	--

20F-V13 AC (Balanced)

4 - 7 Lams			8 - 10 Lams			11 or More Lams		
5%	302-20 AC	1:16	5%	302-22 AC	--	5%	302-24 AC	--
10%	L1S AC	--	10%	L1S AC		5%	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	--
10%	L1S AC	--	10%	L1S AC	--	5%	L1S AC	--
5%	302-20 AC	1:16	5%	302-22 AC	--	5%	302-24 AC	--

20F-V14 POC (Unbalanced)

4 - 7 Lams			8 - 10 Lams			11 Lams			12 or More Lams		
5%	L1D POC	--	5%	L1D POC	--	5%	L1D POC	--	10%	L1D POC	--
--	--	--	5%	L2 POC	--	5%	L2 POC	--	5%	L2 POC	--
--	L3 POC	--	--	L3 POC	--	--	L3 POC	--	--	L3 POC	--
--	--	--	--	--	--	--	--	--	5%	L2 POC	--
10%	L2 POC	--	10%	L1D POC	--	10%	L1D POC	--	5%	L1D POC	--
5%	302-20 POC	1:14	5%	302-20 POC	1:14	5%	302-24 POC	--	5%	302-24 POC	--

20F-V15 POC (Balanced)

4 - 7 Lams			8 - 10 Lams			11 Lams			12 or More Lams		
5%	302-20 POC	1:14	5%	302-20 POC	1:14	5%	302-24 POC	--	5%	302-24 POC	--
10%	L2 POC	--	10%	L1D POC	--	10%	L1D POC	--	5%	L1D POC	--
--	--		--	--	--	--	--	--	5%	L2 POC	--
--	L3 POC	--	--	L3 POC	--	--	L3 POC	--	--	L3 POC	--
--	--	--	--	--	--	--	--	--	5%	L2 POC	--
10%	L2 POC	--	10%	L1D POC	--	10%	L1D POC	--	5%	L1D POC	--
5%	302-20 POC	1:14	5%	302-20 POC	1:14	5%	302-24 POC	--	5%	302-24 POC	--

24F-V4 DF (Unbalanced)

4 - 7 Lams			8 - 10 Lams			11 or More Lams		
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	--
10%	L1 DF	--	10%	L1 DF	--	5%	L1 DF	--
5%	302-20 DF	1:14	5%	302-22 DF	--	5%	302-24 DF	--

24F-V5 DF/HF (Unbalanced)

4 - 7 Lams			8 - 10 Lams			11 or More Lams		
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	--
15%	L1 DF	--	15%	L1 DF	--	10%	L1 DF	--
5%	302-20 DF	1:14	5%	302-22 DF	--	5%	302-24 DF	--

24F-V8 DF (Balanced)

4 - 7 Lams			8 - 10 Lams			11 or More Lams		
5%	302-20 DF	1:14	5%	302-22 DF	--	5%	302-24 DF	--
5%	L1 DF	--	5%	L1 DF	--	5%	L1 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	--
5%	L1 DF	--	5%	L1 DF	--	5%	L1 DF	--
5%	302-20 DF	1:14	5%	302-22 DF	--	5%	302-24 DF	--

TABLE B1 (Continued)

LAY-UP REQUIREMENTS FOR STRUCTURAL GLUED LAMINATED SOFTWOOD TIMBER COMBINATIONS

24F-V10 DF/HF (Balanced)

4 - 7 Lams			8 - 10 Lams			11 or More Lams		
5%	302-20 DF	1:14	5%	302-22 DF	--	5%	302-24 DF	--
15%	L1 DF	--	15%	L1 DF	--	10%	L1 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	--
15%	L1 DF	--	15%	L1 DF	--	10%	L1 DF	--
5%	302-20 DF	1:14	5%	302-22 DF	--	5%	302-24 DF	--

26F-V1 DF (Unbalanced)

4 - 7 Lams			8 - 10 Lams			11 or More Lams		
25%	L1 DF	--	25%	L1 DF	--	25%	L1 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	--
20%	L1 DF	--	20%	L1 DF	--	20%	L1 DF	--
5%	302-22 DF	--	5%	302-24 DF	--	5%	302-26 DF	--

26F-V2 DF (Balanced)

4 - 7 Lams			8 - 10 Lams			11 or More Lams		
5%	302-22 DF	--	5%	302-24 DF	--	5%	302-26 DF	--
20%	L1 DF	--	20%	L1 DF	--	20%	L1 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	--
20%	L1 DF	--	20%	L1 DF	--	20%	L1 DF	--
5%	302-22 DF	--	5%	302-24 DF	--	5%	302-26 DF	--

E-rated Western Species

16F-E2 HF (Unbalanced)

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

16F-E2 HF (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 DF (Unbalanced)

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

16F-E6 DF (Balanced)

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

16F-E7 HF (Balanced)

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

16F-E7 HF (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	--

20F-E2 HF (Unbalanced)

4 - 7 Lams			8 - 10 Lams			11 or More Lams		
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	--	--	--	--
5%	1.9E6 HF	--	5%	1.9E6 HF	--	15%	1.9E6 HF	--
5%	302-20 HF	1.9E6	5%	302-20 HF	1.9E6	5%	302-20 HF	1.9E6

20F-E2 HF (Alternate)

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

20F-E3 DF (Unbalanced)

4 - 10 Lams			11 - 13 Lams			14 or More Lams		
10%	1.9E2 DF	--	15%	1.9E2 DF	--	15%	1.9E2 DF	--
--	--	--	--	--	--	--	--	--
--	L3 DF	--	--	L3 DF	--	--	L3 DF	--
15%	1.9E6 DF	--	15%	1.9E6 DF	--	10%	1.9E6 DF	--
5%	302-20 DF	1.9E6	5%	302-22 DF	1.9E6	5%	302-22 DF	1.9E6

20F-E3 DF (Alternate)

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

TABLE B1 (Continued)

LAY-UP REQUIREMENTS FOR STRUCTURAL GLUED LAMINATED SOFTWOOD TIMBER COMBINATIONS

20F-E6 DF (Balanced)

4 - 10 Lams			11 - 13 Lams			14 or More Lams		
5%	302-20 DF	1.9E6	5%	302-22 DF	1.9E6	5%	302-22 DF	1.9E6
15%	1.9E6 DF	--	15%	1.9E6 DF	--	10%	1.9E6 DF	--
--	L3 DF	--	--	L3 DF	--	--	L3 DF	--
15%	1.9E6 DF	--	15%	1.9E6 DF	--	10%	1.9E6 DF	--
5%	302-20 DF	1.9E6	5%	302-22 DF	1.9E6	5%	302-22 DF	1.9E6

20F-E6 DF (Alternate)

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

20F-E7 HF (Balanced)

4 - 7 Lams			8 - 10 Lams			11 or More Lams		
5%	302-20 HF	1.9E6	5%	302-22 HF	1.9E6	5%	302-22 HF	1.9E6
5%	1.9E6 HF	--	5%	1.9E6 HF	--	15%	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	--	--	--	--
5%	1.9E6 HF	--	5%	1.9E6 HF	--	15%	1.9E6 HF	--
5%	302-20 HF	1.9E6	5%	302-22 HF	1.9E6	5%	302-22 HF	1.9E6

20F-E7 HF (Alternate)

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

20F-E8 ES (Unbalanced)

4 - 7 Lams			8 - 9 Lams			9 - 13 Lams			14 - 16 Lams			17 or More Lams		
10%	C6 ES	--	10%	C6 ES	--	15%	C6 ES	--	10%	C6 ES	--	15%	C6 ES	--
15%	D4 ES	--	15%	D4 ES	--	10%	D4 ES	--	15%	D4 ES	--	10%	D4 ES	--
--	D ES	--	--	D ES	--	--	D ES	--	--	D ES	--	--	D ES	--
15%	C4 ES	--	15%	C4 ES	--	10%	C4 ES	--	10%	C4 ES	--	10%	C4 ES	--
5%	B ES	--	5%	B ES	--	15%	B ES	--	10%	B ES	--	10%	B ES	--
5%	302-20 ES	B ES	5%	302-22 ES	B ES	5%	302-22 ES	B ES	5%	302-24 ES	B ES	5%	302-24 ES	B ES

24F-E/SPF1 (Balanced)

4 - 7 Lams			8 or More Lams		
5%	302-24 SPF	2.0E6	5%	302-24 SPF	2.0E6
15%	2.0E6 SPF	--	10%	1.8E3 SPF	--
5%	1.8E3 SPF	--	--	--	--
--	1.4E2 SPF	--	--	1.4E2 SPF	--
5%	1.8E3 SPF	--	--	--	--
15%	2.0E6 SPF	--	10%	1.8E3 SPF	--
5%	302-24 SPF	2.0E6	5%	302-24 SPF	2.0E6

24F-E/SPF3 (Unbalanced)

4 - 7 Lams			8 or More Lams		
20%	L2D DF	--	5%	L2D DF	--
5%	1.8E3 SPF	--	10%	1.8E3 SPF	--
--	1.4E2 SPF	--	--	1.4E2 SPF	--
5%	1.8E3 SPF	--	--	--	--
15%	2.0E6 SPF	--	10%	1.8E3 SPF	--
5%	302-24 SPF	2.0E6	5%	302-24 SPF	2.0E6

24F-E4 DF (Unbalanced)

4 - 10 Lams			11 - 13 Lams			14 - 15 Lams			16 or More Lams		
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	--
15%	2.1E6 DF	--	5%	2.1E6 DF	--	5%	2.1E6 DF	--	5%	2.1E6 DF	--
5%	302-20 DF	2.1E6	5%	302-22 DF	2.1E6	5%	302-22 DF	2.1E6	5%	302-24 DF	2.1E6

24F-E11 HF (Balanced)

4 - 8 Lams			9 - 13 Lams			14 or More Lams		
5%	302-20 HF	2.1E6	5%	302-22 HF	2.1E6	5%	302-24 HF	2.1E6
5%	2.1E6 HF	--	5%	2.1E6 HF	--	5%	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	--
5%	2.1E6 HF	--	5%	2.1E6 HF	--	5%	2.1E6 HF	--
5%	302-20 HF	2.1E6	5%	302-22 HF	2.1E6	5%	302-24 HF	2.1E6

24F-E13 DF (Balanced)

4 - 10 Lams			11 - 13 Lams			14 - 15 Lams			16 or More Lams		
5%	302-22 DF	2.1E6	5%	302-24 DF	2.1E6	5%	302-24 DF	2.1E6	5%	302-24 DF	2.1E6
15%	2.1E6 DF	--	5%	2.1E6 DF	--	5%	2.1E6 DF	--	5%	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	--
15%	2.1E6 DF	--	5%	2.1E6 DF	--	5%	2.1E6 DF	--	5%	2.1E6 DF	--
5%	302-22 DF	2.1E6	5%	302-24 DF	2.1E6	5%	302-24 DF	2.1E6	5%	302-24 DF	2.1E6

24F-E15 HF (Unbalanced)

4 - 7 Lams			8 - 10 Lams			11 - 14 Lams			15 - 19 Lams			20 or More Lams		
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	--
5%	2.1E6 HF	--	5%	2.1E6 HF	--	5%	2.1E3 HF	--	5%	2.1E3 HF	--	5%	2.1E3 HF	--
5%	302-20 HF	2.1E6	5%	302-22 HF	2.1E6	5%	302-24 HF	2.1E3	5%	302-24 HF	2.1E3	5%	302-24 HF	2.1E3

24F-E18 DF (Balanced)

4 - 8 Lams			9 - 11 Lams			12 - 15 Lams			16 or More Lams		
5%	302-20 DF	2.21E6	5%	302-22 DF	2.2E6	5%	302-22 DF	2.2E2	5%	302-22 DF	2.2E2
5%	2.2E6 DF	--	5%	2.2E6 DF	--	5%	2.2E2 DF	--	5%	2.2E2 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	--
5%	2.2E6 DF	--	5%	2.2E6 DF	--	5%	2.2E2 DF	--	5%	2.2E2 DF	--
5%	302-20 DF	2.2E6	5%	302-22 DF	2.2E6	5%	302-22 DF	2.2E2	5%	302-22 DF	2.2E2

TABLE B1 (Continued)

LAY-UP REQUIREMENTS FOR STRUCTURAL GLUED LAMINATED SOFTWOOD TIMBER COMBINATIONS

Visually Graded Southern Pine

16F-V2 SP (Unbalanced)

4 or More Lams		
10%	N2M	--
--	--	--
--	N2M	--
--	--	--
5%	N1D	--

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

16F-V3 SP (Alternate)

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

16F-V5 SP (Balanced)

4 or More Lams		
5%	N1M	--
5%	N2M	1:10
--	N2M	--
5%	N2M	1:10
5%	N1M	--

16F-V5 SP (Alternate)

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

20F-V2 SP (Unbalanced)

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

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

20F-V3 SP (Unbalanced)

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

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

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			9 - 10 lams			11 or More Lams		
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%	302-20	1:14	5%	302-22	--	5%	302-24	--

24F-V3 SP (Unbalanced)

4 - 8 Lams			9 - 10 lams			11 or More Lams		
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%	302-20	1:14	5%	302-22	--	5%	302-24	--

TABLE B1 (Continued)

LAY-UP REQUIREMENTS FOR STRUCTURAL GLUED LAMINATED SOFTWOOD TIMBER COMBINATIONS

	4 - 5 Lams			6 - 8 Lams			9 - 10 Lams			11 or More Lams		
24F-V4 SP (Unbalanced)	5%	N1M	1:12	5%	N1M	1:14	5%	N1M	1:12	5%	N1M	1:14
	10%	N1M	--	5%	N1M	--	5%	N1M	--	10%	N1M	1:12
	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	--
	25%	N1D	--	15%	N1D	--	15%	N1D	--	10%	N1D	1:14
	5%	302-20	1:14	5%	302-20	1:14	5%	302-22	--	5%	302-24	--
	4 - 8 Lams			**9 - 10 Lams**			**11 or More Lams**					
24F-V5 SP (Balanced)	5%	302-20	1:14	5%	302-22	--	5%	302-24	--			
	5%	N1D	--	5%	N1D	--	5%	N1D	1:12			
	10%	N2D	--	5%	N2D	--	5%	N2D	1:10			
	--	N2M	--	--	N2M	--	--	N2M	--			
	10%	N2D	--	5%	N2D	--	5%	N2D	1:10			
	5%	N1D	--	5%	N1D	--	5%	N1D	1:12			
	5%	302-20	1:14	5%	302-22	--	5%	302-24	--			
	4 - 8 Lams			**9 - 10 Lams**			**11 or More Lams**					
24F-V8 SP (Balanced)	5%	302-20	1:14	5%	302-22	--	5%	302-24	--			
	5%	N1D	--	5%	N1D	--	5%	N1D	1:12			
	10%	N2D	--	5%	N2D	--	10%	N2D	1:10			
	--	N2M	--	--	N2M	--	--	N2M	--			
	10%	N2D	--	5%	N2D	--	10%	N2D	1:10			
	5%	N1D	--	5%	N1D	--	5%	N1D	1:12			
	5%	302-20	1:14	5%	302-22	--	5%	302-24	--			
	7 - 8 Lams			**9 - 10 Lams**			**11 or More Lams**					
26F-V1 SP (Unbalanced)	20%	N1D	--	5%	N1D	1:12	5%	N1D	1:12			
	--	--	--	15%	N1D	--	5%	N1D	--			
	--	--	--	--	--	--	10%	N2D	--			
	--	N1M	--	--	N2D	--	--	N2M	--			
	--	--	--	--	--	--	15%	N2D	1:10			
	20%	N1D	--	20%	N1D	--	5%	N1D	1:14			
	5%	302-22	--	5%	302-24	--	5%	302-26	--			
	7 - 8 Lams			**9 - 10 Lams**			**11 or More Lams**					
26F-V2 SP (Unbalanced)	20%	N1D	--	5%	N1D	1:12	5%	N1D	1:12			
	--	--	--	15%	N1D	--	20%	N1D	--			
	--	N2D	--	--	N2D	--	--	N2D	--			
	--	--	--	--	--	--	15%	N1D	--			
	20%	N1D	--	20%	N1D	--	5%	N1D	1:12			
	5%	302-22	--	5%	302-24	--	5%	302-26	--			
	7 - 8 Lams			**9 - 10 Lams**			**11 or More Lams**					
26F-V3 SP (Unbalanced)	20%	N1D	--	5%	N1D	1:12	5%	N1D	1:12			
	--	--	--	15%	N1D	--	20%	N1D	--			
	--	N1M	--	--	N1M	--	--	N1M	--			
	--	--	--	--	--	--	15%	N1D	--			
	20%	N1D	--	20%	N1D	--	5%	N1D	1:12			
	5%	302-22	--	5%	302-24	--	5%	302-26	--			
	7 - 8 Lams			**9 - 10 Lams**			**11 or More Lams**					
26F-V4 SP (Balanced)	5%	302-22	--	5%	302-24	--	5%	302-26	--			
	5%	N1D	1:12	5%	N1D	1:12	5%	N1D	1:12			
	15%	N1D	--	15%	N1D	--	15%	N1D	--			
	--	N1M	--	--	N1M	--	--	N1M	--			
	15%	N1D	--	15%	N1D	--	15%	N1D	--			
	5%	N1D	1:12	5%	N1D	1:12	5%	N1D	1:12			
	5%	302-22	--	5%	302-24	--	5%	302-26	--			
	7 - 8 Lams			**9 - 10 Lams**			**11 or More Lams**					
26F-V5 SP (Balanced)	5%	302-22	--	5%	302-24	--	5%	302-26	--			
	5%	N1D	1:12	5%	N1D	1:12	5%	N1D	1:12			
	15%	N1D	--	15%	N1D	--	15%	N1D	--			
	--	N2D	--	--	N2D	--	--	N2D	--			
	15%	N1D	--	15%	N1D	--	15%	N1D	--			
	5%	N1D	1:12	5%	N1D	1:12	5%	N1D	1:12			
	5%	302-22	--	5%	302-24	--	5%	302-26	--			
E-rated Southern Pine												
	4 or More Lams											
16F-E1 SP (Unbalanced)	5%	1.9E2	--									
	--	--	--									
	--	N2M	--									
	5%	1.9E6	--									
	5%	302-20	1.9E6									
	4 - 10 Lams											
16F-E1 SP (Alternate)	10%	1.9E2	--									
	--	--	--									
	--	N2M	--									
	--	--	--									
	10%	2.1E6	--									
	4 or More Lams											
16F-E3 SP (Balanced)	10%	1.9E6	--									
	--	--	--									
	--	N2M	--									
	--	--	--									
	10%	1.9E6	--									

TABLE B1 (Continued)

LAY-UP REQUIREMENTS FOR STRUCTURAL GLUED LAMINATED SOFTWOOD TIMBER COMBINATIONS

	4 - 8 Lams			9 - 10 Lams			11 - 13 Lams			14 or More Lams		
20F-E1 SP (Unbalanced)	10%	1.9E2	--	10%	1.9E2	--	5%	1.9E2	--	15%	1.9E2	--
	--	--	--	--	--	--	--	--	--	--	--	--
	--	N2M	--	--	N2M	--	--	N2M	--	--	N2M	--
	--	--	--	10%	1.9E6	--	5%	1.9E6	--	--	--	--
	5%	2.1E6	--	5%	2.1E6	--	--	--	--	10%	1.9E6	--
	5%	302-20	2.1E6	5%	302-20	2.1E6	5%	302-20	2.1E6	5%	302-20	1.9E6
	4 - 8 Lams			**9 - 10 Lams**								
20F-E1 SP (Alternate)	10%	2.1E2	--	10%	2.1E2	--						
	--	--	--	--	--	--						
	--	N2M	--	--	N2M	--						
	--	--	--	15%	1.9E6	--						
	25%	2.1E6	--	15%	2.1E6	--						
	4 - 10 Lams			**11 - 14 Lams**			**15 or More Lams**					
20F-E3 SP (Balanced)	5%	302-20	1.9E6	5%	302-20	2.1E6	5%	302-20	1.9E6			
	15%	1.9E6	--	5%	1.9E6	--	10%	1.9E6	--			
	--	N2M	--		N2M	--	--	N2M	--			
	15%	1.9E6	--	5%	1.9E6	--	10%	1.9E6	--			
	5%	302-20	1.9E6	5%	302-20	2.1E6	5%	302-20	1.9E6			
	4 - 8 Lams			**9 - 10 Lams**								
20F-E3 SP (Alternate)	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	--						
	4 - 8 Lams			**9 - 10 Lams**			**11 or More Lams**					
24F-E1 SP (Unbalanced)	10%	2.1E2	--	10%	2.1E2	--	20%	1.9E2	--			
	--	--	--	--	--	--	--	--	--			
	--	N2M	--	--	N2M	--	--	N2M	--			
	25%	1.9E6	--	20%	1.9E6	--	10%	1.9E6	--			
	5%	2.1E6	--	5%	2.1E6	--	5%	2.1E6	--			
	5%	302-20	2.1E6	5%	302-22	2.1E6	5%	302-24	2.1E6			
	4 - 8 Lams			**9 - 10 Lams**			**11 or More Lams**					
24F-E4 SP (Balanced)	5%	302-20	2.1E6	5%	302-22	2.1E6	5%	302-24	2.1E6			
	15%	2.1E6	--	15%	2.1E6	--	15%	2.1E6	--			
	10%	1.9E6	--	10%	1.9E6	--	10%	1.9E6	--			
	--	N2M	--	--	N2M	--	--	N2M	--			
	10%	1.9E6	--	10%	1.9E6	--	10%	1.9E6	--			
	15%	2.1E6	--	15%	2.1E6	--	15%	2.1E6	--			
	5%	302-20	2.1E6	5%	302-22	2.1E6	5%	302-24	2.1E6			
	4 - 10 Lams			**11 or More Lams**								
28F-E1 SP (Unbalanced)	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	--						
	15%	N1D 2.3E	--	5%	N1D 2.3E	--						
	5%	302-28	2.3E5	5%	302-30	2.3E5						
	4 - 10 Lams			**11 or More Lams**								
28F-E2 SP (Balanced)	5%	302-28	2.3E5	5%	302-30	2.3E5						
	15%	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	--						
	15%	N1D 2.3E	--	5%	N1D 2.3E	--						
	5%	302-28	2.3E5	5%	302-30	2.3E5						
	4 - 10 Lams			**11 or More Lams**								
30F-E1 SP (Unbalanced)	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	--						
	15%	N1D 2.3E	--	5%	N1D 2.3E	--						
	5%	302-28	2.3E5	5%	302-30	2.3E5						
	4 - 10 Lams			**11 or More Lams**								
30F-E2 SP (Balanced)	5%	302-28	2.3E5	5%	302-30	2.3E5						
	15%	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	--						
	15%	N1D 2.3E	--	5%	N1D 2.3E	--						
	5%	302-28	2.3E5	5%	302-30	2.3E5						
California Redwood												
	4 - 7 Lams			**8 - 10 Lams**			**11 or More Lams**					
16F-V1 CR (Balanced)	5%	302-20	L1 or L2	5%	302-22	L1 or L2	5%	302-24	L1 or L2			
	25%	L1 or L2	--	20%	L1 or L2	--	20%	L1 or L2	--			
	--	--	--	5%	L3	--	5%	L3	--			
	--	L4 or L5	--	--	L4 or L5	--	--	L4 or L5	--			
	--	--	--	5%	L3	--	5%	L3	--			
	25%	L1 or L2	--	20%	L1 or L2	--	20%	L1 or L2	--			
	5%	302-20	L1 or L2	5%	302-22	L1 or L2	5%	302-24	L1 or L2			

* 30F combinations are restricted to a maximum 6 in. nominal width unless the manufacturer has qualified for wider widths based on full-scale tests subject to approval by an accredited inspection agency

TABLE B2

LAY-UP REQUIREMENTS FOR UNIFORM GRADE MEMBERS

Combination Symbol	Grade/ Species
Douglas Fir-Larch	
1	L3 DF
2	L2 DF
3	L2D DF
4	L1CL DF
5	L1 DF
Hem-Fir	
14	L3 HF
15	L2 HF
16	L1 HF
17	L1D HF
Softwoods	
22	L3 SW
Alaska Cedar	
69	L3 AC
70	L2 AC
71	L1D AC
72	L1S AC
Port-Orford Cedar	
73	L3 POC
74	L2 POC
75	L1D POC

Combination Symbol	Grade/ Species
Southern Pine	
47	N2M12 SP
47 1:10	N2M10 SP
47 1:8	N2M SP
48	N2D12 SP
48 1:10	N2D10 SP
48 1:8	N2D SP
49	N1M16 SP
49 1:14	N1M14 SP
49 1:12	N1M12 SP
40 1:10	N1M SP
50	N1D14 SP
50 1:12	N1D12 SP
50 1:10	N1D SP

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Standard Specification for Structural Glued Laminated Timber of Softwood Species

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

www.apawood.org

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

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