ANSI 117-2015 Letter Ballot (Ballot 3)

**Ballot issue date: 02/14/2015 Ballot closing date: 03/20/2015**

**Ballot Instructions:**

1. All members are required to return the letter ballot. Failure to return 3 consecutive letter ballots will lead to the termination of the membership from this committee.
2. All votes shall be cast by marking the appropriate column of each ballot item.
3. Ballot items marked Negative or Affirmative-with-Comment shall be accompanied by a written explanation and proposed resolution that would address the negative using the comment form at the end of this ballot form.

Exception: A written explanation and proposed resolution is not required for a ballot item to find a negative non-persuasive.

1. The Committee activities for the development of this standard can be found at [www.apawood.org/standards](http://www.apawood.org/standards).
2. Return ballot by e-mail to [borjen.yeh@apawood.org](mailto:borjen.yeh@apawood.org). Please attach the completed ballot and comments as a word processor file (e.g., Microsoft Word) to facilitate the collection of comments for committee actions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
| Committee Member Name | | Signature (not required with e-mail) | | Date |

**Ballot** (Aff = affirmative; Aw/C = affirmative with comment; Neg = negative; Abst = abstention)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Item | Section | Description | Aff | Aw/C | Neg | Abst |
| 1 | As attached | **Approve all revisions as attached to this ballot.** |  |  |  |  |

**Comment Form for the ANSI 117-2015 Letter Ballot 3**

Required only for Negative or Affirmative-with-Comment

**Please attach this page to the e-mail ballot return**

|  |  |
| --- | --- |
| Item | Comments |
| 1 |  |

Revise ANSI 117-2010, as shown below.

**Rationale:** These revisions have been previously approved by the committee through Ballots 1 and 2. This ballot serves as the final approval of **ANSI 117-2015**, as amended, in conjunction with the public comment, as required by ANSI.

1. **Preface (Item 1 of Ballot 1)**

Add the following sentence at the end of the 4th paragraph:

The design values of glued laminated timber used in utility structures can be obtained by multiplying the reference design values provided in this Specification by the conversion factors specified in ANSI O5.2 (4).

1. **Section 1.2 (Item 6 of Ballot 2)**

Revise the table in Section 1.2, as shown in **Attachment C1**.

1. **Section 2.5 (Item 2 of Ballot 1)**

Revise Section 2.5, as shown in **Attachment C2**.

1. **Section 2.11 (Item 3 of Ballot 1, as amended by Item 1 of Ballot 2 and further amended based on a comment from Ballot 2)**

Revise the 1st sentence of Section 2.11 and add a new note as follows:

In lieu of specific data, the modulus of rigidity shall be taken as 1/16 of the long-span modulus of elasticity, as defined in ASTM D3737 (9), or Etrue for the lowest grade lamination used in the lay-up.

Note:  The lowest grade lamination used in the lay-up can be found in Annex B.  The Etrue for the lowest grade lamination can be determined from Table A2 based on Etrue = Eaxial, as specified in Section 2.4.

1. **Section 2.12 (Item 4 of Ballot 1)**

Revise the 2nd sentence in the 3rd paragraph as follows:

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.

1. **Section 3.1 (Item 5 of Ballot 1, as amended by Item 2 of Ballot 2)**

Revise Section 3.1 as follows:

Lumber grades shall be in accordance with Annex C of this Standard and Section 4.3 – *Lumber for Laminating* of ANSI A190.1 (~~4~~3). *~~AITC Grading Handbook for Laminating Lumber~~* ~~(1) summarizes the requirements for laminating grades of approved species and references approved grading rules.~~

1. **Section 3.3 (Item 6 of Ballot 1)**

Revise the 1st paragraph and 1st example in Section 3.3, as shown in **Attachment C3**.

1. **Section 3.6 (Item 7 of Ballot 1)**

Revise the last sentence as follows:

Tudor arches (Figure 3.6-2) shall be laid up in accordance with *AITC/WCLIB 200* (~~2~~1) or *APA Quality Assurance Policy for Structural Glued Laminated Timber* (5), unless specified otherwise.

1. **Tables A1, A1-Expanded, A2, and A3 (Item 8 of Ballot 1, as amended by Item 4 of Ballot 2)**

Revise Table A1, A1-Expanded, A2, and A3, as shown in **Attachment C4**.

1. **References (Item 9 of Ballot 1, as amended by Item 5 of Ballot 2)**

Revise References, as shown in **Attachment C5**, and renumber the references in the text of the entire standard accordingly.

1. **New Annex C (Item 3 of Ballot 2)**

Add a new Annex C, as shown in **Attachment C6**.

**Attachment C1 (Attachment B4 of Ballot 2)**

## **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, Norway (Red) Pine, Ponderosa Pine, Sitka Spruce, 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(a) | SPF | Alpine Fir, Balsam Fir, Black Spruce, Engelmann Spruce, Jack Pine, Lodgepole Pine, Norway (Red) Pine, Red Spruce, Sitka Spruce, White Spruce |

1. Including Spruce-Pine-Fir and Spruce-Pine-Fir (South).

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

Attachment C2 (Attachment 1 of Ballot 1)

## **2.5 Modulus of Elasticity Design Values, Ex true, Ex app, Ex min, Ey true, Ey, app, Ey min, Eaxial, and Eaxial min**

Design values for modulus of elasticity (E) are tabulated for bending about either axis (x-x or y-y, as shown in Figure 2.1-1). In general, the apparent moduli of elasticity, Ex app and Ey app, are used for calculation of deflection of bending members, and Ex min and Ey min are used for stability calculations for columns and beams.

Ex app and Ey app are based on a span to depth ratio of 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 (8) presents one method of accounting for shear deformations.

Ex true and Ey ture are shear-free moduli of elasticity and generally estimated as 1.05 Ex app and 1.05 Ey app, respectively. When Ex true and Ey true are used, the calculated deflection of members accounts for the deflection due to bending only and therefore, the deflection due to shear must be calculated separately and then added to the bending deflection to account for the total deflection of the members.

For the calculation of extensional deformations, the axial modulus of elasticity for mixed grade lay-up combinations provided in Tables A1 and A1-Expanded, can be estimated as Eaxial = 1.05 Ey app = Ey true, such as for use in calculating deflection of trusses. The bending modulus of elasticity for uniform grade lay-up combinations provided in Table A2 can be estimated as Ex true = Ey ture = Eaxial, and Ex app = Ey app = 0.95 Eaxial.

Ex min, ~~and~~ Ey min, and Eaxial min are calculated using the following formula:



where: Emin = Ex min, ~~or~~ Ey min, or Eaxial min as appropriate

Eapp = Ex app, ~~or~~ Ey app, or 0.95 Eaxial as appropriate

CoVE = 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.~~

Attachment C3 (Attachment 2 of Ballot 1)

## **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 expressed in the number of laminations. 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 combined number of 302-24 and L1 laminations is: ~~16 x 0.15 – (1 – 0.8) = 2.4 – 0.2 = 2.2 lams~~ 16 x (0.05 + 0.15) = 3.2 lams (round up to ~~3~~ 4). Since there is already 1 lam of 302-24 from the calculation above, the required number of L1 lams is 4 - 1 = 3 lams.

The combined number of 302-24, L1, and L2 lams is ~~16 x 0.1 – (3 – 2.2) = 1.6 – 0.8 = 0.8 (rounded up to 1)~~ 16 x (0.05 + 0.15 + 0.10) = 4.8 lams (rounded up to 5). Since there are already 1 lam of 302-24 and 3 lams of L1 from the calculation above, the required number of L2 lams is 5 - 4 = 1 lam.

Attachment C4 (Attachment 3 of Ballot 1, as amended by Attachment B2 of Ballot 2)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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** |
| Tension Parallel  to Grain | Compression Parallel  to Grain | Specific Gravity for  Fastener Design |
| 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 | | |
| 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** | **Fbx+**  (psi) | **Fbx– (1)**  (psi) | **Fc⊥x**  (psi) | **Fvx (4)**  (psi) | **Ex true**  (106 psi) | **Ex app**  (106 psi) | **Ex min**  (106 psi) | **Fby**  (psi) | **Fc⊥y**  (psi) | **Fvy (5)**  (psi) | **Ey true**  (106 psi) | **Ey app**  (106 psi) | **Ey min**  (106 psi) | **Ft**  (psi) | **Fc**  (psi) | **G** |
| **16F-1.3E**  **20F-1.5E**  **24F-1.7E** | 1600  2000  2400 | 925  1100  1450 | 315  425  500 | 195  195(6)  210(6) | 1.4  1.6  1.8 | 1.3  1.5  1.7 | 0.69  0.79  0.90 | 800  800  1050 | 315  315  315 | 170  170  185 | 1.2  1.3  1.4 | 1.1  1.2  1.3 | 0.58  0.63  0.69 | 675  725  775 | 925  925  1000 | 0.41  0.41  0.42 |
| **24F-1.8E** | 2400 | 1450(2) | 650 | 265(3) | 1.9 | 1.8 | 0.95 | 1450 | 560 | 230(3) | 1.7 | 1.6 | 0.85 | 1100 | 1600 | 0.50(10) |
| **26F-1.9E(7)**  **28F-2.1E SP(7)**  **30F-2.1E SP(7)(8)** | 2600  2800  3000 | 1950  2300  2400 | 650  805  805 | 265(3)  300  300 | 2.0  2.2(9)  2.2(9) | 1.9  2.1(9)  2.1(9) | 1.00  1.09  1.09 | 1600  1600  1750 | 560  650  650 | 230(3)  260  260 | 1.7  1.8  1.8 | 1.6  1.7  1.7 | 0.85  0.90  0.90 | 1150  1250  1250 | 1600  1750  1750 | 0.50(10)  0.55  0.55 |
| **Footnotes to Table A1**   1. For balanced layups, **Fbx–** shall be equal to **Fbx+** for the stress class. Designer shall specify when balanced layup is required. 2. Negative bending stress, **Fbx–**, 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, **Fvx** and **Fvy**, are permitted to be increased to **300 psi**, and **260 psi**, respectively. 4. The design values for shear, **Fvx** and **Fvy,** 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, **Fvx**, shall be multiplied by 0.67 if wane is allowed on both sides. If wane is limited to one side, **Fvx** 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, Ex true = 2.1 x 106 psi and **Ex app** = 2.0 ~~million~~ x 106 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 ~~a~~re 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. | | | | | | | | | | | | | | | | | | | |
| Combination Symbol | Species Outer/Core | **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 |
| **Fbx+**  (psi) | **Fbx–**  (psi) | **Fc⊥x**  (psi) | | **Fvx (2)**  (psi) | **Ex true**  (106 psi) | **Ex app**  (106 psi) | **Ex min**  (106 psi) | **Fby**  (psi) | **Fc⊥y**  (psi) | **Fvy (3)**  (psi) | **Ey true**  (106 psi) | **Ey app**  (106 psi) | **Ey min**  (106 psi) | **Ft**  (psi) | **Fc**  (psi) | **G** | |
| **16F-1.3E** | | **1600** | **925** | **315** | | **195** | **1.4** | **1.3** | **0.69** | **800** | **315** | **170** | **1.2** | **1.1** | **0.58** | **675** | **925** | **0.41** | |
| 16F-V3  16F-V6  16F-E2  16F-E3  16F-E6  16F-E7 | DF/DF  DF/DF HF/HF DF/DF DF/DF HF/HF | 1600  1600  1600  1600  1600  1600 | 1250  1600  1050  1200  1600  1600 | 560  560  375  560  560  375 | 560  560  375  560  560  375 | 265  265  215  265  265  215 | 1.6  1.7  1.5  1.7  1.7  1.5 | 1.5  1.6  1.4  1.6  1.6  1.4 | 0.79  0.85  0.74  0.85  0.85  0.74 | 1450  1450  1200  1400  1550  1350 | 560  560  375  560  560  375 | 230  230  190  230  230  190 | 1.6  1.6  1.4  1.6  1.6  1.4 | 1.5  1.5  1.3  1.5  1.5  1.3 | 0.79  0.79  0.69  0.79  0.79  0.74 | 975  1000  825  975  1000  875 | 1500  1600  1150  1600  1600  1250 | 0.50  0.50  0.43  0.50  0.50  0.43 | 0.50  0.50  0.43  0.50  0.50  0.43 |
|  | | | | | | | | | | | | | | | | | | | |
| 16F-V2  16F-V3  16F-V5  16F-E1  16F-E3 | SP/SP  SP/SP  SP/SP  SP/SP  SP/SP | 1600  1600  1600  1600  1600 | 1400  1450  1600  1250  1600 | 740  740  650  650  650 | 650  740  650  650  650 | 300  300  300  300  300 | 1.6  1.5  1.7  1.7  1.8 | 1.5  1.4  1.6  1.6  1.7 | 0.79  0.74  0.85  0.85  0.90 | 1450  1450  1600  1400  1650 | 650  650  650  650  650 | 260  260  260  260  260 | 1.5  1.5  1.6  1.7  1.7 | 1.4  1.4  1.5  1.6  1.6 | 0.74  0.74  0.79  0.85  0.85 | 1000  975  1000  1050  1100 | 1300  1400  1550  1550  1550 | 0.55  0.55  0.55  0.55  0.55 | 0.55  0.55  0.55  0.55  0.55 |
| **20F-1.5E** | | **2000** | **1100** | **425** | | **195** | **1.6** | **1.5** | **0.79** | **800** | **315** | **170** | **1.3** | **1.2** | **0.63** | **725** | **925** | **0.41** | |
| 20F-V3  20F-V7  20F-V12  20F-V13  20F-V14  20F-V15  20F-E2  20F-E3  20F-E6  20F-E7  20F-E8  24F-E/SPF1  24F-E/SPF3 | DF/DF  DF/DF AC/AC AC/AC POC/POC POC/POC HF/HF DF/DF DF/DF HF/HF  ES/ES SPF/SPF SPF/SPF | 2000  2000  2000  2000  2000  2000  2000  2000  2000  2000  2000  2400  2400 | 1450  2000  1400  2000  1450  2000  1400  1200  2000  2000  1300  2400  1550 | 650  650  560  560  560  560  500  560  560  500  450  560  560 | 560  650  560  560  560  560  500  560  560  500  450  560  650 | 265  265  265  265  265  265  215  265  265  215  200  215  215 | 1.7  1.7  1.6  1.6  1.6  1.6  1.7  1.8  1.8  1.8  1.6  1.7  1.7 | 1.6  1.6  1.5  1.5  1.5  1.5  1.6  1.7  1.7  1.6  1.5  1.6  1.6 | 0.85  0.85  0.79  0.79  0.79  0.79  0.85  0.90  0.90  0.85  0.79  0.85  0.85 | 1450  1450  1250  1250  1300  1300  1200  1400  1550  1450  1000  1150  1200 | 560  560  470  470  470  470  375  560  560  375  315  470  470 | 230  230  230  230  230  230  190  230  230  190  175  190  195 | 1.6  1.7  1.5  1.5  1.5  1.5  1.5  1.7  1.7  1.5  1.5  1.7  1.6 | 1.5  1.6  1.4  1.4  1.4  1.4  1.4  1.6  1.6  1.4  1.4  1.6  1.5 | 0.79  0.85  0.74  0.74  0.74  0.74  0.74  0.85  0.85  0.74  0.74  0.85  0.79 | 1000  1050  925  950  900  900  925  1050  1150  1050  825  1150  900 | 1550  1600  1500  1550  1600  1600  1350  1600  1650  1450  1100  2000  1750 | 0.50  0.50  0.46  0.46  0.46  0.46  0.43  0.50  0.50  0.43  0.41  0.42  0.42 | 0.50  0.50  0.46  0.46  0.46  0.46  0.43  0.50  0.50  0.43  0.41  0.42  0.42 |
|  | | | | | | | | | | | | | | | | | | | |
| 20F-V2  20F-V3  20F-V5  20F-E1  20F-E3 | SP/SP  SP/SP  SP/SP  SP/SP  SP/SP | 2000  2000  2000  2000  2000 | 1550  1450  2000  1300  2000 | 740  650  740  650  650 | 650  650  740  650  650 | 300  300  300  300  300 | 1.6  1.6  1.7  1.8  1.8 | 1.5  1.5  1.6  1.7  1.7 | 0.79  0.79  0.85  0.90  0.90 | 1450  1600  1450  1400  1700 | 650  650  650  650  650 | 260  260  260  260  260 | 1.5  1.6  1.5  1.7  1.7 | 1.4  1.5  1.4  1.6  1.6 | 0.74  0.79  0.74  0.85  0.85 | 1000  1000  1050  1050  1150 | 1400  1400  1500  1550  1600 | 0.55  0.55  0.55  0.55  0.55 | 0.55  0.55  0.55  0.55  0.55 |
| **24F-1.7E** | | **2400** | **1450** | **500** | | **210** | **1.8** | **1.7** | **0.90** | **1050** | **315** | **185** | **1.4** | **1.3** | **0.69** | **775** | **1000** | **0.42** | |
| 24F-V5  24F-V10  24F-E11  24F-E15 | DF/HF  DF/HF HF/HF HF/HF | 2400  2400  2400  2400 | 1600  2400  2400  1600 | 650  650  500  500 | 650  650  500  500 | 215  215  215  215 | 1.8  1.9  1.9  1.9 | 1.7  1.8  1.8  1.8 ~~1.7~~ | 0.90  0.95  0.95  0.95 | 1350  1450  1550  1200 | 375  375  375  375 | 200  200  190  190 | 1.6  1.6  1.6  1.6 | 1.5  1.5  1.5  1.5 | 0.79  0.79  0.79  0.79 | 1100  1150  1150  975 | 1450  1550  1550  1500 | 0.50  0.50  0.43  0.43 | 0.43  0.43  0.43  0.43 |
|  | | | | | | | | | | | | | | | | | | | |
| 24F-V1  24F-V4(4)  24F-V5 | SP/SP  SP/SP  SP/SP | 2400  2400  2400 | 1750  1650  2400 | 740  740  740 | 650  650  740 | 300  210  300 | 1.8  1.8  1.8 | 1.7  1.7  1.7 | 0.90  0.90  0.90 | 1450  1350  1700 | 650  470  650 | 260  230  260 | 1.6  1.6  1.7 | 1.5  1.5  1.6 | 0.79  0.79  0.85 | 1100  975  1150 | 1500  1350  1600 | 0.55  0.55  0.55 | 0.55  0.43  0.55 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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. | | | | | | | | | | | | | | | | | | | | |
| Combination Symbol | Species Outer/Core | | **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 |
| **Fbx+**  (psi) | **Fbx–**  (psi) | **Fc⊥x**  (psi) | | **Fvx (2)**  (psi) | **Ex true**  (106 psi) | **Ex app**  (106 psi) | **Ex min**  (106 psi) | **Fby**  (psi) | **Fc⊥y**  (psi) | **Fvy (3)**  (psi) | Ey true  (106 psi) | **Ey app**  (106 psi) | **Ey min**  (106 psi) | **Ft**  (psi) | **Fc**  (psi) | **G** | |
| **24F-1.8E** | | | **2400** | **1450** | **650** | | **265** | **1.9** | **1.8** | **0.95** | **1450** | **560** | **230** | **1.7** | **1.6** | **0.85** | **1100** | **1600** | **0.50** | |
| 24F-V4  24F-V8  24F-E4  24F-E13  24F-E18 | | DF/DF  DF/DF DF/DF DF/DF DF/DF | 2400  2400  2400  2400  2400 | 1850  2400  1450  2400  2400 | 650  650  650  650  650 | 650  650  650  650  650 | 265  265  265  265  265 | 1.9  1.9  1.9  1.9  1.9 | 1.8  1.8  1.8  1.8  1.8 | 0.95  0.95  0.95  0.95  0.95 | 1450  1550  1400  1750  1550 | 560  560  560  560  560 | 230  230  230  230  230 | 1.7  1.7  1.8  1.8  1.8 | 1.6  1.6  1.7  1.7  1.7 | 0.85  0.85  0.90  0.90  0.90 | 1100  1100  1100  1250  975 | 1650  1650  1700  1700  1700 | 0.50  0.50  0.50  0.50  0.50 | 0.50  0.50  0.50  0.50  0.50 |
|  | | | | | | | | | | | | | | | | | | | | |
| 24F-V3  24F-V8  24F-E1  24F-E4 | | SP/SP  SP/SP SP/SP SP/SP | 2400  2400  2400  2400 | 2000  2400  1450  2400 | 740  740  805  805 | 740  740  650  805 | 300  300  300  300 | 1.9  1.9  1.9  2.0 | 1.8  1.8  1.8  1.9 | 0.95  0.95  0.95  1.00 | 1700  1700  1550  1850 | 650  650  650  650 | 260  260  260  260 | 1.7  1.7  1.8  1.9 | 1.6  1.6  1.7  1.8 | 0.85  0.85  0.90  0.95 | 1150  1150  1150  1450 | 1650  1650  1600  1750 | 0.55  0.55  0.55  0.55 | 0.55  0.55  0.55  0.55 |
| **26F-1.9E(5)** | | | **2600** | **1950** | **650** | | **265** | **2.0** | **1.9** | **1.00** | **1600** | **560** | **230** | **1.7** | **1.6** | **0.85** | **1150** | **1600** | **0.50** | |
| 26F-V1  26F-V2 | | DF/DF  DF/DF | 2600  2600 | 1950  2600 | 650  650 | 650  650 | 265  265 | 2.1  2.1 | 2.0  2.0 | 1.06  1.06 | 1850  1850 | 560  560 | 230  230 | 1.9  1.9 | 1.8  1.8 | 0.95  0.95 | 1350  1350 | 1850  1850 | 0.50  0.50 | 0.50  0.50 |
|  | | | | | | | | | | | | | | | | | | | |  |
| 26F-V1  26F-V2  26F-V3  26F-V4  26F-V5 | | SP/SP  SP/SP SP/SP SP/SP SP/SP | 2600  2600  2600  2600  2600 | 2000  2100  2100  2600  2600 | 740  740  740  740  740 | 740  740  740  740  740 | 300  300  300  300  300 | 1.9  2.0  2.0  2.0  2.0 | 1.8  1.9  1.9  1.9  1.9 | 0.95  1.00  1.00  1.00  1.00 | 1700  1950  1950  1700  1950 | 650  740  650  650  650 | 260  260  260  260  260 | 1.7  1.9  1.9  1.9  1.9 | 1.6  1.8  1.8  1.8  1.8 | 0.85  0.95  0.95  0.95  0.95 | 1150  1300  1250  1200  1300 | 1600  1850  1800  1600  1850 | 0.55  0.55  0.55  0.55  0.55 | 0.55  0.55  0.55  0.55  0.55 |
| **28F-2.1E SP(5)** | | | **2800** | **2300** | **805** | | **300** | **2.2(7)** | **2.1(7)** | **~~1.09~~1.11** | **1600** | **650** | **260** | **1.8** | **1.7** | **0.90** | **1250** | **1750** | **0.55** | |
| 28F-E1  28F-E2 | | SP/SP SP/SP | 2800  2800 | 2300  2800 | 805  805 | 805  805 | 300  300 | 2.2**(7)**  2.2**(7)** | 2.1**(7)**  2.1**(7)** | ~~1.09~~1.11  ~~1.09~~1.11 | 1600  2000 | 650  650 | 260  260 | 1.8  1.8 | 1.7  1.7 | 0.90  0.90 | 1300  1300 | 1850  1850 | 0.55  0.55 | 0.55  0.55 |
| **30F-2.1E SP(5)(6)** | | | **3000** | **2400** | **805** | | **300** | **2.2(7)** | **2.1(7)** | **~~1.09~~1.11** | **1750** | **650** | **260** | **1.8** | **1.7** | **0.90** | **1250** | **1750** | **0.55** | |
| 30F-E1  30F-E2 | | SP/SP SP/SP | 3000  3000 | 2400  3000 | 805  805 | 805  805 | 300  300 | 2.2**(7)**  2.2**(7)** | 2.1**(7)**  2.1**(7)** | ~~1.09~~1.11  ~~1.09~~1.11 | 1750  1750 | 650  650 | 260  260 | 1.8  1.8 | 1.7  1.7 | 0.90  0.90 | 1250  1350 | 1750  1750 | 0.55  0.55 | 0.55  0.55 |
| **Footnotes to Table A1-Expanded:**   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 ~~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, **Fvx** and **Fvy** 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. 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, **FVX**, shall be multiplied by 0.67 if wane is allowed on both sides. If wane is limited to one side, **Fvx** 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, Ex true = 2.1 million psi, **Ex app** = 2.0 ~~million~~ x 106 psi, and Ex min = 1.06 x 106 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** | | | | **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 | |
| Modulus of  Elasticity | | | Compression Perpendicular to Grain  **Fc**⊥  (psi) | Tension Parallel to Grain | Compression  Parallel to Grain | |
| Bending | | | Shear Parallel  to Grain(1)(2) | Bending | Shear Parallel  to Grain(3) |
| 2 or More Lami- nations  **Ft**  (psi) | 4 or More Lami- nations  **Fc**  (psi) | 2 or 3  Lami- nations  **Fc**  (psi) | 4 or More Lami- nations  **Fby**  (psi) | 3  Lami- nations  **Fby**  (psi) | 2  Lami- nations  **Fby**  (psi) | **Fvy**  (psi) | 2 Lami- nations to  15 in. Deep(4)  **Fbx**  (psi) | **Fvx**  (psi) |
| **Eaxial**  (106 psi) | **0.95 Eaxial**  (106 psi) | **Eaxial min**  (106 psi) |
| Visually Graded Western Species | | | | | | |  | | | | | | | | |
| 1  2  3  4  5 | DF  DF  DF  DF  DF | L3  L2  L2D L1CL  L1 | 1.6  1.7  2.0  2.0  2.1 | 1.5  1.6  1.9  1.9  2.0 | 0.79  0.85  1.00  1.00  1.06 | 560  560  650  590  650 | 950  1250  1450  1400  1650 | 1550  1950  2300  2100  2400 | 1250  1600  1900  1950  2100 | 1450  1800  2100  2200  2400 | 1250  1600  1850  2000  2100 | 1000  1300  1550  1650  1800 | 230  230  230  230  230 | 1250  1700  2000  2100  2200 | 265  265  265  265  265 |
| 14  15  16  17 | HF  HF  HF  HF | L3  L2  L1  L1D | 1.4  1.5  1.7  1.8 | 1.3  1.4  1.6  1.7 | 0.69  0.74  0.85  0.90 | 375  375  375  500 | 800  1050  1200  1400 | 1100  1350  1500  1750 | 1050  1350  1500  1750 | 1200  1500  1750  2000 | 1050  1350  1550  1850 | 850  1100  1300  1550 | 190  190  190  190 | 1100  1450  1600  1900 | 215  215  215  215 |
| 22(5) | SW | L3 | 1.1 | 1.0 | 0.53 | 315 | 525 | 850 | 725 | 800 | 700 | 575 | 170 | 725 | 195 |
| 69  70  71  72 | AC  AC  AC  AC | L3  L2  L1D  L1S | 1.3  1.4  1.7  1.7 | 1.2  1.3  1.6  1.6 | 0.63  0.69  0.85  0.85 | 470  470  560  560 | 725  975  1250  1250 | 1150  1450  1900  1900 | 1100  1450  1900  1900 | 1100  1400  1850  1850 | 975  1250  1650  1650 | 775  1000  1400  1400 | 230  230  230  230 | 1000  1350  1750  1900 | 265  265  265  265 |
| 73  74  75 | POC  POC POC | L3  L2  L1D | 1.4  1.5  1.8 | 1.3  1.4  1.7 | 0.69  0.74  0.90 | 470  470  560 | 775  1050  1350 | 1500  1900  2300 | 1200  1550  2050 | 1200  1450  1950 | 1050  1300  1750 | 825  1100  1500 | 230  230  230 | 1050  1400  1850 | 265  265  265 |
| Visually Graded Southern Pine | | | | | | |  | | | | | | | | |
| 47  47 1:10  47 1:8  48  48 1:10  48 1:8  49  49 1:14  49 1:12  49 1:10  50  50 1:12  50 1:10 | SP  SP  SP  SP  SP  SP  SP  SP  SP  SP  SP  SP  SP | N2M12  N2M10  N2M N2D12  N2D10  N2D N1M16  N1M14  N1M12  N1M N1D14  N1D12  N1D | 1.5  1.5  1.5  1.8  1.8  1.8  1.8  1.8  1.8  1.8  2.0  2.0  2.0 | 1.4  1.4  1.4  1.7  1.7  1.7  1.7  1.7  1.7  1.7  1.9  1.9  1.9 | 0.74  0.74  0.74  0.90  0.90  0.90  0.90  0.90  0.90  0.90  1.00  1.00  1.00 | 650  650  650  740  740  740  650  650  650  650  740  740  740 | 1200  1150  1000  1400  1350  1150  1350  1350  1300  1150  1550  1500  1350 | 1900  1700  1500  2200  2000  1750  2100  2000  1900  1700  2300  2200  2000 | 1150  1150  1150  1350  1350  1350  1450  1450  1450  1450  1700  1700  1700 | 1750  1750  1600  2000  2000  1850  1950  1950  1950  1850  2300  2300  2100 | 1550  1550  1550  1800  1800  1800  1750  1750  1750  1750  2100  2100  2100 | 1300  1300  1300  1500  1500  1500  1500  1500  1500  1500  1750  1750  1750 | 260  260  260  260  260  260  260  260  260  260  260  260  260 | 1400  1400  1400  1600  1600  1600  1800  1800  1800  1800  2100  2100  2100 | 300  300  300  300  300  300  300  300  300  300  300  300  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, **Fvy**, 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, **Fvy**, 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, **Fvy**, 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, **Fvx** and **Fvy**, 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. The tabulated Fbx values are for members without special tension lams up to 15 inches in depth. If the member depth is greater than 15 inches without special tension lams, the tabulated Fbx values must be multiplied by a factor of 0.88. If special tension lams are used, the tabulated Fbx values are permitted to be increased by a factor of 1.18 regardless of the member depth. ~~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, **Fvx** and **Fvy**, 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 | **Fbx**+(psi) | **Ex true**(106 psi) | **Ex app**(106 psi) | **Ex min**(106 psi) | **Fc⊥x Top**(psi) | **Fvx(3)** (psi) |
| **16F-1.3E** | | **1050** | **1.3** | **1.2** | **0.63** | **315** | **140** |
| 16F-V3  16F-V6  16F-E2  16F-E3  16F-E6  16F-E7  16F-V2  16F-V3  16F-V5  16F-E1  16F-E3 | DF/DF  DF/DF HF/HF DF/DF DF/DF HF/HF SP/SP SP/SP SP/SP SP/SP SP/SP | 1600  1600  1350  1600  1600  1350  1450  1550  1550  1600  1600 | 1.6  1.6  1.5  1.7  1.7  1.5  1.6  1.5  1.6  1.7  1.7 | 1.5  1.5  1.4  1.6  1.6  1.4  1.5  1.4  1.5  1.6  1.6 | 0.79  0.79  0.74  0.85  0.85  0.74  0.79  0.74  0.79  0.85  0.85 | 560  560  375  560  560  375  650  650  650  650  650 | 190  190  155  190  190  155  215  215  215  215  215 |
| **20F-1.5E** | | **1250** | **1.5** | **1.4** | **0.74** | **375** | **150** |
| 20F-V3  20F-V7  20F-V12  20F-V13  20F-E2  20F-E3  20F-E6  20F-E7  20F-V2  20F-V3  20F-V5  20F-E1  20F-E3 | DF/DF  DF/DF AC/AC  AC/AC  HF/HF  DF/DF  DF/DF  HF/HF  SP/SP  SP/SP  SP/SP  SP/SP  SP/SP | 1900  1900  1650  1650  1700  1900  1900  1700  1500  1700  1500  1950  1900 | 1.7  1.7  1.5  1.5  1.6  1.7  1.7  1.6  1.5  1.6  1.6  1.7  1.7 | 1.6  1.6  1.4  1.4  1.5  1.6  1.6  1.5  1.4  1.5  1.5  1.6  1.6 | 0.85  0.85  0.74  0.74  0.79  0.85  0.85  0.79  0.74  0.79  0.79  0.85  0.85 | 560  560  470  470  375  560  560  375  650  650  650  650  650 | 190  190  190  190  155  190  190  155  215  215  215  215  215 |
| **24F-1.7E** | | **1250** | **1.5** | **1.4** | **0.74** | **375** | **150** |
| 24F-V5  24F-V10  24F-E2  24F-E11  24F-E15  24F-V1  24F-V4  24F-V5 | DF/HF  DF/HF  HF/HF  HF/HF  HF/HF  SP/SP  SP/SP  SP/SP | 1900  1900  1900  1900  1900  1800  1250  2100 | 1.7  1.7  1.7  1.7  1.7  1.7  1.5  1.8 | 1.6  1.6  1.6  1.6  1.6  1.6  1.4  1.7 | 0.85  0.85  0.85  0.85  0.85  0.85  0.74  0.90 | 375  375  375  375  375  650  470  650 | 190  155  155  155  155  215  215  215 |
| **24F-1.8E** | | **2000** | **1.8** | **1.7** | **0.90** | **560** | **190** |
| 24F-V4  24F-V8  24F-E4  24F-E13  24F-E18  24F-V3  24F-V8  24F-E1  24F-E4 | DF/DF  DF/DF  DF/DF DF/DF  DF/DF  SP/SP  SP/SP  SP/SP  SP/SP | 2100  2100  2100  2100  2100  2100  2100  2100  2100 | 1.8  1.8  1.8  1.8  1.8  1.8  1.8  1.8  1.8 | 1.7  1.7  1.7  1.7  1.7  1.7  1.7  1.7  1.7 | 0.90  0.90  0.90  0.90  0.90  0.90  0.90  0.90  0.90 | 560  560  560  560  560  650  650  650  650 | 190  190  190  190  190  215  215  215  215 |
| **26F-1.9E** | | **2000** | **1.8** | **1.7** | **0.90** | **560** | **190** |
| 26F-V1  26F-V2  26F-V1  26F-V2  26F-V3  26F-V4  26F-V5 | DF/DF DF/DF SP/SP  SP/SP  SP/SP  SP/SP  SP/SP | 2100  2100  2000  2400  2000  2000  2000 | 1.8  1.8  1.8  1.9  1.9  1.9  1.9 | 1.7  1.7  1.7  1.8  1.8  1.8  1.8 | 0.90  0.90  0.90  0.95  0.95  0.95  0.95 | 560  560  650  740  650  650  740 | 190  190  215  215  215  215  215 |
| **28F-2.1E** | | **2400** | **2.0** | **1.9** | **1.00** | **650** | **215** |
| 28F-E1  28F-E2 | SP/SP  SP/SP | 2400  2400 | 2.0  2.0 | 1.9  1.9 | 1.00  1.00 | 650  650 | 215  215 |
| **30F-2.1E** | | **2400** | **2.0** | **1.9** | **1.00** | **650** | **215** |
| 30F-E1  30F-E2 | SP/SP  SP/SP | 2400  2400 | 2.0  2.0 | 1.9  1.9 | 1.00  1.00 | 650  650 | 215  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. | | | | | | | |

**Attachment C5 (Attachment B3 of Ballot 2)**

# **References**

1. ~~AITC/WCLIB. 2009.~~ *~~Grading Handbook for Laminating Lumber.~~* ~~West Coast Lumber Inspection Bureau. Portland, Oregon.~~
2. AITC/WCLIB. ~~2004~~2009. Standard 200. *Manufacturing Quality Control Systems Manual.* ~~American Institute of Timber Construction. Centennial, Colorado~~ West Coast Lumber Inspection Bureau. Portland, Oregon.
3. AITC. ~~2003~~2012. *Timber Construction Manual.* ~~4th~~6th ed. John Wiley & Sons. New York, New York.
4. ANSI~~/AITC~~. ~~2007~~2012. ANSI~~/AITC~~ A190.1. *American National Standard for Wood Products–Structural Glued Laminated Timber.* ~~American Institute of Timber Construction. Centennial, Colorado.~~ APA – The Engineered Wood Association. Tacoma, Washington.
5. ANSI. 2012. ANSI O5.2. *American National Standard for Wood Products–Structural Glued Laminated Timber for Utility Structures*. American Wood Protection Association. Birmingham, Alabama.
6. APA. 2015. *Quality Assurance Policy for Structural Glued Laminated Timber.* APA – The Engineered Wood Association. Tacoma, Washington.
7. ASTM. ~~1994 (2007)~~2014. Standard D143. *Standard Test Methods for Small Clear Specimens of Timber.* ASTM International. West Conshohocken, Pennsylvania.
8. ASTM. 2014. Standard D2395. *Standard Test Methods for Density and Specific Gravity (Relative Density) of Wood and Wood-Based Materials.* ASTM International. West Conshohocken, Pennsylvania.
9. ASTM. ~~2003~~2010. Standard D2915. *Standard Practice for ~~Evaluating Allowable Properties for Grades of Structural Lumber~~ Sampling and Data-Analysis for Structural Wood and Wood-Based Products.* ASTM International. West Conshohocken, Pennsylvania.
10. ASTM. ~~2008~~2012. Standard D3737. *Standard Practice for Establishing Allowable Properties for Structural Glued Laminated Timber (Glulam).* ASTM International. West Conshohocken, Pennsylvania.
11. ASTM. 2007. Standard D4442. *Standard Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials.* ASTM International. West Conshohocken, Pennsylvania.
12. ASTM. 2013. Standard D4444. *Standard Test Method for Laboratory Standardization and Calibration of Hand-Held Moisture Meters.* ASTM International. West Conshohocken, Pennsylvania.
13. ASTM. 2013. Standard D4761. *Standard Test Methods for Mechanical Properties of Lumber and Wood-Base Structural Material.* ASTM International. West Conshohocken, Pennsylvania.
14. ASTM. ~~2008~~2014. Standard D7341. *Standard Practice for Establishing Characteristic Values for Flexural Properties of Structural Glued Laminated Timber by Full-Scale Testing.* ASTM International. West Conshohocken, Pennsylvania.
15. ASTM. 2012. Standard D7469. *Standard Test Methods for End-Joints in Structural Wood Products.* ASTM International. West Conshohocken, Pennsylvania.
16. AWC. 2015. *National Design Specification for Wood Construction*. American Wood Council. Leesburg, Virginia.

**Attachment C6 (Attachment B1 of Ballot 2)**

**Editorial note to voters: This is a new annex, but is not underlined for clarity.**

**Annex C**

**Laminating Lumber Grading Rules for Structural Glued Laminated Timbers**

# 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.

# Definitions/Measurement of Characteristics

## Moisture Content

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

## 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.

## 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.

## Knotholes

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

## Slope of Grain

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

## 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.

## Shakes

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

## Checks

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

## Warp

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

### Bow

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

### Crook

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

### Cup

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

## Torn Grain

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

## 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.

## Wane

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

## Decay

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

### 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.

### Honeycomb

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

## 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.

## Springwood or Earlywood

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

## **Summerwood** or Latewood

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

## Growth Rate

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

# General Requirements

## 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 A190.1. These qualification tests shall be performed using lumber with the maximum moisture content to be qualified (not to exceed 20%).

## 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 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.

## Knots

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

### 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.

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.

## 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.

## 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.

## Checks

Seasoning checks are permitted.

## 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.

## 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.

## Torn Grain

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

## 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.

## 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.

## Decay

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

## Timber Breaks

Timber breaks shall not be permitted.

## 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.

## 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.

## Growth Rate

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

1. 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.
2. Close (CL): Douglas-Fir-Larch 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.
3. Medium (M): 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.
4. 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.

# Visual Grades

## General Requirements

### 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.

### 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.

### 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.

### 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 | Ave. SG at 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 |

## Laminating Grades

### 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.

### 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:

#### L1D

1. Density: Dense.

# Exception: “L1” for Douglas Fir-Larch/Douglas Fir South is considered dense. No density designation as per 4.2.2 is required.

1. Knot Size: Knots shall not occupy more than 1/4 of the cross-section.
2. Slope of Grain: The basic slope of grain shall not exceed 1:14 for the full length of the piece.

#### L1

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

#### L1CL

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

#### L2D

1. Density: Dense.
2. Knot Size: Knots shall not occupy more than 1/3 of the cross-section.
3. Slope of Grain: The basic slope of grain shall not exceed 1:12 for the full length of the piece
4. 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.

#### L2

1. Density: Medium.
2. Knot Size: Knots shall not occupy more than 1/3 of the cross-section.
3. Slope of Grain: The basic slope of grain shall not exceed 1:12 for the full length of the piece.
4. 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.

#### L3

1. Density: Medium.
2. Knot Size: Knots shall not occupy more than 1/2 of the cross-section.
3. Slope of Grain: The basic slope of grain shall not exceed 1:8 for the full length of the piece.
4. 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.

## 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.

## 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 Sections 4.1 and 4.2, the following requirements apply for additional grades:

### SSS

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

## 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* of the Western Wood Products Association, the *Standard Grading Rules for West Coast Lumber* of the West Coast Lumber Inspection Bureau, *Standard Specifications for Grades of California Redwood Lumber* of the Redwood Inspection Service, *Standard Grading Rules for Northeastern Lumber* of the Northeastern Lumber Manufacturers Association or the *Standard Grading Rules for Canadian Lumber* of the National Lumber Grades Authority in Canada.

## 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* of the Southern Pine Inspection Bureau (SPIB).

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. This standard (ANSI 117) specifies slope of grain requirements for a particular lamination.

### 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:

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Width (in.) | 4 | 6 | 8 | 10 | 12 |
| Edge Knot (in.) | 1 | 1-1/2 | 2 | 2-1/2 | 3 |
| Center Knot (in.) | 1-1/2 | 2-1/4 | 2-3/4 | 3-1/4 | 3-3/4 |

### 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:

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Width (in.) | 4 | 6 | 8 | 10 | 12 |
| Edge Knot (in.) | 1 | 1-1/2 | 2 | 2-1/2 | 3 |
| Center Knot (in.) | 1-1/2 | 2-1/4 | 2-3/4 | 3-1/4 | 3-3/4 |

### 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:

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Width (in.) | 4 | 6 | 8 | 10 | 12 |
| Edge Knot (in.) | 1-1/4 | 1-7/8 | 2-1/2 | 3-1/4 | 3-3/4 |
| Center Knot (in.) | 2 | 2-7/8 | 3-1/2 | 4-1/4 | 4-3/4 |

### 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:

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Width (in.) | 4 | 6 | 8 | 10 | 12 |
| Edge Knot (in.) | 1-1/4 | 1-7/8 | 2-1/2 | 3-1/4 | 3-3/4 |
| Center Knot (in.) | 2 | 2-7/8 | 3-1/2 | 4-1/4 | 4-3/4 |

### 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:

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Width (in.) | 4 | 6 | 8 | 10 | 12 |
| Edge Knot (in.) | 1-3/4 | 2-3/4 | 3-1/2 | 4-1/2 | 5-1/2 |
| Center Knot (in.) | 2-1/2 | 3-3/4 | 4-1/2 | 5-1/2 | 6-1/2 |

### 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:

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Width (in.) | 4 | 6 | 8 | 10 | 12 |
| Edge Knot (in.) | 1-3/4 | 2-3/4 | 3-1/2 | 4-1/2 | 5-1/2 |
| Center Knot (in.) | 2-1/2 | 3-3/4 | 4-1/2 | 5-1/2 | 6-1/2 |

## 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 Sections 4.1 and 4.2, the following additional requirements/exceptions apply by grade:

### L1S

1. Density: Dense.
2. 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.
3. Slope of Grain: The basic slope of grain shall not exceed 1:14 for the full length of the piece.

### L1D

1. Density: Dense.
2. 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.
3. Slope of Grain: The basic slope of grain shall not exceed 1:12 for the full length of the piece.

## 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* 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* 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.

# E-rated Grades (Other than 302-Tension Laminations)

## 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.

## Long-Span E (LSE)

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

### 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 (/d) of approximately 100.

### Measurement

Long-span E shall be measured by the procedures of ASTM D4761, *Bending Flatwise-Center Point Loading*.

### 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 ASTM D4761, *Bending Flatwise-Center Point Loading*.

## E-Rated Laminating Lumber Specifications

### 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.

### E Specifications for E-rated Lumber for Qualification

#### 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, Et, shall meet the following criteria:

E t ≥ Es - 1.303

where:

St = the estimated population standard deviation (106 psi)

St = (Et - Est) / 1.684 (106 psi)

nt = sample size ( ≥ 40)

Et = mean long-span E of the sample (106 psi)

Es = grade long-span E (106 psi)

Est = 5th percentile long-span E calculated from the test data (106 psi)

#### 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 Specification | | |
| Grade | Mean (106 psi) | 5th Percentile (106 psi) |
| 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 |

### Visual Limitations

#### 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 |

#### Untested Portions

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

1. 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.
2. Cross-Section Knots: Displacement of all knots in the same cross section shall not exceed the size of the permitted non-edge knot.
3. Slope of Grain: The general slope of grain in the untested portion shall not be steeper than:

|  |  |
| --- | --- |
| Slope | Edge Characteristic (Disp.) |
| 1 in 12 | 1/6 |
| 1 in 10 | > 1/6 to ≤1/4 |
| 1 in 8 | > 1/4 |

## Production Quality Control

### Supervision

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

### Quality Control

#### 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.

#### 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.

#### Quality Control Records

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

## Reinspection of Individual Lots for Conformance to Specifications

### 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.

### Disposition of Nonconforming Lots

#### 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 ASTM D4761, *Bending Flatwise-Center Point Loading*, 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.

#### 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.

# Special Tension Lamination Grades

## 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:

### Cross Section

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

### Density

Growth rate requirements shall apply to the full length of the piece. All tension laminations shall 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.

## 302-20

### Primary Rules (All Species)

#### 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:

1. Knots shall not occupy more than 1/4 of the width in any cross section.
2. 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.
3. 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.

#### Visually Graded Combinations

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

1. 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.

#### E-Rated Combinations

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

1. 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.
2. 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

### Alternate Rules

#### Douglas Fir-Larch

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

1. 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 |

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 are permitted to occupy up to 1/4 of the cross section.
2. Slope of grain shall not be steeper than 1:10.
3. Pieces shall have a specific gravity of 0.45 or above based on oven-dried weight and volume at 12% moisture content.
4. **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 ASTM D7469 and ANSI A190.1.

#### 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:

1. Centerline knots shall not occupy more than 1/4 of the cross section.
2. Edge knots are limited to that allowed by the E-rated grade.
3. **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:
4. The untested portion(s) of the piece shall have the same general character as the remainder of the piece.
5. The general slope of grain shall not be steeper than 1:12.
6. Any cross section shall have at least 1/2 clear wood free of strength reducing characteristics.
7. **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.
8. **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.

## 302-22

### Primary Rules (All Species)

#### 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:

1. Knots shall not occupy more than 1/4 of the width in any cross section.
2. 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 are permitted to occupy up to 40% of the cross section.
3. 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.

#### Visually Graded Combinations

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

1. 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.

#### E-Rated Combinations

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

1. 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.
2. 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.

### Alternate Rules

#### Douglas Fir-Larch

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

1. 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 |

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 are permitted to occupy up to 1/4 of the cross section.
2. Slope of grain shall not be steeper than 1:16.
3. 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.
4. **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 ASTM D7469 and ANSI A190.1.

#### Douglas Fir-Larch

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

1. 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 |

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 are permitted to occupy up to 1/4 of the cross section.
2. Slope of grain shall not be steeper than 1:12.
3. 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.
4. The long-span modulus of elasticity shall not be less than 1,700,000 psi.
5. **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 1:12. Test procedures and criteria for acceptance of this test are as contained in ASTM D7469 and ANSI A190.1.

#### 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 an E-rating system which employs continuously measured lowest point modulus of elasticity. In addition to these basic requirements the following limitations shall apply:

1. Centerline knots shall not occupy more than 1/4 of the cross section.
2. Edge knots are limited to that allowed by the E-rated grade.
3. **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:
4. The untested portion(s) of the piece shall have the same general character as the remainder of the piece.
5. The general slope of grain shall not be steeper than 1:12.
6. Any cross section shall have at least 60% clear wood free of strength reducing characteristics.
7. **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.
8. **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.

## 302-24

### Primary Rules

#### 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:

1. Knots shall not occupy more than 1/5 of the width in any cross section.
2. 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 are permitted to occupy up to 1/3 of the cross section.
3. Maximum size single strength-reducing characteristics when not in the same horizontal projection shall be at least two feet apart measured center to center.
4. 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.

#### Visually Graded Combinations

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

1. 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.

#### E-Rated Combinations

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

1. 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.
2. 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.

### Alternate Rules

#### Douglas Fir-Larch

Exceptions 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:

1. 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 |

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 are permitted to occupy up to 1/4 of the cross section.
2. Maximum size single strength-reducing characteristics when not in the same horizontal projection shall be as least 2 feet apart measured center to center.
3. Slope of grain shall not be steeper than 1:12.
4. The long-span modulus of elasticity shall not be less than 1,800,000 psi.
5. **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 ASTM D7469 and ANSI A190.1.

#### 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 an E-rating system which employs continuously measured lowest point modulus of elasticity. In addition to these basic requirements the following limitations shall apply:

1. Centerline knots shall not occupy more than 1/5 of the cross section.
2. Maximum size single strength-reducing characteristics when not in the same horizontal projection shall be at least two feet apart measured center to center.
3. Edge knots are limited to that allowed by the E-rated grade.
4. **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:
5. The untested portion(s) of the piece shall have the same general character as the remainder of the piece.
6. The general slope of grain shall not be steeper than 1:12.
7. Any cross section shall have at least 2/3 clear wood free of strength reducing characteristics.
8. **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.
9. **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 ASTM D7469 and ANSI A190.1.
10. **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.

## 302-26

### 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:

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

## 302-28

### 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:

1. Average Long Span E for the grade shall be 2.3 x106 psi with no piece less than 1.96 x 106 psi and shall be verified through daily quality control.

## 302-30

### Primary Rules

In addition to the basic requirements of the 302-26 lamination grade as tabulated in Section 6.5, the following limitations shall apply:

1. Average Long Span E for the grade shall be 2.3 x106 psi with no piece less than 1.96 x 106 psi and shall be verified through daily quality control.

## Alternate Rules by Species

### Southern Pine

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

1. 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 |

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.
2. Slope of grain shall be no steeper than 1:10 for 302-20 and 1:12 for 302-22 and 302-24.
3. **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 ASTM D7469 and ANSI A190.1.

### 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:

1. 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.
2. Laminations shall conform to WCLIB Standard No. 17, paragraph 101-c except that the 3 in. cutout provision does not apply.
3. 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.
4. 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.
5. 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 are permitted to occupy up to 1/3 of the cross section.
6. Slope of grain shall be no steeper than 1:12.
7. 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.
8. **Special Provisions for Ends of Piece**: The untested portion of each end of each piece shall be visually graded to meet the following:
9. The ends of the piece shall have the same general character as the remainder of the piece.
10. 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 are 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.
11. **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 1:12. Test procedures and criteria for acceptance of this test are as contained in ASTM D7469 and ANSI A190.1.
12. **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 at 5th Percentile, psi |
| 302-24 | 4,000 |
| 302-22 | 3,670 |
| 302-20 | 3,340 |

## C-14: Alternate Provision for Machine Graded Tension Laminations

### 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 accredited third-party inspection agency of the laminator.

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.

### 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 shall apply.

### 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.

### 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 lumber grading agency and the accredited third-party inspection agency of the laminator.

If the lumber is supplied to the laminator as meeting the requirements of Sections 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 Section 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.

### Identification

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

### Changes in Practice

If, in the judgment of the accredited third-party inspection agency of the laminator, significant changes are made in the visual or machine grading practice, the qualification prescribed herein shall be invalid and shall be re-qualified.

### 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 ASTM D4761, *Bending Flatwise-Center Point Loading*, shall be used for testing long-span E.

### Criteria for Acceptance

#### 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 at 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, Fbx. 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 inches 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.

#### End Joint Qualification

Manufacturers using tension laminations qualified under this alternative provision shall qualify the end joints by following procedures in ASTM D7469 by testing 30 end joints in tension made from representative lumber from the machine grading system.

### 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.

### 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.

### Records

The grading agency that supervises qualification to the provisions of C14 shall report a summary of the qualification results to the accredited third-party inspection agency of the laminator.

# Method for Determination of Specific Gravity

## 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 is weighed and a weight per volume is calculated. From this number the specific gravity can 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.

## Moisture Content

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

## Size

The thickness and width of lumber shall be maintained according to ANSI 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.

## Method of Weighing

Any method of weighing the nearest 0.01 lbf is satisfactory.

## Calculation of Specific Gravity

Calculation of specific gravity shall be normalized to 12% moisture content in order to compare it to the required levels. ASTM D2395 shall be used to calculate specific gravity.