



# American Institute of Timber Construction

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## AITC 401-2005

### STANDARD FOR MANUFACTURED LUMBER FOR USE IN STRUCTURAL GLUED LAMINATED TIMBER

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#### 401.1. SCOPE

This standard describes the requirements for manufactured lumber to be used as a substitute for established grades of lumber in structural glued laminated timber. Manufactured lumber is comprised of two or more pieces of sawn lumber, structurally glued to form a single lamination. Manufactured lumber is permitted to be used as a substitute for standard laminating grades, but is primarily intended for use as an alternate to AITC special tension lamination grades: 302-20, 302-22, 302-24, 302-26, 302-28, and 302-30.

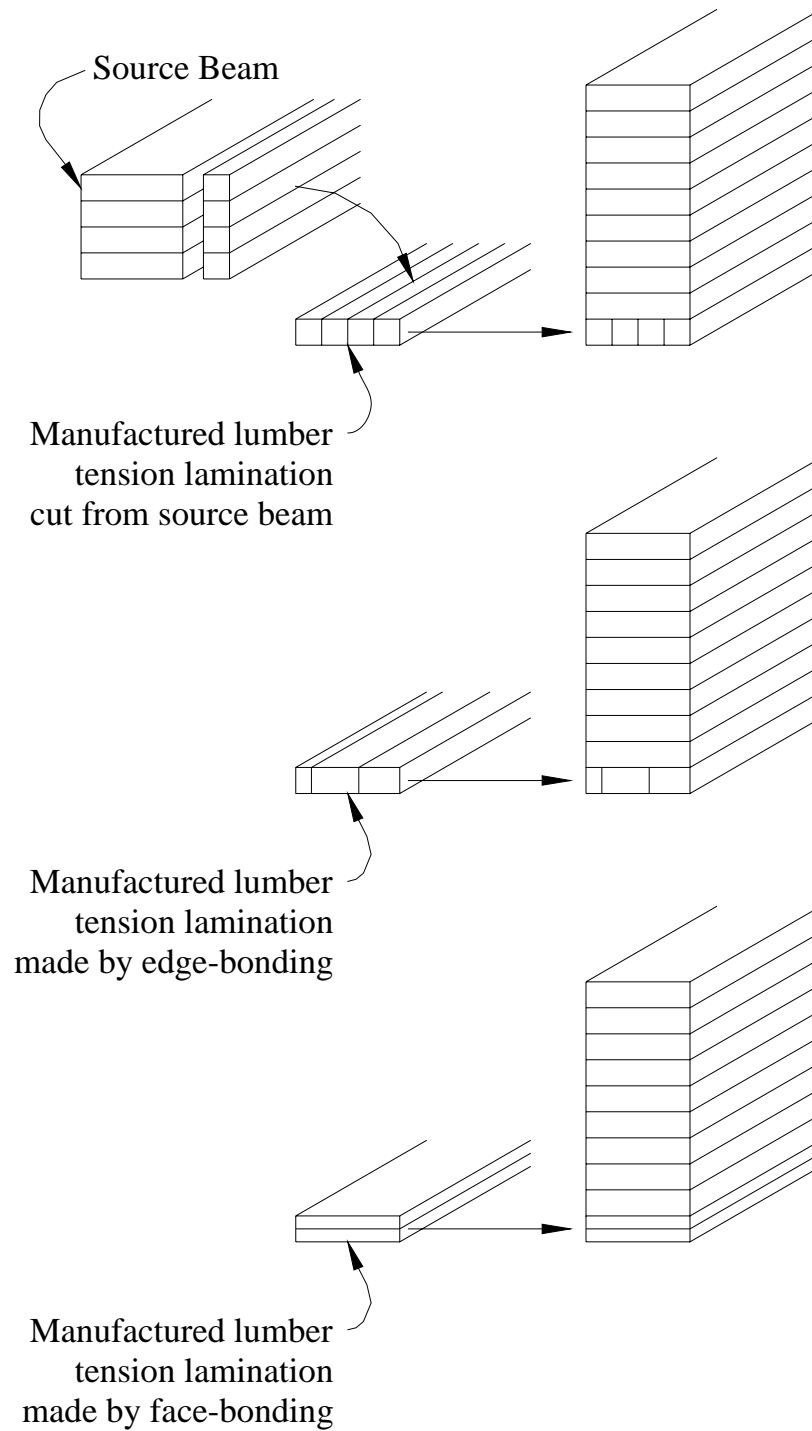
Manufactured lumber is permitted to be produced in full length pieces or in pieces no less than 6 feet long that are joined end to end to form laminations. Shorter length pieces are permitted if laminations are proof loaded in tension in accordance with ANSI/AITC A190.1. Multiple piece laminations (across the width) are not considered to be manufactured lumber, provided that each piece of the lumber meets the specified grade requirements when graded as separate pieces.

All manufactured lumber meeting the requirements of this standard shall be qualified by test prior to use. Lumber qualified under this standard is permitted to be used for all applicable structural glued laminated timber combinations provided that the average long-span E, tension strength, and shear strength requirements of the grade of lumber for which it is being substituted are met, and the compression perpendicular to grain design values are satisfied. Additionally, full scale beam tests may be required to demonstrate adequate performance.

This standard is not intended as a primary means of approval for new species intended to be used in structural glued laminated timber. The applicability of this standard to new species shall not occur prior to new species approval per ANSI/AITC A190.1.

#### 401.2. MANUFACTURE

**401.2.1. Types of Manufactured Lumber.** Manufactured lumber may be produced by one of several methods (Figure 401-1). It can be created by re-sawing laminations from a source beam, by edge bonding pieces of lumber, by face bonding pieces of lumber, or by a combination of these. A source beam is a glued laminated timber beam that has been manufactured for the purpose of re-sawing to produce laminations consisting of multiple edge-glued pieces.



**Figure 401-1.** *Types of Manufactured Lumber.*

**401.2.2. Constituent Lumber Grading – Criteria for Reproducibility.** To assure that the manufactured lumber qualified under this standard can be reproduced in routine production, all criteria used to select the lumber from which test specimens are made shall be recorded prior to testing and/or bonding. The lumber shall be graded according to ANSI/AITC A190.1. If E-rating or other machine sorting techniques are used, the procedures and criteria shall be recorded. Lumber used in producing the test specimens shall be representative of the material to be used in production.

**401.2.3. Bonding of Manufactured Lumber.** Face, end and edge joint bonding shall be in accordance with ANSI/AITC A190.1. End joint strength levels in the component lumber shall be determined and recorded to ensure reproducibility in routine production. Knots in and near end joints shall be limited as required in ANSI/AITC A190.1.

**401.2.4. Partial-width End Joint Spacing Within Manufactured Lumber.** Partial-width end joints in manufactured lumber shall be spaced a minimum of 6 inches between adjacent laminations across the width of the manufactured lumber when used on the tension side of members in the outer 1/8 of the depth of the member plus one lamination thickness or in tension members stressed to more than 75% of the design value. This requirement shall be waived if laminations are proof loaded in accordance with ANSI/AITC A190.1.

**401.2.5. Surfacing of Manufactured Lumber.** Manufactured lumber shall be re-surfaced after bonding if necessary to meet the surfacing requirements and thickness tolerances for laminations from ANSI/AITC A190.1.

**401.2.6. Grading of Manufactured Lumber After Bonding.** All criteria used to sort manufactured lumber by grade prior to qualification testing shall be recorded to assure reproducibility in daily production.

### **401.3. QUALIFICATION TESTING**

**401.3.1. Mechanical Properties.** The properties that shall be evaluated include tensile strength parallel to grain, long span modulus of elasticity, shear strength and compression perpendicular to grain. Testing shall be conducted or witnessed by a qualified third-party agency acceptable to the laminator's accredited inspection and testing agency. Test results shall be certified by the witnessing agency.

**401.3.1.1. Tensile Strength.** Manufactured lumber shall be qualified for tensile strength by testing in accordance with AITC Test T123 using a sample of 53 or more pieces selected at random from production. Each specimen for the tension test shall contain a typical number of partial-width end joints in the tested portion of the piece. The maximum number of joints of any partial-width end joints in any individual test specimen shall not exceed the average number of partial-width end joints per specimen for the qualification sample by more than 30%. The frequency of partial-width end joints established during qualification shall be maintained or reduced in subsequent production.

**401.3.1.2. Modulus of Elasticity.** Manufactured lumber shall be qualified for long span modulus of elasticity (E) by testing in accordance with AITC Test T116 using a sample of 53 or more pieces selected at random from production. When manufactured lumber is produced in long lengths, an individual test specimen is permitted to be formed from each 12-ft or longer length.

**401.3.1.3 Shear Strength.** Shear strength of the manufactured lumber shall be as established for the species and growth rate of the component lumber used to produce the manufactured lumber in accordance

with ASTM D3737. Alternatively, the manufactured lumber shear strength is permitted to be determined by testing in accordance with ASTM D3737.

**401.3.1.4. Compression Perpendicular to Grain.** The design value for compression perpendicular to grain for the manufactured lumber shall be as established for the species and growth rate of the component lumber used to produce the manufactured lumber in accordance with ASTM Standard D3737.

**401.3.2 Full-width End Joint Strength.** Plants using full-width end joints in manufactured lumber pieces to form longer laminations shall qualify their end joints using manufactured lumber representative of production following the procedures in AITC Test T119 and ANSI/AITC A190.1.

**401.3.3 Beam Tests.** If manufactured lumber will be used in the outer 5% of the depth on the tension side of horizontally laminated beams, qualification tests shall include full-scale beam tests representative of production. A minimum of one layup representing each group of similar layups within the combination shall be tested. A minimum of 15 members per group shall be tested with 30 or more members tested for the combination. The width of test specimens shall be representative of intended production sizes, and the depth shall be determined by the representative layups described above. Separate beam tests shall be required for each grade of manufactured lumber. Beam test requirements are permitted to be waived if the manufactured lumber tensile strength exceeds 2.1 times the QSL level of the laminated timber beam and will be maintained at that level during production, subject to approval by the accredited inspection and testing agency certifying the manufacturing process.

#### **401.4. CRITERIA FOR USE**

**401.4.1. Tensile Strength.** The 5% tolerance limit with 75% confidence determined by this test shall equal or exceed the corresponding value for the grade shown in Table 1.

To substitute for grades that are not tabulated, the appropriate strength levels shall be determined as follows:

For standard laminating grades, the five percent tolerance limit with 75% confidence determined from the test shall equal or exceed 2.1 times the minimum tensile strength determined from ASTM D3737 as follows: the tensile stress index shall be multiplied by the lesser of (1) the minimum strength ratio for knots or (2) the tension stress modification factor for slope of grain.

For special tension laminations, the required 5% tolerance limit with 75% confidence shall be determined by multiplying the ASTM D3737 bending stress index by 1.15 for 302-24 grade, 1.05 for 302-22 grade, or 0.95 for 302-20 grade.

**401.4.2. Modulus of Elasticity.** The upper 95% confidence bound on the sample mean long-span modulus of elasticity (E) shall equal or exceed the value for the grade shown in Table 1. For grades that are not tabulated, the upper 95% confidence bound on the sample mean long span E shall equal or exceed the long span E for the grade as determined by the procedures of ASTM D3737.

**Table 1. Qualification Levels for Laminating Grades**

| Grade     | Tension Strength<br>5% TL (psi) | E<br>(10 <sup>6</sup> psi) |
|-----------|---------------------------------|----------------------------|
| 302-26 DF | 4340                            | 2.1                        |
| 302-24 DF | 4010                            | 2.1                        |
| 302-22 DF | 3670                            | 2.1                        |
| 302-20 DF | 3340                            | 2.1                        |
| L1 DF     | 2420 <sup>1</sup>               | 2.1                        |
| L2D DF    | 1930 <sup>1</sup>               | 2.0                        |
| L2 DF     | 1680 <sup>1</sup>               | 1.7                        |
| L3 DF     | 1010 <sup>1</sup>               | 1.6                        |
|           |                                 |                            |
| 302-30 SP | 5010                            | 2.3                        |
| 302-28 SP | 4680                            | 2.3                        |
| 302-26 SP | 4340                            | 2.0                        |
| 302-24 SP | 4010                            | 2.0                        |
| 302-22 SP | 3670                            | 2.0                        |
| 302-20 SP | 3340                            | 1.9                        |
| N1D SP    | 2000 <sup>2</sup>               | 2.0                        |
| N1 SP     | 1890 <sup>2</sup>               | 1.8                        |
| N2D SP    | 1630 <sup>2</sup>               | 1.8                        |
| N2 SP     | 1520 <sup>2</sup>               | 1.5                        |
| N3 SP     | 890 <sup>2</sup>                | 1.4                        |
|           |                                 |                            |
| 302-24 HF | 4010                            | 1.8                        |
| 302-22 HF | 3670                            | 1.8                        |
| 302-20 HF | 3340                            | 1.7                        |
| L1D HF    | 2320                            | 1.8                        |
| L1 HF     | 1980                            | 1.7                        |
| L2 HF     | 1580                            | 1.5                        |
| L3 HF     | 870                             | 1.3                        |

<sup>1</sup> Values obtained by tests reported by Evans and Marx, 1988. (Forest Products Journal 38(7/8):6-14).

<sup>2</sup> 2x6 tension values from 2002 SPIB Standard Grading Rules for Southern Pine Lumber multiplied by 2.1.

**401.4.3. Shear Strength.** The design value for shear of the manufactured lumber shall equal or exceed the design value in shear for the grade of lumber being replaced.

**401.4.4. Compression Perpendicular to Grain.** The design value for compression perpendicular to grain for the manufactured lumber shall equal or exceed the design value in compression perpendicular to grain of the grade of lumber being replaced.

**401.4.5. Full-width End Joint Strength.** The 5% tolerance limit with 75% confidence strength of full-width end joints (if used) shall be a minimum of 1.67 times the qualification stress level (QSL) defined in ANSI/AITC A190.1.

**401.4.6. Beam Performance.** The beam strength 5% tolerance limit with 75% confidence determined in accordance with ASTM D2915 shall be a minimum of 2.1 times the design value for the beam, after adjustment for the volume effect. The test results of beams sampled in accordance with 401.3.3. shall be considered representative of all layups in the combination meeting the following requirements.

(a) The lamination properties (grades, species, end joint strengths) and grade placement below the neutral axis of the beam shall be similar to the tested layup.

(b) The predicted stresses on the manufactured lumber shall be lower than the stresses at failure of the manufactured lumber in the tested layup at the assigned characteristic stress value.

#### **401.5. END JOINT SPACING**

Full-width end joints in manufactured lumber shall be spaced in accordance with ANSI/AITC A190.1. Partial-width end joints in manufactured lumber laminations shall not occur within 6 inches of a full-width end joint in the same lamination.

#### **401.6. QUALITY CONTROL**

For manufactured lumber qualified under this standard, quality control procedures shall be implemented and maintained at the laminating plant in accordance with ANSI/AITC A190.1. Quality control procedures shall ensure that the requirements of 401.2 are met on a continuing basis and that the end joint strength from qualification is maintained. Tension strength and long span modulus of elasticity shall be maintained through approved statistical process control techniques using AITC Tests T123 and T116, respectively. Quality control procedures for manufactured lumber shall be approved by an accredited inspection and testing agency and documented in the plant quality control manual.