Designation: D 6570 – 00a

Standard Practice for Assigning Allowable Properties for Mechanically-Graded Lumber[1]

This standard is issued under the fixed designation D 6570; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice provides for the methodology of grade qualification, assignment of design properties, and requirements for the quality control of mechanically graded solid sawn lumber.

1.2 This practice acknowledges alternative methods for the assignment of specific properties. These methods are assignment by test, relationship to other properties, and by procedures in other appropriate standards.

2. Referenced Documents

2.1 *ASTM Standards:*

D 9 Terminology Relating to Wood[2]

D 143 Method of Testing Small Clear Specimens of Timber[2]

D 198 Test Methods of Static Tests of Lumber in Structural Sizes[2]

D 245 Practice for Establishing Structural Grades and Related Allowable Properties for Visually-Graded Lumber[2]

D 1165 Nomenclature of Domestic Hardwoods and Softwoods[2]

D 1990 Practice for Establishing Allowable Properties for Visually-Graded Dimension Lumber from In-Grade Tests of Full-Size Specimens[2]

D 2395 Test Methods for Specific Gravity of Wood and Wood-Based Materials[2]

D 2555 Test Methods for Establishing Clear Wood Strength Values[2]

D 2915 Practice for Evaluating Allowable Properties for Grades of Structural Lumber[2]

D 3737 Practice for Establishing Stresses for Structural Glued Laminated Timber (Glulam)[2]

D 4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials[2]

D 4444 Test Methods for Use and Calibration of Hand-Held Moisture Meters[2]

D 4761 Test Method for Mechanical Properties of Lumber and Wood-Based Structural Material[2]

2.2 *ANSI Standards:*

ANSI/AITC A190.1, American National Standard for Wood Products—Structural Glued Laminated Timber[3]

ANSI/AF&PA NDS, National Design Specification for Wood Construction[3]

2.3 *Canadian Standards Association Standard:*

CSA O141, Softwood Lumber[4]

2.4 *National Institute of Standards and Technology Standard:*

Voluntary Product Standard PS 20, American Softwood Lumber Standard[5]

3. Terminology

3.1 *Definitions*—For definitions of terms related to wood, refer to Terminology D 9.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *mechanical evaluation*, *n*—identification and appraisal of one or more physical or mechanical lumber characteristics as part of the lumber segregation process.

3.2.2 *mechanically-graded lumber*, *n*—solid sawn lumber graded by mechanical evaluation. Visual evaluation also may be required. The material has assigned design properties and is manufactured for use as structural members.

3.2.3 *qualified agency*, *n*—an organization, hereafter referred to as the agency, that has trained personnel and procedures to ensure the system evaluations and grades comply with all applicable requirements of this practice.

3.2.3.1 *Discussion*—The agency shall have no financial interest in, nor shall be financially dependent upon, any single company manufacturing the product being inspected or tested; and shall not be owned, operated, or controlled by any such company.

3.2.3.2 *Discussion*—The agency shall conform with the provisions for agency accreditation under the appropriate consensus standard.

---

[1] This practice is under the jurisdiction of ASTM Committee D07 on Wood and is the direct responsibility of Subcommittee D07.02 on Lumber and Engineered Wood Products.

Current edition approved Oct. 10, 2000. Published December 2000. Originally published as D 6570-00. Last previous edition D 6570-00.

[2] *Annual Book of ASTM Standards*, Vol 04.10.

[3] Available from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

[4] Available from the National Institute of Standards and Technology, U.S. Department of Commerce, Washington, DC 20234.

[5] Available from Canadian Standards Association, 178 Rexdale, Ontario, Canada M9W IR3.

3.2.4 *visual evaluation, n*—identification and appraisal of lumber growth and manufacturing characteristics by visual means as part of the lumber segregation process.

NOTE 1—In the United States and Canada, criteria for agency accreditation are contained in PS-20, ANSI/AITC A190, and CSA O141.

4. Significance and Use

4.1 The procedures described in this practice are intended to be used to establish appropriate allowable unit stresses, moduli of elasticity, and specific gravity for mechanically graded solid sawn lumber. An on-going quality control program to monitor compliance with the assigned grade properties is required.

5. System Requirements

5.1 *Mechanical Device Requirements*—A mechanical device used as part of the grading process shall demonstrate the ability to measure the mechanical or physical wood property used to segregate the lumber.

5.2 *Visual Requirements*:

5.2.1 Characteristics to be limited by visual evaluation, shall be documented as part of the qualification and quality control procedures. Such limitations shall be part of the grade requirements.

5.2.2 Personnel conducting visual evaluations shall be qualified by the agency.

6. Criteria for Grade Qualification

6.1 *General Requirements*:

6.1.1 A minimum of one assigned property of a grade shall be qualified by test. The grade assignment for properties qualified by test is given in 7.2.

6.1.1.1 If the modulus of elasticity (MOE) is the only property assigned to a grade, it shall be evaluated by test.

6.1.1.2 If both strength and MOE properties are assigned to a grade, a minimum of one strength property and one MOE property shall be evaluated by test. If only one strength property is tested, that property shall be either the modulus of rupture (MOR) or ultimate tensile stress (UTS).

6.1.2 Each grade shall be qualified at each size and for each species/species group.

6.1.3 Sampling, evaluation, and presentation of data shall be in accordance with Practice D 2915.

6.2 *Qualification Samples*:

6.2.1 The criteria for selecting qualification samples shall be documented and shall be in accordance with 6.1.3.

6.2.2 All qualification samples shall meet the visual requirements established for the grade.

6.2.3 The minimum sample size for estimation of strength properties, and MOE shall be 53 specimens.

6.2.4 The minimum sample size for estimation of mean or median property values, other than MOE, shall be 30 specimens.

6.2.5 When the allowable shear stress parallel to grain (Fv) or the allowable compressive stress perpendicular to grain (Fc⊥) are determined in accordance with 7.3.4 and 7.3.5 respectively, the specific gravity of a minimum of 30 qualification test specimens shall be measured and recorded.

6.3 *Qualification Test Methods*:

6.3.1 When mechanical and physical properties in Section 7 are determined by tests, the appropriate ASTM standards shall be used.

6.3.2 Mechanical test methods shall be in accordance with either Test Method D 198 or Test Methods D 4761.

6.3.2.1 The determination of the MOE and MOR by edgewise bending shall employ third-point in accordance with Test Methods D 4761.

6.3.2.2 The determination of the MOE by flat-wise bending shall be in accordance with Test Methods D 4761.

6.3.2.3 The UTS of a sample shall be determined according to Test Methods D 4761. Whenever possible, a minimum gauge length of not less than 96-in. (2.44 m) shall be used. When determination of the tension parallel to the grain MOE is desired, testing shall be conducted according to the provisions of Test Method D 198.

6.3.3 Specific gravity shall be based on weight and dimensions when oven-dry as specified in Test Methods D 2395. Measurements shall either be taken on oven-dried specimens, or at some other moisture content and the values adjusted to the oven-dry condition.

6.3.4 Determination of the moisture content of the lumber sample shall be in accordance with Test Methods D 4442 or D 4444.

7. Procedures for Assignment of Allowable Mechanical Properties and Specific Gravity

7.1 Allowable mechanical properties and specific gravity shall be assigned using the qualification test procedures of 7.2, the property correlation procedures of 7.3, or the procedures of 7.4. These alternative procedures of 7.2, 7.3, and 7.4 define the maximum property values, which are permitted to be assigned to a grade of mechanically-graded lumber.

7.1.1 Selection of the procedures specified in 7.1 to establish a value for any particular property assigned to a grade is the prerogative of the grade specification author.

7.1.2 The factors used in 7.2 and 7.3 apply to softwood lumber. Hardwood lumber species shall be reduced by the applicable factors in Practice D 245, Table 10.

7.1.3 If the Fb is to be an assigned property, it shall be determined by the test procedures of 7.2.

7.2 *Assignment of Allowable Properties by Qualification Tests*:

7.2.1 Assignment of allowable properties by test shall follow the procedures of this section. Test results shall be evaluated according to Practice D 2915.

7.2.1.1 Qualification tests are used to either establish allowable mechanical property values for new grades or to qualify for published grade categories.

7.2.2 *Extreme Fiber Stress in Bending (Fb)*—The fifth percentile tolerance limit (75 % confidence) for the MOR of the qualification sample shall equal or exceed 2.1 times the assigned Fb value.

7.2.3 *Fiber Stress in Tension Parallel to Grain (Ft)*—The fifth percentile tolerance limit (75 % confidence) for the UTS of the qualification sample shall equal or exceed 2.1 times the assigned Ft value.

7.2.4 *Fiber Stress in Compression Parallel to Grain (Fc)*—The fifth percentile tolerance limit (75 % confidence) for ultimate compressive strength parallel to grain (UCS) of the qualification sample shall equal or exceed 1.9 times the assigned Fc value.

7.2.5 *Shear Stress Parallel to Grain (Fv)*—The fifth percentile tolerance limit (75 % confidence) Fv for the qualification sample shall equal or exceed 2.1 times the assigned Fv value.

7.2.6 *Modulus of Elasticity*—The upper 95 % confidence interval of the qualification sample mean MOE shall equal or exceed, the assigned grade MOE.

7.2.7 *Specific Gravity (SG)*—The upper 95 % confidence interval of the qualification sample mean specific gravity shall equal or exceed the assigned specific gravity value.

7.3 *Assignment of Allowable Properties Based on Relationships*:

7.3.1 The methods of 7.3 permit assignment of certain allowable properties based on recognized relationships between the assigned properties. This assignment shall be in accordance with the following procedures.

7.3.2 *Fiber Stress in Tension Parallel to Grain*:

7.3.2.1 The maximum allowable Ft shall be assigned in accordance with an established grade assignment model based on the assigned Fb which has been published by the agency.

7.3.2.2 In the absence of corroborative data, a maximum Ft/Fb ratio of 0.45 shall be used.

7.3.3 *Fiber Stress in Compression Parallel to Grain*:

7.3.3.1 The maximum allowable Fc shall be calculated from the following equation:

$$Fc = (0.7098Fb + 2060.7)/1.9 \quad (1)$$

where:
Fb = the assigned Fb for the grade.

7.3.4 *Shear Parallel to Grain*—The Fv determined by a specific gravity based model (see Appendix X1) is permitted when the specific gravity is assigned in accordance with 7.2.7 or 7.3.6.

7.3.5 *Fiber Stress in Compression Perpendicular to Grain ($Fc^{\perp}$)*—The $Fc^{\perp}$ determined by a specific gravity based model (see Appendix X1) is permitted when specific gravity is assigned in accordance with 7.2.7 or 7.3.6.

7.3.6 *Specific Gravity*—It is permitted to assign specific gravity in accordance with a model that relates grading machine measurement to specific gravity. When such a model is used, the agency shall develop corroborative data to support the appropriateness of the assigned specific gravity.

7.4 *Assignment of Allowable Properties by Other Standards*:

7.4.1 The methods of 7.4 permit assignment of certain allowable properties based on procedures in the appropriate ASTM and ANSI standards.

7.4.2 *Shear Parallel to Grain Stress*—The Fv shall be assigned in accordance with the procedures of Practice D 245 for visually-graded solid sawn lumber of the same species or species group.

7.4.3 *Fiber Stress in Compression Perpendicular to Grain*—The Fc⊥ shall be assigned in accordance with the procedures of Practice D 245 for visually-graded solid sawn lumber of the same species or species group.

7.4.4 *Specific Gravity*—The specific gravity shall be assigned as reported in ANSI/AF&PA - NDS for visually-graded solid sawn lumber of the same species or species group.

8. Minimum Allowable Property Increment

8.1 Allowable properties shall be rounded in accordance with Table 1.

9. Quality Control

9.1 A quality control program shall be developed for each mechanical grading system. The quality control program shall delineate the respective responsibilities of the producer and the agency.

9.2 The quality control program shall include monitoring and control of both the mechanical and visual portions of the system.

9.2.1 The visual evaluation of the grade shall be conducted in accordance with the applicable agency requirements.

9.2.2 The quality control program shall address the procedures for quality control of the mechanical system.

9.3 The quality control program shall require periodic evaluation of at least one of the assigned properties qualified in 6.1.1.

9.4 A quality manual shall be prepared for each production facility.

9.4.1 The quality manual shall address precision and bias of calibration and measurement.

9.4.2 The manual shall describe the inspection, sampling, testing, and analysis to be conducted in accordance with this practice and other applicable requirements.

9.4.3 The manual shall describe corrective action to be taken with nonconforming material.

9.4.4 Documentation requirements of the quality control program shall be described in the manual, including retention and other applicable requirements.

9.4.5 The manual shall describe the individual and joint responsibilities of the production facility and the agency.

10. Keywords

10.1 lumber; mechanically-graded lumber; solid sawn lumber; wood

TABLE 1 Rounding Rules for Allowable Property Values

MOE	100 000 psi
Fb	50 psi at 1000 psi and above 25 psi below 1000 psi
Ft	25 psi
Fc	25 psi
Fc⊥	5 psi
Fv	5 psi
SG	0.01

APPENDIXES

(Nonmandatory Information)

X1. FORMULAS FOR DETERMINING THE SHEAR STRESS PARALLEL TO GRAIN AND FIBER STRESS IN COMPRESSION PERPENDICULAR TO GRAIN

X1.1 Shear Stress Parallel to Grain

X1.1.1 When qualified by measurement of the specific gravity (SG), the allowable stress in shear stress parallel to the grain (*Fv*) shall be calculated by a relationship between SG (based on oven dry weight/oven dry volume basis) and *Fv*:

X1.1.2 For Douglas Fir, Douglas Fir-Larch, Douglas Fir-South, Hem-Fir, Southern Pine, Spruce-Pine-Fir (South), Western Woods, and Western Cedars:

$$Fv = (266 \times SG) + 40$$

X1.1.3 For Douglas Fir-Larch (N), Hem-Fir (N), and Spruce-Pine-Fir:

$$Fv = (284.8 \times SG) + 26.6$$

where:
SG = specific gravity (oven-dry weight/oven-dry volume basis)

X1.2 Compression Perpendicular to the Grain (Fc⊥) (0.04-in. deformation limit)

X1.2.1 When qualified by measurement of the SG, the allowable stress shall be calculated by a relationship between SG (based on oven dry weight/oven dry volume) and Fc⊥:

X1.2.1.1 For Douglas Fir, Douglas Fir-Larch, Douglas Fir-South, Hem-Fir, Southern Pine, Spruce-Pine-Fir (South), Western Woods, and Western Cedars:

$$Fc\perp = (2252.4 \times SG) - 480$$

X1.2.1.2 For Douglas Fir-Larch (N), Hem-Fir (N), and Spruce-Pine-Fir:

$$Fc\perp = (2243.8 \times SG) - 473.8$$

X1.3 Compression Perpendicular to the Grain (Fc⊥) (0.02-in. deformation limit)

X1.3.1 Refer to the appropriate agency grading rules for equations to adjust the Fc⊥ from a 0.04-in. deformation limit to a 0.02-in. deformation limit.

X2. EXPLANATION OF SOLID SAWN LUMBER PRODUCTS CURRENTLY PRODUCED IN THE UNITED STATES AND CANADA BY NONDESTRUCTIVE EVALUATION

X2.1 Mechanically-Graded Lumber

X2.1.1 *General*—The process where each piece of lumber is nondestructively evaluated by a machine to determine the value of the sorting parameter or grading algorithm. Mechanically graded lumber also is required to meet certain visual requirements. The process assigns strength and MOE values based on a model that combines information from the nondestructive parameter and visual characteristics. One exception is E-rated lumber; strength values are not assigned to E-rated lumber.

X2.2 Machine Stress-Rated Lumber

X2.2.1 Lumber sorted by machine and graded based on the following criteria, established under the ALSC PS-20:

X2.2.1.1 Average edge MOE equal to or greater than the assigned average edge MOE.

X2.2.1.2 At least 95 % of pieces have an edge MOE greater than 82 % of the assigned edge MOE.

X2.2.1.3 At least 95 % of the pieces have a MOR greater than 2.1 times the assigned Fb.

X2.3 Machine Evaluated Lumber

X2.3.1 Machine evaluated lumber is sorted by machine and graded based on the following criteria, established under the ALSC PS-20:

X2.3.1.1 Average edge MOE equal to or greater than the assigned average edge MOE.

X2.3.1.2 At least 95 % of pieces have an edge MOE greater than 75 % of the assigned edge MOE.

X2.3.1.3 At least 95 % of the pieces have a MOR greater than 2.1 times the assigned Fb.

X2.3.1.4 At least 95 % of the pieces have an UTS greater than 2.1 times the assigned Ft.

X2.4 E-Rated Lumber

X2.4.1 E-rated lumber is graded by mechanical grading into specific MOE categories. The process assigns a long-span flat-wise MOE value and requires adherence to a 5^{th} percentile MOE value. Practice D 3737, Annex A1, specifies the relationship between the mean and 5^{th} percentile MOE values:

$$MOE_{5th} = 0.955\ MOE_{mean} - 0.233$$

X3. TRADITIONAL VISUAL GRADING REQUIREMENTS FOR MECHANICALLY GRADED LUMBER PRODUCED IN THE UNITED STATES AND CANADA

X3.1 Introduction

X3.1.1 Mechanically-graded lumber has traditionally been, and is currently, a performance-based product. Prior to 1990, a common set of visual limitations was widely utilized in the United States and Canada. These limitations had been developed to enhance sorting efficiency. Since 1990, some of the regional grading agencies have developed alternate visual limitations keyed more closely to the performance and growth characteristics of the species or species grouping involved. This portion of the appendix is presented to document the historical baseline requirements for these visual characteristics.

X3.2 Some grade rules for machine stress rated (MSR) lumber have traditionally limited edge characteristics as follows:

X3.2.1 Knots, knot holes, burls, distorted grain, or decay partially or wholly at edges of wide faces must not occupy more of the net cross-section than:

⅙—≥2100 Fb
¼—1500 Fb to 2050 Fb
⅓—1000 Fb to 1450 Fb
½—≤1000 Fb

X3.3 Grade rules for E-rated lumber have traditionally limited edge characteristics similar to MSR, however, at an MOE level, more than one edge characteristic value is permitted, each one forming a separate grade. For example, at an MOE level of 2.3, one grade may be 2.3 ⅙(an edge characteristic ⅙th of the cross-section is permitted) while a second grade may be 2.3–½ (a ½ cross-section characteristic is permitted).

X3.4 Some grade rules for MSR and E-rated lumber have traditionally limited edge characteristics and slope of grain in areas of the piece not mechanically-graded as follows:

X3.4.1 *Edge Characteristics*—Limited as listed in X3.2.

X3.4.2 *Non-Edge Knots*—Equal to the largest non-edge knot in the tested portion of the piece or the next larger edge characteristics, whichever is greater. For ½ edge characteristics categories, non-edge knot limited to ⅔ cross-section.

X3.4.3 *Slope of Grain*—The general slope of grain shall not exceed:

Slope	Fb Class
1 in 12	≥2100
1 in 10	1500 to 2050
1 in 8	1050 to 1450
1 in 4	≤1000

X3.5 Some visual criteria have been required of mechanically graded lumber to assure specific market utilization. One example is that E-rated grades must meet surfacing and other laminating requirements. Visual "over-rides" equivalent to some visual grades commonly are required of mechanically-graded lumber. While these visual criteria are usually not linked directly to mechanical performance criteria, as in X3.2 and X3.4, their existence affects selection of samples for performance tests and influences grade yields.

X4. COMMENTARY

TABLE X4.1

Section	Comments
3.2.1	Mechanically-graded lumber is the generic terminology adopted by the committee to encompass grading systems that incorporate the methods described in 3.2.2. In the first years of mechanical grading in and in some contemporary systems outside of the United States and Canada, little or no visual evaluation is incorporated in the system. In the United States (U.S.) and Canada at the time of the origin of this practice, all commercial methods incorporated both mechanical (or physical) and visual evaluations. Historically, the terminology used with mechanical grading, such as EMSR, MSR, and E-rated, referred to the process of grading. In 1996, the American Lumber Standard Committee (ASLC) adopted a different procedure in which the nomenclature reflected the qualification requirements rather than the process. Consequently, at the time of the origin of this standard, there are three types of grading systems, machine stress rated (MSR), machine evaluated lumber (MEL), and E-rated, all defined by the testing requirements. These definitions are included in Appendix X2. It is with the background in these systems and their evaluation that this standard has been prepared. EMSR denotes electromechanical stress rated lumber graded with the continuous lumber tester.
3.2.3	The sense of the committee is that optical detection systems are intended to be included in this section.
3.2.4.2	Agency responsibilities are emphasized in this practice. Decisions such as final requirements for qualification and quality control, based on this practice, are to be made by the agency. To ensure that the agency is qualified for these responsibilities, this practice requires accreditation under recognized consensus standard procedures.
4.1	Presently in the US and Canada, mechanical grading is applied to dimension lumber only. The grading equipment measures one physical or mechanical property (such as flexural stiffness or density) which, along with visual characteristics, is used to establish allowable properties. Some allowable properties are developed by relationship to the measured property.
5.1	Presently in the U.S. and Canada, the ALSC and the Canadian Lumber Standards Accreditation Board (CLSAB) have established criteria for appraisal and approval of the performance of equipment for mechanical lumber grading. The performance characteristics of E-rated lumber are specified under ANSI/AITC A190.1.
5.2.1	In U.S. and Canadian practice, characteristics are limited by grade level and location in the piece, see Appendix X3. The provisions of this section are not intended to apply to those visual over-rides that are applied on a customer-specific basis for market acceptance reasons, as discussed in Appendix X3.

TABLE X4.1 *Continued*

Section	Comments
5.2.2	In the US and Canada, qualification of personnel for visual evaluation of mechanically graded lumber has been conducted under the auspices of PS-20, ANSI/AITC A190.1, and CSA O141.
6.1.1	Some mechanical grades, such as E-rated lumber may claim only one allowable property; consequently, 6.1.1.1 requires that property be evaluated in qualification. Some mechanical grades may claim more than one strength property and modulus of elasticity. Section 6.1.1.2 requires that at least one strength and one modulus be evaluated. This does not imply that more cannot be required by the agency. Experience with performance of species/grade/sizes in qualification and quality control tests provides guidance to the agency. It is the intent of 6.1.1 that the final requirements for qualification are the responsibility of the agency. Please see commentary under 7.3.1 for additional information regarding qualification requirements.
6.1.1.2	The MOE selection relates to end use. See 6.3 for MOE qualification requirements
6.1.2	This practice recognizes that properties have been assigned by traditional relationships between allowable properties and measured variables or other allowable properties. An example for over 20 years was the relationship between F_c and F_b(recently changed). While the choice of this relationship approach must be acceptable to both the producer (for marketing reasons) and the agency (for technical reasons), adherence to this practice and that of the agency is required. Again, reference to the commentary under 7.3.1 may be appropriate. It is important to make sure that sampling is conducted in a way that reflects the condition when more than one grade is pulled at a time from the same population. An example of this would be when one grade with a ¼ edge characteristic limit, as defined in Appendix X3, and another grade with a ⅙ edge characteristic limit are produced at the same time. North American commercial species groups are listed in Nomenclature D 1165 and PS-20.
6.1.3	This is a traditional requirement. Accumulated data on size and grade effects continues to support the appropriateness of this requirement. It is not the intent of the committee to limit analysis and presentation to the methods of Practice D 2915. More extensive methods are encouraged where appropriate and documented.
6.2.3	This requirement is based on the need to estimate the 5th percentile of a population from a sample. In accordance with Practice D 2915, the point estimate (PE) or the tolerance limit (TL) are used; often, the 5 % nonparametric TL (with 75 % confidence). The PE is required for flat-wise MOE of E-rated lumber and the TL for tensile, bending, and compression parallel strength properties. Samples larger than the minimum specified in 6.2 are recommended for a more substantial data base because, while a sample of 53 specimens meets the requirements of this standard, the information obtained from minimal sample sizes is restricted. A larger sample may provide more representative data and a better base for subsequent quality control.
6.2.4	This requirement comes into effect only where no near-minimum requirement exists. Further, since confidence intervals are used to judge adequacy of the mean MOE, a larger sample may enhance the analysis as well as provide a better data base for future use.
6.2.5	Please see 6.2.3 and 6.2.4. Shear parallel to grain also is referred to as horizontal shear.
6.3.2	This requirement standardizes the measurement and adjustment process so that subsequent adjustments may be made if needed. Other ASTM standards are important adjunct test methods even if the primary goal is a mechanical test. It is recommended that ASTM standards be used to determine specific gravity and moisture content even if these are not property establishment.
6.3.2.1	The past practice of some agencies edge bending test procedures included the random placement of the maximum edge defect with respect to the tension or compression edge. For MOR testing, the maximum edge defect is placed in the middle third of the testing span, whenever possible.
6.3.2.3	In the U.S. and Canada, agencies often specify the maximum edge defect be located in the gauge length whenever possible.
7.1	In the U.S. and Canada, the grade specifications for mechanically graded lumber are customarily authored by one or more of the regional grading agencies accredited by the ALSC and CLSAB, or agencies qualified under ANSI/AITC A190.1. In the U.S. and Canada, usually six properties are assigned to mechanically graded lumber. These properties are assigned by qualification test, property relationship, or by optional assignment. Traditionally, the assignment of properties is as follows:

Traditional Procedures for the Assignment of MGL Property Values

Property	Fb	Ft	Fc	Fv	Fc⊥	MOE
Property Assignment Procedure	Test	Test or Optional Assignment	Property Relationship	Test or Property Relationship	Test or Property Relationship	Test

Traditionally, the SG for mechanically graded lumber was based on the species-specific assignment developed using Test Methods D 2555 and published in the ANSI/AF&PA NDS. In the 1990s, the ALSC adopted a program for the assignment of a grade-specific SG for certain MGL grades where the SG qualified by test and monitored as part of a quality control program.

Prior to 1996, when the long-span modulus of elasticity (LS MOE) for mechanically graded lumber was assigned, such as for E-rated lumber, the lumber had to be qualified by test. In 1996 ALSC recognized the relationship between the edge MOE and the LS MOE.

Contemporary Optional Procedures for the Assignment of MGL Property Values

Property	SG	LS MOE
Property Assignment Procedure	Test or Optional Assignment	Test or Property Relationship

Section	Comments
7.2	Assignment requirements in this section are traditional bases for establishing allowable properties for mechanical grades by test. The reduction factors incorporated in the requirements are adopted from Practice D 245.
7.2.1.1	The distinctions in this section between two objectives is to clarify that the procedures of this standard apply to both. Other criteria not part of this standard, such as sampling and special analysis considerations for implementation, also may apply and may differ according to objective. Presently, there are no approved small clear ASTM test methods for pieces less than 2-in. in thickness for C⊥ and Fv; therefore, these properties are not addressed at this time.
7.2.2	Prior to the adoption of this standard, the PE commonly was used in determining the MOR.
7.2.6	This section emphasizes that the goal is to estimate the mean of the target population from a small and finite sample. This estimated mean is required to not significantly differ from the grade MOE. One method is to calculate a confidence interval about the mean estimate for comparison of the sample to the grade requirement. This section interacts with the sample size requirements of 6.2. In the U.S. and Canada, some agencies specify a near minimum (lower quantile) qualification requirement for MOE.

TABLE X4.1 *Continued*

Section	Comments
7.2.7	Please see 7.2.6 discussion on confidence intervals.
7.2.7.2	There are different ways of specifying the near minimum requirement for the MOE of a mechanical grade (see referenced documents). As examples, one current specification sets the minimum value based on a standard COV for all grades, another specification sets the minimum based on assumed grade specific COV. The goal is to have an agency requirement that is relevant to the mechanical grade.
7.3.1	*General*—When MSR was developed, the allowable tensile stresses were assigned to equal the allowable bending stresses **(1)**.[A] After a short time, the procedure was changed to set the allowable tension stress at 80 % of the allowable bending stress. Somewhat later, a graduated scale was developed in which a value of 80 % was assigned at high F_b levels, and incrementally scaled down to a minimum 50 % at low levels. This has been the standard procedure for some 25 years. "Standard," in this case, means where the assignment is based on test of E_e and F_b only. *Width Effect*—It is important to note that much of the above history and the test observations made in the first 20+ years of MSR were based on 2×4. Further, it was difficult to conduct a full-size tensile test outside of a research laboratory until the early 1980s because of the development history of test equipment **(1)**. In the '80's, test data on more grades and widths of MSR began to accumulate. The result was recognition that width effects in MSR lumber are very similar to those recognized in visually graded lumber **(1,2)**. The difference is that the MSR system can adapt to the width effect and "hold" the same strength properties by adjusting the selection criteria, for example, E. As an example, a current Douglas Fir grade in 2×4 may require a 2.2 average E_e to make a 1925 F_t assignment while, 2×6, may require an E_e of 2.4 million psi for the same F_t. The impact of accommodating the width effect in lumber grades interacts with marketing of the grades. A common solution is to ignore the width effect to simplify marketing; in this scenario, the grade in the above example would be marketed with the same F_t and E_e, even though test and QC data would support a higher value of E for the 2×6.
7.3.2.1	*Tension/Bending Ratios*—As more experience (data) has developed with the advent of tensile and bending tests of MSR grades, the question of the appropriate tensile/bending ratios has reopened. The early observations referred to above often were based on samples of limited size and grades and, necessarily, on inferences to be applied to a number of species/grade combinations. As more data developed, methods of data analysis also improved, and as noted above, the adherence to a strict set of "standard" grade properties changed. Some analysis have now shown that the "standard" of 80 % ≥ 50 % of F_b for assignment of F_t may not be correct for some species/grades. A high value of about 70 % appears more optimal, while a value of 55–60 % appears more correct for some grades with a ⅓-edge knot. These observations have several potential impacts. For marketing efficiency, it may be desirable to restrain the proliferation of grade property combinations. To do this, however, requires verification by test that the values assigned by "standard" or other non-test procedures are adequate. This is critical from two aspects. If only F_b is checked in qualification, and a "too high" ratio is used to set F_t, this F_t may not be verifiable by test. If, on the other hand, qualification is carried out by F_t, and the ratio used is" too low," the calculated F_b may be higher than can be verified by test. The conclusion is that a corroboration of both F_t and F_b is desirable.
7.3.2.2	The default ratio of 0.45 for F_t/F_b is based on Practice D 1990 and agency test observations.
7.3.3.1	*Compression Parallel to Grain*—The previous discussion has dealt only with the relationship between E_e, F_b, and F_t. F_c also is of interest. Traditionally, this property had a higher ratio to F_b than the visual grades. F_c was evaluated thoroughly for visual grades in the North American In-Grade Lumber Testing Program **(3)**. Subsequently, tests of four MSR grades at Washington State University were analyzed using the analytical method developed in the in-grade program. These tests verified a new F_c/F_b relationship for MSR that is now used in the American Lumber Standard Committee-approved rules.
7.3.6	The intent of this section is to recognize the specific gravity predictive relationships that may be established by agencies with the machine measurement variable(s). Corroborative data in support of the model used in 7.3.6 may include qualification and quality control data developed in accordance with the requirements of 7.2.6, 7.2.7, and Section 9.
7.4	These relationships are traditional. Some are based on a clear wood data base of species or species groups. The values determined by this section may differ from those of 7.3; however, the relevance of the property to end uses and traditional applications may be important in determining use of 7.4.
8	These increments are consistent with other ASTM standards.
9	This section emphasizes that, while Sections 6-8 of the standard "set-the-stage" for production through qualification procedures, a comprehensive and responsible grading system relies on the follow through of a quality control system and agency monitoring.

[A] The boldface numbers in parentheses refer to the list of references at the end of this standard

REFERENCES

(**1**) Galligan, W.L., Gerhards, C.C., and Ethington, R.L., 1979, "Evolution of Tensile Design Stresses for Lumber," General Report FPL-28, USDA Forest Service, Forest Products Laboratory, Madison, WI.

(**2**) Galligan, W.L., Shelley, B.E., and Pellerin, R.F., 1993, "The Influence of Testing and Size Variables on the Tensile Strength of Machine Stress-rated Lumber," *Forest Products Journal*, Vol 43(4) pp. 70–74.

(**3**) In-Grade Testing Program Technical Committee, 1989, *Proceedings: In-Grade Testing of Structural Lumber*, Proceedings 47363, Forest Products Society, Madison, WI p. 110.

(**4**) Maloney, T.M., Allwine, R., and Nilson, N.A., 1991, "Evaluation of MSR Lumber for Compression Parallel to Grain Values," Research Report No. WMEL 113/91, Washington State University Wood Material and Engineering Laboratory, Pullman, WA.

(**5**) Green, D.W. and Kretschmann, D.E., 1991," Lumber Property Relationships for Engineering Design Standards," *Wood and Fiber Science*, Vol 23(3) pp. 436–456.