



**Designation: ~~D245–06 (Reapproved 2019)~~ D245 – 22**

# Standard Practice for Establishing Structural Grades and Related Allowable Properties for Visually Graded Lumber<sup>1</sup>

This standard is issued under the fixed designation D245; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

## 1. Scope

1.1 This practice (**1, 2**)<sup>2</sup> covers the basic principles for establishing related unit stresses and stiffness values for design with visually-graded solid sawn structural lumber. This practice starts with property values from clear wood specimens and includes necessary procedures for the formulation of structural grades of any desired strength ratio.

1.2 The grading provisions used as illustrations herein are not intended to establish grades for purchase, but rather to show how stress-grading principles are applied. Detailed grading rules for commercial stress grades which serve as purchase specifications are established and published by agencies which formulate and maintain such rules and operate inspection facilities covering the various species.

1.3 The material covered in this practice appears in the following order:

	Section
Scope	1
Significance and Use	3
Basic Principles of Strength Ratios	4
Estimation and Limitation of Growth Characteristics	5
Allowable Properties for Timber Design	6
Modification of Allowable Properties for Design Use	7
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1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information purposes only and are not considered standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

<sup>1</sup> 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.

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<sup>2</sup> The boldface numbers in parentheses refer to references at the end of this practice.

## 2. Referenced Documents

### 2.1 *ASTM Standards:*<sup>3</sup>

D9 Terminology Relating to Wood and Wood-Based Products

D143 Test Methods for Small Clear Specimens of Timber

D2555 Practice for Establishing Clear Wood Strength Values

E105 Guide for Probability Sampling of Materials

IEEE/ASTM SI-10 Practice for Use of the International System of Units (SI) (the Modernized Metric System)

## 3. Significance and Use

### 3.1 *Need for Lumber Grading:*

3.1.1 Individual pieces of lumber, as they come from the saw, represent a wide range in quality and appearance with respect to freedom from knots, cross grain, shakes, and other characteristics. Such random pieces likewise represent a wide range in strength, utility, serviceability, and value. One of the obvious requirements for the orderly marketing of lumber is the establishment of grades that permit the procurement of any required quality of lumber in any desired quantity. Maximum economy of material is obtained when the range of quality-determining characteristics in a grade is limited and all pieces are utilized to their full potential. Many of the grades are established on the basis of appearance and physical characteristics of the piece, but without regard for mechanical properties. Other grades, called structural or stress grades, are established on the basis of features that relate to mechanical properties. The latter designate near-minimum strength and near-average stiffness properties on which to base structural design.

3.1.2 The development of this practice is based on extensive research covering tests of small clear specimens and of full-sized structural members. Detailed studies have included the strength and variability of clear wood, and the effect on strength from various factors such as density, knots (See Terminology D9), and other defects, seasoning, duration of stress, and temperature.

3.2 *How Visual Grading is Accomplished*— Visual grading is accomplished from an examination of all four faces and the ends of the piece, in which the location as well as the size and nature of the knots and other features appearing on the surfaces are evaluated over the entire length. Basic principles of structural grading have been established that permit the evaluation of any piece of stress-graded lumber in terms of a strength ratio for each property being evaluated. The strength ratio of stress-graded lumber is the hypothetical ratio of the strength property being considered compared to that for the material with no strength-reducing characteristic. Thus a piece of stress-graded lumber with a strength ratio of 75 % in bending would be expected to have 75 % of the bending strength of the clear piece. In effect, the strength ratio system of visual structural grading is thus designed to permit practically unlimited choice in establishing grades of any desired quality to best meet production and utilization requirements.

### 3.3 *Classification of Stress-Graded Lumber:*

3.3.1 The various factors affecting strength, such as knots, deviations of grain, shakes, and checks, differ in their effect, depending on the kind of loading and stress to which the piece is subjected. Stress-graded lumber is often classified according to its size and use. Four classes are widely used, as follows:

3.3.1.1 *Dimension Lumber*—Pieces of rectangular cross section, from nominal 2 to 4 in. thick and 2 or more in. wide, graded primarily for strength in bending edgewise or flatwise, but also frequently used where tensile or compressive strength is important. Dimension lumber covers many sizes and end uses. Lumber graded for specific end uses may dictate a special emphasis in grading and require an identifying grade name.

NOTE 1—For example, in North American grading under the American Lumber Standards Committee, stress graded dimension lumber categories that reflect end use include Light Framing, Structural Light Framing, Structural Joists and Planks, and Studs.

3.3.1.2 *Beams and Stringers*—Pieces of rectangular cross section, 5 in. nominal and thicker, nominal width more than 2 in. greater than nominal thickness, graded for strength in bending when loaded on the narrow face.

3.3.1.3 *Posts and Timbers*—Pieces of square or nearly square cross section, 5 by 5 in., nominal dimensions and larger, nominal width not more than 2 in. greater than nominal thickness, graded primarily for use as posts or columns.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.3.1.4 *Stress-Rated Boards*—Lumber less than 2 in. nominal in thickness and 2 in. or wider nominal width, graded primarily for mechanical properties.

3.3.2 The assignment of names indicating the uses for the various classes of stress-graded lumber does not preclude their use for other purposes. For example, posts and timbers may give service as beams. The principles of stress grading permit the assignment of any kind of allowable properties to any of the classes of stress-graded lumber, whether graded primarily for that property or not. Recommendations for allowable properties may include all properties for all grades or use classes. While such universal application may result in loss of efficiency in some particulars, it offers the advantage of a more simple system of grades of stress-graded lumber.

#### 3.4 *Essential Elements in a Stress-Grade Description:*

3.4.1 A stress grade formulated by this practice contains the following essential elements:

3.4.2 A grade name that identifies the use-class as described in 3.3.

3.4.3 A description of permissible growth characteristics that affect mechanical properties. Characteristics that do not affect mechanical properties may also be included.

3.4.4 One or more allowable properties for the grade related to its strength ratio.

### 4. Basic Principles of Strength Ratios

#### 4.1 *General Considerations:*

4.1.1 Strength ratios associated with knots in bending members have been derived as the ratio of moment-carrying capacity of a member with cross section reduced by the largest knot to the moment-carrying capacity of the member without defect. This gives the anticipated reduction in bending strength due to the knot. For simplicity, all knots on the wide face are treated as being either knots along the edge of the piece (edge knots) or knots along the centerline of the piece (centerline knots).

4.1.2 Strength ratios associated with slope of grain in bending members, and in members subjected to compression parallel to grain, were obtained, experimentally (3).

4.1.3 Strength ratios associated with shakes, checks, and splits are assumed to affect only horizontal shear in bending members. These strength ratios were derived, as for knots, by assuming that a critical cross section is reduced by the amount of the shake, or by an equivalent split or check.

4.1.4 Strength ratios associated with knots in compression members have been derived as the ratio of load-carrying capacity of a member with cross section reduced by the largest knot to the load-carrying capacity of the member without defect. No assumption of combined compression and bending is made.

4.1.5 Tensile strength of lumber has been related to bending strength and bending strength ratio from experimental results (4).

4.1.6 Strength in compression perpendicular to grain is little affected in lumber by strength-reducing characteristics, and strength ratios of 100 % are assumed for all grades.

4.1.7 Modulus of elasticity of a piece of lumber is known to be only approximately related to bending strength ratio. In this standard, the relationship between full-span, edgewise bending modulus of elasticity and strength ratio was obtained experimentally.

4.1.8 In developing a stress-grade rule, economy may be served by specifying strength ratios such that the allowable stresses for shear and for extreme fiber in bending will be in balance, under the loading for which the members are designed.

4.1.9 A strength ratio can also be associated with specific gravity. Three selection classes called dense, close grain, and medium grain are described herein, based on experimental findings (5).

#### 4.2 *Strength Ratios:*

4.2.1 **Table 1** gives strength ratios, corresponding to various slopes of grain for stress in bending and compression parallel to grain.

4.2.2 Strength ratios for various combinations of size and location of knot and width of face are given in **Table 2**, **Table 3**, and **Table 4**. Since interpolation is often required in the development of grading rules, the use of formulas in **Table 2**, **Table 3** and **Table 4** is acceptable. These formulas are found in the Appendix.

4.2.2.1 Use of the tables is illustrated by the following example: The sizes of knots permitted in a 7½ by 15½-in. (190 by ~~394-mm~~) 394 mm (actual) beam in a grade having a strength ratio of 70 % in bending are desired. The smallest ratio in the column for a 7½-in. (~~190-mm~~) (190 mm) face in **Table 2** that equals or exceeds 70 % is opposite 2⅛ in. (54 mm) in the size-of-knot column. A similar ratio in the column for 15½-in. (~~394-mm~~) (394 mm) face in **Table 3** is opposite 4¼ in. (108 mm). Hence, the permissible sizes are 2⅛ in. (54 mm) on the 7½-in. (~~190-mm~~) (190 mm) face and at the edge of the wide face (see **5.3.5.2**) and 4¼ in. (108 mm) on the centerline of the 15½-in. (~~394-mm~~) (394 mm) face.

4.2.3 For all lumber thicknesses, a strength ratio of 50 % shall be used for all sizes of shakes, checks and splits. ~~A 50 %~~ A 50 % strength ratio is the maximum effect a shake, check or split can have on the load-carrying capacity of a bending member. Limitations in grading rules placed on the characteristics at time of manufacture are for appearance and general utility purposes, and these characteristics shall not be used as a basis for increasing lumber shear design values.

NOTE 2—The factor of 0.5 (50 %) is not strictly a “strength ratio” for horizontal shear, since the factor represents more than just the effects of shakes, checks and splits. The factor also includes differences between test values obtained in **Test Methods D143** shear block tests and full-size solid-sawn beam shear tests. The strength ratio terminology is retained for compatibility with prior versions of **Practice D143**, but prior provisions permitting design increases for members with lesser-size cracks have been deleted since the factor is related to more than shakes, checks and splits.

4.2.4 Modulus of elasticity is modified by a quality factor that is related to bending strength ratio, as given in **Table 5**.

4.2.5 Strength ratios in tension parallel to grain are 55 % of the corresponding bending strength ratios.

4.2.6 **Table 6** gives strength ratios and quality factors for the special specific gravity classes described in **4.1.9**.

## 5. Estimation and Limitation of Growth Characteristics

### 5.1 General Quality of Lumber:

5.1.1 All lumber should be well manufactured.

5.1.2 Only sound wood, free from any form of decay, shall be permitted, unless otherwise specified. Unsound knots and limited amounts of decay in its early stages are permitted in some of the lower stress-rated grades of lumber intended for light frame construction.

5.1.3 In stress-grading, all four faces and the ends shall be considered.

### 5.2 Slope of Grain:

**TABLE 1 Strength Ratios Corresponding to Various Slopes of Grain**

Slope of Grain	Maximum Strength Ratio, %	
	Bending or Tension Parallel to Grain	Compression Parallel to Grain
1 in 6	40	56
1 in 8	53	66
1 in 10	61	74
1 in 12	69	82
1 in 14	74	87
1 in 15	76	100
1 in 16	80	...
1 in 18	85	...
1 in 20	100	...

TABLE 2 Strength Ratios Corresponding to Knots in the Narrow Face of Bending Members

Knot Size, in. (mm) <sup>A</sup>	Percentage Strength Ratio When Actual Width of Narrow Face, in. (mm), is <sup>A</sup>															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1/4 (6)	85	89	93	95	96	97	97	97	97	97	97	98	98	98	98	98
1/2 (13)	67	76	84	88	91	93	93	94	94	94	94	95	95	95	95	95
3/4 (19)	48	62	75	84	87	88	89	90	91	91	91	92	92	92	93	93
1 (25)	4	49	60	75	80	85	86	87	88	88	89	89	90	90	90	90
1 1/4 (32)	...	...	58	72	79	81	82	83	84	85	86	86	87	87	87	88
1 1/2 (38)	...	...	49	67	75	79	78	80	81	82	83	83	84	84	85	85
1 3/4 (44)	...	...	57	62	70	73	75	76	77	78	79	80	81	82	82	83
2 (51)	...	...	32	49	68	71	73	74	75	76	77	78	79	80	80	80
2 1/4 (57)	...	...	22	35	64	67	69	71	72	73	74	75	76	77	77	78
2 1/2 (64)	...	...	...	26	59	65	67	68	69	70	71	72	73	74	75	75
2 3/4 (70)	...	...	...	18	54	61	63	64	66	67	68	69	70	71	72	73
3 (76)	...	...	...	...	50	57	60	61	62	64	65	66	67	68	69	70
3 1/4 (83)	...	...	...	26	41	53	56	59	61	63	65	66	67	68	69	70
3 1/2 (89)	...	...	...	...	50	59	60	61	62	64	65	66	67	68	69	70
3 3/4 (95)	...	...	...	...	36	45	48	50	52	55	58	59	60	61	62	63
4 (102)	...	...	...	...	...	46	48	50	51	55	57	59	60	61	62	63
4 1/4 (108)	...	...	...	...	...	...	45	48	49	50	52	53	54	55	56	57
4 1/2 (114)	...	...	...	...	...	...	...	46	47	49	50	51	52	53	54	55
4 3/4 (121)	...	...	...	...	...	...	...	...	46	46	47	49	50	51	52	53
5 (127)	...	...	...	...	...	...	...	...	...	...	...	46	48	49	50	51

<sup>A</sup> Ratios corresponding to other sizes of knots and face widths can be found by linear interpolation.

TABLE 3 Strength Ratios Corresponding to Centerline Knots in the Wide Face of Bending Members, and to Knots in Compression Members

Size of Knot, in. (mm) <sup>A</sup>	Percentage Strength Ratio When Actual Width of Wide Face, in. (mm), is <sup>A</sup>																									
	3	3½	4	4½	5	5½	6	7	7½	8	9	9½	10	11	11½	12	13	13½	14	15	15½	16	18	20	22	24
(76)	(89)	(102)	(114)	(127)	(140)	(152)	(178)	(190)	(203)	(229)	(241)	(254)	(279)	(292)	(302)	(330)	(343)	(356)	(381)	(394)	(406)	(457)	(508)	(559)	(610)	
¼ (6)	94	95	96	96	96	97	97	97	97	97	98	98	98	98	98	98	98	98	98	98	98	99	99	99	99	99
½ (13)	86	88	90	91	91	92	93	94	94	95	95	96	96	96	96	96	96	96	97	97	97	97	97	97	97	97
¾ (19)	79	82	84	85	87	88	89	91	91	92	92	93	93	94	94	94	94	95	95	95	95	95	95	95	96	96
1 (25)	72	75	78	80	82	84	85	87	88	89	90	90	91	92	92	92	93	93	93	93	93	94	94	94	94	94
1¼ (32)	64	69	72	75	78	79	81	84	85	86	87	88	89	90	90	90	91	91	91	91	91	92	92	92	93	93
1½ (38)	57	62	67	70	73	75	78	81	82	83	85	86	87	88	88	89	89	89	89	89	90	90	91	91	91	91
1¾ (44)	49	56	61	65	68	71	74	77	79	80	82	84	85	86	86	87	87	87	87	87	88	88	89	89	90	90
2 (51)	35	49	55	60	64	67	70	74	76	77	79	80	81	83	84	84	85	85	85	86	86	87	88	88	88	89
2¼ (57)	26	37	50	55	59	62	66	71	72	73	77	79	81	82	82	83	83	83	84	84	84	85	86	87	87	87
2½ (64)	18	30	39	50	54	58	62	67	69	71	74	75	77	79	80	81	81	81	81	82	82	83	84	85	86	86
2¾ (70)	...	23	32	40	50	54	61	63	66	68	71	73	74	76	77	78	79	79	79	80	80	81	82	83	84	84
3 (76)	...	...	26	36	45	51	57	60	62	66	69	72	74	75	76	77	78	78	78	79	79	80	81	82	83	84
3¼ (83)	...	...	...	31	37	47	54	57	59	64	68	72	74	75	76	77	78	78	78	79	79	80	81	82	83	84
3½ (89)	...	...	...	...	36	45	51	57	60	66	71	75	77	78	79	80	81	81	81	82	82	83	84	85	86	86
3¾ (95)	...	...	...	...	26	32	38	47	54	61	66	70	72	73	74	75	75	75	76	76	77	77	78	79	80	81
4 (102)	...	...	...	...	21	28	34	47	50	53	58	60	62	66	67	68	69	69	70	71	71	72	73	74	75	76
4¼ (108)	...	...	...	...	23	30	40	47	50	56	60	63	65	68	68	69	69	70	71	72	73	74	75	76	77	78
4½ (114)	...	...	...	...	19	26	36	41	46	50	58	61	63	65	66	67	68	68	69	70	70	72	73	74	75	75
4¾ (121)	...	...	...	...	...	21	33	37	41	48	53	55	59	61	62	63	64	64	65	65	66	67	68	70	71	73
5 (127)	...	...	...	...	...	17	29	34	38	48	50	53	57	59	60	61	62	62	64	64	64	65	67	68	70	71
5¼ (133)	...	...	...	...	...	...	25	30	35	45	48	50	55	57	58	59	60	61	62	62	63	65	67	68	70	71
5½ (140)	...	...	...	...	...	...	22	27	32	39	45	48	52	54	56	57	58	59	60	61	61	63	65	67	68	68
5¾ (146)	...	...	...	...	...	...	...	24	29	37	40	46	50	52	54	55	56	57	58	59	61	63	65	67	68	68
6 (152)	...	...	...	...	...	...	...	...	26	34	37	40	46	50	52	54	55	56	57	58	59	62	64	65	67	67
6½ (165)	...	...	...	...	...	...	...	...	19	28	34	41	48	50	52	54	55	56	57	58	59	62	64	65	67	67
7 (178)	...	...	...	...	...	...	...	...	13	23	32	41	46	48	50	52	53	54	55	56	57	60	62	64	65	65
7½ (190)	...	...	...	...	...	...	...	...	...	17	27	35	41	46	48	49	50	51	52	53	54	57	59	61	62	62
8 (203)	...	...	...	...	...	...	...	...	...	...	22	30	37	40	42	45	46	47	49	49	50	51	53	55	57	57
8½ (216)	...	...	...	...	...	...	...	...	...	...	...	25	32	35	38	40	41	42	45	45	46	47	49	51	52	52
9 (230)	...	...	...	...	...	...	...	...	...	...	...	20	28	31	34	36	37	39	41	42	43	44	47	49	51	51
9½ (243)	...	...	...	...	...	...	...	...	...	...	...	15	23	26	30	32	33	35	37	37	38	39	41	46	49	49

<sup>A</sup>Ratees Ratios corresponding to other sizes of knots and face widths can be found by linear interpolation.

TABLE 4 Strength Ratios Corresponding to Edge Knots in the Wide Face of Bending Members

Knot Size, in. (mm) <sup>A</sup>	Percentage Strength Ratio When Actual Width of Wide Face, in. (mm), is <sup>A</sup>																												
	2	2½	3	3½	4	4½	5	5½	6	7	7½	8	9	9½	10	11	11½	12	13	13½	14	15	15½	16	18	20	22	24	
¼ (6)	83	86	88	89	91	91	92	93	94	94	94	95	95	96	96	96	97	97	97	97	97	97	97	97	97	97	97	97	98
½ (13)	65	71	75	78	80	82	84	85	86	88	89	90	90	91	91	92	92	93	93	93	93	93	93	93	94	94	94	94	95
¾ (19)	49	57	62	67	70	73	75	77	79	82	83	84	86	86	87	88	89	89	89	89	89	90	90	90	90	91	91	92	92
1 (25)	27	38	51	57	61	65	68	70	73	76	77	79	81	82	83	84	85	85	85	86	86	86	87	87	88	88	88	89	89
1¼ (32)	16	27	36	47	52	57	60	63	66	71	72	74	76	77	78	80	81	82	82	83	83	83	83	84	84	85	85	86	86
1½ (38)	...	17	26	34	40	49	53	57	60	64	67	69	72	73	74	76	77	78	79	79	79	79	80	80	80	81	82	83	84
1¾ (44)	...	...	19	26	33	38	47	50	54	60	62	64	67	69	70	72	74	75	75	75	76	76	77	77	77	78	79	80	81
2 (51)	...	...	...	19	26	32	37	45	49	55	57	59	63	65	66	69	70	71	72	72	73	73	73	74	74	75	77	78	78
2¼ (57)	...	...	...	...	20	26	31	36	40	50	52	55	59	61	62	65	66	68	68	69	69	69	70	71	71	73	74	75	76
2½ (64)	...	...	...	...	15	21	26	31	35	48	51	55	57	59	62	63	65	66	66	66	66	66	67	68	68	70	71	72	73
2¾ (70)	...	...	...	...	...	16	21	26	30	38	41	46	51	53	55	59	60	61	62	63	63	63	64	65	65	67	68	70	71
3 (76)	...	...	...	...	...	...	17	21	26	33	37	40	47	50	52	55	57	58	60	60	60	60	61	62	62	64	66	67	68
3¼ (83)	...	...	...	...	...	...	...	17	22	29	32	36	41	46	48	52	54	55	56	57	57	57	58	59	60	62	63	65	66
3½ (89)	...	...	...	...	...	...	...	18	26	29	32	39	41	43	49	52	54	55	56	56	56	56	56	56	59	61	62	63	63
3¾ (95)	...	...	...	...	...	...	...	...	23	26	29	35	37	40	46	48	48	49	50	51	52	53	54	54	56	58	60	61	61
4 (102)	...	...	...	...	...	...	...	...	...	22	26	32	34	37	41	45	47	48	48	48	48	49	50	51	52	54	56	58	59
4¼ (108)	...	...	...	...	...	...	...	...	...	...	...	22	28	31	34	38	40	42	44	45	46	46	48	49	51	54	56	58	59
4½ (114)	...	...	...	...	...	...	...	...	...	...	...	20	26	28	31	35	37	39	41	42	43	43	45	46	47	49	51	53	54
4¾ (121)	...	...	...	...	...	...	...	...	...	...	...	...	23	26	28	33	35	37	39	40	41	42	43	44	47	49	51	53	54
5 (127)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	25	30	32	34	36	37	38	40	40	41	44	47	49	51	52

<sup>A</sup> Ratios corresponding to other sizes of knots and face widths can be found by linear interpolation.

**TABLE 5 Quality Factors for Modulus of Elasticity**

Bending Strength Ratio, %	Quality Factor for Modulus of Elasticity, %
≥55	100
45 to 54	90
≤44	80

**TABLE 6 Strength Ratios and Quality Factors for Special Specific Gravity Classifications**

Property	Specific Gravity Classification, %		
	Dense	Close Grain	Medium Grain
Bending stress	117	107	100
Tensile stress parallel to grain			
Compressive stress parallel to grain			
Compressive stress perpendicular to grain			
Modulus of elasticity	105	100	100

5.2.1 Slope of grain resulting from either diagonal sawing or from spiral or twisted grain in the tree is measured by the angle between the direction of the fibers and the edge of the piece. The angle is expressed as a slope. For instance, a slope of grain of 1 in 15 means that the grain deviates 1 in. (25 mm) from the edge in 15 in. (381 mm) of length.

5.2.2 When both diagonal and spiral grain are present, the combined slope of grain is taken as the effective slope.

5.2.3 Slope of grain is measured and limited at the zone in the length of a structural timber that shows the greatest slope. It shall be measured over a distance sufficiently great to define the general slope, disregarding such short local deviations as those around knots except as indicated in 5.2.5.

5.2.4 In 1-in. nominal boards (See Terminology D9), or similar small sizes of lumber, a general slope of grain anywhere in the length shall not pass completely through the thickness of the piece in a longitudinal distance in inches less than the number expressing the specified permissible slope. Where such a slope varies across the width of the board, its average may be taken.

5.2.5 Local deviations must be considered in small sizes, and if a local deviation occurs in a piece less than 4 in. nominal in width or on the narrow face of a piece less than 2 in. nominal in thickness, and is not associated with a permissible knot in the piece, the measurement of slope shall include the local deviation.

5.3 *Knots:*

5.3.1 A knot cluster is treated as an individual knot. Two or more knots closely spaced, with the fibers deflected around each knot individually, are not a cluster.

5.3.2 Holes associated with knots are measured and limited in the same way as knots.

5.3.3 A knot on the wide face of a bending or tension member is considered to be at the edge of the wide face if the center of the knot lies within two thirds of the knot diameter from the edge.

5.3.4 *Knots in Dimension Lumber:*

5.3.4.1 Knots in dimension lumber may be measured by displacement method, in which the proportion of the cross section of the knot to the cross section of the piece is multiplied by actual face width to establish the equivalent knot size (see Fig. 1). This value is used in the strength ratio tables.

5.3.4.2 Alternatively, knots in dimension lumber may be measured on the surface of the piece. Methods of measuring knots by this alternative are given in 5.3.4.3 – 5.3.4.5.



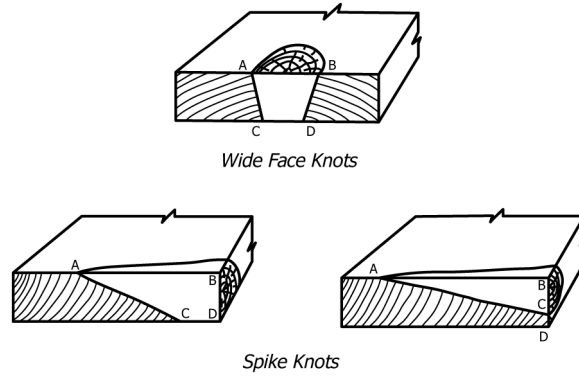


FIG. 1 Measurement of Knots in Dimension Lumber Using Displacement Method (Primary Method)

5.3.4.3 The size of a knot on a narrow face is its width between lines enclosing the knot and parallel to the edges of the piece (Fig. 2). A narrow-face knot that appears also in the wide face of a side-cut piece (but does not contain the intersection of those faces) is measured and graded on the wide face.

5.3.4.4 The size of a knot on a wide face is the average of its largest and smallest dimensions (Fig. 2).

5.3.4.5 Any knot that contains the intersection of two faces, including a knot extending entirely across the width of a face in a side-cut piece, is a corner knot. A corner knot is measured on its end between lines parallel to the edges of the piece and is graded with respect to the face on which it is measured (Fig. 2). A corner knot in a piece containing the pith is measured either by its width on the narrow face between lines parallel to the edge, or by its smallest diameter on the wide face, whichever is more restrictive (Fig. 2). If a corner knot appears also on an opposite face, its limitation there as well as on the corner is necessary.

5.3.4.6 The sum of the sizes of all knots in any 6 in. (152 mm) of length of piece shall not exceed twice the size of the largest permitted knot. Two or more knots of maximum or near maximum permissible size shall not be allowed in the same 6 in. (152 mm) of length on a face. Any combination of knots that, in the judgment of the lumber grader, will make the piece unfit for its intended use, shall not be admitted.

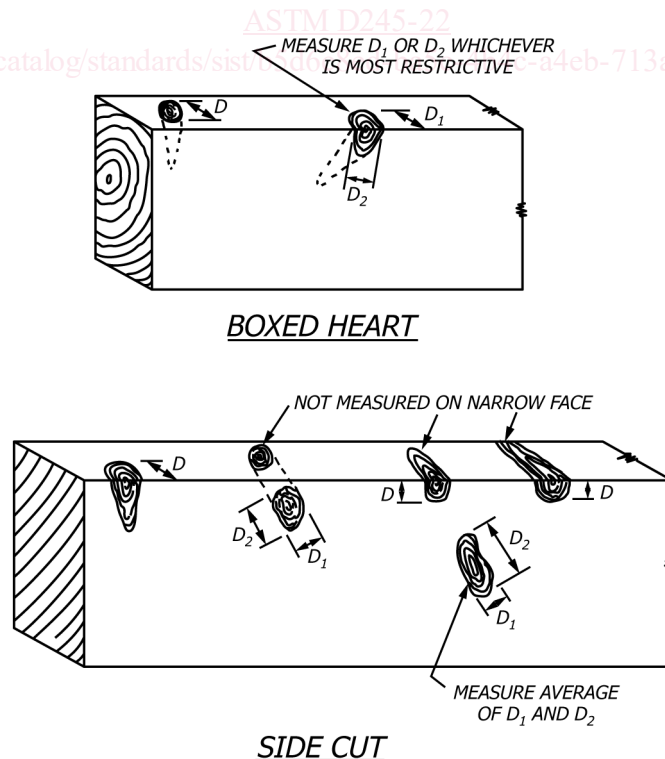


FIG. 2 Measurement of Knots in Dimension Lumber Using Alternative Method

5.3.4.7 For sizes 3 by 3 in. nominal and smaller the effects of grain distortion associated with knots can be so severe that all knots shall be limited as if they were wide-face edge knots in the face on which they appear.

5.3.4.8 Where the grade is intended to be used for single-span bending applications only, the sizes of knots on narrow faces and at the edge of wide faces may increase proportionately from the size permitted in the middle one third of the length to twice that size at the ends of the piece, except that the size of no knot shall exceed the size permitted at the center of the wide face. The size of knots on wide faces may be increased proportionately from the size permitted at the edge to the size permitted at the centerline (Fig. 3).

5.3.4.9 Where the grade is intended to be used on continuous spans, the restrictions for knots in the middle one third of their lengths shall be applied to the middle two thirds of the length of pieces continuous on three supports, and to the full length of pieces continuous on four or more supports.

5.3.5 *Knots in Beams and Stringers:*

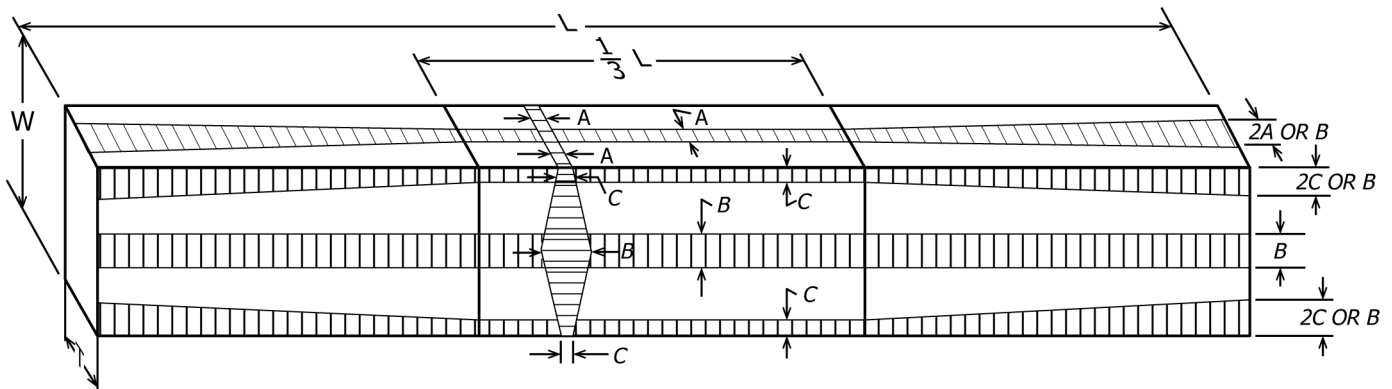
5.3.5.1 The size of a knot on a narrow face of a beam or stringer is its width between lines enclosing the knot and parallel to the edges of the piece (Fig. 4). When a knot on a narrow face of a side-cut piece extends into the adjacent one fourth of the width of a wide face, it is measured on the wide face.

5.3.5.2 The size of a knot on the wide face is measured by its smallest diameter (Fig. 4). An edge knot on the wide face is limited to the same size as a knot on the narrow face.

5.3.5.3 A corner knot in a beam or stringer containing the pith is measured either by its width on the narrow face between lines parallel to the edges or by its smallest diameter on the wide face, whichever is greater (Fig. 4). A corner knot in a side-cut piece is measured by whichever of these two is least.

5.3.5.4 The sum of the sizes of all knots within the middle one half of the length of a face, in a beam 20 ft (6.1 m) or less in length, when measured as specified for the face under consideration, shall not exceed four times the size of the largest knot allowed on that face. This restriction in a beam longer than 20 ft (6.1 m) shall apply to any 10 ft (3.0 m) of length within the middle one half of the length.

5.3.5.5 Where the grade is used for single-span bending applications only, the sizes of knots on narrow faces and at the edges of wide faces may be increased proportionately from the size permitted in the middle one third of the length to twice that size at the ends of the piece, except that the size of no knot shall exceed the size permitted at the center of the wide face. The size of knots on wide faces may be increased proportionately from the size permitted at the edge to the size permitted at the center line (Fig. 3).



- A, maximum size on narrow face in middle third of length with a uniform increase to 2A but not to exceed B, at the ends.
- B, maximum size at center of wide face.
- C, maximum size at edge of wide face in middle third of length with a uniform increase to 2C but not to exceed B at the ends and a uniform increase to B at the center of the wide face. In beams and stringers, A and C are equal.
- L, length.
- W, width of wide face.
- T, width of narrow face.

FIG. 3 Maximum Size of Knots Permitted in Various Parts of Joists and Planks, and Beams and Stringers

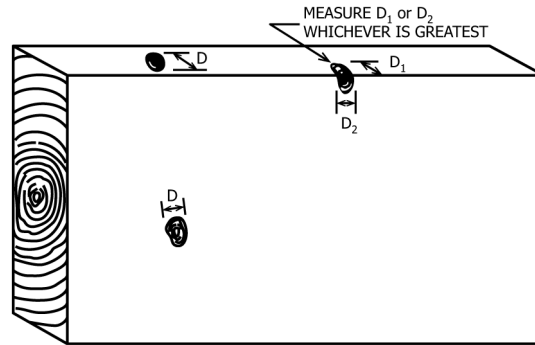


FIG. 4 Measurement of Knots in Beams and Stringers

5.3.5.6 Where the grade is intended to be used on continuous spans, the restrictions for knots in the middle one third of their lengths shall be applied to the middle two thirds of the length of pieces continuous on three supports, and to the full length of pieces continuous on four or more supports.

5.3.6 *Knots in Posts and Timbers:*

5.3.6.1 The size of a knot on any face of a post or timber is taken as the diameter of a round knot, the lesser of the two diameters of an oval knot, or the greatest diameter perpendicular to the length of a spike knot (Fig. 5).

5.3.6.2 A corner knot is measured wherever the measurement will represent the true diameter of the branch causing the knot.

5.3.6.3 The sum of the sizes of all knots in any 6 in. (152 mm) of length of a post or timber shall not exceed twice the size of the largest permitted knot. Two or more knots of maximum or near maximum permissible size shall not be allowed in the same 6 in. (152 mm) of length on a face.

5.3.6.4 In compression members with greater width than thickness, the sizes of knots in both the narrow and the wide faces are allowed up to the size permitted in the wide face.

5.3.7 *Knots in Stress-Rated Boards:*

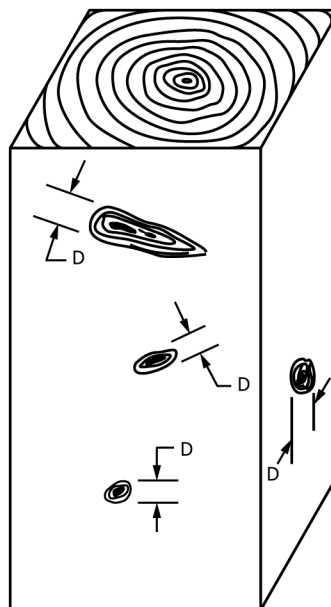


FIG. 5 Measurement of Knots in Posts and Timbers or Other Compression Members