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SUPPLEMENT TO U. S. DEPARTMENT OF AGRICULTURE MISCELLANEOUS PUBLICATION 185: "GUIDE TO THE GRADING OF STRUCTURAL TIMBERS AND THE DETERMINATION OF WORKING STRESSES"

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SUPPLEMENT TO U. S. DEPARTMENT OF AGRICULTURE MISCELLANEOUS PUBLICATION 185,

"GUIDE TO THE GRADING OF STRUCTURAL TIMBERS AND THE DETERMINATION OF WORKING STRESSES"

By

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PROVISIONS FOR STRUCTURAL DIMENSION (JOIST AND PLANK) IN GRADES HAVING LESS THAN 50 PERCENT OF THE STRENGTH OF CLEAR MATERIAL

Scope and Purpose

Miscellaneous Publication 185 provides for grades having "strength ratios" of 50 to 100 percent, but does not consider material whose strength as reduced by defects is less than 50 percent of that of clear wood. The purpose of this supplement is to extend the system of strength grading to dimension material that is below the 50 percent limit in strength.

The grading methods for these lower grades are similar to those of Miscellaneous Publication 185, with one principal exception. To simplify the grading and in order that material cut to shorter lengths subsequent to grading will not be lowered in grade, knots are limited to the same size regardless of their position in the length of the piece, and slope of grain is limited to the same value throughout the length.

Special Provisions

Following the procedure of Miscellaneous Publication 185, the structural grading requirements are based on strength considerations only. However, for uses such as house framing the desirability of seasoned material and of reasonably straight members is recognized, and provision is accordingly made for use requirements limiting moisture content and crook.

Specification Requirements for Joist and Plank of __ Grade (Joists, Rafters, Studs, Planks, Factory Flooring, Etc.)[1]

500. The strength ratios of this grade are -- percent for stress in extreme fiber and -- percent for stress in horizontal shear.

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[1] Applicable to grade-strength ratios of 25 to 50 percent.

501. Primary use.--As beams with load applied to either the wide or the narrow face.

502. Nominal dimensions.--Two to 4 inches in thickness and 3 inches and wider. Actual dimensions shall conform to the following: Rough (unsurfaced) pieces shall be sawn full to nominal dimension except that occasional slight variation in sawing is permissible. At no part of the length shall any piece because of such variation be more than 3/16 inch under the nominal dimension when this is 3 to 7 inches, inclusive, nor more than 1/4 inch under the nominal dimension when this is 8 inches or greater. The actual thickness of nominal 2-inch material shall not be less than 1-7/8 inches at any part of the length. Further, no shipment shall contain more than 20 percent of pieces of minimum dimension.

Surfacing, whether on one or both of a pair of opposite faces, shall leave the finished size not more than 3/8 inch under the nominal dimension when this is 7 inches or less and not more than 1/2 inch under the nominal dimension when this is 8 inches or more.

503. Decay.--Pieces containing unsound knots are acceptable provided the surrounding wood is firm and sound and the sizes of knots do not exceed the limits later specified. Pieces containing soft streaks or spots are acceptable provided these do not occupy more than 1/3 the width at any point and do not extend through more than 1/3 of the thickness. "Firm red heart" (red heart that has not reached the pocket stage), "heart stain," and similar early stages of decay are acceptable.

504. Slope of grain.--Slope of grain is to be measured over a distance sufficiently great to determine the general slope disregarding slight local deviations and is not to be steeper than 1 in 8.

505. The size of a knot on a narrow face is taken as the width between lines enclosing the knot and parallel to the edges of the piece. The only knots measured on narrow faces (see paragraph 507), are those that do not show on the wide faces and spike knots which cross the corners of side-cut pieces.

506. The size of a knot on a wide face is the average of its largest and smallest diameters.

507. Corner knots.--A spike knot which crosses a corner of a side-cut piece and contains the intersection of adjacent faces, or a knot which extends entirely across a face of a piece, shall be measured only on its end or ends, between lines parallel to the edges of the piece and shall be considered to be on the face on which the measurement is taken. Knots crossing the corners of side-cut pieces are disregarded if they do not extend farther on either face than the permissible wane (see paragraph 515).

508. Shakes are measured at the ends of the piece. Only those within the middle half of the width of the wide face of the piece are considered. The size of a shake is the distance between lines enclosing the shake and parallel to the wide faces of the piece. The permissible size is determined by the width of the narrow face of the piece.

509. Maximum permissible sizes of knots and shakes[2] are shown in the following schedule:

Size of knot			Nominal: width of face or end	Size of shake	
On narrow face	At edge of wide face	Along center line of wide face		In green piece	In seasoned piece
1	2	3	4	5	6
Inches	Inches	Inches	Inches	Inches	Inches
(Find sizes from table 1 according to width of face and the strength ratio for stress in extreme fiber as specified in paragraph 500)	(Find sizes from table 2 according to width of face and the strength ratio for stress in extreme fiber as specified in paragraph 500)	(Find sizes from table 3 according to width of face and the strength ratio for stress in extreme fiber as specified in paragraph 500)	2 2-1/2 3 4 6 8 etc.	(Find sizes from section A of table 4 according to width of end and the strength ratio for stress in horizontal shear as specified in paragraph 500)	(Find sizes from section B of table 4 according to width of end and the strength ratio for stress in horizontal shear as specified in paragraph 500)

510. The size of knots on wide faces may increase proportionately from the size permitted at the edge to the size permitted along the center line.

511. Cluster knots and knots in groups are not permitted.

512. Knot holes and holes from causes other than knots are measured and limited as provided for knots.

513. Checks.--Checks near each end of the piece are limited to the same size as shakes. Checks are measured within the middle half of the width of the piece and within three times the width from the end, the size being taken as one-third the sum of seven depth measurements, one on the end

[2]The following is an alternative to the schedule of sizes of shakes in paragraph 509 and is designated paragraph 509a: The size of shake shall not exceed __ of the width of the end of a green piece nor __ of the width of end of a seasoned piece. (Values for the blanks in paragraph 509a are found from equations given in the footnote to table 4.)

and three on each side of the piece. Each measurement shall represent the greatest depth of any check within the central half of the width; the measurement on the end shall be taken at the center of the thickness, and those on the sides at distances from the end of one, two, and three times the width. Each measurement shall be determined by the penetration into the piece of a probe 1/64-inch thick and 1/4-inch wide.

514. Splits.--Splits at either end and within the central half of the width shall not exceed in length[3] -- times the width of the wide face.

515. Wane at any point on any face shall not exceed one-third the width of the face.

Requirements in Addition to Strength

The following additional requirements are suggested for inclusion in specifications for house-framing material.

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[3] The value to be inserted is to be taken from table 5 to correspond to the strength ratio for stress in horizontal shear specified in paragraph 500.

516. Material shall be seasoned to a moisture content of not to exceed 19 percent[4] in any individual piece.

517. Crook shall not exceed 1/4 inch in any 8 feet of the length of pieces 6 inches or less in width nor 3/16 inch in any 8 feet of length of pieces more than 6 inches in width. Crook is to be measured after the material has been seasoned as specified in paragraph 516.

DISCUSSION OF SPECIFICATION REQUIREMENTS

Slopes of grain steeper than 1 in 8 could be permitted in grades with strength ratios below about 45 percent as far as direct effect of strength is concerned. Aside from spiral grain, however, such slopes are unlikely to occur except in material from logs with excessive taper, crooked logs, or logs with crooked pith, or as a result of gross mismanufacture. Steep slope of grain from any of these causes is conducive to severe warping and twisting with resultant high stress in pieces held in position while drying or forced into position after they have become warped and twisted. Consequently, it is considered inadvisable to permit slopes steeper than 1 in 8.

One-third the actual dimension is set as the maximum wane in order to provide bearing for framing members and to provide for reasonably satisfactory junctions of covering materials on such members.

The object of a limitation of crook in house framing material is to provide for the alignment of members over which flexible surfacing materials are to be attached and to avoid stresses induced by drawing members to a common "level" in attaching stiffer sheathing, subflooring, etc., The limitation is not fully effective unless the material is of such a grade and character that objectionable crook does not develop in drying or unless inspection is made after seasoning to a moisture content reasonably close to that which will obtain in service. Otherwise, objectionable crook may develop after inspection and if the development occurs after the framing is covered misalignment, severe stress, or breakage of plaster may occur.

If the curvature is uniform, a crook of 1/4 inch in 8 feet or 3/16 inch in 8 feet is approximately equivalent to a total crook of 1 inch or 3/4 inch, respectively, in pieces 16 feet long. Limiting the crook in any 8 feet of the length is simpler and more definite than the common practice of stating the limit for 16-foot pieces with the provision that in shorter pieces the crook may be in proportion to the length. The suggested limitation would restrict crook of the "dog leg" type to 1/2 inch or 3/8 inch when measured over the full length of 16-foot pieces.

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[4] Since seasoning to an average moisture content well below 19 percent is desirable for house-framing material, this figure should be regarded as a maximum, subject to revision downward as increased drying facilities become available.

COMMENTS ON TABLES OF SIZES OF DEFECTS

Computation of Strength Ratios

In the tabulations of sizes of knots and shakes in Miscellaneous Publication 185 strength ratios were based on the relation of the size of defect to the nominal dimensions of the piece. Extension of the same system to lower grades leads to obvious absurdities and to unsafe strength ratings. For example, in a 25 percent grade the size of knot allowable on a narrow face of a piece 2 inches thick is 3/4 the width of that face. If this fraction is applied to the nominal 2-inch dimension the computed permissible size of knot is 1-1/2 inches whereas the standard thickness of nominal 2-inch stock when S1S or S2S is only 1-5/8 inches. In the following tables of sizes of knots and shakes, strength ratios of 45 percent or higher are based on nominal dimensions and others on A.L.S. standard dimensions for surfaced material. Otherwise the tables were derived in exactly the same way as those in Miscellaneous Publication 185. Strength ratios for nominal 2-1/2-inch thickness have been added in tables 1 and 4.

Choice of Strength Ratio for Stress in Horizontal Shear

If the rated strength in horizontal shear is too low, the span of a joist will be limited by shear without the rated stress in outer fiber in bending being attained. Hence, it is desirable that in any grade the rating in shear be at least high enough to "balance" the rated bending strength. The following formula may be used to determine the shearing stress necessary to effect such balance:

$$S = \sqrt{\frac{fws}{192b}} - \frac{ws}{96b}$$

S = stress in horizontal shear -- pounds per square inch.
f = stress in outer fiber in bending -- pounds per square inch.
w = uniformly-distributed load -- pounds per square foot.
s = joist spacing -- inches.
b = thickness of joist -- inches.

If S is made at least as great as indicated by this formula spans will not be limited by shear when the allowable fiber stress is f. For example, if w is 50 pounds per square foot, f is 900 pounds per square inch; s is 16 inches, b is 1-5/8 inches, and then the value of S from the formula above is 43 pounds per square inch, and if this value of shearing strength is provided, the spans for 2-inch joists spaced 16 inches and carrying 50 pounds per square foot will in no instance be limited by shear.

It may be noted that the required value of S is independent of the depth of the joist and is greater the greater are the values of f, w, and s and is less the greater is the thickness b. This last relation suggests that the strength ratio for stress in shear might be varied with the thickness without disturbing the balance between shear resistance and bending strength of joists.

Tables for Use in Determining Permissible Sizes of Knots, Shakes, and Splits in Accordance with the Strength Ratio

Table 1.--Knots on narrow face. Strength ratios for stress in extreme fiber in bending corresponding to various combinations of size of knot and width of face

Size of knot	Percentage strength ratios for nominal face width (inches) indicated			
	2	2-1/2	3	4
Inches				
1	52			
1-1/8	47			
1-1/4	40	52		
1-3/8	33	47		
1-1/2	27	42	51	
1-5/8		37	47	
1-3/4		32	43	
1-7/8		27	39	
2			36	51
2-1/8			31	48
2-1/4			26	45
2-3/8				36
2-1/2				32
2-5/8				29
2-3/4				25

Strength ratios of 45 percent or higher are based on the relation of size of knot to nominal width of face; others on relation of size of knot to actual width.

Table 2.--Knots at edge of wide face. Strength ratios for stress in extreme fiber in bending corresponding to various combinations of size of knot and width of face

Size of knot	Percentage strength ratios for nominal face width (inches) indicated							Size of knot	Percentage strength ratios for nominal face width (inches) indicated		
	3	4	6	8	10	12	14		10	12	14
Inches								Inches			
1	46							4	31	45	48
1-1/8	34	53						4-1/8	30	42	47
1-1/4	29	49						4-1/4	28	40	46
1-3/8		40						4-3/8	27	39	43
1-1/2		36						4-1/2	25	37	41
1-5/8		32						4-5/8		36	40
1-3/4		28	51					4-3/4		35	39
1-7/8			48					4-7/8		33	37
2			45					5		32	36
2-1/8			40					5-1/8		31	35
2-1/4			37	52				5-1/4		30	34
2-3/8			34	50				5-3/8		29	33
2-1/2			32	48				5-1/2		28	32
2-5/8			29	46				5-5/8		26	30
2-3/4			27	42				5-3/4		25	29
2-7/8			25	40	51			5-7/8			28
3				38	50			6			27
3-1/8				36	48			6-1/8			26
3-1/4				34	46			6-1/4			25
3-3/8				32	39						
3-1/2				30	37	51					
3-5/8				28	35	49					
3-3/4				26	34	48	51				
3-7/8					33	46	50				

Strength ratios of 45 percent or higher are based on the relation of size of knot to nominal width of face; others on relation of size of knot to actual width.

Table 3.--Knots along center line of wide face. Strength ratios for stress in extreme fiber in bending corresponding to various combinations of size of knot and width of face

Size of knot	Percentage strength ratios for nominal face width (inches) indicated						
	3	4	6	8	10	12	14
Inches							
1-1/2	51						
1-3/4	35						
2	25	51					
2-1/4		45					
2-1/2		32					
2-3/4		25					
3			51				
3-1/4			47				
3-1/2			39				
3-3/4			34	54			
4			29	50			
4-1/4			25	47			
4-1/2				41			
4-3/4				37	53		
5				34	50		
5-1/4				31	48		
5-1/2				27	45		
5-3/4					40	52	
6					37	50	
6-1/4					35	48	52
6-1/2					32	46	50
6-3/4					29	42	48
7					27	39	46
7-1/4						37	43
7-1/2						35	42
7-3/4						33	40
8						31	38
8-1/4						29	36
8-1/2						26	34
8-3/4							32
9							30
9-1/4							28
9-1/2							26

Strength ratios of 45 percent or higher are based on the relation of size of knot to nominal width of face; others on relation of size of knot to actual width.

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Table 4.--Shakes. Strength ratios for stress in horizontal shear corresponding to various combinations of size of shake and thickness of piece

A				Section	B			
Green material				Size of shake[1]	Seasoned material			
Percentage strength ratio for nominal thickness (inches) indicated					Percentage strength ratio for nominal thickness (inches) indicated			
2	2-1/2	3	4		2	2-1/2	3	4
				Inches				
52				1				
48				1-1/8				
25	52			1-1/4	45			
	47			1-3/8	20			
	31	51		1-1/2		47		
	25	47		1-5/8		29	53	
		35		1-3/4			48	
		30		1-7/8			34	
		25	51	2			29	
			48	2-1/8				54
			39	2-1/4				50
			36	2-3/8				47
			32	2-1/2				37
			29	2-5/8				33
			25	2-3/4				29
				2-7/8				25

Strength ratios of 45 percent or higher are based on the relation of size of shake to nominal thickness; others on relation of size of shake to actual thickness.

[1]If it is desired to state the permissible size of shake as a fraction or proportion (see footnote to paragraph 509) of the thickness instead of tabulating the size for each thickness, the correct fraction can be found from the following equations:

For green material $S = \frac{100 - R}{100}$; For seasoned material $S = \frac{900 - 8R}{900}$

Where S is the allowable size of shake expressed as a fraction of the thickness and R is the strength ratic, in percent, for stress in horizontal shear.
Examples: If R is 40 percent

$$\text{For green material } S = \frac{100 - 40}{100} = 0.60 \text{ or } 60 \text{ percent}$$

$$\text{For seasoned material } S = \frac{900 - 320}{900} \doteq 0.67 \text{ or } 67 \text{ percent.}$$

R being less than 45 percent, the allowable size of shake is 60 percent of the actual thickness in green material of 67 percent of this thickness in seasoned material.

Table 5.--Splits. Strength ratios for stress in horizontal shear corresponding to splits whose length is various multiples of the width of the wide face

Length of split in terms of nominal width of wide face	Strength ratio for stress in horizontal shear
	Percent
1-1/4	58
1-1/2	50
1-3/4	42
2	33
2-1/4	25