

# TENSILE STRENGTH OF SPECIAL DOUGLAS-FIR AND HEM-FIR 2-INCH DIMENSION LUMBER

*James W. Johnson*

Associate Professor Forest Products  
School of Forestry, Oregon State University, Corvallis, OR 97331

and

*Robert H. Kunesh*

Wood Technologist  
Trus-Joist Corporation, Boise, ID 83702

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## ABSTRACT

Nominal 2- by 4-, 6-, 8-, and 10-inch Douglas-fir and hem-fir dimension lumber was tested in tension parallel-to-grain. Five hundred ninety-three pieces of hem-fir and 563 of Douglas-fir were included in various categories of none, single small and large center and edge knots, and multiple knots. Tension stress, specific gravity, and modulus of elasticity in flatwise bending decreased as width of lumber increased. Tensile strength decreased with increased knot size. Pieces of lumber with single center knots occupying 21% of the width were similar in tensile strength to pieces of lumber with single edge knots occupying 14%. Pieces containing several small knots, well scattered, were as strong in tension as those with single small knots. Tensile strengths of Douglas-fir and hem-fir were not significantly different. In estimating lower exclusion values, adjustments should be made for skewed distributions. One method is suggested.

*Additional keywords:* *Pseudotsuga menziesii*, *Tsuga heterophylla*, *Abies spp.*, edge knots, center knots, single knots, multiple knots, specific gravity, modulus of elasticity, skewed distributions, strength tests, lumber strength.

## INTRODUCTION

The objective of this study was to determine the tensile strength parallel-to-grain of high-grade Douglas-fir and hem-fir dimension lumber. We believe that where tensile strength becomes a critical factor in specialized uses, these uses will demand the higher grades of material, or possibly a newly established special grade. Our primary effort was directed toward providing information to those concerned with establishing lumber grades and to those using Douglas-fir and hem-fir dimension lumber in tension.

This work was the major part of a series of tension tests started several years ago at Oregon State University's Forest Research Laboratory. Results have been published (Kunesh 1966; Kunesh and Johnson 1972; Kunesh and Johnson 1974). The work reported herein was more extensive than our previous studies and was intended to

supplement studies made by others, referred to by Kunesh and Johnson (1972), who have done work with Douglas-fir and other species, not including hem-fir.

The species combination, hem-fir, includes western hemlock (*Tsuga heterophylla* [Raf.] Sarg.), California red fir (*Abies magnifica* A. Murr.), grand fir (*Abies grandis* [Dougl.] Lindl.), noble fir (*Abies procera* Rehd.), Pacific silver fir (*Abies amabilis* [Dougl.] Forbes), and white fir (*Abies concolor* [Gord. & Glend.] Lindl.). Identification by piece was not made, but a sampling indicated that probably 85% or more of the hem-fir specimens were western hemlock. Probably, most of the *Abies* was *grandis* and little *magnifica* or *concolor* was included.

## PROCEDURE

Five hundred ninety-three pieces of hem-fir and 563 of Douglas-fir were se-

TABLE 1. Summary of tension parallel-to-grain tests made on Douglas-fir and hem-fir dimension lumber showing numbers of pieces tested that contained different types and sizes of single knots, plus clear pieces, plus some pieces of lumber with a combination of knots

Type of knot	Douglas-fir			Hem-fir		
	Size of knot <sup>1</sup> In.	Per-cent knot <sup>2</sup> %	Number of pieces	Size of knot <sup>1</sup> In.	Per-cent knot <sup>2</sup> %	Number of pieces
<b>Nominal 2 by 4 inch (1.5 by 3.5 actual)</b>						
None (clear)	---	--	22	---	--	22
Edge (small)	1/2	14.3	22	1/2	14.3	22
Edge (large)	1	28.6	22	7/8	25.0	22
Center (small)	3/4	21.4	22	3/4	21.4	22
Center (large)	1 1/4	35.7	16	1 1/8	32.1	22
Combination A <sup>3</sup>	1/2 E & 3/4 C	--	22	1/2 E & 3/4 C	--	22
Combination B	same <sup>4</sup>	--	22	same <sup>4</sup>	--	22
<b>Nominal 2 by 6 inch (1.5 by 5.5 actual)</b>						
None (clear)	---	--	22	---	--	22
Edge (small)	3/4	13.6	22	3/4	13.6	22
Edge (large)	1 1/2	27.3	22	1 1/4	22.7	22
Center (small)	1 1/8	20.5	22	1 1/8	20.5	22
Center (large)	1 7/8	34.1	5	1 5/8	29.5	17
Combination A <sup>3</sup>	3/4 E & 1 1/8 C	--	22	3/4 E & 1 1/8 C	--	22
Combination B	same <sup>4</sup>	--	22	same <sup>4</sup>	--	22
<b>Nominal 2 by 8 inch (1.5 by 7.25 actual)</b>						
None (clear)	---	--	22	---	--	22
Edge (small)	1	13.8	22	1	13.8	22
Edge (large)	2	27.6	22	1 5/8	22.4	22
Center (small)	1 1/2	20.7	22	1 1/2	20.7	22
Center (large)	2 1/2	34.5	9	2 1/8	29.3	19
Combination A <sup>3</sup>	1 E & 1 1/2 C	--	22	1 E & 1 1/2 C	--	22
Combination B	same <sup>4</sup>	--	22	same <sup>4</sup>	--	22
<b>Nominal 2 by 10 inch (1.5 by 9.25 actual)</b>						
None (clear)	---	--	22	---	--	22
Edge (small)	1 1/4	13.5	22	1 1/4	13.5	22
Edge (large)	2 1/2	27.0	22	2 1/8	23.0	22
Center (small)	1 7/8	20.3	22	1 7/8	20.3	22
Center (large)	3 1/8	33.8	5	2 3/4	29.7	7
Combination A <sup>3</sup>	1 1/4 E & 1 7/8 C	--	22	1 1/4 E & 1 7/8 C	--	22
Combination B	same <sup>4</sup>	--	22	same <sup>4</sup>	--	22

<sup>1</sup>Width of knot measured on wide face between lines parallel to edge of piece.

<sup>2</sup>These are approximate. Size of knot in column 2 divided by the actual widths corresponding to the respective nominal sizes.

<sup>3</sup>More than one knot in a piece, but limited to the same size as the smallest edge (E) or center (C) knot. Knots well scattered (2-foot minimum spacing, except when small knots in a 1-foot section were accumulated).

<sup>4</sup>Same as Combination-A, but these were pieces that were just on the borderline of being in the Combination-A category.

lected from five mills in western Oregon. Test material was nominal 2- by 4-, 6-, 8-, and 10-inch dimension lumber. Seven categories (samples) were established within each width of lumber and in each species that depended on ratio of knots to lumber width, on location of knots in the lumber, and on combinations of knots. These cate-

gories did not correspond to standard grades. We selected pieces with single knots to isolate knots as a variable. Pieces with combinations of knots were selected for comparison because most pieces that are manufactured contain multiple knots.

In this report, small edge knots refer to knots that occupied about 14% of the

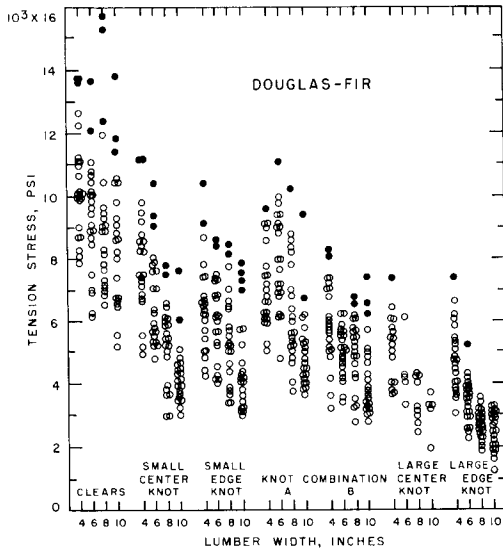


FIG. 1. Distributions of tension stress obtained from tests of nominal 2- by 4-, 6-, 8-, and 10-inch Douglas-fir dimension lumber at 9% moisture content. See Table 1 for sizes of knots in the different samples within each size of lumber. Solid circles were the values excluded so that remaining values were the adjusted distributions.

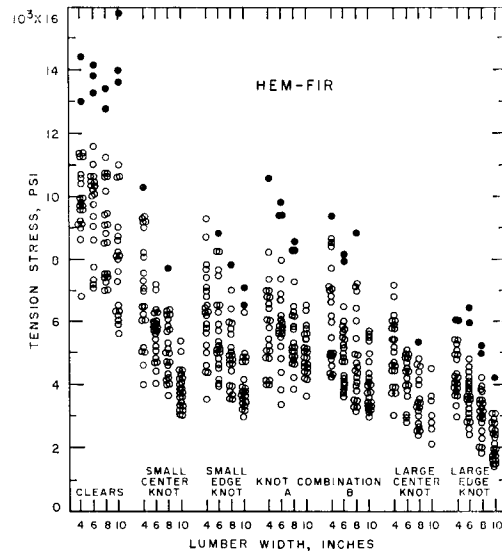


FIG. 2. Distributions of tension stress obtained from tests of nominal 2- by 4-, 6-, 8-, and 10-inch hem-fir dimension lumber at 10% moisture content. See Table 1 for sizes of knots in the different samples within each size of lumber. Solid circles were the values excluded so that remaining values were the adjusted distributions.

width of the piece of lumber and small center knots occupied about 21%. For Douglas-fir, large edge and center knots occupied 28 and 35% of widths, respectively; and in hem-fir the percentages occupied were about 23 for large edge and 30 for large center knots. Exact sizes of knots and percentages are given in Table 1, along with the number of pieces tested in each category.

The seven categories were: (one) clear lumber; (two) a single small edge knot; (three) a single large edge knot; (four) a single small center knot; (five) a single large center knot; (six) pieces of lumber that contained more than one knot (Combination A); and (seven) pieces quite similar to those of Combination A, but of borderline quality based on visual characteristics (Combination B). All test specimens were chosen randomly from the mills, consistent with the restrictions placed on each category.

Restrictions and comments regarding the selection of specimens are as follows:

1. General slope of grain not to exceed 1 in 16 was required for all specimens.
2. Exceptionally light-weight pieces, amounting to about 1% of pieces otherwise suitable, were not included. Lightest Douglas-fir piece had a specific gravity of 0.38 (oven-dry weight and volume); lightest hem-fir was 0.32.
3. Pieces with excessive grain distortion around a knot or excessive local grain (large knot missing, but grain deviation still present) were not included.
4. Knot size was an average width of knot measured on the 2 wide faces between lines parallel to edges of the piece, with a tolerance of plus or minus  $\frac{1}{8}$  inch for sizes up to 2 inches and  $\frac{1}{4}$  inch for sizes 2 inches and greater. Few spike-type knots were included.
5. Edge knots generally were whole knots (not parts of big knots), and at least  $\frac{3}{4}$  of the knot was within the outside quarter-width of the piece. In most pieces, the knots touched the edge.























