Wood and Fiber, 9(4), 1978, pp. 289–294

SOME STRENGTH PROPERTIES OF DIGGER PINE

Arno P. Schniewind and *Barry Gammon*[1]

Professor of Forestry and Assistant Specialist, respectively, Forest Products Laboratory, University of California, Richmond, CA 94804

(Received 18 July 1977)

ABSTRACT

The mechanical properties of Digger pine (*Pinus sabiniana* Douglas), a species indigenous to California, were evaluated using a random mill sample of ten logs. The logs, averaging 18 inches in diameter, had a growth rate of 8.6 rings per inch and a specific gravity of 0.43, based on green volume and oven-dry weight. All tests were performed in the green condition, in accordance with ASTM D143–52. Mechanical properties were: MCS in compression parallel-to-grain, 2450 psi; shear strength, 780 psi; FSPL in compression perpendicular-to-grain, 360 psi; MOR in static bending, 5280 psi; and MOE in static bending, 1,040,000 psi. These results show that Digger pine is very similar in its mechanical properties to ponderosa pine.

Keywords: *Pinus sabiniana*, mechanical properties, static bending, compression parallel-to-grain, compression perpendicular-to-grain, shear, specific gravity, modulus of elasticity, modulus of rupture.

INTRODUCTION

Digger pine (*Pinus sabiniana* Douglas) grows in open groups or scattered on the dry foothills of northern and central California, at elevations from 500 to 4000 ft. It is distinctive for its thin, gray foliage by which it can be identified at great distances. Mature trees are usually forked, with a main stem 20 to 30 ft long. They may attain a height of up to 80 ft and diameters of 18 to 30 inches.

Digger pine is not presently a major commercial species but is cut for lumber on occasion. The work reported here was started at the request of a saw mill cutting Digger pine exclusively, with the objective of developing information on some of the more important strength properties. No such prior information could be found in the literature except for two bending tests and two compression tests reported by Sargent [1884]. Not only were these older tests limited in number but the test methods differed from those of today and the specimens included defects, so that the properties of Digger pine are in effect unreported.

[1] The authors wish to acknowledge the cooperation of Kem Ker Tie and Lumber Company, which furnished the test material and financial support.

MATERIALS AND METHODS

The test material was obtained from the log decks of Kem Ker Tie and Lumber Company, Cottonwood, California. Cottonwood is in Shasta County, close to the border of Tehama County, and the logs may have originated from either county. Ten logs were selected from log decks containing approximately 700 logs. This selection was made by determining the approximate number of logs available for sampling, giving each log a number, and then using a random number generator to draw the sample logs. The sample logs were marked and accumulated as the particular log decks

TABLE 1. *Log characteristics*

Log no.	No. of rings	Diameter (inch)	Rings/inch
1	75	21	7.0
2	70	19	7.5
3	91	20	9.2
4	77	24	6.3
5	91	19	9.4
6	83	21	8.1
7	72	16	8.9
8	72	12	12.1
9	54	13	8.6
10	73	16	9.2
Average	76	18	8.6

TABLE 2. *Strength test data*

Log No.	Moisture content %		Specific gravity[a]		Compression parallel-to-grain; maximum crushing strength, psi		Shear strength, psi		Compression perpendicular-to-grain; fiber stress at proportional limit, psi		Static bending: Modulus of rupture, psi		Static bending: Modulus of elasticity, 1000 psi	
	Mean[b]	CV[c]	Mean[b]	CV[c]	Mean[d]	CV[c]	Mean[d]	CV[c]	Mean[d]	CV[c]	Mean[d]	CV[c]	Mean[d]	CV[c]
1	83	63	0.41	3	1850	14	700	6	400	7	4370	3	750	6
2	89	38	0.46	4	2620	9	900	7	400	11	4810	19	890	36
3	120	44	0.44	8	2340	13	780	8	400	15	4910	10	920	23
4	95	43	0.47	4	2690	18	780	4	330	10	6040	5	1300	13
5	115	44	0.42	5	2160	11	740	8	320	4	5130	8	1160	12
6	120**	49	0.39**	8	1760*	14	620	2	310	26	4030	3	790	8
7	88	66	0.41	4	2500	11	780	9	340	22	5620	5	1230	8
8	102**	52	0.44**	8	2750	7	870	11	380	12	5560*	8	910*	29
9	117	23	0.43	3	2730	5	800	2	340	12	6140	4	1290	8
10	90	47	0.44	9	3120	17	840	13	420	16	6220	9	1190	19
Digger Pine Average[e]	102	15	0.43	6	2450	18	780	10	360	11	5280	14	1040	20
Ponderosa Pine[f]	(green)		0.38		2450		700		280		5100		1000	
Coast Douglas-fir[f]	(green)		0.45		3780		900		380		7700		1560	

[a] Based on green volume and oven-dry weight.
[b] Average of 20 (or 19, indicated by **) measurements.
[c] Coefficient of Variation, in percent.
[d] Strength values are an average of four tests, except for those marked by a single asterisk (*) which are based on three tests, and all shear data which include eight tests each.
[e] Average giving each log equal weight; coefficient of variation based on the ten log means.
[f] From *Wood Handbook* (US Forest Products Laboratory, 1974).

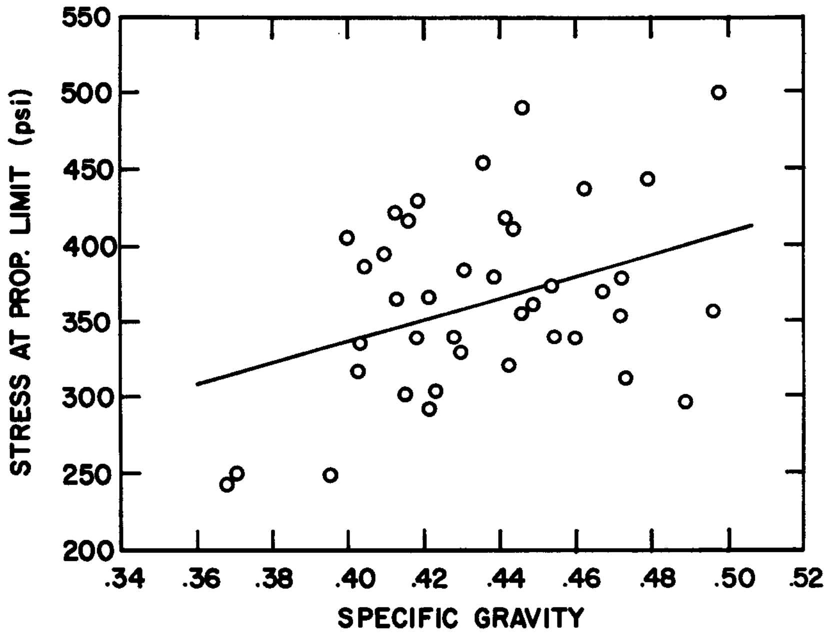

FIG. 1. Fiber stress at proportional limit in compression perpendicular-to-grain as a function of specific gravity.

were being sawn. Since Digger pine usually yields only one log per tree, it was reasonable to expect that ten trees would be represented in the sample.

From the butt end of each of the sample logs, a cant 8 ft long was sawn at the mill. The cants were 2-½ inches thick and extended through the pith from bark to bark. They were wrapped in plastic to prevent drying and were shipped promptly to the California Forest Products Laboratory, Richmond.

At the laboratory, the cants were sawn into squares and surfaced to obtain 2-inch-square test blanks. The blanks were cut into specimens for the following tests: static bending, compression parallel-to-grain, compression perpendicular-to-grain, and shear. Four specimens were selected from each of the 10 cants, for each of the four types of tests. For the shear test the number of specimens was doubled since the tests were done in pairs (radial and tangential shear plane). Thus, there were a total of 80 shear specimens and 40 for each of the other three types of tests, for a grand total of 200 specimens.

Tests were made in the green condition only, following the methods set forth in ASTM D143–52 [ASTM 1976]. Moisture content and specific gravity, based on green volume and oven-dry weight, were determined for each test specimen after test.

Sections cut from the butt ends of each cant prior to specimen preparation were used to determine diameter, total number of rings, and rings per inch.

RESULTS

Ring count, diameter, and rings per inch of the sample logs are shown in Table 1. Growth rate ranged from 6.3 to 12.1 rings per inch, with an average of 8.6, indicating that Digger pine is a relatively fast-growing species.

Strength test data are shown in Table 2. Average values for each log are listed, as well as grand averages. One static bending and one compression parallel-to-grain specimen had to be culled, so that the grand average strength values for these tests are based on 39 rather than 40 specimens.

As might be expected, there is consider-

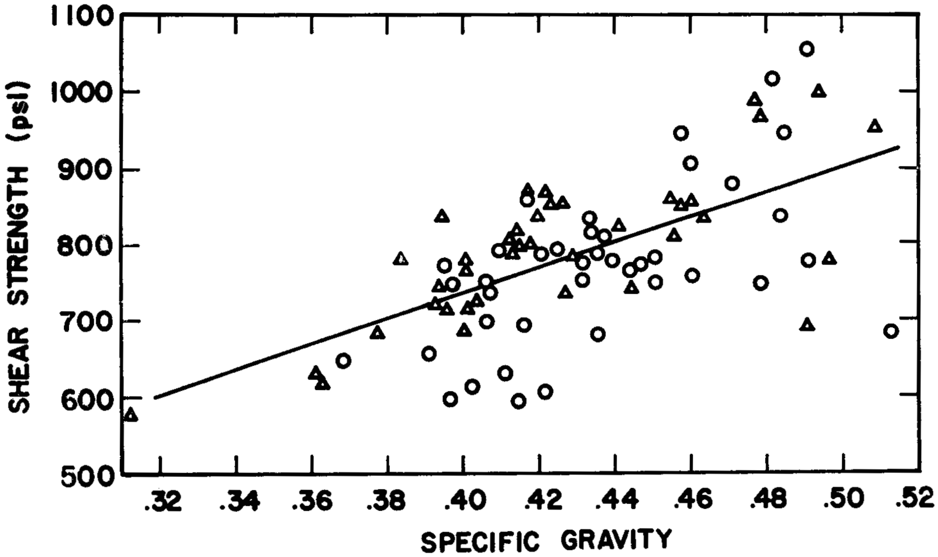

FIG. 2. Shear strength in shear parallel-to-grain as a function of specific gravity. Circles denote radial-longitudinal shear plane, triangles tangential-longitudinal shear plane.

able variation from log to log in the strength values obtained. In addition to the grand average values for the present tests of Digger pine, comparable data for Coast Douglas-fir and ponderosa pine were taken from the *Wood Handbook* (USFPL 1974) and listed in Table 2 for comparison. Ponderosa pine was chosen because Digger pine is more similar to it than any other softwood species listed in the *Wood Handbook*. For each of the strength values those of Digger pine are either equal to or greater than those of ponderosa pine. Digger pine is much lower in strength than Coast Doug-

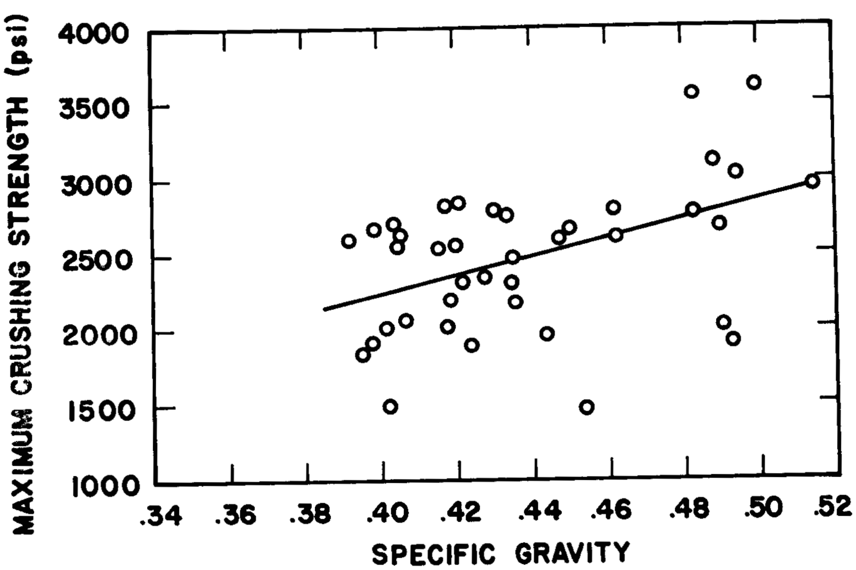

FIG. 3. Maximum crushing strength in compression parallel-to-grain as a function of specific gravity.

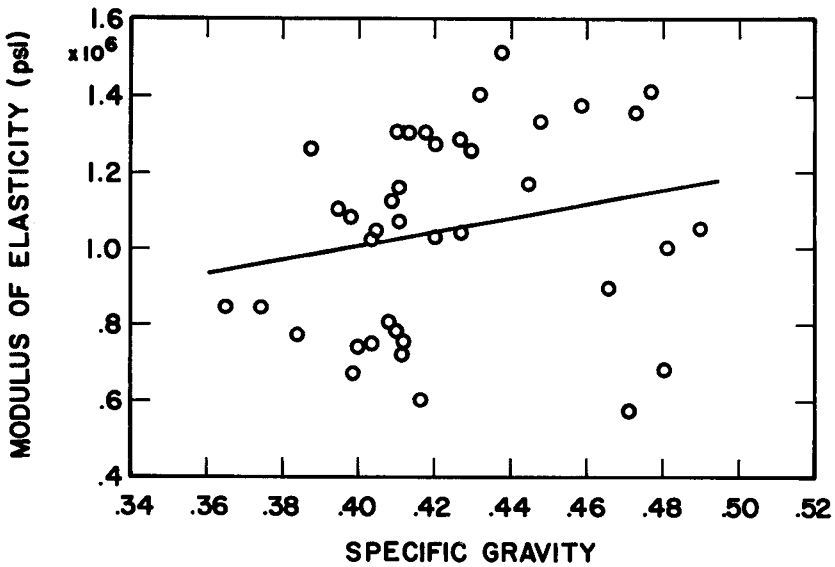

FIG. 4. Modulus of elasticity in static bending as a function of specific gravity.

las-fir for most of the properties listed. However, the fiber stress at proportional limit in compression perpendicular-to-grain differs but little when comparing Digger pine and Douglas-fir. The same holds true for specific gravity. This is a strong indication that the ability of Digger pine to hold nails, spikes, and other mechanical fastenings, should be relatively good.

The strength data were plotted as a function of specific gravity and these plots are shown in Figs. 1 to 5. Linear regression equations were computed and the resulting equations are shown in Table 3. The coefficients of determination (r^2) are generally small, which shows that only the smaller part of the total variation in strength can be attributed to specific gravity varia-

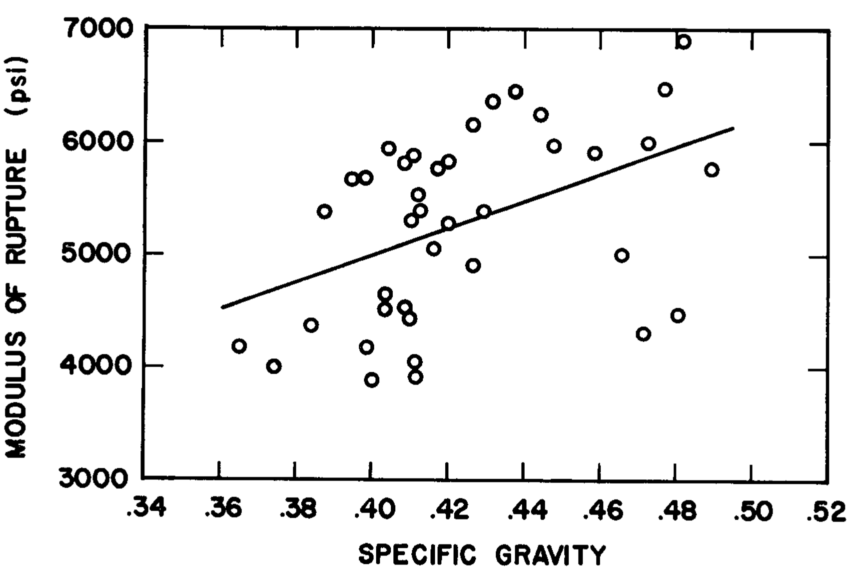

FIG. 5. Modulus of rupture as a function of specific gravity.

TABLE 3. *Regression equations for strength on specific gravity*

Property	Intercept, A[a]	Slope, B[a]	r^2	F[b]	N
FSPL, compression perpendicular	41.141	742.03	0.15	6.59*	40
Shear	68.528	1659.13	0.38	47.24**	80
Maximum crushing strength	−189.80	6059.0	0.19	8.62**	39
Static bending:					
MOE	0.27938×10^6	1.8111×10^6	0.05	1.84 n.s.	39
MOR	103.00	12,209	0.21	9.80*	39

[a] Regression model: strength = A + B (Specific gravity).
[b] Significance of Regression (r and B): * = 5% level; ** = 1% level, n.s. = not significant.

tions. In part this may be due to sample size, since the shear data with double the number of observations also show the greatest r^2 and F values. However, all of the regressions are significant on at least the 5% level with the sole exception of modulus of elasticity in static bending. Thus, the validity of the present data could be extended in the future by making a density survey of the species and combining the results with those of the present study.

In conclusion, the data show that Digger pine is very similar in its mechanical properties to ponderosa pine, and it is therefore suggested that these species might be grouped where strength is an important consideration.

REFERENCES

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM). 1976. Standard methods of testing small clear specimens of timber, D142–52. Annual Book of Standards. ASTM, Philadelphia.

SARGENT, C. S. 1884. Report on the forests of North America. Dept. Interior, Census Office, Washington, D.C.

U.S. FOREST PRODUCTS LABORATORY (USFPL). 1974. Wood Handbook. U.S. Dept. Agric., Agric. Handb. 72, rev. ed., Washington, D.C.