A STUDY

OF

STRUCTURAL SOUTHERN PINE

By

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In Charge of Investigation

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Dean of Engineering

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SYNOPSIS

A shipment of 5,591 board feet of dense select structural southern pine, graded and inspected to conform to standard grading rules for southern pine lumber, was carefully investigated in order to determine (1) whether the lumber is within grade limitations, (2) what are the variations in and ranges of its physical and mechanical properties, and (3) whether it fulfills anticipations of design specifications.

Within its limitations, the study indicates that the investigated lumber fulfills the expectations of the National Design Specification despite the fact that some of the planks are found below grade according to the standard grading rules. Hence, those recommendations of the National Design Specification subjected to investigation are substantiated by laboratory test data on a commercially stress-graded shipment of southern pine lumber.

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I. INTRODUCTION

During the recent war as much wood as could be made available was used for structural purposes. Because of the shortage in lumber, certain deviations from pre-war practices were employed which, in most cases, proved to be satisfactory. Probably the most pronounced of these changes were increases in the allowable working stresses. Many of the expediencies employed were based on assumptions made by designing engineers because of the lack of readily available information on characteristics and properties of the material.

It is the purpose of this investigation to provide designing engineers with definite information concerning what they actually may expect from a shipment of stress-graded lumber on the basis of laboratory studies of such a shipment.* Although only 1.5 to 2 percent of the nine billion board feet of southern pine lumber manufactured during 1947 were sold as dense select structural,[1] this grade was chosen for the study because the freedom of the grade from defects facilitates performance of directly comparative tests. Futhermore, it allows use of the highest allowable working stresses approved for any stress-graded southern pine lumber. For the latter reason, dense select structural southern pine requires especially careful inspection during grading to assure compliance with performance anticipations.

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* "Testing of southern pine has been for the most part on small clear specimens, and tests have not been made on structural sizes in commercial grade groups which would show the expected range in strength properties." (Correspondence of August 11, 1949, from Forest Products Laboratory to the author.)

1. Southern Pine Association, "Lumber Production," New Orleans: 1947.

The grading of lumber, according to the provisions given in Standard Grading Rules for Southern Pine Lumber,[2] cannot be considered an exact science because it is based on visual inspection of each piece and on the judgment of the grader. No arbitrary rules for inspection can be maintained with full satisfaction; therefore, exceptions from any given rule are suggested on the basis of good judgment. On the other hand, the grading provisions are sufficiently explicit to establish an amount of five percent below grade as a reasonable variation in judgment between graders and inspectors.

The reasons for difficulties in carrying out with satisfaction definite grading rules result from the characteristic variations in any piece of wood. Because of the nonhomogeneity of the material and these difficulties in grading, variations in physical and mechanical properties within a specific structural grade of southern pine are expected to occur. These variations are accepted within given specified ranges taken into consideration in setting up design specifications.

The investigation was undertaken specifically in order to: (1) determine whether a shipment of 5,591 board feet of carefully inspected dense select structural southern pine is within grade limitations. (2) indicate the existing variations and ranges in physical and mechanical properties within this shipment of lumber. (3) determine if this shipment fulfills anticipations of design specifications.

All test data, except those found in U. S. Forest Products Laboratory publications, were obtained in the V.P.I. Wood Research Laboratory under

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2. Southern Pine Inspection Bureau of the Southern Pine Association, Standard Grading Rules for Southern Pine Lumber, New Orleans: 1948, p. 8.

the auspices of the V.P.I. Research Foundation, Inc. Funds for the investigation were provided from a Frederick Gardner Cottrell Grant of the Research Corporation to the V.P.I. Wood Research Laboratory for a study of box columns, this investigation being part thereof. Gratitude is expressed to E. George Stern, Research Professor of Wood Construction, for the recommendation of this study and his guidance throughout the investigation. Acknowledgment is made to B. Y. Kinzey, Jr., Assistant Professor of Architecture, for his advice and help during the performance of the tests. Appreciation is extended to the Roper Bros. Lumber Company, Inc., of Petersburg, Virginia, and to Mr. R. C. Gregory, Inspector of the Southern Pine Inspection Bureau of the Southern Pine Association, for selecting, grading, and certifying the lumber under investigation before its shipment to the V.P.I. Wood Research Laboratory.

II. DESCRIPTION OF INVESTIGATION

A. Procedure

The variations in physical properties within a random-selected 2-in. by 8-in. by 8-ft. sapwood plank were determined from 1/2-in. thick consecutive full cross-sectional specimens. Variations in physical properties within 317 planks were found according to similar specimens sawn from an end of 8-ft. planks or from mid-length of 16-ft. planks.

The number of annual rings per inch was measured according to rules given in the Standard Grading Rules for Southern Pine Lumber.[3]

The percentage of summerwood was estimated visually for each specimen.

The specific gravity was determined upon drying the specimens at 97° C. in an electric oven; weighing them with a triple-beam balance, having a sensitivity of 0.01 g. and a capacity of 200 g.; and weighing their volumes when submerged in mercury.

Minor bending tests were made at a constant testing speed of 0.100 in. per min. with a Tinus Olsen testing machine, having a sensitivity of 50 lbs. and a capacity of 60,000 lbs.

B. Material

The tests were performed on dense select structural southern pine planks, originating in the area of Petersburg, Virginia. These planks were sawn, air-dried, and planed in the mill of the Roper Brothers Lumber Company, Inc. of Petersburg, Virginia. Each plank was carefully inspected and stamped by an official inspector of the Southern Pine Inspection Bureau. Some of the planks were resawn, planed, and reinspected before their shipment to the V.P.I. Laboratory, where the lumber was stacked and stickered until used for test purposes.

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3. Ibid. p. 47

III. TEST DATA

A. Physical Properties

The test data on variations in physical properties within a random-selected dense structural southern pine sapwood plank according to 136 consecutive specimens are tabulated in Appendix A. These data include the number of annual rings per inch, percentage of summerwood, and specific gravity.

The test data on variations in the above physical properties for specimens from the 317 dense select structural southern pine planks are tabulated in Appendix B.

B. Mechanical Properties

Minor test data on eight random-selected specimens tested in flexure for determination of the modulii of elasticity are given in Appendix C.

IV. TEST RESULTS

A. Variations in Physical Properties

1. Specific Gravity

Specific-gravity limitations are not given in the grading of lumber because of the necessity of destructive sampling and the time required for sawing specimens and performing the tests. However, this property is limited indirectly by requirements concerning the number of annual rings per inch and the percentage of summerwood.

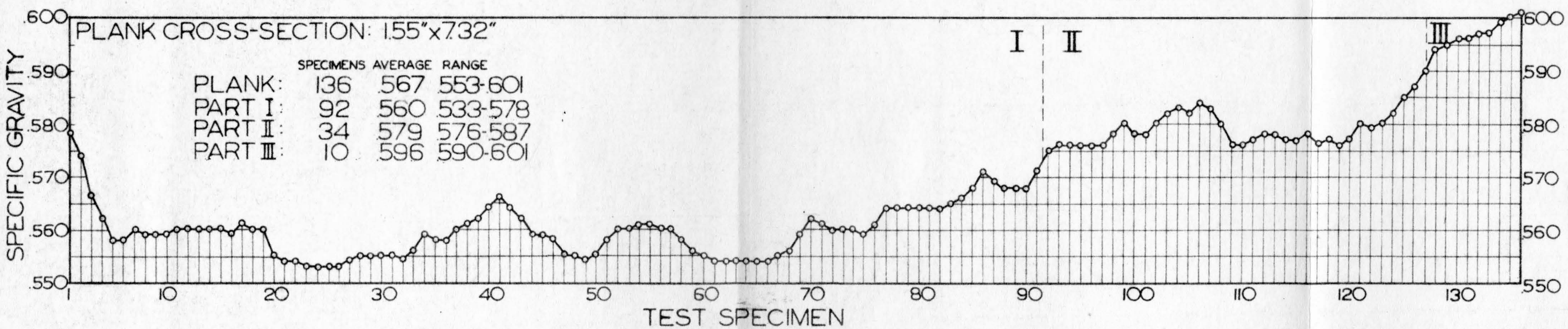
The variation in specific gravity according to the 136 specimens sawn from the random-selected sapwood plank is shown on Chart 1. The specific gravity ranges from 0.553 to 0.601 with an average of 0.567. As shown on Chart 2, ninety-five percent of the specific-gravity values are within the range of 0.553 to 0.594, and 50 percent of the values are within the range of 0.560 to 0.580.

The specific-gravity frequency distribution of this particular plank appears to fall into three groups. These groups are fully attributable to origin of samples within the tested plank, as shown on Chart 1.

The variation in specific gravity within the 315 planks tested is given on Chart 3. The specific gravity ranges from 0.448 to 0.745 with an average of 0.581. Ninety-five percent of the values are within the range from 0.490 to 0.700. Fifty percent of the values are within the range from 0.550 to 0.616.

CHART I

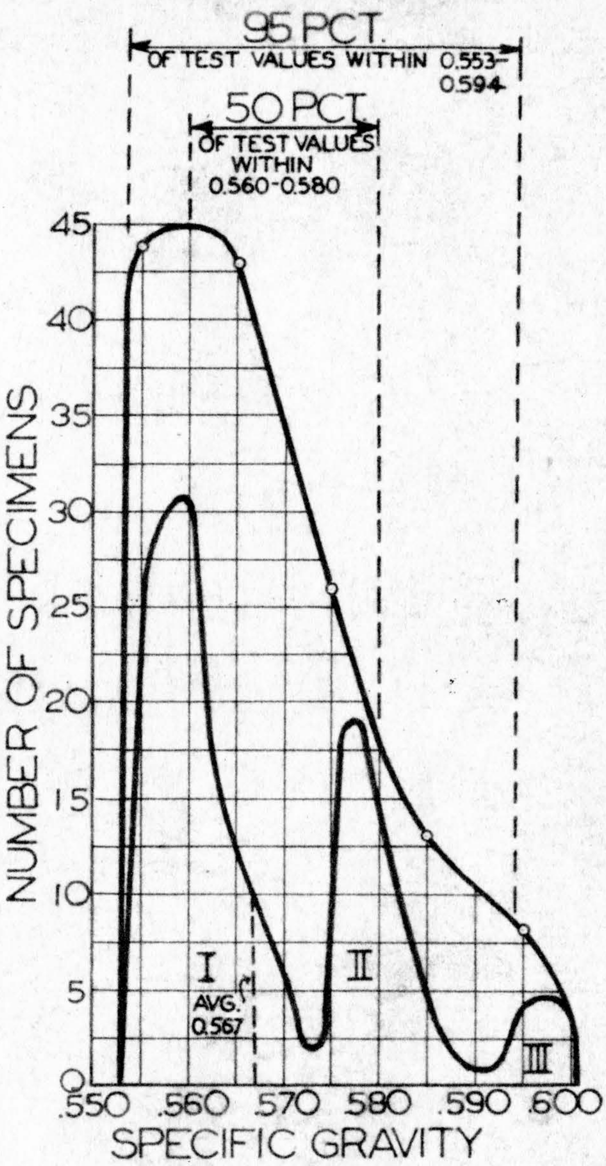
VARIATION IN SPECIFIC GRAVITY WITHIN 8-FT. DENSE STRUCTURAL SOUTHERN PINE SAPWOOD PLANK



SPECIFIC-GRAVITY DISTRIBUTION WITHIN PLANK

CHART 2

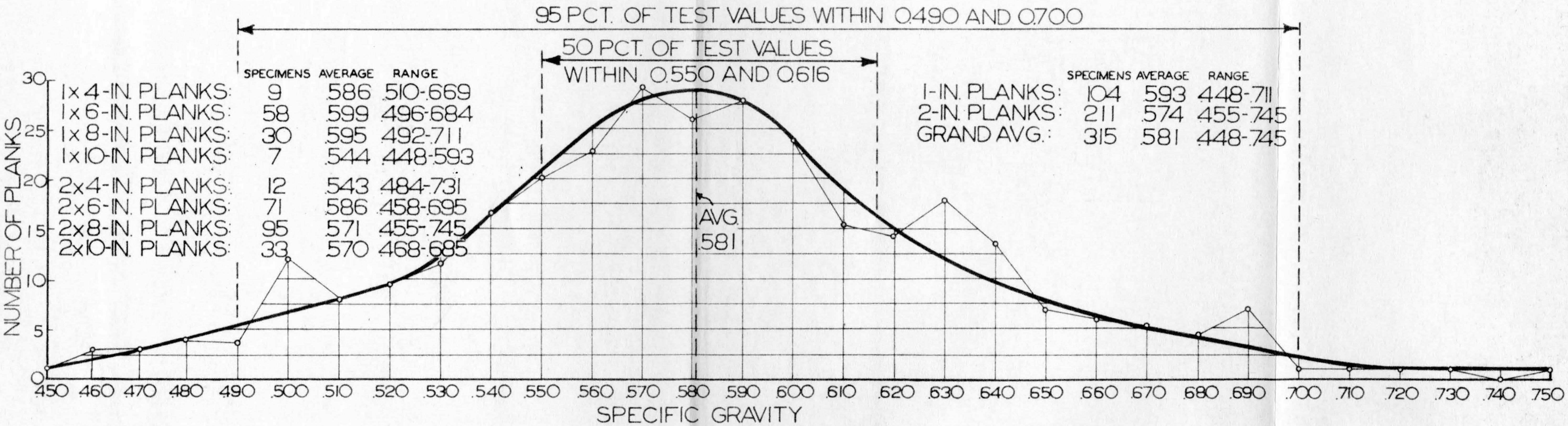
VARIATION IN SPECIFIC GRAVITY WITHIN 8-FT. DENSE STRUCTURAL SOUTHERN PINE SAPWOOD PLANK



AVERAGE FREQUENCY-DISTRIBUTION CURVE

CHART 3

VARIATION IN SPECIFIC GRAVITY OF 315 16-FT. DENSE STRUCTURAL SOUTHERN PINE PLANKS



AVERAGE FREQUENCY-DISTRIBUTION CURVE

2. Number of Annual Rings and Percentage of Summerwood

According to the grading rules for southern pine lumber,[4] a plank must have a minimum of six annual rings per inch, and in addition, one-third or more summerwood to meet the requirements of dense structural grade. However, a plank with less than six annual rings per inch meets the requirements of this grade if it averages one-half or more summerwood.

The number of annual rings per inch for the 317 planks ranges, as shown on Chart 4, from 4 to 19 with an average of 9. Ninety-five percent of the test values range between 5 and 16 annual rings per inch. Fifty percent of the test values are within the range from 8 to 11.

The amount of summerwood for the 317 planks ranges, as shown on Chart 5, from 25 to 65 percent with an average of 44 percent. Ninety-five percent of the test values range from 30 to 55 percent. Forty-six percent of the test values are within the range from 40 to 45 percent.

According to the above grading rules, 23 planks, that is 7.3 percent, do not meet grade requirements. This amount is 2.3 percent more than the 5 percent below grade established as a reasonable variation in observation. Of these 23 planks, 13 fail to meet the requirements for dense structural southern pine because each contains from one-third to one-half summerwood and less than six annual rings per inch. Ten planks, including two which average less than six annual rings per inch, fail to meet the above requirements because each has less than one-third summerwood.

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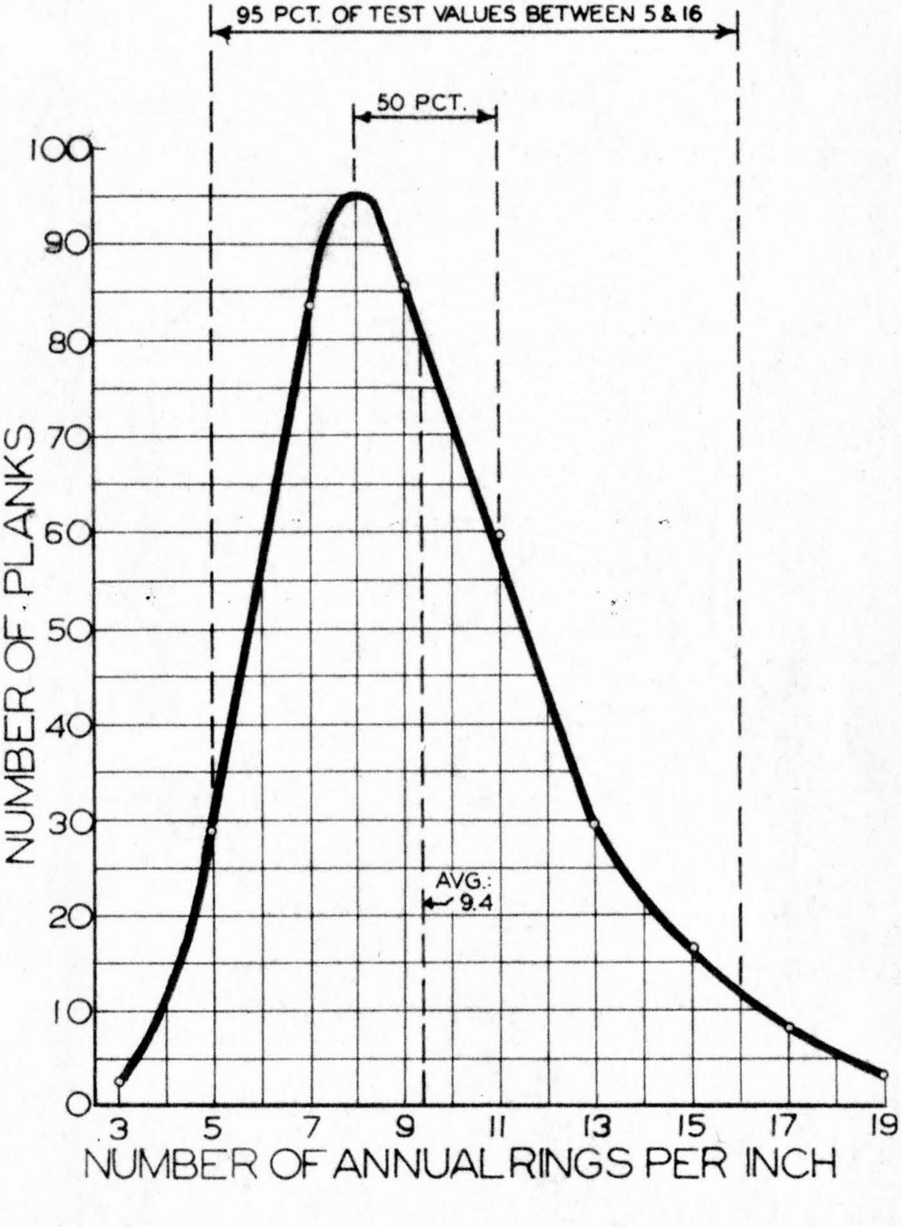
4. Ibid. p. 47.

CHART 4

VARIATION IN NUMBER OF ANNUAL RINGS PER INCH OF 317 16-FT. DENSE STRUCTURAL SOUTHERN PINE PLANKS

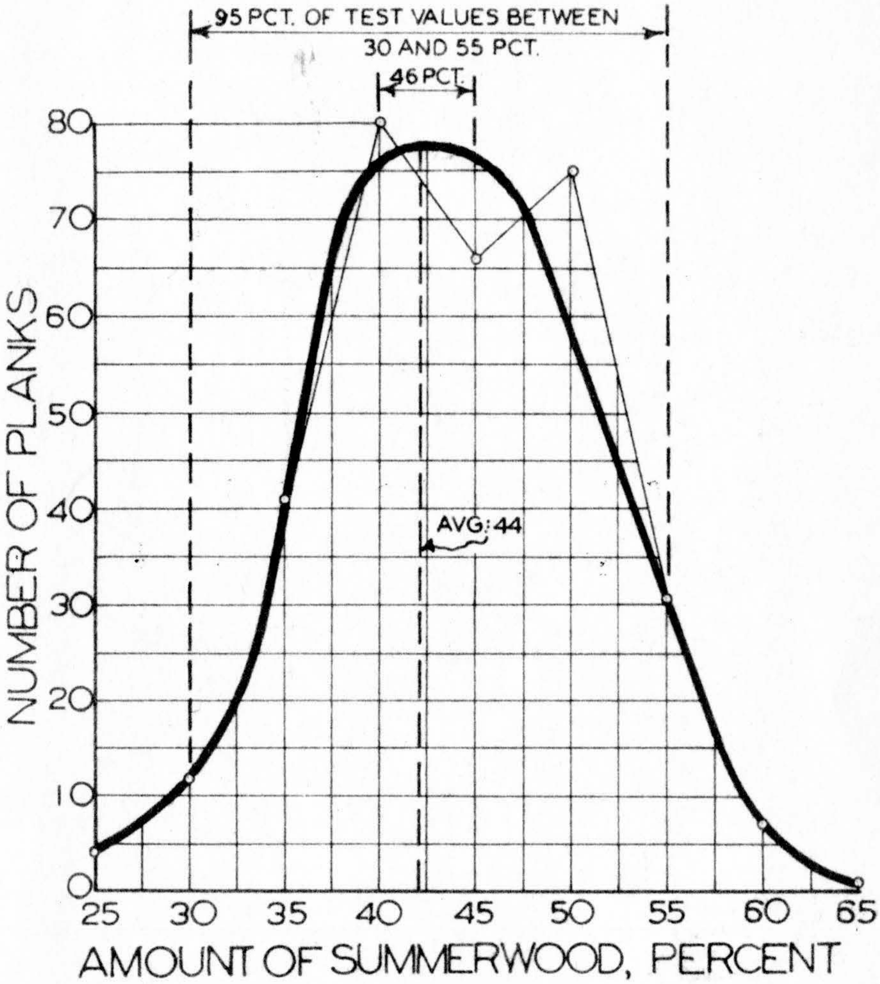


AVERAGE FREQUENCY-DISTRIBUTION CURVE

	SPECIMENS	AVERAGE	RANGE
1x4-IN. PLANKS:	9	10	7-13
1x6-IN. PLANKS:	58	10	5-18
1x8-IN. PLANKS:	30	9	5-15
1x10-IN. PLANKS:	7	7	5-9
2x4-IN. PLANKS:	12	11	5-15
2x6-IN. PLANKS:	72	9	5-16
2x8-IN. PLANKS:	96	9	4-18
2x10-IN. PLANKS:	33	9	4-19
1-IN. PLANKS:	104	10	5-18
2-IN. PLANKS:	213	9	4-19
AVERAGE:	317	9	4.-19

CHART 5

VARIATION IN AMOUNT OF SUMMERWOOD OF 317 16-FT. DENSE STRUCTURAL SOUTHERN PINE PLANKS



AVERAGE FREQUENCY-DISTRIBUTION CURVE

	SPECIMENS	AVERAGE	RANGE
1x4-IN. PLANKS:	9	47	40-50
1x6-IN. PLANKS:	58	46	25-60
1x8-IN. PLANKS:	30	48	40-60
1x10-IN. PLANKS:	7	42	25-55
2x4-IN. PLANKS:	12	35	30-40
2x6-IN. PLANKS:	72	45	35-65
2x8-IN. PLANKS:	96	42	25-55
2x10-IN. PLANKS:	33	42	30-50
1-IN. PLANKS:	104	46	25-60
2-IN. PLANKS:	213	43	25-65
AVERAGE:	317	44	25-65

B. Variations in Mechanical Properties

Since a considerable range in specific gravity exists within the test material, a similar range in mechanical properties may be expected. The modulus of elasticity for eight random-selected specimens which were tested in flexure varies from 1,560,000 to 2,230,000 psi, that is -24 and +9 percent from the average of 2,040,000 psi.

V. CORRELATION OF PHYSICAL AND MECHANICAL PROPERTIES

A. Specific Gravity as Related to Mechanical Properties

The strength of wood is indicated by its density, which in the metric system is numerically equal to its specific gravity. Some mechanical properties of wood vary directly with the specific gravity, while others, such as modulus of rupture and fiber stress at proportional limit in flexure, vary with a power of specific gravity larger than one.

General formulas have been established[5] to determine the mechanical properties of wood on the basis of average relations of specific gravity to strength properties among different species. However, these formulas are not fully applicable to all individual wood species for the following reasons: (1) Some species of wood contain relatively large amounts of resins, gums, and other extractives, which increase the specific gravity but do not contribute as much to the strength as would a like amount of wood substance. (2) The structural arrangement of fibers varies among different species.

A statistical analysis of the flexural test data, given in Appendix D, indicates that for the tested southern pine, the difference between the modulus of elasticity as computed from flexure tests and the modulus of elasticity as computed from specific-gravity data according to the above general formulas is statistically insignificant. Consequently, the use of the general formulas seems to be justified for determining modulus of elasticity and other mechanical properties of the test material.

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5. Markwardt, L. J. and Wilson, T. R. C., Strength and Related Properties of Woods Grown in the United States, Washington: United States Department of Agriculture. September, 1935, p. 37.

The ranges for moduli of elasticity and other mechanical properties, as computed according to the general Forest Products Laboratory formulas and specific-gravity test data, are presented in Table I, which indicate the formulas used, extreme ranges, 95 percent ranges, and average values.

B. Number of Annual Rings and Percentage of Summerwood as Related to Mechanical Properties

The average number of annual rings per inch within a plank is not a direct indication of the plank's mechanical properties. These annual rings merely show the tree's favorable or unfavorable rate of growth, which may or may not seriously affect the strength of the wood within the tree. Wood which is grown at a medium rate of growth in a tree supplied with plenty of plant food and a reasonable amount of water has better mechanical properties than does the same volume of wood grown at a very fast rate and formed from a sparce amount of plant food and an abundance of water. For this reason, the number of annual rings per inch alone, without consideration of the wood density, is no true criterion upon which to base the mechanical properties of wood.

The above statements are substantiated by the reported findings. Thirteen of the 23 planks fail to meet grade requirements for dense select structural southern pine because each contains between one-third and one-half summerwood and less than six annual rings per inch. However, the specific gravity for each of these planks is well above 0.490, which is the lower limit for the 95 percent range for specific gravity of the tested material. Furthermore, the specific-gravity values for four of these specimens are above the average value of 0.581 for the 315 tested planks. The structural use of these 13 planks appears justified as their mechanical properties, computed

TABLE I

Ranges in Mechanical Properties within 315 Dense Select Structural Southern Pine Planks as Expected According to Specific-Gravity Test Data

Property	Formula	Extreme Range	Ninety-Five Percent Range	Average
Specific Gravity		0.448 - 0.745	0.490 - 0.700	0.581
		Psi	Psi	Psi
Static Bending:				
Fiber Stress at Proportional Limit	$7{,}700\left(\frac{G}{0.54}\right)^{1.25}$	6,100 - 11,500	6,810 - 10,600	8,440
Modulus of Rupture................	$12{,}800\left(\frac{G}{0.54}\right)^{1.25}$	10,100 - 19,100	11,200 - 17,400	14,000
Modulus of Elasticity.............	$\frac{1{,}760{,}000}{0.54}G$	1,460,000 - 2,430,000	1,600,000 - 2,280,000	1,890,000
Compression Parallel to Grain:				
Fiber Stress at Proportional Limit	$\frac{5{,}090}{0.54}G$	4,220 - 7,020	4,620 - 6,600	5,480
Maximum Crushing Strength.........	$\frac{7{,}700}{0.54}G$	6,390 - 10,600	6,990 - 9,980	8,280
Compression Perpendicular to Grain:				
Fiber Stress at Proportional Limit	$1{,}000\left(\frac{G}{0.54}\right)^{2.25}$	659 - 2,060	803 - 1,790	1,180

Note: G represents specific gravity of oven-dry specimen.

according to previously given formulas, are high in value, even though the planks are expected to be below grade according to grading rules.

The remaining 10 of these 23 planks fail to meet the grade requirements because each contains less than one-third summerwood. The structural use of these 10 planks is not recommended for construction specifying dense select structural southern pine because all of the planks have specific-gravity values of less than 0.490, except two, which are only 3 percent and 1.6 percent above the value of 0.490.

From the previous cases, it appears that in the southern pine tested, the percentage of summerwood, as an indication of density, is of more importance than the number of annual rings per inch in estimating the mechanical properties of the material. This fact can be explained on the basis that an annual ring is composed of both springwood and summerwood. Summerwood is normally harder, stronger, and less brash than the springwood. Consequently, a higher percentage of summerwood gives higher mechanical properties of the material.

VI. ANTICIPATED PROPERTIES VS. TEST PROPERTIES

A comparison of the test properties, shown in Table I, with basic information from which National Design Specification[6] design data were derived, may be made to determine whether the investigated shipment of lumber fulfills anticipations of this specification. The allowable design stresses were derived from U. S. Forest Products Laboratory average test data, as summarized in Technical Bulletin No. 479.[7] These average data and the corresponding 95 percent ranges, the latter according to Forest Products Laboratory files,[8] are compared in Table II with the respective properties of the investigated lumber. For comparative purposes, correction is made for the influence of seasoning since the design data were derived from test values for green material and the investigated shipment of lumber was tested when air-dry. This correction is made on the basis of data given in Table I of the above Technical Bulletin.

According to Table II, the 95 percent ranges of all test properties given for the investigated material are within the 95 percent ranges for the corresponding Forest Products Laboratory data. Furthermore, the minimum values for the extreme, that is, 100 percent ranges are greater than the corresponding values for the 95 percent ranges of the Forest Products Laboratory data. Hence, all of the investigated lumber fulfills anticipations of the National Design Specification despite the following facts:

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6. National Lumber Manufacturers Association, National Design Specification for Stress-Grade Lumber and Its Fastenings, Washington: 1948, p. 12.

7. Markwardt, L. J. and Wilson, T. R. C., Strength and Related Properties of Woods Grown in the United States, Washington: United States Department of Agriculture. September, 1935, (Technical Bulletin No. 479), Table I.

8. Correspondence of August 11, 1949, from Forest Products Laboratory to the author.

TABLE II

Properties According to Forest Products Laboratory Data
for Small Clear Green Longleaf-Pine Test Specimens and for
315 Dense Select Structural Southern Pine Planks, Corrected to Green Condition

(All Mechanical Properties in Psi.)

	F.P.L. Test Data		V.P.I. Test Data		
Property	95 Pct. Range	Average	95 Pct. Range	Extreme Range	Average
Specific Gravity	0.390 - 0.700	0.620	0.490 - 0.700	0.448 - 0.745	0.581 (-6.3%)*
Static Bending:					
Fiber Stress at Proportional Limit	2,500 - 6,000	5,200	3,800 - 5,900	3,400 - 6,400	4,720 (-9.2%)
Modulus of Rupture	-	8,700	6,600 - 10,000	6,000 - 11,000	8,290 (-4.7%)
Mod. of Elasticity	1,100,000 - 2,500,000	1,600,000	1,300,000 - 1,800,000	1,200,000 - 2,000,000	1,520,000 (-5.0%)
Compression Parallel to Grain:					
Fiber Stress at Proportional Limit	1,500 - 4,500	3,430	2,600 - 3,700	2,400 - 3,900	3,120 (-9.0%)
Compression Perpendicular to Grain					
Fiber Stress at Proportional Limit	200 - 1,000	590	400 - 900	327 - 1,000	585 (-0.8%)

* Percentage Variation from F.P.L. Average.

(1) The average test data for the investigated lumber are from 0.8 to 9.2 percent lower than the corresponding average Forest Products Laboratory data. (2) According to the design of the standard grading rules, 7.3 percent of the 315 planks are found to be below grade.

The average specific gravity for the tested lumber, which is 6.3 percent smaller than that determined for the Forest Products Laboratory tested material, results in such smaller average strength properties as listed in Table II. These decreases are of no appreciable influence on the design data computed for the tested lumber. Analogous derivation of the flexural design stress for dense select structural southern pine according to both F.P.L. and V.P.I. data is presented in Table III. From an average modulus of rupture of 8,700 psi., according to F.P.L. tests, the design stress of 2,400 psi. is derived which corresponds to that given in the National Design Specification. From the corresponding V.P.I. data of 8,290 psi., the design stress of 2,320 psi. may be derived, if the F.P.L. variability factor of one-quarter is employed. However, a design stress of 2,470 psi. is computed if the variability factor of one-fifth for 95 percent of the tested 315 planks is used.

The presented data for the investigated lumber substantiate the justification of the use of a flexural design stress of 2,400 psi., as recommended since 1944 in the National Design Specification for dense select structural southern pine.

This design stress of 2,400 psi. was increased only on the basis of additional field experience with erected structures from 2,000 psi., recommended prior to 1944. Tests never were performed on commercially stress-gradedlumber in order to verify the greater expected strength properties. Since this investigation of a carefully stress-graded and certified lumber

TABLE III

Derivation of Design Data for Flexural Stresses
for
Dense Select Structural Southern Pine

(All Stresses in Psi.)

		F.P.L. Derivation	V.P.I. Derivation for Variability of	
			1/4	1/5
Test Stress	Average Modulus of Rupture....................	8,700	8,290	8,290
	Deduct 1/4 or 25% for F.P.L. Variability....	6,525	6,218	6,632
	Deduct 7/16 or 43.7% for Time Effect........	3,670	3,498	3,730
	Deduct 1/3 or 33.3% for Size Effect.........	2,437	2,332	2,487
Basic Stress	Add 1/20 or 5% for Field Experience.........	2,559	2,449	2,611
Working Stress	Deduct (1/4) or 26% for Strength Ratio of 74% Plus 1/2 or 50% of Strength Ratio above 50% for Dry Location, that is, a total of (1/7) or 14%..............	2,201	2,106	2,245
	Add 1/10 or 10% for Normal Loading..........	2,421	2,317	2,469
Design Stress	Rounding Out................................	2,400	2,400	

shipment gives satisfactory evidence that the investigated anticipated strength properties are justified, the corresponding design data recommended since 1944 can be considered trustworthy and dependable.

VII. SUMMARY

(1) The shipment of 5,591 board feet of dense select structural southern pine, graded and inspected to conform to the standard grading rules for southern pine lumber, contained 23 of 317 planks, that is 7.3 percent, which do not fully meet grade requirements on the basis of careful laboratory inspection of full cross-sectional specimens sawn from mid-length of 16-ft. or an end of 8-ft. planks. This amount is 2.3 percent more than the 5 percent below grade established as a reasonable variation in judgment between graders and inspectors. However, the use of 13 of the 23 planks as dense select structural grade may be justified because of satisfactory specific-gravity values.

(2) The variation in specific gravity within a random-selected sapwood plank ranges from -2.5 to +6.0 percent of its average value of 0.567.

The variation in specific gravity within the 315 planks tested ranges from -23 to +28 percent of its average value of 0.581. This latter value is 6.3 percent smaller than the respective value given by the Forest Products Laboratory for this grade of southern pine. Correspondingly, the computed average flexural fiber stress at proportional limit is 9 percent smaller, the modulus of rupture and flexural modulus of elasticity are 5 percent smaller, and the compression-parallel and perpendicular-to-grain fiber stresses at proportional limit are 9 and 1 percent smaller, respectively.

The computed 95 percent ranges for all test properties for the investigated material are within the 95 percent test ranges for the corresponding Forest Products Laboratory data, and the computed minimum values for the extreme ranges are greater than the corresponding values for the 95 percent ranges of the Forest Products Laboratory data.

(3) Since derivation of flexural design stresses for the investigated lumber shipment indicates that the use of a design stress of 2,400 psi. is justified, the shipment fulfills the anticipation of the National Design Specification. Hence, the flexural design data for the investigated lumber grade, as recommended in the National Design Specification, can be considered fully reliable in light of this investigation.

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APPENDIX A

VIRGINIA POLYTECHNIC INSTITUTE
Engineering Experiment Station
WOOD RESEARCH LABORATORY
DATA SHEET

Project No: Res. Found. No. 117 Series No.: S. Y. P. Date: March, 1949

Project: Variations in Physical Properties of a 2" x 8" x 8' Dense Select Structural Southern Pine Plank (Sapwood Only)

Observers: O. J. Blake; E. G. Stern

Testing Machine: Triple-Beam Balance, Mercury Volumeter

Test Number	No. of Rings	Pct. of Summerw.	Oven-Dry Weight	Weight In Merc.	Specific Gravity
1	5½	35	52.94	5215	.578
2	5½	35	57.78	5745	.574
3	5½	35	53.01	5345	.566
4	5½	35	51.15	5190	.562
5	5½	40	53.20	5435	.558
6	5½	40	58.37	5950	.558
7	5½	35	60.82	6190	.560
8	5½	35	56.63	5805	.559
9	5½	35	58.45	5985	.559
10	5½	35	58.36	5965	.559
11	5½	35	58.73	5980	.560
12	5½	35	56.71	5775	.560
13	5½	35	55.69	5680	.560
14	5½	35	58.29	5935	.560
15	5½	35	56.91	5795	.560
16	5½	35	55.48	5670	.559
17	5½	35	57.49	5835	.561
18	5½	35	58.80	6005	.560
19	5½	40	57.20	5820	.560
20	5½	40	57.22	5895	.555
21	5½	40	54.11	5580	.554
22	5½	40	57.81	5960	.554
23	5½	40	56.72	5860	.553
24	5½	40	55.88	5760	.553
25	5½	40	57.25	5900	.553
26	5½	40	58.47	6025	.553
27	5½	40	58.19	5990	.554
28	5½	40	55.31	5685	.555
29	5½	40	58.32	6030	.555
30	5½	35	56.84	5865	.555
31	5½	35	58.96	6040	.555
32	5½	35	58.50	6020	.554
33	5½	35	57.31	5870	.556
34	5½	35	55.82	5690	.559
35	5½	35	55.62	5660	.558
36	5½	35	58.91	6020	.558
37	5½	35	60.90	6210	.560
38	5½	35	59.25	6035	.561
39	5½	35	59.05	6005	.562
40	5½	35	57.56	5840	.564
41	5½	35	57.23	5740	.566
42	5½	35	57.76	5830	.564
43	5½	35	57.43	5840	.562
44	5½	35	59.63	6110	.559
45	5½	35	55.84	5710	.559
46	5½	35	56.65	5800	.558

47	5½	35	57.24	5895	.555
48	5½	35	58.22	5970	.555
49	5½	35	58.25	5940	.554
50	5½	35	56.82	5800	.555
51	5	40	57.69	5900	.558
52	5	40	58.61	5955	.560
53	5	40	57.10	5805	.560
54	5	40	57.27	5805	.561
55	5	40	57.44	5840	.561
56	5	40	57.17	5830	.560
57	5	40	57.23	5840	.560
58	5	40	57.90	5920	.558
59	5	40	57.09	5850	.558
60	5	40	57.18	5865	.557
61	5	40	57.76	5955	.554
62	5	40	58.42	6020	.554
63	5	40	57.47	5920	.554
64	5	40	55.09	5655	.554
65	5	40	57.88	5920	.554
66	5	40	57.87	5925	.554
67	5	40	55.04	5655	.555
68	5	40	56.29	5765	.556
69	5	40	57.28	5830	.559
70	5	40	58.88	5975	.562
71	5	40	55.60	5635	.561
72	5	40	59.15	6015	.560
73	5	40	57.33	5855	.560
74	5	40	55.52	5655	.560
75	5	40	56.78	5780	.559
76	5	40	57.24	5815	.561
77	5	40	59.28	5985	.564
78	5	40	60.11	6080	.564
79	5	40	56.75	5735	.564
80	5	40	56.61	5745	.564
81	5	40	57.12	5785	.564
82	5	40	60.19	6075	.564
83	5	40	55.94	5645	.566
84	5	40	53.76	5395	.567
85	5	40	56.90	5700	.568
86	5	40	55.82	5560	.571
87	5	40	59.61	5975	.569
88	5	40	53.24	5360	.568
89	5	40	58.84	5910	.568
90	5	40	56.31	5650	.568
91	5	40	59.85	5950	.571
92	5	40	59.18	5855	.575
93	5	40	56.45	5560	.576
94	5	40	58.59	5790	.576
95	5	40	58.45	5780	.576
96	5	40	58.14	5750	.576
97	5	40	57.58	5685	.576
98	5½	40	59.13	5805	.578
99	5½	40	59.13	5800	.580
100	5	40	58.83	5795	.578
101	5	40	57.25	5640	.578
102	5	40	53.63	5250	.580

103	5	40	58.50	5705	.582
104	5	40	59.12	5765	.583
105	5	40	57.02	5580	.582
106	5	40	58.93	5760	.584
107	5	40	56.55	5525	.583
108	5	40	57.85	5685	.580
109	5	40	54.32	5375	.576
110	5	40	59.36	5855	.576
111	5	40	59.67	5865	.577
112	5	40	58.18	5730	.577
113	5	40	59.59	5860	.578
114	5	40	58.00	5710	.577
115	5	40	56.37	5540	.577
116	5	40	56.64	5555	.579
117	5	40	56.72	5615	.576
118	5	40	58.56	5765	.577
119	5	40	59.08	5845	.576
120	5	40	58.87	5795	.577
121	5	40	57.98	5655	.580
122	5	40	59.47	5855	.579
123	5	40	58.21	5700	.580
124	5	40	58.77	5725	.582
125	5	40	56.30	5475	.585
126	5	40	59.40	5735	.587
127	5	40	59.20	5680	.590
128	5	40	57.93	5520	.594
129	5	40	58.54	5575	.595
130	5	40	59.83	5690	.596
131	5	40	60.64	5765	.596
132	5	40	59.31	5625	.597
133	5	40	59.85	5680	.597
134	5	40	59.44	5625	.599
135	5	40	59.32	5580	.600
136	5	40	62.71	5900	.601
Avg.					.567

APPENDIX B

VIRGINIA POLYTECHNIC INSTITUTE
Engineering Experiment Station
WOOD RESEARCH LABORATORY
DATA SHEET

Project No: Res. Found. No. 117, Series No.: S. Y. P. Date: March, 1949

Project: Variations in Physical Properties of Dense Select Structural Southern Pine

Observers: O. J. Blake; E. G. Stern

Testing Machine: Triple-Beam Balance, Mercury Volumeter

Test Number	Plank Size	Plank Sign	No. of Rings Per In.	Pct. of Summerw.	Pct. of Heartw.	Oven-Dry Weight g.	Weight In Merc. g.	Specific Gravity
1	1"x4"	jA33Nac	11	50	0	15.00	1400	.607
2		jA33Nbd	12	45	0	15.03	1450	.589
3		jA33'Nac	10	45	0	10.33	1100	.535
4		jA33'Nbd	9	40	0	12.40	1240	.568
5		jA33"Nac	8	50	0	12.94	1215	.603
6		jA33"Nbd	12	45	0	12.00	1340	.510
7		jB34Nd	7	50	0	12.20	1030	.669
8		jB34'Nbd	8	55	0	12.76	1140	.630
9		jB34"Nbd	13	40	0	8.18	830	.560
Avg.								.586
10	1"x6"	jB34Nb	17	50	0	15.77	1390	.640
11		jB34Nac	13	55	0	18.80	1685	.633
12		jB34'Nac	16	55	0	19.06	1665	.649
13		jB34"Nac	9	50	0	18.97	1725	.622
14		iA31Nac	8	45	0	21.30	1975	.612
15		iA31Nbd	13	40	15	21.17	2010	.597
16		iA31'Nac	10	40	0	18.80	1910	.560
17		iA31'Nbd	14	50	0	20.57	1945	.600
18		iA31"Nac	9	50	0	21.44	1975	.615
19		iA31"Nbd	8	55	0	21.91	1970	.631
20		iB32Nbd	6	60	0	14.80	1530	.550
21		iB32'Nbd	9	45	0	14.42	1540	.535
22		iB32"Nac	7	40	0	14.97	1480	.575
23		iB32"Nbd	7	35	0	16.53	1690	.557
24		gA23Na	10	35	0	17.65	1725	.581
25		gA23Nb	11	50	0	21.20	1830	.656
26		gA23Nc	14	45	0	17.31	1600	.612
27		gA23Nd	10	50	0	18.01	1630	.625
28		gA23'Na	5	45	0	17.51	1680	.590
29		gA23'Nb	8	55	0	13.95	1255	.629
30		gA23'Nc	14	40	50	18.08	1760	.584
31		gA23'Nd	9	50	0	19.47	1735	.635
32		gA23"Na	9	50	0	23.30	1960	.673
33		gA23"Nb	13	35	0	9.90	995	.565
34		gA23"Nc	8	35	0	17.07	1745	.556
35		gA23"Nd	12	55	0	12.62	1035	.685
36		gAS24Na	9	45	0	18.02	1660	.616
37		gAS24Nb	12	55	0	31.68	2700	.663
38		gAS24Nc	12	35	0	17.60	1780	.564
39		gAS24Nd	10	35	0	17.43	1690	.585
40		gAS24'Na	7	40	0	16.90	1595	.600
41		gAS24'Nb	11	45	0	14.36	1635	.500
42		gAS24'Nc	10	35	0	19.54	1795	.619
43		gAS24'Nd	8	35	0	18.07	1805	.570
44		gB25Na	8	45	0	19.73	1750	.638

45		gB25Nb	7	55	0	19.14	1695	.640	
46		gB25Nc	18	50	0	17.07	1730	.560	
47		gB25Nd	6	60	0	19.56	1850	.600	
48		gB25'Na	9	50	0	19.32	1710	.640	
49		gB25'Nb	18	40	25	17.75	1775	.570	
50		gB25'Nc	10	45	0	18.86	1810	.592	
51		gB25'Nd	9	50	0	16.83	1655	.580	
52		gB25"Na	15	40	0	18.71	1775	.598	
53		gB25"Nb	7	55	0	17.85	1625	.623	
54		gB25"Nc	7	45	0	17.68	1780	.565	
55		gB25"Nd	7	50	0	18.89	1685	.635	
56		gBS26Na	6	25	0	14.90	1710	.498	
57		gBS26Nb	12	50		18.09	1695	.605	
58		gBS26Nc	10	35		14.59	1685	.496	
59		gBS26Nd	18	50		16.88	1605	.597	
60		gBS26'Na	7	35		16.21	1745	.532	
61		gBS26'Nb	8	45		19.43	1690	.650	
62		gBS26'Nc	15	50		13.97	1255	.630	
63		gBS26'Nd	8	50		32.77	3300	.565	
64		gBS26"Na	16	60		18.98	1690	.635	
65		gBS26"Nb	10	55		26.77	2430	.629	
66		gBS26"Nc	13	40		17.89	1580	.640	
67		gBS26"Nd	10	50		28.22	3035	.532	
Avg.								.599	
68	1"x8"	iB32Nac	11	50		18.84	1575	.675	
69		iB32'Nac	11	60		23.94	2166	.627	
70		gAS24"Na	14	55		24.35	2135	.646	
71		gAS24"Nb	7	45		20.43	2180	.536	
72		gAS24"Nc	8	50		22.63	2155	.597	
73		gAS24"Nd	13	50		25.94	2120	.691	Small Pitch Pockets
74		gB25Nac	9	50		20.17	1670	.683	
75		gB25'Nac	7	45		23.77	2275	.593	
76		gB25"Nac	15	45		25.47	2280	.633	
77		gBS26Nac	7	40		20.27	2305	.504	
78		gBS26'Nac	7	50		25.84	2305	.634	
79		gBS26"Nac	5	40		7.86	900	.499	
80		hA27Nac	8	40		23.36	2490	.535	
81		hA27Nbd	12	50		22.74	2485	.524	
82		hA27'Nac	7	45		16.25	1505	.611	
83		hA27'Nbd	11	55		23.56	2425	.553	
84		hA27"Nac	5	45		23.24	2470	.538	
85		hA27"Nbd	15	55		25.70	2325	.627	
86		hAS28Nac	6	40	0	33.22	3110	.605	
87		hAS28Nbd	9	45	0	25.17	2060	.688	
88		hAS28'Nac	9	50	0	23.32	2430	.547	
89		hAS28'Nbd	8	45	0	23.67	2435	.553	
90		hAS28"Nac	7	45	0	22.11	2345	.539	
91		hAS28"Nbd	12	50	0	26.20	2360	.629	
92		hB29Nbd	9	55	0	23.16	2070	.634	
93		hB29N'bd	10	55	0	22.29	2105	.601	
94		hB29N"bd	7	50	0	21.48	2145	.571	
95		hBS30Nbd	7	50	0	21.93	2195	.570	
96		hBS30'Nbd	7	40	0	19.90	2320	.492	
97		hBS30"Nbd	12	60	0	26.01	2060	.711	
Avg.								.595	

68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97

98		hB29Nac	6	45	0	29.45	2945	.568	
99		hB29'Nac	7	45	0	32.60	3135	.590	
100	1" x 10"	hB29"Nac	5	25	0	22.72	2920	.448	
101		hBS30Nac	6	30	0	22.54	2835	.457	
102		hBS30'Nac	9	50	20	22.34	2175	.585	
103		hBS30"Na	7	55	0	24.71	2495	.565	
104		hBS30"Nc	7	45	0	31.48	3010	.593	
								.544	
105		fB22Nd	10	40	8	32.75	2525	.731	Small Pitch Pocket
106		fB22Nb	10	30	1	19.55	2315	.484	
107		fB22'Nb	9	35	0	23.72	2225	.604	
108	2" x 4"	fB22'Nd	12	35	0	11.99	1465	.469	
109		fA21NTa	11	40	2	22.43	2565	.501	Small Pitch Pocket
110		fA21NTb	5	35	30	24.85	2585	.548	Knot, Pitch Pocket
111		fA21NTc	15	35	60	17.79	1935	.525	
112		fA21NTd	10	40	5	19.89	2095	.542	
113		fA21'NTa	8	35	0	20.16	2105	.547	
114		fA21'NTb	12	35	3	19.05	2010	.542	
115		fA21'NTc	15	35	8	20.44	2340	.500	Small Pitch Pocket
116		fA21'NTd	11	35	35	9.66	1060	.520	Close to Pitch Pocket
								.543	
117		fA21'Nbd	5	40	0	12.70	1305	.555	
118		fA21"Nac	8	40	0	32.10	3120	.585	
119		fA21"Nbd	6	60	20	39.09	3600	.615	
120		fB22Nac	10	45	0	36.55	3508	.592	
121		fB22'Nac	5	30	0	23.00	2815	.469	
122		fB22"Nac	15	45	35	19.10	1850	.586	Small Pitch Pocket
123		fB22"Nbd	9	55	0	10.94	935	.663	Knots
124		eB20NGbd	8	40	0	33.64	3320	.577	
125		eB20'NGbd	10	55	0	10.82	1055	.582	
126		eB20"NGbd	12	45	0	43.51	3925	.628	
127		eB19Nbd	16	60	0	43.75	3740	.663	Small Pitch Pockets
128	2" x 6"	eB19'Nbd	8	50	0	38.48	3750	.584	
129		eB19"Nbd	12	50	0	30.70	2945	.592	
130		eA18NGac	11	50	0	42.19	3610	.662	Small Pitch Pockets
131		eA18NGbd	13	45	15	38.31	3850	.567	
132		eA18'NGac	8	50	0	41.61	3820	.618	
133		eA18'NGbd	9	45	5	26.35	2640	.569	Small Pitch Pocket
134		eA18"NGac	5	50	0	16.35	1660	.562	
135		eA18"NGbd	9	45	0	30.00	3765	.458	
136		eA17Nac	7	40	0	31.26	3370	.530	
137		eA17Nbd	9	50	0	31.39	2990	.597	
138		eA17'Nac	6	40	0	33.71	3715	.520	
139		eA17'Nbd	11	50	0	35.32	3570	.538	
140		eA17"Nac	8	55	0	43.33	3770	.651	
141		eA17"Nbd	8	35	1	32.73	3330	.560	
142		cB14NGc6	13	45	20	38.94	4015	.553	
143		cB14'NGc6	7	40	0	44.12	4370	.575	
144		cB14'NGa6	9	40	0	34.43	3520	.557	
145		cB14"NGac	6	65	0	21.14	1750	.682	
146		cB13Na	9	40	0	39.06	4055	.550	Small Knot
147		cB13Nc	11	55	15	36.49	3590	.578	
148		cB13'Na	8	40	0	36.11	3760	.547	
149		cB13'Nc	10	45	20	35.43	3360	.598	
150									

151		cB13"Na	10	55	0	48.44	3965	.690	Small Pitch Pocket
152		cB13"Nc	9	50	0	41.30	3800	.617	
153		bBS10Nac6	14	45	0	37.26	3625	.585	
154		bBS10Nd	15	55	0	11.43	1110	.580	
155		bBS10Nb	7	40	0	38.59	3765	.583	Small Pitch Pocket
156		bBS10'Nac6	12	55	0	34.34	3435	.570	
157		bBS10'Nd	10	45	0	33.40	3540	.539	
158		bBS10'Nb	9	40	0	32.37	3485	.530	
159		bBS10"Nac6	7	40	0	40.79	3695	.627	
160		bBS10"Nd	9	45	0	40.33	3565	.641	
161		bBS10"Nb	8	50	0	40.87	3805	.610	
162		bB9Nac6	10	45	20	35.02	3175	.625	Small Pitch Pocket
163		bB9Nb	8	35	15	24.29	2650	.524	Small Pitch Pocket
164		bB9Nd	13	50	0	45.27	4355	.592	
165		bB9'Nac6	7	45	0	36.05	3530	.582	
166		bB9'Nb	8	45	0	28.33	3000	.542	
167		bB9'Nd	10	40	0	23.62	2450	.549	
168		bB9"Nac6	11	45	0	34.79	3520	.563	
169		bB9"Nb	6	35	0	42.06	4075	.588	
170		bB9"Nd	11	55	0	42.70	3465	.695	
171		bAS8Na	10	50	0	39.46	3445	.647	
172		bAS8Nb	10	40	0	34.18	3465	.562	
173		bAS8Nc	12	40	5	32.11	3045	.598	
174		bAS8Nd	8	50	0	43.14	3645	.670	
175		bAS8'Na	9	40	0	30.59	2955	.589	
176		bAS8'Nb	7	30	0	29.15	4070	(.414)	
177		bAS8'Nc	11	50	0	30.74	3115	.562	
178									
179		bA7Na	12	45	0	38.95	3725	.592	
180		bA7Nb	12	55	0	36.51	3415	.607	
181		bA7Nc	9	40	0	36.44	4010	.520	
182		bA7Nd	8	40	0	35.06	3550	.562	
183		bA7'Na	11	35	15	38.70	3715	.592	Small Pitch Pocket
184		bA7'Nb	8	40	0	39.62	3540	.635	
185		bA7'Nc	11	45	15	37.36	3635	.585	
186		bA7'Nd	7	45	0	39.15	3630	.612	
187		bA7"Na	8	40	0	12.69	1200	.598	
188		bA7"Nb	9	45	10	37.28	3625	.585	
199		bA7"Nc	6	40	0	14.05	1615	.497	Pitch Pocket
190		bA7"Nd	12	45	65	43.75	3915	.633	
	Avg.							.586	
191		eB20NGac	13	40	20	38.48	4290	.513	
192		eB20'NGac	8	50	0	33.73	3505	.548	
193		eB20"NGac	11	35	0	36.45	4260	.490	
194		eB19Nac	7	35	0	35.12	3785	.530	
195	2" x 8"	eB19'Nac	10	45	10	41.00	3745	.620	
196		eB19"Nac	9	40	0	39.18	4050	.548	
197		dB16Nbd	7	50	0	34.96	3190	.620	
198		dB16'Nbd	9	35	0	36.39	3610	.575	
209		dB16"Nbd	7	45	5	37.77	3715	.578	
200		dA15Nac	8	35	0	37.42	3820	.558	
201		dA15Nbd	8	40	0	28.32	3388	.479	
202		dA15'Nac	4	45	0	44.03	4435	.567	
203		dA15'Nbd	8	35	0	38.61	4350	.508	
204		dA15"Nac	16	40	35	40.58	4055	.571	
205		dA15"Nbd	11	40	50	17.61	2230	.455	

206	cB14NGa6	10	40	0	41.67	3900	.606	
207	cB14NGac	11	45	10	38.68	3890	.566	
208	cB14'NGac	13	50	5	40.44	3835	.598	
209	cB14"NGac	7	45	30	35.28	3530	.568	
210	cB13Nac	16	40	35	32.60	3325	.558	
211	cB13'Nac	7	45	0	46.53	4470	.591	
212	cB13"Nac	6	30	20	37.50	3860	.554	
213	bBS10Nac	8	40	15	45.33	4110	.625	
214	bBS10'Nac	9	50	0	23.28	2175	.603	Close to Knot
215	bBS10"Nc	10	35	0	24.24	2505	.550	Small Pitch Pocket
216	bBS10"Na	9	35	0	39.29	3955	.567	
217	bB9Nac	7	40	0	36.63	3600	.578	
218	bB9'Nac	11	45	0	35.73	3850	.530	
219	bB9"Nac	8	40	5	18.08	1660	.617	Pitch
220	bAS8'Nd	11	40	50	31.06	2905	.604	
221	bAS8"Na	7	45	95	41.43	3410	.685	Pitch Pocket
222	bAS8"Nc	8	35	0	37.02	3890	.543	
223	bAS8"Nd	11	40	0	40.82	4275	.548	
224	bAS8"Nb	13	45	1	26.46	2780	.544	
225	aB(S)6NGac	11	45	5	36.74	4175	.505	
226	aB(S)6NGd	5	50	0	51.21	5010	.580	
227	aB(S)6NGb	8	55	25	52.19	4480	.660	Small Pitch Pocket
228	aB(S)6'NGd	12	50	0	22.55	1530	(.812)	Pitch
229	aB(S)6'NGac	8	50	1	24.60	2030	.685	
230	aB(S)6'NGb	7	30	0	35.25	4010	.505	
231	aB(S)6"NGac	8	45	0	30.61	2980	.583	
232	aB(S)6"NGd	5	55	0	14.98	1295	.655	
233	aB(S)6"NGb	10	35	0	37.40	4175	.514	
234	aBS5Nac	7	35	10	37.11	3925	.540	
235	aBS5Nb	6	35	0	32.72	3630	.516	
236	aBS5Nd	6	35	0	47.81	5180	.551	
237	aBS5'Nac	14	40	0	32.81	3355	.560	
238	aBS5'Nb	10	50	25	38.55	3775	.581	
239	aBS5'Nd	8	35	45	51.33	5705	.515	Small Pitch
240	aBS5"Nac	10	35	2	39.99	4035	.564	
241	aBS5"Nb	6	50	0	57.69	5495	.595	
242	aBS5"Nd	7	45	0	53.58	5180	.583	
243	aB4Nac	9	40	0	16.30	1615	.575	Close to Knot
244	aB4Nb	10	35	0	68.16	6670	.582	
245	aB4Nd	10	50	0	55.23	4775	.655	
246	aB4"Na	8	55	0	53.88	4790	.687	
247	aB4"Nb	8	40	0	51.47	5565	.530	
248	aB4"Nc	10	50	0	48.03	4710	.580	
249	aB4"Nd	6	40	0	34.71	3400	.580	
250	aB4'Nac	11	40	0	49.99	4995	.570	
251	aB4'Nb	6	55	0	34.87	3325	.595	
252	aB4'Nd	9	40	0	51.72	5350	.550	
253	aA(S)3NGa	14	50	2	45.15	4130	.620	
254	aA(S)3NGb	15	50	1	30.22	3050	.555	
255	aA(S)3NGc	7	55	0	51.20	4705	.616	
256	aA(S)3NGd	8	40	0	27.14	2620	.588	Pitch
257	aA(S)'3NGa	4	40	0	32.19	3420	.536	
258	aA(S)'3NGb	12	40	5	39.80	4520	.503	
259	aA(S)'3NGd	14	45	0	38.27	3725	.585	
260	aA(S)"3NGa	6	40	0	22.99	2640	.499	

263		aA(S)"3NGb	9	45	0	29.12	2830	.585	
264		aA(S)"3NGc	18	50	0	47.19	4190	.638	
265		aA(S)"3NGd	10	45	0	41.23	4185	.564	
266		aAS2Na	7	50	0	27.99	2805	.567	
267		aAS2Nc	8	50	0	39.66	3770	.598	
268		aAS2Nb	5	40	0	34.31	3375	.590	
269		aAS2Nd	9	55	0	24.96	1880	.745	
270		aAS2'Na	16	40	2	37.29	3635	.582	
271		aAS2'Nb	8	40	40	42.73	4085	.595	
272		aAS2'Nc	8	35	0	36.43	4165	.520	
273		aAS2'Nd	17	40	25	37.91	3730	.580	
274		aAS2"Na	12	45	0	26.47	2330	.643	
275		aAS2"Nb	6	40	5	39.55	4215	.538	
276		aAS2"Nc	9	25	2	35.31	4245	.475	Small Pitch Pock
277		aAS2"Nd	8	50	0	36.37	3495	.591	
278		aAlNa	9	50	0	36.10	2850	.715	Small Pitch Pocke
279		aAlNc	10	50	0	33.72	3470	.555	
280		aAlNd	7	45	0	37.59	3705	.578	
281		aAl'Na	11	40	0	28.27	3190	.510	
282		aAl'Nb	9	35	0	29.24	3370	.498	
283		aAl'Nc	11	50	0	20.08	1825	.625	
284		aAl'Nd	10	30	0	34.92	4250	.475	
285		aAl"Na	5	35	0	34.13	3745	.522	
286		aAl"Nb	12	40	10	37.85	4375	.488	
287		aAl"Nc	11	50	0	43.94	4265	.588	
288		aAl"Nd	6	35	0	41.94	4580	.575	
289	Avg.							.571	
290	2"x10"	aB4Nac	12	40	50	17.27	1525	.640	Pitch
291		aB4'Nac	7	40	0	59.73	6270	.545	
292		aB4"Nac	10	50	0	69.17	5685	.685	Small Pitch
293		aBS5Nac	8	40	0	50.45	5755	.504	
294		aBS5'Nac	5	35	0	52.76	5145	.584	
295		aBS5"Nac	12	50	10	53.80	4585	.665	
296		aB(S)6NGac	9	50	0	50.13	5015	.570	
297		aB(S)6'NGac	8	40	0	56.79	5715	.566	
298		aB(S)6"NGac	5	50	0	17.18	1835	.536	
299		cAllNac	9	45	0	54.26	5450	.566	
300		cAllNbd	8	40	5	47.71	5180	.631	
301		cAll'Nac	8	40	0	45.03	5175	.500	
302		cAll'Nbd	6	30	0	41.30	5070	.468	
303		cAll"Nac	12	40	20	57.90	5690	.578	Small Knot
304		cAll"Nbd	6	40	0	61.88	6145	.575	
305		cAl2NGac	10	40	20	55.26	5530	.570	
306		cAl2NGbd	7	45	0	45.42	4335	.596	
307		cAl2'NGac	6	35	0	53.60	5910	.520	
308		cAl2'NGbd	8	45	20	59.53	6005	.565	
309		cAl2"NGac	11	45	10	34.74	3685	.545	
310		cAl2"NGbd	19	50	40	55.67	5750	.561	
311		cB13Nbd	18	50	20	58.86	5510	.605	
312		cB13'Nbd	6	40	0	46.22	5015	.528	
313		cB13"Nbd	4	40	0	64.28	6575	.558	
314		cB14NGbd	7	50	0	58.69	6065	.551	
315		cB14'NGbd	6	45	2	54.96	6400	.492	
316		cB14"NGbd	16	50	2	58.13	5440	.605	
317		dB16Nac	9	40	5	59.19	5915	.570	

318	dB16'Nac	11	50	5	64.19	5940	.611	
319	dB16"Nac	4	35	0	61.03	6110	.570	
320	fA21Nac	7	40	0	55.60	6115	.520	
321	fA21'Nac	5	35	0	53.83	5005	.611	Pitch
322	fA21Nbd	8	50	20	59.88	5590	.608	
							.570	
Avg.							.581	

APPENDIX C

Minor Tests on Specimens
from
Random-Selected Dense Select Structural Southern Pine Planks

Test Number	Height in.	Width in.	I in.^{4}	No. Rings per in.	Oven Dry Weight	Weight In Merc.	Specific Gravity G	Computed E# 1000psi	Def. for 1000lb.	Slope lb./in.	Test E' 1000psi	Corrected E'* 1000psi
1	1.54	1.54	0.4687	8	11.13	1,015	0.620	2,020	0.245	4,080	2,100	2,080
2	1.56	1.57	0.4967	8	12.82	1,220	0.595	1,940	0.310	3,230	1,570	1,560
3	1.55	1.54	0.4779	7	12.31	1,080	0.644	2,100	0.215	4,650	2,350	2,230
4	1.54	1.57	0.4778	6	11.18	1,030	0.613	2,000	0.261	3,830	1,930	1,920
5	1.53	1.56	0.4656	9	10.05	1,065	0.537	1,750	0.233	4,290	2,220	2,200
6	1.55	1.55	0.4610	8	12.30	1,240	0.564	1,840	0.215	3,650	1,910	1,890
7	1.53	1.56	0.4656	16	11.11	1,185	0.530	1,730	0.256	3,910	2,030	2,010
8	1.57	1.54	0.4866	9	11.18	1,190	0.535	1,740	0.256	3,910	1,940	1,920

#Computed $E = \frac{1,760,000}{0.54} G$

*Corrected for Form Factor of 1.0084

APPENDIX D

Minor Tests on Modulus of Elasticity of Dense Select Structural Southern Pine
For Determination of Validity of Use of Modulus of Elasticity
On Basis of Specific-Gravity Data According to General F.P.L. Formula

Test Number	Computed E psi.	Test E' psi.	Variation of E from E' pct.	Variation of E from E' d psi.	d-$\bar{d}$	(d-$\bar{d}$)^2
1	2,020,000	2,080,000	- 2.9	- 60,000	-210,000	44,100,000,000
2	1,940,000	1,560,000	+24.3	+380,000	+230,000	52,900,000,000
3	2,100,000	2,230,000	- 5.8	-130,000	-280,000	78,400,000,000
4	2,000,000	1,920,000	+ 4.2	+ 80,000	- 70,000	4,900,000,000
5	1,750,000	2,200,000	-20.0	-450,000	-600,000	360,000,000,000
6	1,840,000	1,890,000	- 2.6	- 50,000	-200,000	40,000,000,000
7	1,730,000	2,010,000	-13.9	-280,000	-430,000	184,900,000,000
8	1,740,000	1,920,000	- 9.4	-180,000	-330,000	108,900,000,000
						Σ = 874,100,000,000
Avg.	1,890,000	2,040,000	- 3.3			
	1,890,000	2,040,000		$\bar{d}$ = -150,000		

Range of variability from -20.0 to +24.3 pct., with average variability of - 3.3 pct.
Very small average variability for given range, of practical insignificance.

$$t = (2{,}040{,}000 - 1{,}890{,}000)/\sqrt{874{,}100{,}000{,}000/(8 \times 7)} = 1.2$$

For 7 degrees of freedom: t = 3.5 at 1 pct. level.
Hence, statistically insignificant difference for test and computed data.

APPENDIX E

SYMBOLS

E Modulus of elasticity computed from specific gravity by means of Forest Products Laboratory Formulas.

E' Modulus of elasticity determined from flexural tests.

d Difference between E and E'.

$\bar{d}$ Difference between average E and average E'.

G Specific gravity.

I Moment of inertia.

Pct. Percent.

n Number of samples.

Σ Sum.

t $\dfrac{\bar{d}}{\sqrt{\dfrac{(d-\bar{d})^2}{(n-1)n}}}$

Psi. Pounds per square inch.