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TESTS OF CREOSOTED TIMBER.

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During the last few years a quantity of literature has appeared in which the treatment of timber by preservatives has been discussed. The properties of timber, both treated and untreated, have been determined by the Forest Service, United States Department of Agriculture, and through its researches valuable knowledge has come to engineers who have to deal with the design of wooden structures. There is very little information, however, regarding the effect of time on creosoted timber, and for this reason the results given herewith may prove of interest.

The material tested consisted of southern pine stringers having a cross-section approximately 6 by 16 in. and a length of 30 ft. For the purpose of testing, each beam was cut into two parts, each about 15 ft. long. This material had been in use in a trestle of a railroad near New Orleans for 26 years. The stringers were chosen at random to determine the general condition of the trestle. The timber had been exposed to the weather and subjected to heavy train service from the time it was treated until it was tested. The annual rainfall at New Orleans is about 60 in., and the humidity of the air is high. In spite of these conditions, there was no appearance of decay on any of the specimens tested. The specifications under which the timber was treated were as follows:

Timber.

The timber for creosoting shall be long-leafed or southern pine. Sap surfaces on two or more sides are preferred.

Piles.—The piles shall be of long-leafed or southern pine, not less than 14 in. at the butt. They shall be free from defects impairing their strength, and shall be reasonably straight. [38]

The piles shall be cleanly peeled, no inner skin being left on them. The oil used shall be so-called creosote oil, from London, England, and shall be of a heavy quality.

The treatment will vary according to the dimensions of the timbers and length of time they have been cut. Timbers of large and small dimensions shall not be treated in the same charge, neither shall timbers of differing stages of air seasoning, or the close-grained, be treated in the same charge with coarse or open-grained timbers.

The timbers shall be subjected first to live steam superheated to from 250 to 275° Fahr., and under a 30 to 40-lb. pressure. The live steam shall be admitted into the cylinders through perforated steam pipes, and the temperature shall be obtained by using superheated steam in closed pipes in the cylinders.

The length of time this steaming shall last will depend on the size of the timbers and the length of time they have been cut. In piles and large timbers freshly cut, as long a time as 12 hours may be required. After the steaming is accomplished, the live steam shall be shut off and the superheated steam shall be maintained at a temperature of 160° or more and a vacuum of from 20 to 25 in. shall be held for 4 hours or longer, if the discharge from the pumps indicates the necessity.

Oil Treatment.—The temperature being maintained at 160° Fahr., the cylinders shall be promptly filled with creosote oil at a temperature as high as practicable (about 100° Fahr.). The oil shall be maintained at a pressure ranging from 100 to 120 lb., as experience and measurements must determine the length of time the oil treatment shall continue, so that the required amount of oil may be injected.

After the required amount of oil is injected, the superheated steam shall be shut off, the oil let out, the cylinders promptly opened at each end, and the timber immediately removed from the cylinder.

In the erection of timbers the sap side must be turned up, and framing or cutting of timbers shall not be permitted, if avoidable. All cut surfaces of timbers shall be saturated with hot asphaltum, thinned with creosote oil. The heads of piles when cut shall be promptly coated with the hot asphaltum and oil, even though the cut-off be temporary.

Method of Testing.

The tests were made on a Riehlé 100,000-lb. machine in the Experimental Engineering Laboratory of Tulane University of

Louisiana. The machine is provided with a cast-iron beam for cross-bending tests. The distance between supports was 12 ft. The method of support was as follows: Each end of the beam was provided with a steel roller which rested on the cast-iron beam of the testing machine, while above the roller, and, directly under the beam tested, there was a steel plate 6 by 8 in. in area and 1 in. thick. The area was sufficiently great to distribute the load and prevent the shearing of the fibers of the wood. The head of the Riehlé machine is 10 in. wide. A plate, 3/8 in. thick, 6 in. wide and 18 in. long, was placed between the head of the machine and the beam tested.

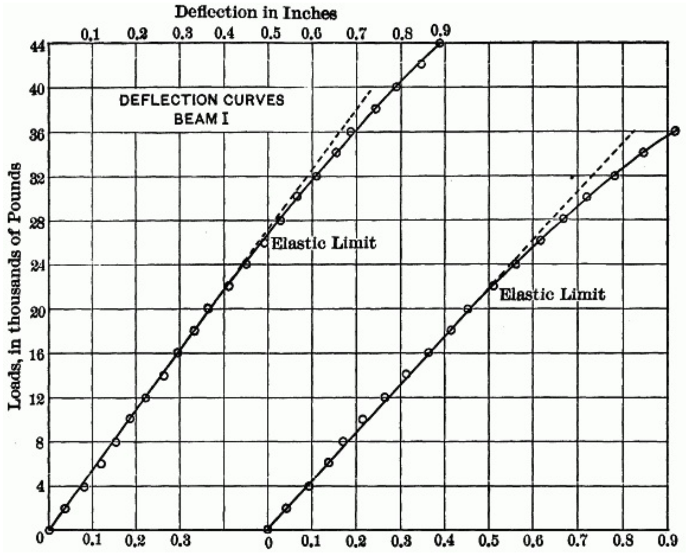

Fig. 1.—DEFLECTON CURVES BEAM I

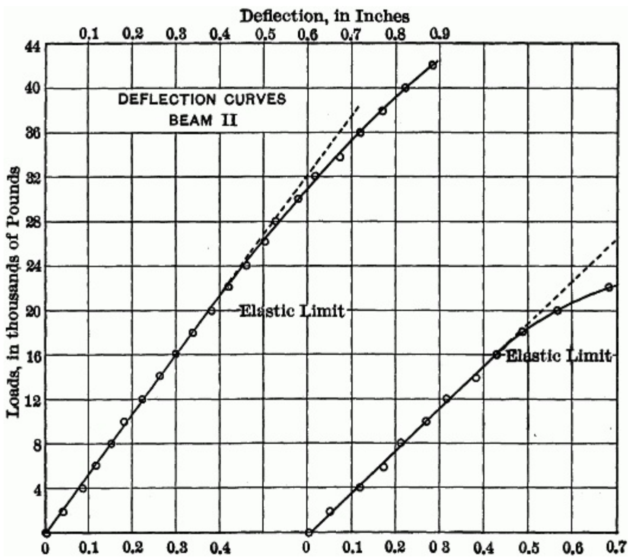

Fig. 2.—DEFLECTON CURVES BEAM II

TABLE 1.—Summary of Results of Transverse Tests of Beams at Tulane University, February 10th to March 2d, 1909.

Number of beam.	Top or butt of log.	*b*	*h*	*I*	Loads:		*S* = *Plc/4I*		*d*, Inches.	*E*	Weight, in pounds per cubic foot.	Remarks.
		Width, in inches.	Height, in inches.	$I = bh^3/12$	Actual at elastic limit.	Maximum.	At elastic limit.	Maximum.	At elastic limit.	$E = Pl^3/48dI$		
I	B	6.28	15.94	2,120	22,000	45,900	2,975	6,200	0.41	1,575,000	50.2	Close-grained pine, long-leaf.
I	T	6.00	15.69	1,934	20,000	38,000	2,915	5,540	0.465	1,383,000	47.5	
II[A]	T	6.37	15.81	2,098	20,000	43,450	2,722	5,918	0.380	1,562,000	40.5	Coarse loblolly, large knots.
II	B	6.41	16.41	2,360	16,000	25,040	1,999	3,130	0.430	979,000	42.2	
III	T	5.88	15.68	1,871	24,000	45,130	3,608	6,785	0.535	1,489,000	40.4	Close-grained, long-leaf no knots.
III	B	5.88	15.90	1,965	21,000	35,190	3,054	5,120	0.515	1,288,000	44.2	
IV	T	6.00	15.43	1,835	22,000	38,425	3,320	5,810	0.465	1,601,000	40.8	Loblolly, with knots.
IV	B	6.12	15.87	2,032	22,000	35,500	3,090	4,983	0.660	1,017,000	41.5	
V	B	6.00	16.00	2,048	22,000	47,000	3,090	6,610	0.400	1,670,000	47.2	Long-leaf yellow pine.
V[A]	T	6.00	15.87	1,999	14,000	22,050	1,998	3,145	0.315	1,382,000	42.1	
VI[A]	B	5.50	15.75	1,790	22,000	51,330	3,484	8,925	0.450	1,695,000	50.2	Long-leaf yellow pine.
VI[A]	T	5.87	15.62	1,865	20,000	44,000	3,013	6,627	0.410	1,625,000	45.2	
VII	B	6.56	15.62	2,083	34,000	51,900	4,580	6,985	0.620	1,637,000	43.7	Long-leaf yellow pine.
VII[A]	T	6.22	15.62	1,975	20,000	49,000	2,845	6,970	0.380	1,658,000	40.2	

[A] Failed in longitudinal shear.

The deflection was measured on both sides of each beam by using silk threads stretched on each side from nails driven about 2 in. above the bottom of the beam and directly over the rollers which formed the supports. From a small piece of wood, tacked to the bottom of the beam at its center and projecting at the sides, the distance to these threads was measured. These measurements were taken to the nearest hundredth of an inch. The mean of the deflections was taken as the true deflection for any load.

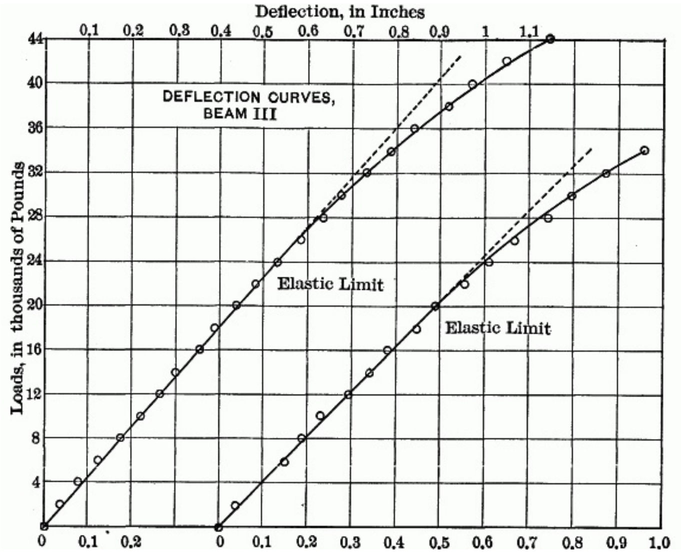

Fig. 3.—DEFLECTON CURVES BEAM III

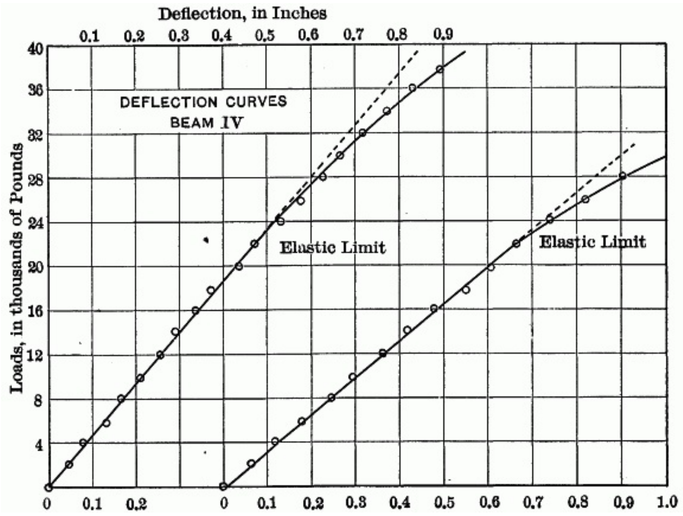

Fig. 4.—DEFLECTON CURVES BEAM IV

In computing the various quantities shown in Table 1, the summary of results, the load has been assumed as concentrated at [42] the center of the beam. While it is true that the load was spread over a length of about 12 in., due to the width of the head of the machine and the plate between it and the beam tested, it is also true that there were irregularities, such as bolt-holes and, in some cases, abrasions due to wear, that could not well be taken into account. Hence, it was deemed sufficiently accurate to consider the load as concentrated. Besides the horizontal bolt-holes, shown in the photographs, there were vertical bolt-holes, at intervals in all the beams. The latter were 7/8 in. in diameter, and in every case they were sufficiently removed from the center of the length of the beam to allow the maximum moment at the reduced section to be relatively less than that at the center of the beam. For this reason, no correction was made for these holes. The broken beams often showed that rupture started at, or was influenced by, some of the holes, especially the horizontal ones.

While some of the heavy oils of a tarry consistency remained, they were only to be found in the sappy portions of the long-leaf pine and in the loblolly (Specimens II and IV). Exposure in a semi-tropical climate for 26 years had resulted in the removal of the more volatile portions of the creosote oil. The penetration of the oil into the sap wood seemed to be perfect, while in the loblolly it varied from a fraction of an inch to 1-1/2 in. In the heart wood there was very little penetration across the grain. The timber had been framed and the holes bored before treatment. The penetration of the creosote along the grain from the holes was often from 4 to 6 in.

Circular 39 of the Forest Service, U. S. Department of Agriculture, entitled "Experiments on the Strength of Treated Timber," gives the results of a great many tests of creosoted ties, principally loblolly pine, from which the following conclusions are quoted:

> "(1) A high degree of steaming is injurious to wood. The degree of steaming at which pronounced harm results will depend upon the quality of the wood and its degree of seasoning, and upon the pressure (temperature) of steam and the duration of its application. For loblolly pine the limit of safety is certainly 30 pounds for 4 hours, or 20 pounds for 6 hours." [Tables 3, 6, and 7.]
>
> "(2) The presence of zinc chlorid will not weaken wood under static loading, although the indications are that the wood becomes brittle under impact." [Tables 3 and 4.]

[43]

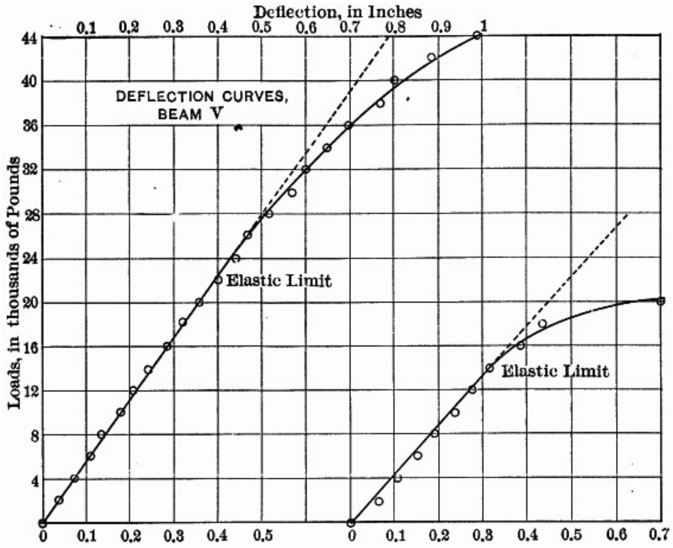

Fig. 5.—DEFLECTON CURVES BEAM V

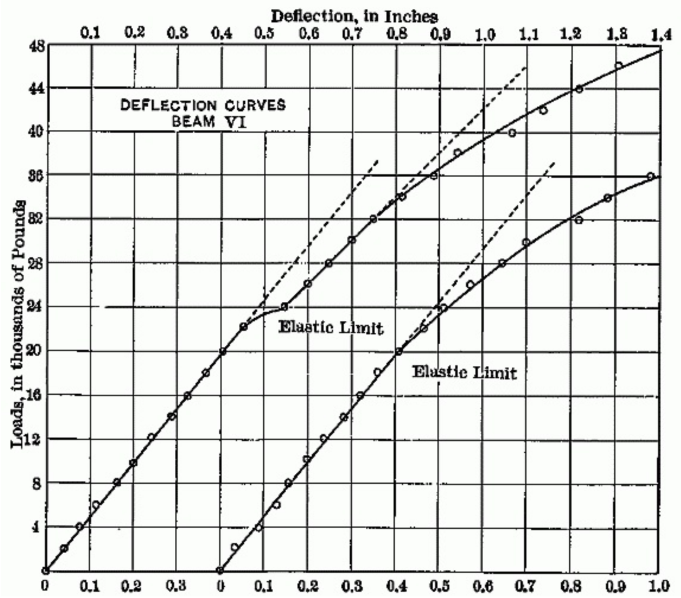

Fig. 6.—DEFLECTON CURVES BEAM VI

"(3) The presence of creosote will not weaken wood of itself. Since apparently it is present only in the openings of the cells, and does not get into the cell walls, its action can only be to retard the seasoning of the wood." [Tables 3, 4, 5, and 6.] [44]

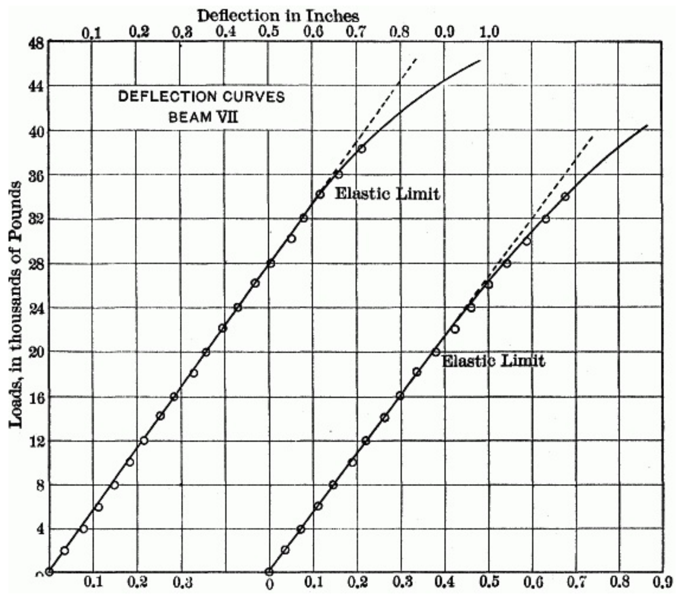

Fig. 7.—DEFLECTON CURVES BEAM VII

Comparisons.

A comparison of the results obtained with tests made on untreated timber is interesting, and to this end Tables 2 and 3, from Circular 115, Forest Service, U.S. Department of Agriculture, by W. Kendrick Hatt, Assoc. M. Am. Soc. C. E., are quoted. The tests made by the writer were from timber raised in Louisiana and Mississippi, while the tests quoted were from timber raised farther north. The number of tests was not sufficient to settle questions of average strength or other qualities. It will be seen, however, that the treated timber 26 years old compares favorably with the new untreated timber.

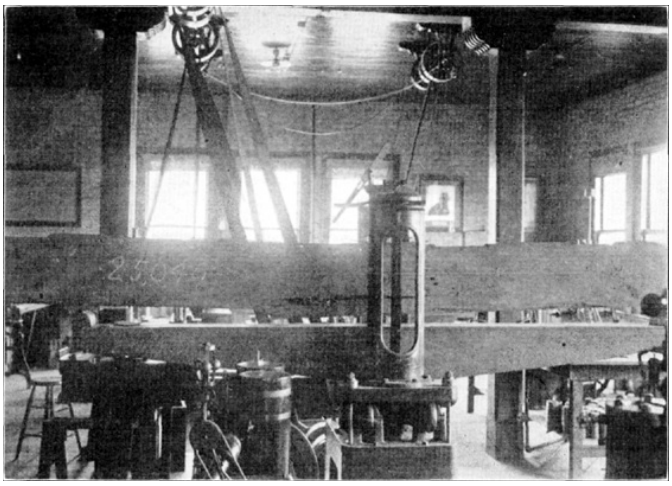

Plate I, Fig. 1.—Specimen in Testing Machine, Showing Method of Support.

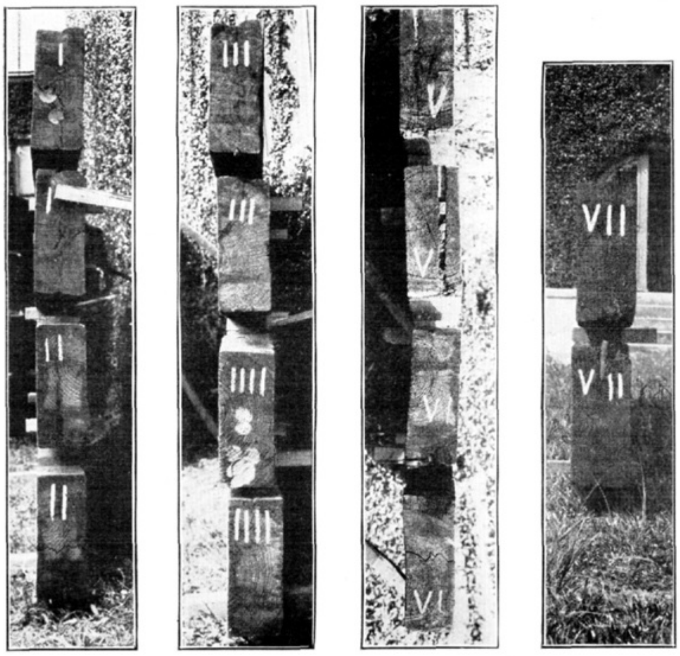

Plate I, Fig. 2.—End Views of Tested Timbers.

TABLE 2.—Bending Strength of Large Sticks.

Loblolly Pine.

Reference number.	Locality of Growth.	Dimensions. Section, in inches.	Dimensions. Span, in feet	Grade.	Condition of seasoning.		Number of tests.	Moisture, per cent.	Rings per inch.	Specific gravity, dry.	Weight per Cubic Foot, in Pounds. As tested.	Weight per Cubic Foot, in Pounds. Oven dry.	Fiber stress at elastic limit, in pounds per square inch.	Modulus of rupture, in pounds per square inch.	Modulus of elasticity, in thousands of pounds per square inch.	Elastic resilience, in inch pounds per cubic inch.	Number failing by longi-tudinal shear.	Remarks
1	South Carolina.	6 by 7 6 by 10 4 by 12 6 by 16 8 by 14 8 by 16	10 to 15.5	Square edge	Green	Average	42	48.0	5.7	0.50	46.2	31.2	3,150	5,580	1,426	0.45	7	Moistur above saturatic point in a cases.
						Maximum		92.1	11.7	0.60	56.8	37.5	5,210	8,460	1,920	0.99		
						Minimum		30.2	2.3	0.40	35.6	25.0	1,675	3,120	905	0.07		
2	South Carolina.	6 by 7 4 by 12 6 by 10 6 by 16 8 by 16 10 by 16	10 to 16	Square edge	Partially air dry.	Average	18	27.7	5.0	0.50	40.0	31.2	3,380	5,650	1,435	0.45	0	Moistur from 25 to per cent
						Maximum		29.2	8.2	0.55	43.7	34.4	4,610	8,090	1,880	0.76		
						Minimum		25.5	2.5	0.45	35.6	28.1	2,115	3,600	1,152	0.20		
3	South Carolina.	6 by 7 4 by 12 6 by 10 6 by 16	10 to 15	Square edge	Partially air dry.	Average	19	21.0	5.6	0.50	37.5	31.2	2,970	5,690	1,340	0.39	2	Moisture l than 25 p cent.
						Maximum		24.9	17.2	0.58	45.6	36.2	4,850	8,100	2,040	0.69		
						Minimum		15.0	2.7	0.41	31.2	25.6	1,730	2,910	906	0.10		
4	Virginia.	8 by 8	6 to 16	Square edge	Partially air dry.	Average	12	22.4	4.8	0.46	35.6	28.8	3,260	5,180	1,180	0.51	0	
						Maximum		27.7	8.8	0.58	43.1	36.2	5,300	8,950	1,728	1.05		
						Minimum		17.8	2.5	0.37	30.0	23.1	1,280	2,180	606	0.13		
5	Virginia.	8 by 8	6 to 15.5	Square edge	Green	Average	17	64.0	3.0	0.43	43.7	26.9	1,935	3,490	744	0.31	0	Very rap growth; p quality.
						Maximum		100.5	4.0	0.51	51.9	31.9	3,185	4,720	1,193	0.78		
						Minimum		38.8	2.5	0.35	35.0	21.9	956	2,180	357	0.12		

Long-Leaf Pine.

	South	6 by 8			Partially	Average		25.0	13.7	0.58	45.6	36.2	3,800	7,160	1,560	0.53		

6	Carolina.	10 by 16	15	Merchantable	air dry	Maximum	22	40.3	25.4	0.76	60.0	47.5	4,970	10,020	2,010	0.78	9	
						Minimum		17.3	6.2	0.50	39.4	31.2	2,220	5,450	1,190	0.21		
7	Georgia.	10 by 12	15	Merchantable	Partially air dry.	Average		27.3	18.0	0.69	54.7	42.9	5,581	8,384	1,820	——		Excellen merchanta grade.
						Maximum	22	34.5	29.0	0.79	—	49.4	9,600	11,410	2,920	——	6	
						Minimum		20.0	11.0	0.50	—	31.4	3,547	4,836	1,167	——		

TABLE 3.—Loblolly Pine.— Bending Tests on Beams Seasoned Under Different Conditions. (8 by 16-in. section; 13-1/2 to 15-ft. span.)

[46]

	Number of tests.	Fiber stress at elastic limit, in pounds per square inch.	Modulus of rupture, in pounds per square inch.	Longitudinal shear at maximum load, in pounds per square inch.	Modulus of elasticity, in thousands of pounds per square inch.	Percentage of moisture.	Rings per inch.	Weight per cubic foot, oven dry, in pounds.	Condition of seasoning.
Average	4	3,580	5,480	364_4	1,780	23.2	9.4	33.7	Air dry, 3-1/2 months in the open.
Maximum		4,070	6,600	440	1,987	24.3	11.5	34.5	
Minimum		3,090	5,000	327	1,530	21.5	8.0	32.5	
Average	5	4,512	5,060	338_3	1,685	20	7.7	33.9	Kiln dry, 6 days.
Maximum		5,840	7,320	488	1,790	22	10.2	38.0	
Minimum		3,180	2,150	143	1,410	18	4.7	27.7	
Average	12	4,331	6,721	493_9	1,688	——	7.7	——	Air dry, 21 months under shelter.
Maximum		4,990	8,560	620	2,002	——	9.5	——	
Minimum		3,110	5,160	380	1,398	——	5.5	——	

Note.—Figures written as subscripts to the figures for longitudinal shear indicate the number of sticks failing in that manner.

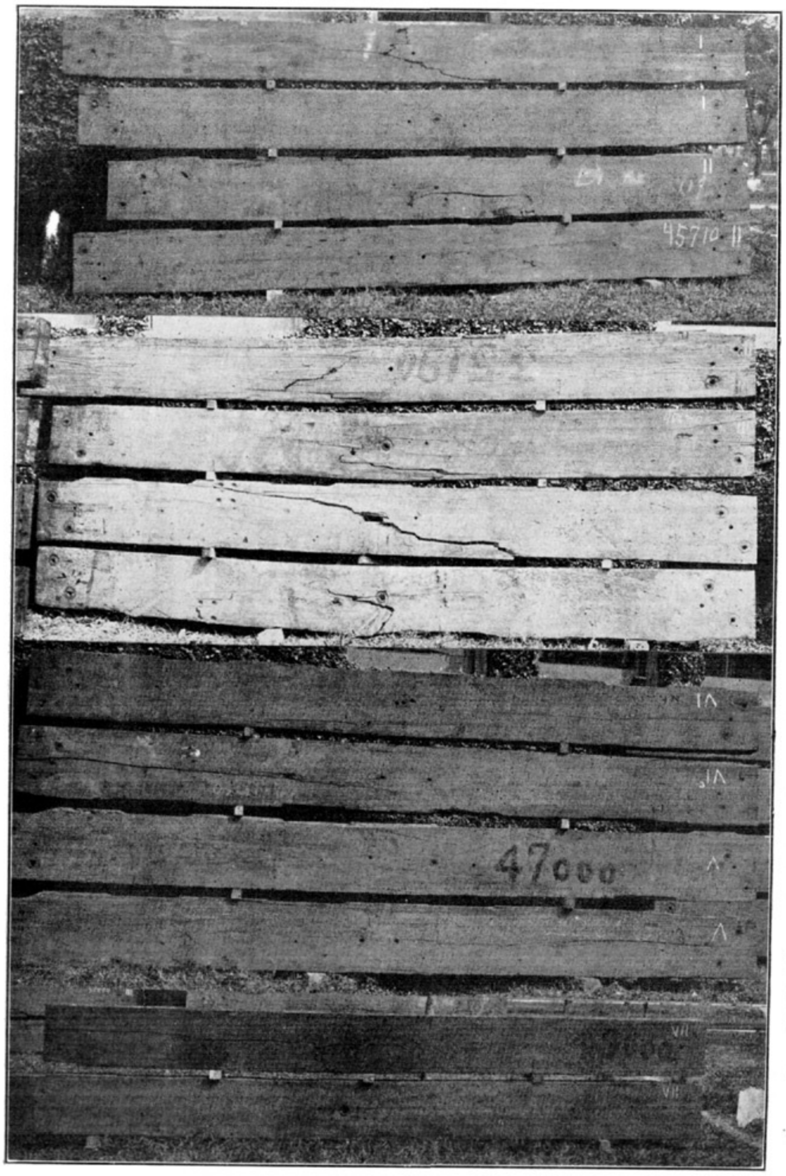

Plate II.—Side Views of Tested Timbers.

TABLE 4.—Load and Deflection Log. Beam I.

[47]

Date: February 26th, 1909. l = 12 ft.; b (mean) = 6-9/32 in.; h (mean) = 15-15/16 in.; c = 7.97 in. Time = 1 hour.	Date: February 24th, 1909. l = 12 ft.; b (mean) = 6 in.; h (mean) = 15.69 in.; c = 7.84 in.

No.	P	Deflection, in Inches.					P	Deflection, in Inches.				
	Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.	Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.
1	0	1.86	0	1.88	0	0	0	1.83	0	1.86	0	0
2	2,000	1.92	0.05	1.90	0.02	0.035	2,000	1.87	0.04	1.90	0.04	0.04
3	4,000	1.96	0.10	1.94	0.06	0.080	4,000	1.91	0.08	1.96	0.10	0.090

4	6,000	1.99	0.13	1.98	0.10	0.115	6,000	1.96	0.13	2.00	0.14	0.135
5	8,000	2.03	0.17	2.02	0.14	0.155	8,000	2.00	0.17	2.04	0.18	0.175
6	10,000	2.05	0.19	2.06	0.18	0.185	10,000	2.04	0.21	2.08	0.22	0.215
7	12,000	2.10	0.24	2.09	0.21	0.225	12,000	2.09	0.26	2.13	0.27	0.265
8	14,000	2.13	0.27	2.13	0.25	0.260	14,000	2.14	0.31	2.18	0.32	0.315
9	16,000	2.17	0.31	2.16	0.28	0.295	16,000	2.19	0.36	2.23	0.37	0.365
10	18,000	2.20	0.34	2.20	0.32	0.330	18,000	2.24	0.41	2.28	0.42	0.415
11	20,000	2.24	0.36	2.25	0.37	0.365	20,000	2.29	0.46	2.33	0.47	0.465
12	22,000	2.28	0.42	2.28	0.40	0.410	22,000	2.34	0.51	2.39	0.53	0.520
13	24,000	2.32	0.46	2.32	0.44	0.450	24,000	2.39	0.56	2.43	0.57	0.565
14	26,000	2.36	0.50	2.36	0.48	0.490	26,000	2.44	0.61	2.48	0.62	0.615
15	28,000	2.40	0.54	2.39	0.51	0.525	28,000	2.49	0.66	2.53	0.67	0.685
16	30,000	2.43	0.57	2.44	0.56	0.565	30,000	2.55	0.72	2.58	0.72	0.720
17	32,000	2.48	0.62	2.48	0.60	0.610	32,000	2.61	0.78	2.65	0.79	0.785
18	34,000	2.52	0.68	2.53	0.65	0.655	34,000[B]	2.68	0.85	2.70	0.84	0.845
19	36,000	2.56	0.70	2.56	0.68	0.690	36,000	2.74	0.91	2.78	0.92	0.915
20	38,000	2.61	0.75	2.62	0.74	0.745	38,000	Broke.				
21	40,000	2.65	0.79	2.67	0.79	0.790						
22	42,000	2.70	0.84	2.73	0.85	0.845						
23	44,000	2.75	0.89	2.77	0.89	0.890						
	37,500 lb., First Crack; 45,900 lb., Failed.											
	At Elastic Limit: Load, 22,000 lb.; deflection, 0.41 in.; *S*, 2,975 lb. Maximum: Load, 45,900 lb.; deflection,.....; *S*, 6,209 lb. *E* = 1,575,000 lb.						At Elastic Limit: Load, 20,000 lb.; deflection, 0.465 in.; *S*, 2,975 lb. Maximum: Load, 38,000 lb.; deflection,.....; *S*, 5,540 lb. *E* = 1,383,000 lb.					

[B] First crack.

[48]

TABLE 4.—(*Continued.*)—Load and Deflection Log. Beam II.

Date: February 20th, 1909. *l* = 12 ft.; *b* (mean) = 6.38 in.; *h* (mean) = 15.81 in.; *c* = 7.91 in. Time = 47.5 min	Date: — *l* = 12 ft.; *b* (mean) = 6.41 in.; *h* (mean) = 16.41 in.; *c* = 8.20 in.

No.	*P*	Deflection, in Inches.					*P*	Deflection, in Inches.				
	Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.	Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.
1	0	1.65	0	1.68	0	0	0	1.86	0	1.87	0	0
2	2,000	1.69	0.04	1.72	0.04	0.040	2,000	1.91	0.05	1.92	0.05	0.05
3	4,000	1.73	0.08	1.77	0.09	0.085	4,000	1.98	0.12	1.98	0.11	0.115
4	6,000	1.76	0.11	1.80	0.12	0.115	6,000	2.05	0.19	2.02	0.15	0.170
5	8,000	1.80	0.15	1.83	0.15	0.150	8,000	2.07	0.21	2.08	0.21	0.210
6	10,000	1.83	0.18	1.86	0.18	0.180	10,000	2.13	0.27	2.13	0.26	0.265
7	12,000	1.87	0.22	1.90	0.22	0.220	12,000	2.18	0.32	2.18	0.31	0.315
8	14,000	1.91	0.26	1.94	0.26	0.260	14,000	2.25	0.39	2.24	0.37	0.380
9	16,000	1.95	0.30	1.98	0.30	0.300	16,000	2.30	0.44	2.29	0.42	0.430
10	18,000	1.98	0.33	2.02	0.34	0.335	18,000[C]	2.35	0.49	2.35	0.48	0.485
11	20,000	2.03	0.38	2.06	0.38	0.380	20,000	2.44	0.58	2.42	0.55	0.565
12	22,000	2.07	0.42	2.10	0.42	0.420	22,000	2.54	0.68	2.54	0.67	0.675
13	24,000	2.11	0.46	2.14	0.46	0.460	25,040	Failed				
14	26,000	2.15	0.50	2.18	0.50	0.500						
15	28,000	2.18	0.53	2.22	0.54	0.535						
16	30,000	2.23	0.58	2.26	0.58	0.580						
17	32,000	2.27	0.62	2.30	0.62	0.620						
18	34,000	2.32	0.67	2.35	0.67	0.670						
19	36,000	2.37	0.72	2.40	0.72	0.720						
20	38,000	2.42	0.77	2.45	0.77	0.770						
21	40,000	2.48	0.83	2.50	0.82	0.825						
22	42,000	2.53	0.88	2.56	0.88	0.880						
23	43,450	Fracture.										
24	45,710	Failed.										
	At Elastic Limit: Load, 20,000 lb.; deflection, 0.38 in.; *S*, 2,722 lb. Maximum: Load, 43,450 lb.; deflection,.....; *S*, 5,918 lb. *E* = 1,562,000 lb.						At Elastic Limit: Load, 16,000 lb.; deflection, 0.43 in.; *S*, 1,999 lb. Maximum: Load, 25,040 lb.; deflection,.....; *S*, 3,130 lb. *E* = 979,000 lb.					

[C] First crack.

[49]

TABLE 4.—(*Continued.*)—Load and Deflection Log. Beam III.

Date: February 13th, 1909. *l* = 12 ft.; *b* (mean) = 5.88 in.; *h* (mean) = 15.63 in.; *c* = 7.82 in.	Date: — *l* = 12 ft.; *b* (mean) = 5.88 in.; *h* (mean) = 15.9 in.; *c* = 7.95 in. Time = 45 min.

No.	*P*	Deflection, in Inches.					*P*	Deflection, in Inches.				
	Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.	Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.
1	0	1.23	0	1.06	0	0	0	1.67	0	1.63	0	0
2	2,000	1.27	.04	1.10	0.04	0.040	2,000	1.70	0.03	1.68	0.05	0.040
3	4,000	1.32	0.09	1.13	0.07	0.080	4,000	1.72	0.05	1.72	0.09	0.070
4	6,000	1.37	0.14	1.17	0.11	0.125	6,000	1.82	0.15	1.78	0.15	0.150
5	8,000	1.42	0.19	1.22	0.16	0.175	8,000	1.86	0.19	1.82	0.19	0.190
6	10,000	1.47	0.24	1.26	0.20	0.220	10,000	1.90	0.23	1.87	0.24	0.235
7	12,000	1.51	0.28	1.31	0.25	0.265	12,000	1.97	0.30	1.92	0.29	0.295
8	14,000	1.55	0.32	1.35	0.29	0.305	14,000	2.00	0.33	1.98	0.35	0.340
9	16,000	1.60	0.37	1.40	0.34	0.355	16,000	2.03	0.36	2.04	0.41	0.385
10	18,000	1.64	0.41	1.44	0.38	0.395	18,000	2.10	0.43	2.09	0.46	0.445
11	20,000	1.68	0.45	1.49	0.43	0.440	20,000	2.13	0.46	2.14	0.51	0.485
12	22,000	1.72	0.49	1.54	0.48	0.485	22,000	2.20	0.53	2.20	0.57	0.550
13	24,000	1.78	0.55	1.58	0.52	0.535	24,000	2.26	0.59	2.26	0.63	0.610
14	26,000	1.82	0.59	1.64	0.58	0.585	26,000	2.31	0.64	2.32	0.69	0.665
15	28,000	1.88	0.65	1.68	0.62	0.635	28,000	2.38	0.71	2.40	0.77	0.740
16	30,000	1.92	0.69	1.73	0.67	0.680	30,000	2.42	0.75	2.47	0.84	0.795

No.	P Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.	P Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.
17	32,000	1.97	0.74	1.79	0.73	0.735	32,000	2.49	0.82	2.55	0.92	0.870
18	34,000	2.02	0.79	1.85	0.79	0.790	34,000	2.58	0.91	2.62	0.99	0.950
19	36,000	2.07	0.84	1.90	0.84	0.840						
20	38,000	2.13	0.90	1.97	0.91	0.915						
21	40,000	2.20	0.97	2.03	0.97	0.970						
22	42,000	2.27	1.04	2.11	1.05	1.045						
23	44,000	2.37	1.14	2.21	1.15	1.145						

39,100 lb. First Crack; 45,130 lb. Failed.
At Elastic Limit: Load, 24,000 lb.; deflection, 0.535 in.; *S* 3,608 lb.
Maximum: Load, 45,130 lb.; deflection,.....; *S* 6,785 lb.
E = 1,489,000 lb.

22,000 lb. First Crack; 35,190 lb. Failed.
At Elastic Limit: Load, 21,000 lb.; deflection, 0.515 in.; *S*, 3,054 lb.
Maximum: Load, 35,190 lb.; deflection,.....; *S* 5,120 lb.
E = 1,288,000 lb.

TABLE 4.—(*Continued.*)—Load and Deflection Log. Beam IV. [50]

Date: February 16th, 1909.
l = 12 ft.; *b* (mean) = 6.0 in.;
h (mean) = 15.43 in.;
c = 7.71 in.

Date: February 10th, 1909.
l = 12 ft.; *b* (mean) = 6.12 in.;
h (mean) = 15.87 in.;
c = 7.93 in. Time = 30 min.

No.	P	Deflection, in Inches.					P	Deflection, in Inches.				
	Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.	Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.
1	0	2.28	0	2.05	0	0	0	1.44	0	1.58	0	0
2	2,000	2.31	0.03	2.10	0.05	0.040	2,000	1.50	0.06	1.64	0.06	0.06
3	4,000	2,34	0.06	2.14	0.09	0.075	4,000	1.55	0.11	1.70	0.12	0.115
4	6,000	2.40	0.12	2.19	0.14	0.130	6,000	1.62	0.18	1.76	0.18	0.180
5	8,000	2.43	0.15	2.23	0.18	0.165	8,000	1.68	0.24	1.82	0.24	0.240
6	10,000	2.47	0.19	2.28	0.23	0.210	10,000	1.72	0.28	1.89	0.31	0.295
7	12,000	2.51	0.23	2.32	0.27	0.250	12,000	1.80	0.36	1.94	0.36	0.360
8	14,000	2.54	0.26	2.37	0.32	0.290	14,000	1.85	0.41	2.00	0.42	0.415
9	16,000	2.59	0.31	2.41	0.36	0.335	16,000	1.90	0.46	2.06	0.48	0.470
10	18,000	2.62	0.34	2.45	0.40	0.370	18,000	1.98	0.54	2.13	0.55	0.545
11	20,000	2.68	0.40	2.50	0.45	0.425	20,000	2.03	0.59	2.19	0.61	0.600
12	22,000	2.72	0.44	2.54	0.49	0.465	22,000	2.09	0.65	2.25	0.67	0.660
13	24,000	2.78	0.50	2.60	0.55	0.525	24,000	2.15	0.71	2.33	0.75	0.730
14	26,000	2.82	0.54	2.65	0.60	0.570	26,000	2.23	0.79	2.42	0.84	0.815
15	28,000	2.87	0.59	2.69	0.64	0.615	28,000	2.32	0.88	2.49	0.91	0.895
16	30,000	2.91	0.63	2.74	0.69	0.660	30,000	2.42	0.98	2.62	1.04	1.010
17	32,000	2.97	0.69	2.78	0.73	0.710	32,000	2.56	1.12	2.74	1.16	1.140
18	34,000	3.01	0.73	2.85	0.80	0.765	34,000	2.67	1.23	2.87	1.29	1.265
19	36,000	3.07	0.79	2.90	0.85	0.820						
20	38,000	3.14	0.86	2.98	0.93	0.895						

34,000 lb. First Crack; 38,425 lb. Failed.
At Elastic Limit: Load, 22,000 lb.; deflection, 0.465 in.; *S* 3,320 lb.
Maximum: Load, 38,425 lb.; deflection,.....; *S* 5,810 lb.
E = 1,601,000 lb.

28,360 lb. Cracked; 35,500 lb, Failed.
At Elastic Limit: Load, 22,000 lb.; deflection, 0.66 in.; *S*, 3,090 lb.
Maximum: Load, 35,500 lb.; deflection,.....; *S* 4,983 lb.
E = 1,017,000 lb.

TABLE 4.—(*Continued.*)—Load and Deflection Log. Beam V. [51]

Date: —
l = 12 ft.; *b* (mean) = 6 in.;
h (mean) = 16 in.;
c = 8 in. Time = 40 min.

Date: February 27th, 1909.
l = 12 ft.; *b* (mean) = 6 in.;
h (mean) = 15.87 in.;
c = 7.94 in.

No.	P	Deflection, in Inches.					P	Deflection, in Inches.				
	Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.	Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.
1	0	1.97	0	1.37	0	0	0	1.31	0	1.25	0	0
2	2,000	2.01	0.04	1.40	0.03	0.035	2,000	1.37	0.06	1.31	0.06	0.06
3	4,000	2.06	0.09	1.43	0.06	0.075	4,000	1.41	0.10	0.36	0.11	0.105
4	6,000	2.08	0.11	1.47	0.10	0.105	6,000	1.46	0.15	0.40	0.15	0.150
5	8,000	2.11	0.14	1.50	0.13	0.135	8,000	1.49	0.18	0.45	0.20	0.190
6	10,000	2.16	0.19	1.54	0.17	0.180	10,000	1.54	0.23	1.49	0.24	0.235
7	12,000	2.19	0.22	1.57	0.20	0.210	12,000	1.58	0.27	1.53	0.28	0.275
8	14,000	2.22	0.25	1.61	0.24	0.245	14,000	1.62	0.31	1.57	0.32	0.315
9	16,000	2.25	0.28	1.65	0.28	0.280	16,000	1.68	0.37	1.65	0.40	0.385
10	18,000	2.29	0.32	1,69	0.32	0.320	18,000	1.78	0.41	1.71	0.46	0.435
11	20,000	2.32	0.35	1.73	0.36	0.355	20,000	1.99	0.68	1.97	0.72	0.700
12	22,000	2.36	0.39	1.78	0.41	0.400						
13	24,000	2.39	0.42	1.83	0.46	0.440						
14	26,000	2.42	0.45	1.85	0.48	0.465						
15	28,000	2.47	0.50	1.90	0.53	0.515						
16	30,000	2.50	0.53	1.95	0.58	0.565						
17	32,000	2.54	0.57	1.99	0.62	0.595						
18	34,000	2.59	0.62	2.04	0.67	0.645						
19	36,000	2.63	0.66	2.09	0.72	0.690						
20	38,000	2.68	0.71	2.17	0.80	0.755						
21	40,000	2.73	0.76	2.21	0.84	0.800						
22	42,000	2.80	0.83	2.30	0.93	0.880						
23	44,000	2.90	0.93	2.40	1.03	0.980						

25,000 lb. Slight Crack; 47,000 lb. Failed.
At Elastic Limit: Load, 22,000 lb.; deflection, 0.40 in.; *S*, 3,090 lb.
Maximum: Load, 47,000 lb.; deflection,.......; *S*, 6,610 lb.
E = 1,670,000 lb.

20,000 lb. First Crack; 22,050 lb. Failed.
At Elastic Limit: Load, 14,000 lb.; deflection, 0.315 in.; *S*, 1,998 lb.
Maximum: Load, 22,050 lb.; deflection,.......; *S*, 3,145 lb.
E = 1,382,000 lb.

TABLE 4.—(*Continued.*)—Load and Deflection Log. Beam VI. [52]

Date: February 12th, 1909.
l = 12 ft.; *b* (mean) = 5.5 in.;
h (mean) = 15.75 in.;
c = 7.88 in. Time = 40 min.

Date: February 13th, 1909.
l = 12 ft.; *b* (mean) = 5.87 in.;
h (mean) = 15.62 in.;
c = 7.81 in.

No.	P	Deflection, in Inches.					P	Deflection, in Inches.				
	Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.	Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.
1	0	1.22	0	1.30	0	0	0	1.28	0	1.30	0	0

2	2,000	1.26	0.04	1.34	0.04	0.04	2,000	1.30	0.02	1.35	0.05	0.035
3	4,000	1.29	0.07	1.38	0.08	0.075	4,000	1.36	0.08	1.39	0.09	0.085
4	6,000	1.33	0.11	1.42	0.12	0.115	6,000	1.40	0.12	1.44	0.14	0.130
5	8,000	1.37	0.15	1.47	0.17	0.160	8,000	1.43	0.15	1.47	0.17	0.160
6	10,000	1.42	0.20	1.51	0.21	0.205	10,000	1.47	0.19	1.51	0.21	0.200
7	12,000	1.45	0.23	1.55	0.25	0.240	12,000	1.51	0.23	1.56	0.26	0.245
8	14,000	1.50	0.28	1.59	0.29	0.285	14,000	1.55	0.27	1.60	0.30	0.285
9	16,000	1.54	0.32	1.63	0.33	0.325	16,000	1.59	0.31	1.64	0.34	0.325
10	18,000	1.58	0.36	1.68	0.38	0.370	18,000	1.62	0.34	1.69	0.39	0.365
11	20,000	1.61	0.39	1.72	0.42	0.405	20,000	1.66	0.38	1.74	0.44	0.410
12	22,000	1.66	0.44	1.76	0.46	0.450	22,000	1.71	0.43	1.80	0.50	0.465
13	24,000	1.81	0.59	1.81	0.51	0.550	24,000	1.77	0.49	1.84	0.54	0.515
14	26,000	1.86	0.64	1.86	0.56	0.600	26,000	1.83	0.55	1.90	0.60	0.575
15	28,000	1.91	0.69	1.91	0.61	0.650	28,000	1.90	0.62	1.97	0.67	0.645
16	30,000	1.96	0.74	1.96	0.66	0.700	30,000	1.97	0.69	2.02	0.72	0.705
17	32,000	2.00	0.78	2.02	0.72	0.750	32,000	2.12	0.84	2.10	0.80	0.820
18	34,000	2.04	0.82	2.11	0.81	0.815	34,000	2.20	0.92	2.16	0.86	0.885
19	36,000	2.10	0.88	2.20	0.90	0.890	36,000	2.29	1.01	2.24	0.94	0.975
20	38,000	2.16	0.94	2.25	0.95	0.945	38,000	2.39	1.11	2.32	1.02	1.065
21	40,000	2.28	1.06	2.38	1.08	1.070						
22	42,000	2.38	1.16	2.42	1.12	1.140						
23	44,000	2.44	1.22	2.52	1.22	1.220						
24	46,000	2.53	1.31	2.60	1.30	1.305						
25	48,000	2.66	1.44	2.71	1.41	1.425						
26	50,000	2.78	1.56	2.87	1.57	1.565						

33,000 lb., First Crack; 51,330 lb., Failed.
At Elastic Limit: Load, 22,000 lb.; deflection, 0.45 in.; *S*, 3,484 lb.
Maximum: Load, 51,330 lb.; deflection,.....; *S*, 8,925 lb.
E = 1,695,000 lb.

24,000 lb., First Crack; 44,000 lb., Failed.
At Elastic Limit: Load, 20,000 lb.; deflection, 0.41 in.; *S*, 3,018 lb.
Maximum: Load, 44,000 lb.; deflection,.....; *S*, 6,627 lb.
E = 1,625,000 lb.

TABLE 4.—(*Continued.*)—Load and Deflection Log. Beam VII.

Date: March 2d, 1909.
l = 12 ft.; *b* (mean) = 6.56 in.;
h (mean) = 15.62 in.;
c = 7.81 in. Time = 1 hr.

Date: February 20th, 1909.
l = 12 ft.; *b* (mean) = 6.22 in.;
h (mean) = 15.62 in.;
c = 7.81 in. Time = 33 min.

No.	*P*	Deflection, in Inches.					*P*	Deflection, in Inches.				
	Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.	Load, in pounds.	Reading.	Total deflection.	Reading.	Total deflection.	Mean total deflection.
1	0	1.84	0	1.71	0	0	0	1.69	0	1.73	0	0
2	2,000	1.88	0.04	1.74	0.03	0.035	2,000	1.72	0.03	1.77	0.04	0.035
3	4,000	1.92	0.08	1.79	0.08	0.080	4,000	1.76	0.07	1.80	0.07	0.070
4	6,000	1.96	0.12	1.81	0.10	0.110	6,000	1.80	0.11	1.84	0.11	0.110
5	8,000	2.00	0.16	1.85	0.14	0.150	8,000	1.84	0.15	1.87	0.14	0.145
6	10,000	2.03	0.19	1.89	0.18	0.185	10,000	1.88	0.19	1.92	0.19	0.190
7	12,000	2.06	0.22	1.93	0.22	0.220	12,000	1.91	0.22	1.95	0.22	0.220
8	14,000	2.11	0.27	1.95	0.24	0.255	14,000	1.95	0.26	2.00	0.27	0.265
9	16,000	2.14	0.30	1.99	0.28	0.290	16,000	1.99	0.30	2.03	0.30	0.300
10	18,000	2.18	0.34	2.03	0.32	0.330	18,000	2.03	0.34	2.06	0.33	0.335
11	20,000	2.22	0.38	2.05	0.34	0.360	20,000	2.07	0.38	2.11	0.38	0.380
12	22,000	2.25	0.41	2.10	0.39	0.400	22,000	2.11	0.42	2.16	0.43	0.425
13	24,000	2.29	0.45	2.13	0.42	0.435	24,000	2.15	0.46	2.20	0.47	0.465
14	26,000	2.32	0.48	2.17	0.46	0.470	26,000	2.19	0.50	2.24	0.51	0.505
15	28,000	2.36	0.52	2.21	0.50	0.510	28,000	2.23	0.54	2.28	0.55	0.545
16	30,000	2.40	0.56	2.25	0.54	0.550	30,000	2.27	0.58	2.33	0.60	0.590
17	32,000	2.43	0.59	2.29	0.58	0.585	32,000	2.32	0.63	2.37	0.64	0.635
18	34,000	2.47	0.63	2.32	0.61	0.620	34,000	2.36	0.67	2.42	0.69	0.680
19	36,000	2.51	0.67	2.37	0.66	0.665	36,000					
20	38,000	2.56	0.72	2.41	0.70	0.710						

27,000 lb., First Crack; 51,900 lb., Failed.
At Elastic Limit: Load, 34,000 lb.; deflection, 0.62 in.; *S*, 4,580 lb.
Maximum: Load, 51,900 lb.; deflection,.....; *S*, 6,985 lb.
E = 1,637,000 lb.

28,000 lb., First Crack; 49,000 lb., Failed.
At Elastic Limit: Load, 20,000 lb.; deflection, 0.38 in.; *S*, 2,845 lb.
Maximum: Load, 49,000 lb.; deflection,.....; *S*, 6,970 lb.
E = 1,658,000 lb.

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