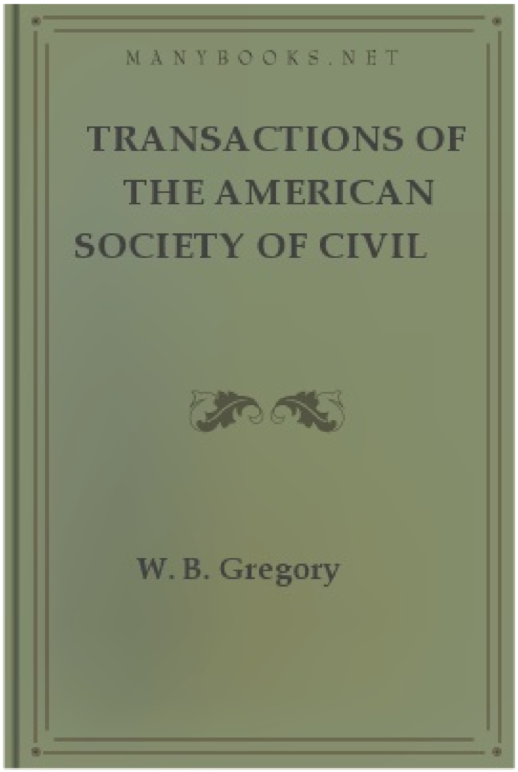

Transactions of the American Society of Civil Engineers, vol. LXX, Dec. 1910

Title: Transactions of the American Society of Civil Engineers, vol. LXX, Dec. 1910 Tests of Creosoted Timber, Paper No. 1168

Author: W. B. Gregory

Release Date: February 16, 2006 [EBook #17776]

Language: English

Character set encoding: ISO-8859-1

Produced by Juliet Sutherland, Sigal Alon and the Online Distributed Proofreading Team at http://www.pgdp.net

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[Transcriber's Note:

1. Mathematical power (superscript) is rendered using a carat (^).

2. Superscript text is rendered using an underscore (_).]

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

TRANSACTIONS

Paper No. 1168

TESTS OF CREOSOTED TIMBER.

BY W. B. GREGORY, M. AM. SOC. C. E.

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.

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.

[Illustration: FIG. 1.--DEFLECTON CURVES BEAM I]

[Illustration: 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.

Columns in table:

1. Number of beam. 2. Top or butt of log. 3. Width, in inches. 4. Height, in inches. 5. I = (bh^3)/12 6. Actual at elastic limit. 7. Maximum. 8. At elastic limit. 9. Maximum. 10. At elastic limit. 11. E = (Pl^3)/(48dI) 12. Weight, in pounds per cubic foot.

		b	h	I	LOADS:		S = (Plc)/(4I)		d, INCHES.
1	2	3	4	5	6	7	8	9	10
I	B	6.28	15.94	2,120	22,000	45,900	2,975	6,200	0.41
I	T	6.00	15.69	1,934	20,000	38,000	2,915	5,540	0.465
II[A]	T	6.37	15.81	2,098	20,000	43,450	2,722	5,918	0.380
II	B	6.41	16.41	2,360	16,000	25,040	1,999	3,130	0.430
III	T	5.88	15.68	1,871	24,000	45,130	3,608	6,785	0.535
III	B	5.88	15.90	1,965	21,000	35,190	3,054	5,120	0.515
IV	T	6.00	15.43	1,835	22,000	38,425	3,320	5,810	0.465
IV	B	6.12	15.87	2,032	22,000	35,500	3,090	4,983	0.660

| | | | | | V | B | 6.00 | 16.00 | 2,048 | 22,000 | 47,000 | 3,090 | 6,610 | 0.400 | V[A]| T | 6.00 | 15.87 | 1,999 | 14,000 | 22,050 | 1,998 | 3,145 | 0.315 | | | | | | | | | | | VI[A]| B | 5.50 | 15.75 | 1,790 | 22,000 | 51,330 | 3,484 | 8,925 | 0.450 | VI[A]| T | 5.87 | 15.62 | 1,865 | 20,000 | 44,000 | 3,013 | 6,627 | 0.410 | | | | | | | | | | | VII | B | 6.56 | 15.62 | 2,083 | 34,000 | 51,900 | 4,580 | 6,985 | 0.620 | VII[A]| T | 6.22 | 15.62 | 1,975 | 20,000 | 49,000 | 2,845 | 6,970 | 0.380 |
==+

[Footnote A: Failed in longitudinal shear.]

=== E | | | | -----------+ | 11 | 12 | Remarks. -----------+------+-------------------------- 1,575,000 | 50.2 | } Close-grained pine, 1,383,000 | 47.5 | } long-leaf. | | 1,562,000 | 40.5 | } Coarse loblolly, 979,000 | 42.2 | } large knots. | | 1,489,000 | 40.4 | } Close-grained, long-leaf 1,288,000 | 44.2 | } no knots. | | 1,601,000 | 40.8 | } Loblolly, with 1,017,000 | 41.5 | } knots. | | 1,670,000 | 47.2 | } Long-leaf yellow 1,382,000 | 42.1 | } pine. | | 1,695,000 | 50.2 | } Long-leaf yellow 1,625,000 | 45.2 | } pine. | | 1,637,000 | 43.7 | } Long-leaf yellow 1,658,000 | 40.2 | } pine.
===

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.

[Illustration: FIG. 3.--DEFLECTON CURVES BEAM III]

[Illustration: 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 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.]

[Illustration: FIG. 5.--DEFLECTON CURVES BEAM V]

[Illustration: 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.]

[Illustration: 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.

[Illustration: PLATE I, FIG. 1.----SPECIMEN IN TESTING MACHINE, SHOWING METHOD OF SUPPORT.]

[Illustration: PLATE I, FIG. 2.--END VIEWS OF TESTED TIMBERS.]

TABLE 2.--BENDING STRENGTH OF LARGE STICKS.

Columns in table:

A: Reference number. B: Number of tests. C: Moisture, per cent. D: Rings per inch. E: Specific gravity, dry. F: WEIGHT PER CUBIC FOOT, IN POUNDS. G: As tested. H: Oven dry. I: Fiber stress at elastic limit, in pounds per square inch. J: Modulus of rupture, in pounds per square inch. K: Modulus of elasticity, in thousands of pounds per square inch. L: Elastic resilience, in inch pounds per cubic inch. M: Number failing by longitudinal shear.

LOBLOLLY PINE.

+==+ | | Locality| DIMENSIONS. | | | | | | | | of +--------------+ Grade. |Condition | | | | | | A | Growth. |Section,|Span,| | of | | B | C | D | | | | in | in | |seasoning.| | | | | | | | inches.|feet | | | | | | +---+---------+--------+-----+---------+---------+-------+---+-----+----+ | | | 6 by 7| | | | | | | | | | | 6 by 10| 10 | | | | | | | | 1 |South | 4 by 12| to | Square | Green |Average| | 48.0| 5.7| | |Carolina.| 6 by 16| 15.5| edge | |Maximum| 42| 92.1|11.7| | | | 8 by 14| | | |Minimum| | 30.2| 2.3| | | | 8 by 16| | | | | | | +---+---------+--------+-----+---------+---------+-------+---+-----+----+ | | | 6 by 7| | | | | | | | | | | 4 by 12| 10 | | | | | | | | 2 |South | 6 by 10| to | Square |Partially |Average| | 27.7| 5.0| | |Carolina.| 6 by 16| 16 | edge |air dry. |Maximum| 18| 29.2| 8.2| | | | 8 by 16| | | |Minimum| | 25.5| 2.5| | | |10 by 16| | | | | | | +---+---------+--------+-----+---------+---------+-------+---+-----+----+ | | | 6 by 7| 10 | | | | | | | | |South | 4 by 12| to

| Square |Partially |Average| | 21.0| 5.6| | 3 |Carolina.| 6 by 10| 15 | edge |air dry. |Maximum| 19| 24.9|17.2| | | | 6 by 16| | | |Minimum| | 15.0| 2.7| +---+---------+--------+-----+---------+----------+-------+---+-----+----+ | | | | 6 | | |Average| | 22.4| 4.8| | 4 |Virginia.| 8 by 8| to | Square |Partially |Maximum| 12| 27.7| 8.8| | | | | 16 | edge |air dry. |Minimum| | 17.8| 2.5| +---+---------+--------+-----+---------+----------+-------+---+-----+----+ | | | | 6 | | |Average| | 64.0| 3.0| | 5 |Virginia.| 8 by 8| to | Square | Green |Maximum| 17|100.5| 4.0| | | | |15.5 | edge | |Minimum| | 38.8| 2.5| +---+---------+--------+-----+---------+----------+-------+---+-----+----+

LONG-LEAF PINE.

+---+---------+--------+-----+---------+----------+-------+---+-----+----+ | | | | | | |Average| | 25.0|13.7| | 6 |South | 6 by 8| 15 |Merchant-|Partially |Maximum| 22| 40.3|25.4| | |Carolina.|10 by 16| |able |air dry |Minimum| | 17.3| 6.2| +---+---------+--------+-----+---------+----------+-------+---+-----+----+ | | | | | | |Average| | 27.3|18.0| | 7 |Georgia. |10 by 12| 15 |Merchant-|Partially |Maximum| 22| 34.5|29.0| | | | | |able |air dry. |Minimum| | 20.0|11.0| +===+

+===+ | | Locality| | F | | | | | | | | | of | +----------+ | | | | | | | A | Growth. | E | | | I | J | K | L | M | Remarks. | | | | | G | H | | | | | | | | | | | | | | | | | | +---+---------+----+----+----+-----+------+-----+----+---+------------+ | | | | | | | | | | |Moisture | | | | | | | | | | | |above | | 1 |South |0.50|46.2|31.2|3,150| 5,580|1,426|0.45| |saturation | | |Carolina.|0.60|56.8|37.5|5,210| 8,460|1,920|0.99| 7 |point in | | | |0.40|35.6|25.0|1,675| 3,120| 905|0.07| |all cases. | | | | | | | | | | | | | +---+---------+----+----+----+-----+------+-----+----+---+------------+ | | | | | | | | | | | | | | | | | | | | | | | | | 2 |South |0.50|40.0|31.2|3,380| 5,650|1,435|0.45| |Moisture | | |Carolina.|0.55|43.7|34.4|4,610| 8,090|1,880|0.76| 0 |from 25 to | | | |0.45|35.6|28.1|2,115| 3,600|1,152|0.20| |30 per cent.| | | | | | | | | | | | | +---+---------+----+----+----+-----+------+-----+----+---+------------+ | | | | | | | | | | | | |South |0.50|37.5|31.2|2,970| 5,690|1,340|0.39| |Moisture | | 3 |Carolina.|0.58|45.6|36.2|4,850| 8,100|2,040|0.69| 2 |less than | | | |0.41|31.2|25.6|1,730| 2,910| 906|0.10| |25 per cent.| +---+---------+----+----+----+-----+------+-----+----+---+------------+ | | |0.46|35.6|28.8|3,260| 5,180|1,180|0.51| | | | 4 |Virginia.|0.58|43.1|36.2|5,300| 8,950|1,728|1.05| 0 | | | | |0.37|30.0|23.1|1,280| 2,180| 606|0.13| | | +---+---------+----+----+----+-----+------+-----+----+---+------------+ | | |0.43|43.7|26.9|1,935| 3,490| 744|0.31| |Very rapid | | 5 |Virginia.|0.51|51.9|31.9|3,185| 4,720|1,193|0.78| 0 |growth; poor| | |0.35|35.0|21.9| 956| 2,180| 357|0.12| |quality. | +---+---------+----+----+----+-----+------+-----+----+---+------------+

LONG-LEAF PINE.

+---+---------+----+----+----+-----+------+-----+----+---+------------+ | | |0.58|45.6|36.2|3,800| 7,160|1,560|0.53| | | | 6 |South |0.76|60.0|47.5|4,970|10,020|2,010|0.78| 9 | | | |Carolina.|0.50|39.4|31.2|2,220| 5,450|1,190|0.21| | | +---+---------+----+----+----+-----+------+-----+----+---+------------+ | | |0.69|54.7|42.9|5,581| 8,384|1,820| -- | |Excellent | | 7 |Georgia. |0.79| -- |49.4|9,600|11,410|2,920| -- | 6 |merchantable| | |0.50| -- |31.4|3,547| 4,836|1,167| -- | |grade. | +===+

TABLE 3.--LOBLOLLY PINE.--BENDING TESTS ON BEAMS SEASONED UNDER DIFFERENT CONDITIONS.

(8 by 16-in. section; 13-1/2 to 15-ft. span.)

Columns in table:

A. Number of tests. B. Fiber stress at elastic limit, in pounds per square inch. C. Modulus of rupture, in pounds per square inch. D. Longitudinal shear at maximum load, in pounds per square inch. E. Modulus of elasticity, in thousands of pounds per square inch. F. Percentage of moisture. G. Rings per inch. H. Weight per cubic foot, oven dry, in pounds. I. Condition of seasoning.

	A	B	C	D	E	F	G	H	I
Average		3,580	5,480	364_{4}	1,780	23.2	9.4	33.7	Air dry,
Maximum	4	4,070	6,600	440	1,987	24.3	11.5	34.5	3-1/2 months
Minimum		3,090	5,000	327	1,530	21.5	8.0	32.5	in the open.
Average		4,512	5,060	338_{3}	1,685	20	7.7	33.9	Kiln dry,
Maximum	5	5,840	7,320	488	1,790	22	10.2	38.0	6 days.
Minimum		3,180	2,150	143	1,410	18	4.7	27.7	
Average		4,331	6,721	493_{9}	1,688	--	7.7	--	Air dry, 21
Maximum	12	4,990	8,560	620	2,002	--	9.5	--	months under
Minimum		3,110	5,160	380	1,398	--	5.5	--	shelter.

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

[Illustration: PLATE II.--SIDE VIEWS OF TESTED TIMBERS.]

TABLE 4.--LOAD AND DEFLECTION LOG. BEAM I.

Columns in table:

A: Load, in pounds. B: Reading. C: Total deflection. D: Mean total deflection.

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

P No.	A	DEFLECTION, IN INCHES. B	C	B	C	D	P A	DEFLECTION, IN INCHES. B	C	B	C	D
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						

45,900 lb., Failed.	37,500 lb., First Crack;
At Elastic Limit: Load, 22,000 lb.; deflection, 0.465 in.; S, 2,975 lb.	At Elastic Limit: Load, 20,000 lb.; deflection, 0.41 in.; S, 2,975 lb.
Maximum: Load, 45,900 lb.; deflection,.....; S, 6,209 lb.	Maximum: Load, 38,000 lb.; deflection,.....; S, 5,540 lb.
E = 1,575,000 lb.	E = 1,383,000 lb.

[Footnote B: First crack.]

TABLE 4.--(*Continued.*)--LOAD AND DEFLECTION LOG. BEAM II.

Columns in table:

A: Load, in pounds. B: Reading. C: Total deflection. D: Mean total deflection.

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

No.	P	DEFLECTION, IN INCHES.					P	DEFLECTION, IN INCHES.				
	A	B	C	B	C	D	A	B	C	B	C	D
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. || At Elastic Limit: Load, 16,000 lb.; deflection, 0.43 in.; *S*, 1,999 lb. || Maximum: Load, 43,450 lb.; deflection,.....; *S*, 5,918 lb. || Maximum: Load, 25,040 lb.; deflection,.....; *S*, 3,130 lb. || *E* = 1,562,000 lb. || *E* = 979,000 lb.

[Footnote C: First crack.]

TABLE 4.--(*Continued.*)--LOAD AND DEFLECTION LOG. BEAM III.

Columns in table:

A: Load, in pounds. B: Reading. C: Total deflection. D: Mean total deflection.

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

No.	P	DEFLECTION, IN INCHES.					P	DEFLECTION, IN INCHES.				
	A	B	C	B	C	D	A	B	C	B	C	D
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 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; ||22,000 lb. First Crack; 45,130 lb. Failed. ||35,190 lb. Failed. || At Elastic Limit: Load, 24,000 lb.; ||At Elastic Limit: Load, 21,000 lb.; deflection, 0.535 in.; || deflection, 0.515 in.; *S* 3,608 lb. || *S*, 3,054 lb. || Maximum: Load, 45,130 lb.; ||Maximum: Load, 35,190 lb.; deflection,.....; || deflection,.....; *S* 6,785 lb. || *S* 5,120 lb. || *E* = 1,489,000 lb. || *E* = 1,288,000 lb.
==

TABLE 4.--(*Continued.*)--LOAD AND DEFLECTION LOG. BEAM IV.

Columns in table:

A: Load, in pounds. B: Reading. C: Total deflection. D: Mean total deflection.

Date: February 16th, 1909. Date: February 10th, 1909. *l* = 12 ft.; *l* = 12 ft.; *b* (mean) = 6.0 in.; *b* (mean) = 6.12 in.; *h* (mean) = 15.43 in.; *h* (mean) = 15.87 in.; *c* = 7.71 in. *c* = 7.93 in. Time = 30 min.

== | P | DEFLECTION, IN INCHES. || P | DEFLECTION, IN INCHES. No.+------+----+----+----+----+-----++---------+----+----+----+----+----- | A | B | C | B | C | D || A | B | C | B | C | D ---+------+----+----+----+----+-----++---------+----+----+----+----+----- 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; ||28,360 lb. Cracked; 38,425 lb. Failed. ||35,500 lb, Failed. || At Elastic Limit: Load, 22,000 lb.; ||At Elastic Limit: Load, 22,000 lb.; deflection, 0.465 in.; || deflection, 0.66 in.; *S* 3,320 lb. || *S*, 3,090 lb. || Maximum: Load, 38,425 lb.; ||Maximum: Load, 35,500 lb.; deflection,.....; || deflection,.....; *S* 5,810 lb. || *S* 4,983 lb. || *E* = 1,601,000 lb. || *E* = 1,017,000 lb.
==

TABLE 4.--(*Continued.*)--LOAD AND DEFLECTION LOG. BEAM V.

Columns in table:

A: Load, in pounds. B: Reading. C: Total deflection. D: Mean total deflection.

Date: -- Date: February 27th, 1909. *l* = 12 ft.; *l* = 12 ft.; *b* (mean) = 6 in.; *b* (mean) = 6 in.; *h* (mean) = 16 in.; *h* (mean) = 15.87 in.; *c* = 8 in. *c* = 7.94 in. Time = 40 min.

No.	P	DEFLECTION, IN INCHES.					P	DEFLECTION, IN INCHES.				
	A	B	C	B	C	D	A	B	C	B	C	D
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.						20,000 lb. First Crack; 22,050 lb. Failed.					
	At Elastic Limit: Load, 22,000 lb.; deflection, 0.40 in.; *S*, 3,090 lb.						At Elastic Limit: Load, 14,000 lb.; deflection, 0.315 in.; *S*, 1,998 lb.					
	Maximum: Load, 47,000 lb.; deflection,.......; *S*, 6,610 lb.						Maximum: Load, 22,050 lb.; deflection,.......; *S*, 3,145 lb.					
	E = 1,670,000 lb.						*E* = 1,382,000 lb.					

TABLE 4.--(*Continued.*)--LOAD AND DEFLECTION LOG. BEAM VI.

Columns in table:

A: Load, in pounds. B: Reading. C: Total deflection. D: Mean total deflection.

Date: February 12th, 1909. Date: February 13th, 1909. *l* = 12 ft.; *l* = 12 ft.; *b* (mean) = 5.5 in.; *b* (mean) = 5.87 in.; *h* (mean) = 15.75 in.; *h* (mean) = 15.62 in.; *c* = 7.88 in. *c* = 7.81 in. Time = 40 min.

No.	P	DEFLECTION, IN INCHES.					P	DEFLECTION, IN INCHES.				
	A	B	C	B	C	D	A	B	C	B	C	D
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; ||24,000 lb., First Crack; 51,330 lb., Failed. ||44,000 lb., Failed. || At Elastic Limit: Load, 22,000 lb.; ||At Elastic Limit: Load, 20,000 lb.; deflection, 0.45 in.; || deflection, 0.41 in.; *S*, 3,484 lb. || *S*, 3,018 lb. || Maximum: Load, 51,330 lb.; ||Maximum: Load, 44,000 lb.; deflection,.....; || deflection,.....; *S*, 8,925 lb. || *S*, 6,627 lb. || *E* = 1,695,000 lb. || *E* = 1,625,000 lb.
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TABLE 4.--(*Continued.*)--LOAD AND DEFLECTION LOG. BEAM VII.

Columns in table:

A: Load, in pounds. B: Reading. C: Total deflection. D: Mean total deflection.

Date: March 2d, 1909. Date: February 20th, 1909. *l* = 12 ft.; *l* = 12 ft.; *b* (mean) = 6.56 in.; *b* (mean) = 6.22 in.; *h* (mean) = 15.62 in.; *h* (mean) = 15.62 in.; *c* = 7.81 in. *c* = 7.81 in. Time = 1 hr. Time = 33 min.

== | P | DEFLECTION, IN INCHES. || P | DEFLECTION, IN INCHES. No.+------+----+----+----+----+-----++---------+----+----+----+----+----- | A | B | C | B | C | D || A | B | C | B | C | D ---+------+----+----+----+----+-----++---------+----+----+----+----+----- 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; ||28,000 lb., First Crack; 51,900 lb., Failed. ||49,000 lb., Failed. || At Elastic Limit: Load, 34,000 lb.; ||At Elastic Limit: Load, 20,000 lb.; deflection, 0.62 in.; || deflection, 0.38 in.; *S*, 4,580 lb. || *S*, 2,845 lb. || Maximum: Load, 51,900 lb.; ||Maximum: Load, 49,000 lb.; deflection,.....; || deflection,.....; *S*, 6,985 lb. || *S*, 6,970 lb. || *E* = 1,637,000 lb. || *E* = 1,658,000 lb.
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