Burch & Heaney

Tests of Plain Concrete Columns

Civil Engineering

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TESTS OF PLAIN CONCRETE COLUMNS

BY

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THESIS

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IN

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

GEORGE FRANCIS BURCH

ARTHUR NOBLE HEANEY

ENTITLED TESTS OF PLAIN CONCRETE COLUMNS

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Civil Engineering

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TESTS OF PLAIN CONCRETE COLUMNS.

INTRODUCTION.

Concrete construction has had a remarkable development in the last decade and is now regarded by engineers and architects generally as a safe form of construction with a wide field of economic application. Common practice established itself at first and all concrete work was given an extravagant factor of safety, but in the last few years since reinforced concrete has attained popularity, the outstanding uncertainties have been under investigation and rapid strides have been made toward establishing "good practice" in concrete construction.

Concrete is characterized by low tensile strength, relatively high compressive strength, and great durability. Its great advantages are; its rust-proof and fire-proof qualities, its cheapness, its availability in almost any location, and the ease with which it can be made into any desirable form. For structural members in which tensile stresses are developed steel must be employed as a reinforcement to the concrete, as in the case of a long slender column where there is lateral bending, but for large and compact compressive members plain concrete is used.

A great many tests have been made upon small test pieces such as cubes and cylinders, but the data gathered from those experiments did not allow a comparison to be made between the strengths of the cubes and cylinders and the corresponding columns, for it has been found that the strength of the cubes is usually greater than that of the columns. For reference two series of column tests, not made at the University of Illinois, will be mentioned. The series made at the Massachusetts Institute of Technology were 8 x 8 inches and 10 x 10 inches in cross section and were all reinforced with rods parallel to the vertical axis. The lengths of the columns were 6, 12, and 17 feet. They were made in a vertical position and tested in a horizontal machine. The second series were made at the Watertown Arsenal. These tests were carefully made, and perhaps compare more favorably with University of Illinois Engineering Experiment Station tests than any other which have been made. Two series of column tests have been made at the Laboratory of Applied Mechanics at the University of Illinois. The first series made in 1906 are reported in the thesis of Mr. R. C. Llewllyn '06, and in Bulletin No. 10 of the University of Illinois Engineering Experiment Station. These tests were made on the 600000 lb. Riehle vertical testing machine. Tests were made on plain, and on two varieties of longitudinal rod reinforced columns. All columns were made square in cross-section and were of two sizes, 12 x 12 inches, and 9 x 9 inches. The lengths were 6, 9, and 12 feet. The second series made in 1907

are reported in the thesis of Messrs. C. L. Mowder, C. E. Hoff and Sidney Grear, class of '07 and in Bulletin No. 20 of the University of Illinois Engineering Experiment Station. These tests were made in the same machine. The columns tested were plain, spiral and hoop reinforced, and were all round, a few being 9 inches in diameter and the rest 12 inches in diameter.

The third series of tests, just completed, will form the subject matter of this thesis. This thesis however will report only the tests made on the plain columns, the spiral and hoop reinforced being treated by Messrs. Weber, Gonnerman, and Slaymaker, and Messrs. Hudson, Grubel, and Burroughs respectively. The plain columns tested were of three different mixtures 1-1-2, 1-2-4, and 1-3-6. Columns in each mixture were of three different ages, 14 days, 60 days, and 1 year. Two short columns were also tested under repeated loads.

A comparison will be made between the strengths of the different columns of the same age and different mixtures, and of the same mixture and different ages. The relation between the load, the deformation, and the resulting modulus of elasticity will be determined. Also an effort will be made to measure Poisson's ratio for plain concrete.

Division of Work:- The work of this thesis was divided as follows. Mr. Burch and Mr. Heaney are together responsible for the computation of data, plotting of curves, and the conclusions. The introduction and description of materials was

written by Mr. Heaney, and the description of apparatus and method of testing by Mr. Burch. The actual testing of the columns included in this thesis was done by all the writers, and the men previously mentioned who have the spiral and hoop reinforced columns as their theses. The responsibility for the accuracy of the data can not be given to any one man, as the men did not occupy the same positions on all the tests.

MATERIALS.

The materials used for the tests were similar to the test materials used for this class of work in this section of the country. The Chicago A A Portland cement was bought in the open market, the Universal Portland cement was furnished for these tests by the manufacturers.

Stone. The stone was crushed limestone from Kankakee, Illinois. It was ordered to pass through a 1-inch screen and over a $\frac{1}{4}$-inch screen.

Table 1 gives the percentage of voids. The results given are the average of several tests. These tests show that it had about 55% of voids and weighed about 80 pounds per cubic foot.

TABLE 1.

Void Tests of Stone.

Weight cu. ft. Dry stone.	Weight cu. ft. Wet stone	Weight of Water	Percent Voids
79.25	115.0		
81.0	113.75		
80.5	114.75		
80.25	114.50	34.2	54.7

TABLE 2.

Sizes	Percent Passing
1	100
3/4	89.2
1/2	54.7
3/8	32.8
3	16.9
5	4.1
10	2.5

Cement:- The cement used in the columns was either Chicago A A or Universal Portland cement. The following tables give the results of the fineness and tensile tests of these cements.

TABLE 3.

Fineness of Cement.

Sieve	Percent Passing Chicago A A	Percent Passing Universal
75	98.3	99.3
100	95.1	98.5
200	80.6	90.1

TABLE 4.

Tensile Tests of Cement.

Cement	7 Days Neat	7 Days 1 - 3	28 Days Neat	28 Days 1 - 3
Chicago A A	666	182	792	284
	811	227	833	307
	665	175	799	266
	732	192	857	318
	559	145	707	247
Average	687	184	798	284
Universal	699	242	754	292
	728	232	776	285
	809	248	885	336
	563	244	764	319
	700	242	795	308

Sand:- The sand was of good quality, sharp, well graded, fairly clean, containing about 28% of voids as determined from pouring perfectly dry sand into a vessel of 1 cubic foot capacity, partly filled with water. The weight of 1 cubic foot of dry sand being known, the weight of the wet sand determined, the percentage of voids was computed. The sand came from near the Wabash river at Attica, Indiana. Tables 5 and 6 give the results of the mechanical analysis of this sand. The values given are averages of 40 or 50 tests of samples taken at different times throughout the season.

TABLE 5.

Void Tests of Sand.

Weight cu. ft. Dry sand	Weight cu. ft. Wet sand	Weight of Water	Percent Voids
101.2	118.75		
101.5			
101.0			
101.2		17.75	28

TABLE 6.

Fineness of Sand.

Sieve Number	Percent Passing
3	99.2
5	89.0
10	64.7
12	57.8
16	49.9
18	39.0
30	21.6
40	11.8
50	5.1
74	2.6
150	0.46

Concrete:- Two men skilled in mixing concrete were employed, and great care was used to make the concrete as good as that found in the best structures. All materials were proportioned by loose volumes. As a check on the volume measurement all materials were weighed. The cement and sand were first placed on the flat steel plate which was used for a mixing board, and thoroughly mixed dry by turning with shovels. The stone, which had previously been thoroughly moistened, was added to the mixed sand and cement. The mass was thoroughly mixed, then water was added, and the mass turned until uniform in appearance. The turning of the mass three times after the water was added was usually sufficient to secure a uniform mixture. A fairly wet mixture was used as this permitted the tamping into the forms to better advantage. The amount of

concrete mixed at one time was just sufficient to make one column and the auxiliary test specimens which were given the same number.

TEST SPECIMENS.

The test specimens were made in as nearly a uniform manner as possible. The conditions of manufacture were practically the same in all cases. Three different mixtures of concrete were used, 1-1-2, 1-2-4, and 1-3-6. The stone and sand used were the same in all cases. The cement was Chicago A A and Universal Portland cement. General data on all the test specimens are given in Table II, page 87.

Plain Concrete Columns:- For the series of 1908 a total of 136 columns were made. Of these 85 were reinforced and 51 were plain concrete. The total number of concrete columns tested in 1908 was 19, 3 of these being of the series of 1907. Of these 17 were cylindrical, 15 of them being 12 inches in diameter and 2 nine inches in diameter. The other two columns tested were 12 inches square. All the cylindrical columns were 10 feet long, and the square columns were 6 feet long. Columns No.'s 107, 161, and 162 from the series of 1907 were tested at the age of one year.

Auxiliary Specimens:- To give a check on the quality of the concrete, cubes and cylinders were made from the same batch that was mixed for each column. The 12 inch cubes were made

in sets of two and the 6 inch cubes in sets of three. A single cylinder was made from some of the batches. The mixture for each set of test specimens was the same as the mixture for the column of the corresponding number. The concrete was well tamped in the forms and was trowled around the sides to insure good surface.

Forms for Columns:- The column forms were of galvanized sheet steel bent into a cylindrical shape and held in position by bands 1 inch wide and 3/16 inch thick. The bands could be adjusted to the proper diameter by means of bolts. The forms were built in sections 2 1/2 feet long and fitted together in stove-pipe fashion. The forms are shown in Fig. 2. The forms for the 12-inch cubes were of the ordinary wooden type two in a set. The 6-inch cube forms were of metal. The cylinder forms were of wrought iron with cast iron bases, being the same as shown in Fig. 2 . All forms remained in place about seven days.

Making of Columns:- The concrete for each column and for the corresponding auxiliary specimens, was mixed in one batch. The form was set up on a cast iron base plate 14 x 14 x 1 3/4 inches which was planed on both sides, and served as a bearing plate in the column test. In making the columns the forms were built up in 2 1/2 foot sections, each section being filled before the next was added. The concrete was put in in layers of about six inches, and tamped or churned until water flushed to the surface. The lengths of all the cylindrical

columns were about 10 feet. The square columns were made in the same manner with one exception that the forms were set up complete before being filled.

Storage of Columns:- The columns were built near the walls of the Laboratory of Applied Mechanics and remained in a vertical position until tested. The forms were taken off 7 days after making, and after that the columns were wetted twice daily until they were tested. The temperature of the room varied from 55° to 65°F. The 12-inch cubes were stored in the open air of the same room. The six-inch cubes and cylinders were stored in damp sand.

Summary of Test Pieces:- Table 7 gives a list of all the test pieces. Specimens having corresponding numbers were made from the same batch of concrete. Tables 8, 9, 10 give the general data on the auxiliary specimens.

TESTING MACHINE USED.

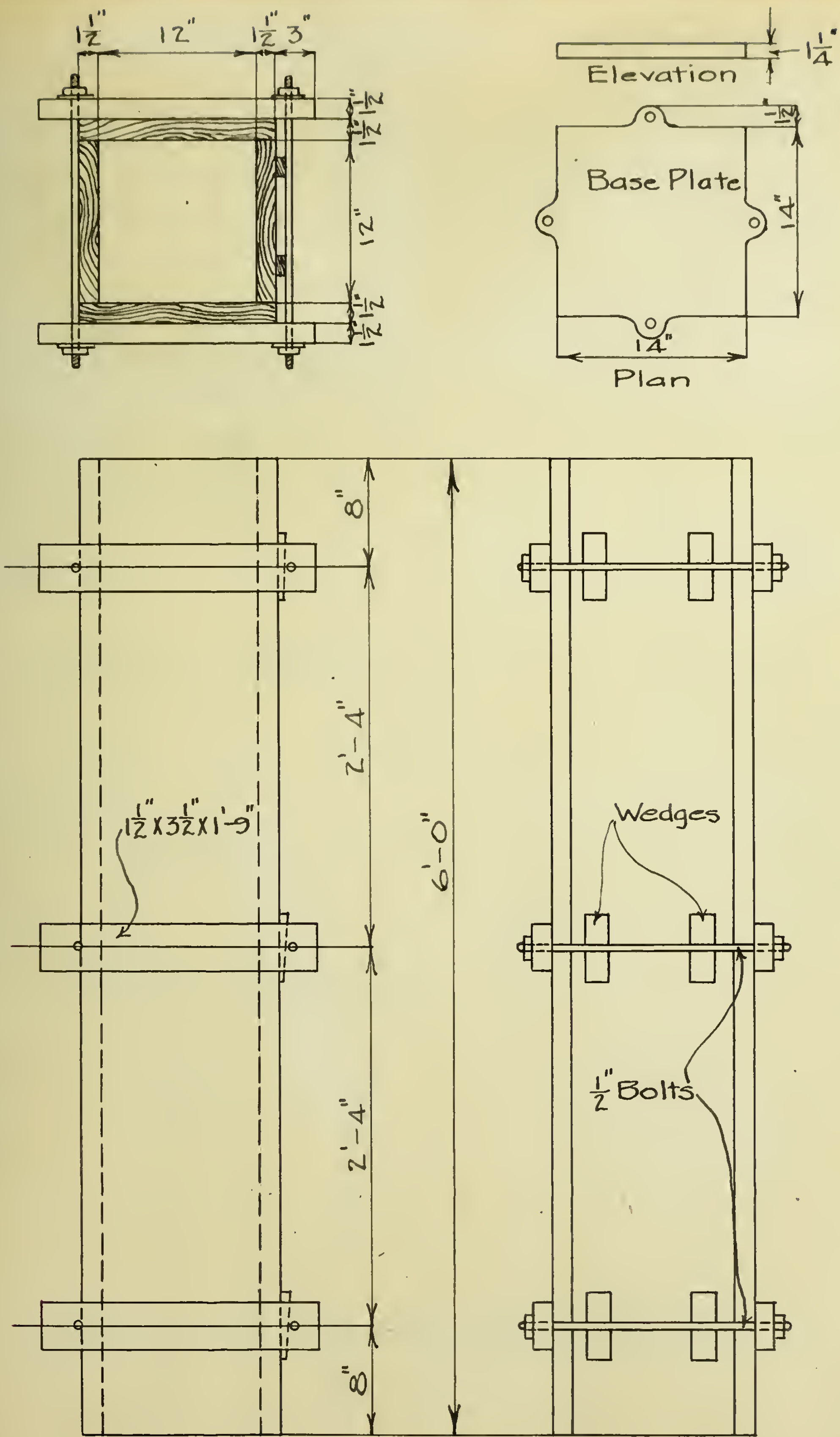
All the columns and 12-inch cubes were tested in the 600000 pound Riehle vertical screw machine of the Laboratory of Applied Mechanics. The slowest speed of 0.05 inch per minute was used, except on two columns where repeated loading was applied. Here a speed of 0.10 inch per minute was used. Fig. 8 shows a column in the machine in position for testing. The 6-inch cubes and 8 x 16-inch cylinders were tested in the Olsen testing machine of 100000 or 200000 pound capacity.

Measuring Devices:- The longitudinal deformations were measured by four extensometers which so magnified the deformation that it was possible to read to ten-thousandths of an inch. The arrangement was such as to give practically two independent sets of readings. The opposite dials were carried by the same yoke. Fig. 3 shows how they were placed. The distance between centers of corresponding yokes was always 100 inches for the 10 foot columns, making the gauged length about 20 inches less than the length of the columns. The gauge length for the square columns was 50 inches. The yokes were placed symmetrically with respect to the middle of the length of the column. The yokes carrying the dials were placed near the bottom of the column and were four inches apart. The yokes carrying the rods were in corresponding positions near the top. The contact rods were of wood 3/8 inch by 3/4 inch and had steel blades at the ends which came in contact with the rollers of the extensometers, and were held in close contact by small elastic bands. The blades had a cylindrical surface so that there was always a bearing along one element.

Lateral Expansion:- The lateral expansion was measured by means of the "Illinois lateral expansion instrument" shown in Fig. 4. The levers for measuring the expansion were hinged to a frame suspended at the middle of the column. At the point where the lever touched the column a small steel disk was fastened to the column with plaster-paris in order to give a good contact. The expansion was multiplied ten times by

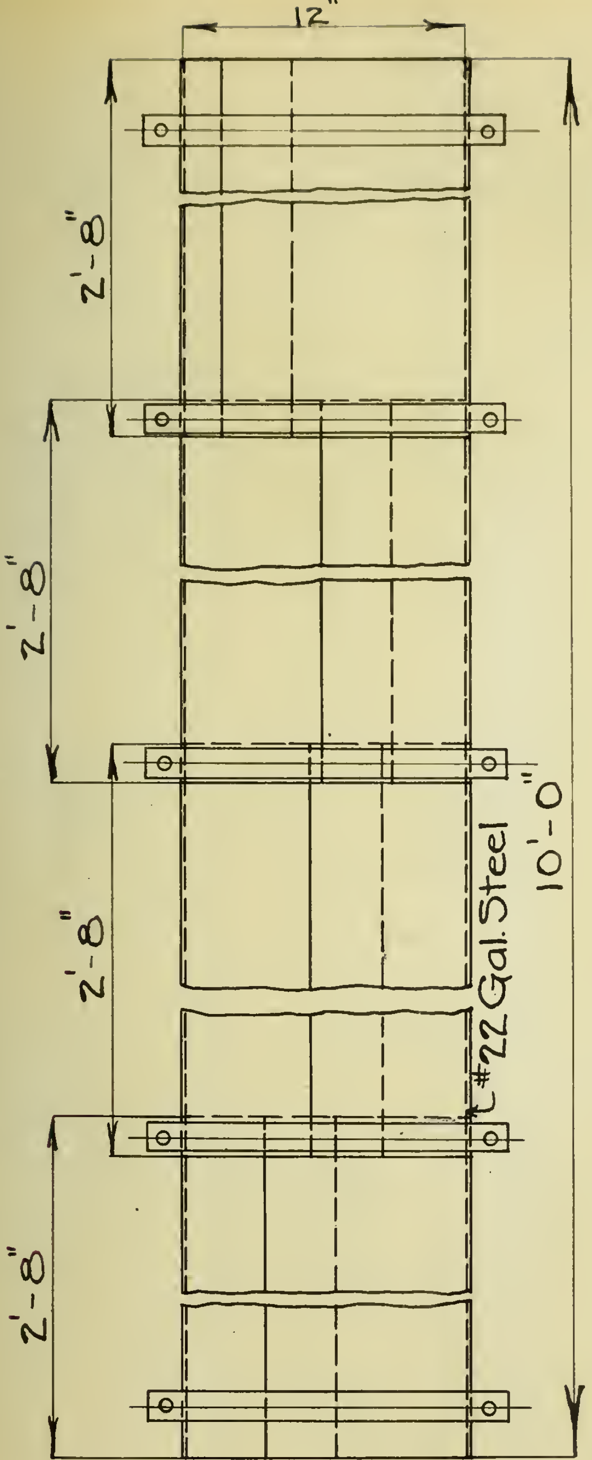
by the levers, and was read by means of two micrometers. These micrometers were read to ten-thousandths of an inch. The contact of the micrometers at the point of reading was noted by the closing of an electric circuit. The closing of this circuit was detected by means of a telephone receiver introduced into the circuit.

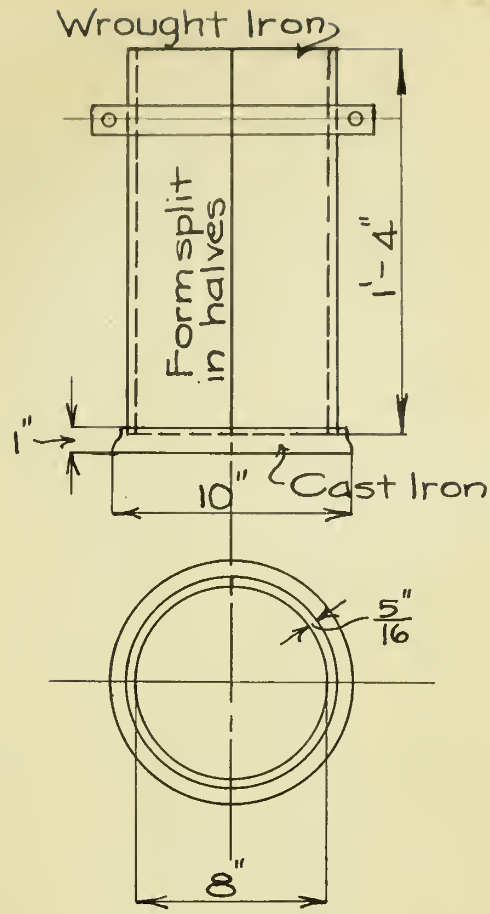
General Method of Testing:- A few days before testing, a plate similar to the base plate shown in Fig. 1 was set on a plaster of paris cushion on top of the column, and served as the top bearing plate in the test. The top and bottom plates were connected with rods, and the columns were carried to the machine in an upright position. The load was applied through a spherical bearing block which was carefully centered on the column. The load was applied in increments of from 10000 to 20000 pounds on the 12-inch column. On the 9-inch column the increment of load rarely ran over 10000 pounds. In Columns 8051 and 8061 the loads were repeated. Readings were taken at about every 10000 pounds change in load. In all cases the machine was stopped while readings on the instruments were taken.



Form For Square Columns

Fig. 1.

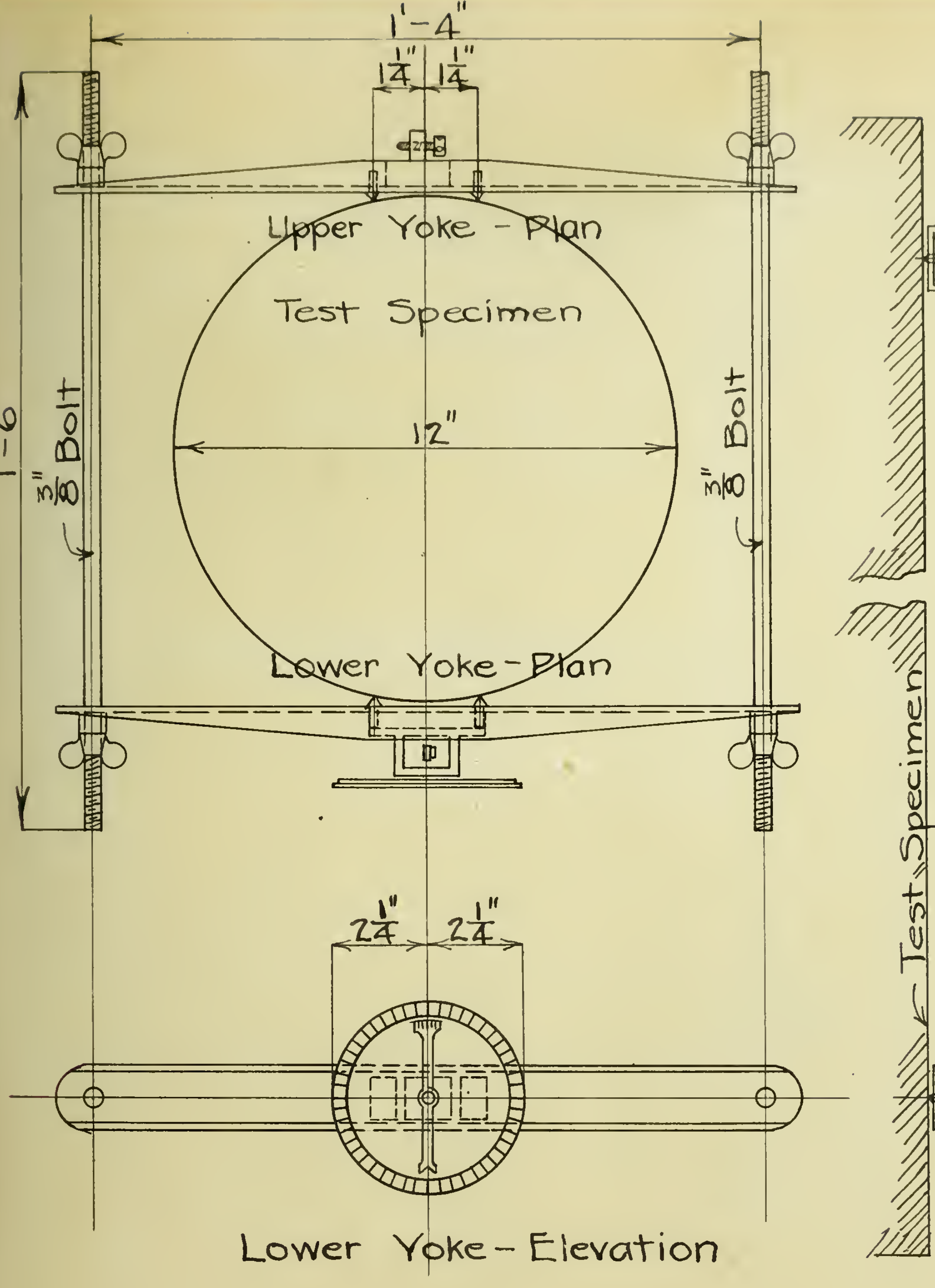




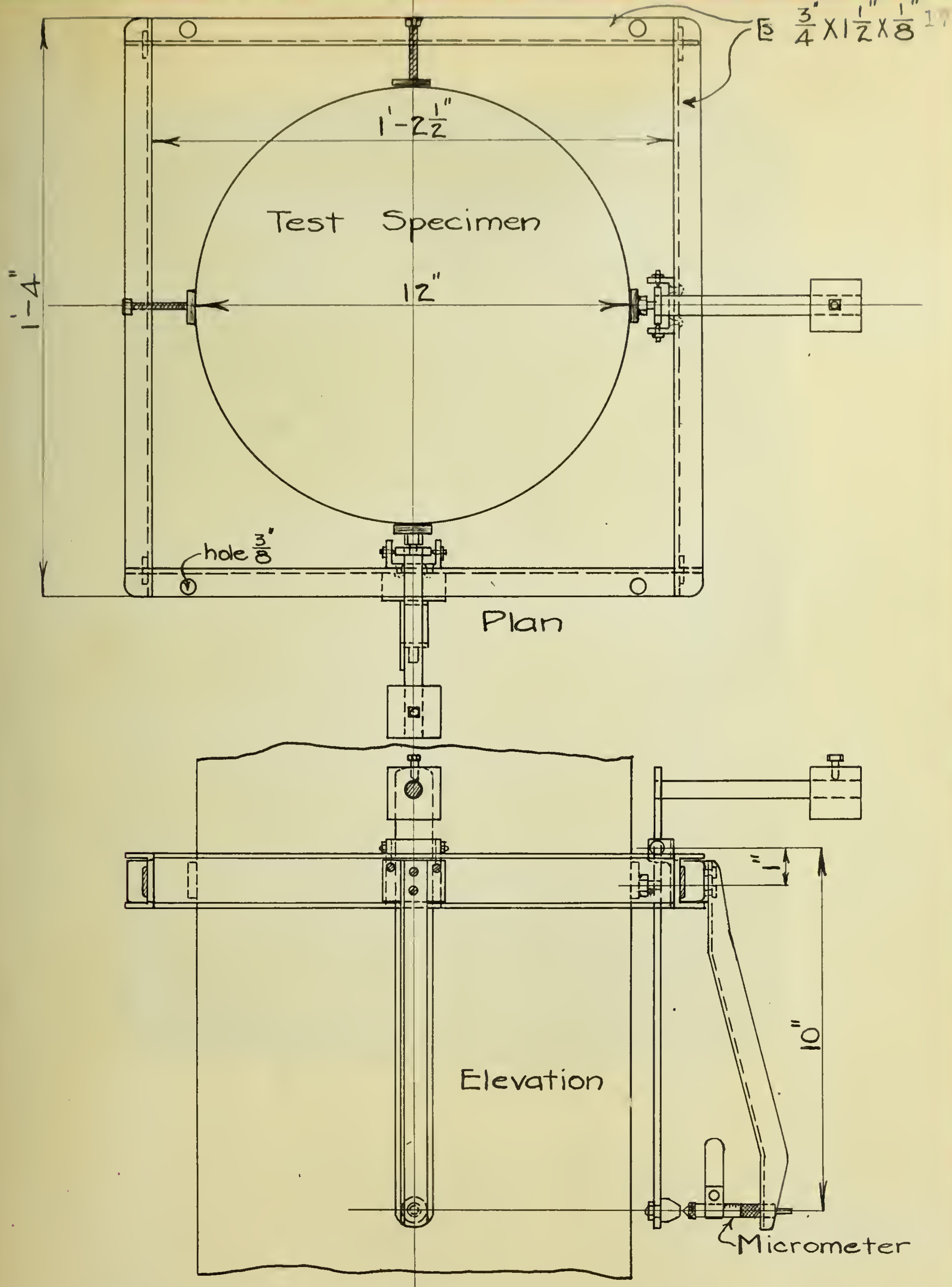
Cylinder Form

Form for Cylindrical Columns

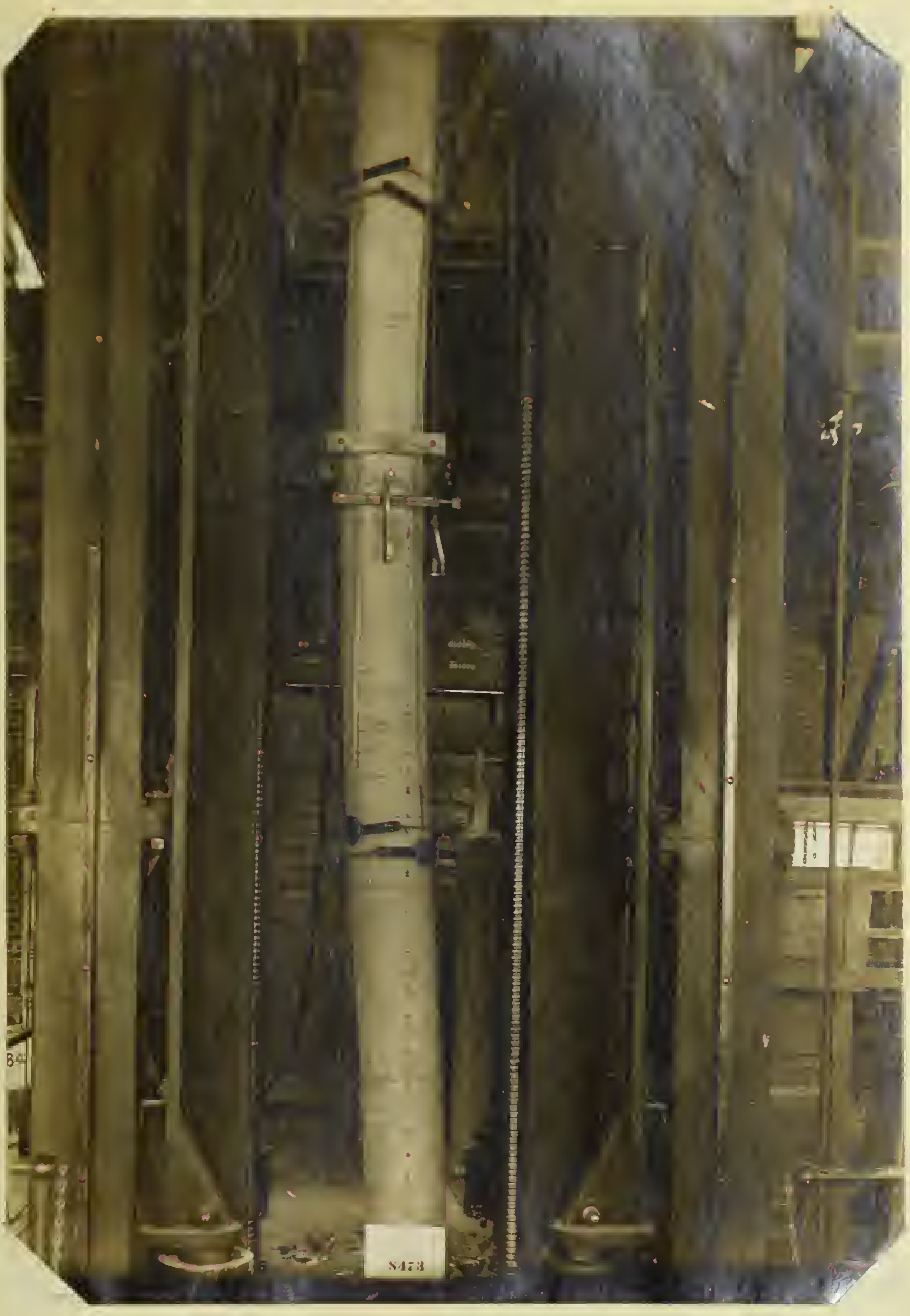
Fig. 2.



Longitudinal Extensometers
Used on Columns
Fig. 3.



Illinois Instrument for measuring Lateral Deformation
Fig. 4.



View Showing Arrangement

of Instruments.

Fig. 8.

TABLE 7

LIST OF TEST COLUMNS AND

AUXILIARY SPECIMENS.

Column Number	Mixture	Age Days	Cement	Diameter of column. Inches.	Auxiliary Specimens Number Made 12" cubes	6" cubes	8"x16" cylinders.
8011	1-1-2	14	Chicago AA	12	2	3	1
8012	1-1-2	14	Chicago AA	12	2	3	1
8051	1-1-2	14	Chicago AA	12 x 11$\frac{3}{4}$	2	3	-
8013	1-1-2	61	Universal	12	2	3	1
8014	1-1-2	60	Universal	12	-	-	-
8015	1-1-2	67	Chicago AA	12	2	3	-
8021	1-2-4	14	Universal	12	2	3	1
8022	1-2-4	14	Chicago AA	12	2	3	1
8061	1-2-4	14	Chicago AA	11 3/16x 12 1/8	2	3	-
8023	1-2-4	66	Universal	12	2	3	1
8024	1-2-4	65	Universal	12	2	3	1
8025	1-2-4	66	Universal	12	2	3	1
107	1-2-4	379	Chicago AA	12	--	-	-
161	1-2-4	377	Chicago AA	9	2	-	-
162	1-2-4	377	Chicago AA	9	2	-	-
8032	1-3-6	14	Chicago AA	12	2	3	1
8033	1-3-6	66	Universal	12	2	3	1
8034	1-3-6	64	Universal	12	2	3	1
8035	1-3-6	67	Chicago AA	12	2	3	-

OBSERVED AND COMPUTED DATA

ON

COLUMNS AND AUXILIARY SPECIMENS.

COLUMN 8011

Observed Data

Length 10 ft. 1 in.
Gauge Length 100 in.
Diameter 12.31 in.

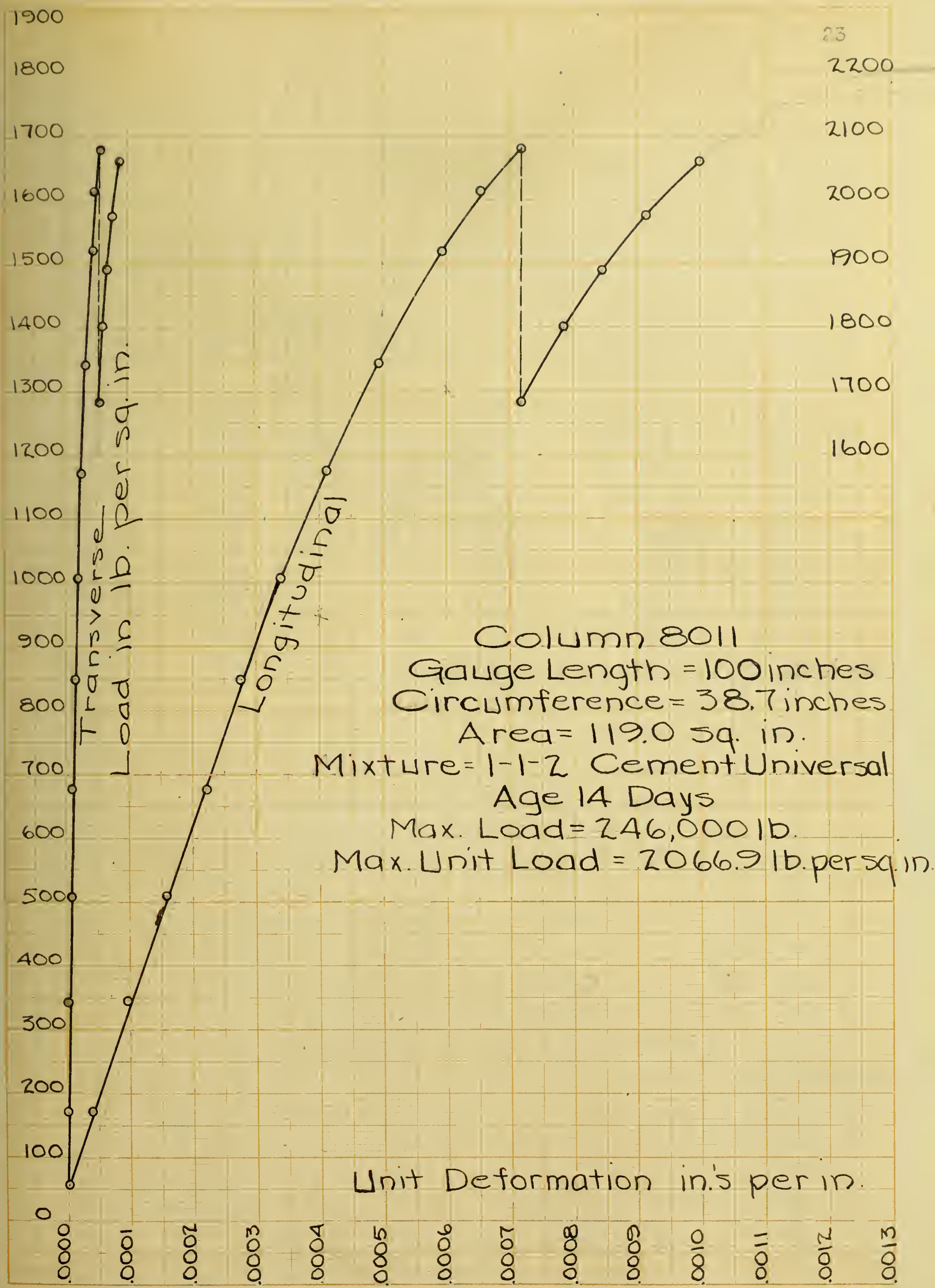
Mixture 1-1-2.
Age when tested, 14 days.
Cement, Universal

Load Pounds	Longitudinal Extensometer Readings				Transverse Extensometer Readings	
	1	2	3	4	E. & W.	N. & S.
6500	.0000	.0000	.0000	.0000		
20500	.0077	.0059	.0009	.0010	.0111	.0011
41000	.0166	.0141	.0042	.0048	.0108	.0107
60500	.0226	.0211	.0099	.0100	.0101	.0104
80500	.0278	.0274	.0167	.0160	.0098	.0100
100000	.0343	.0345	.0187	.0228	.0093	.0095
120500	.0415	.0433	.0210	.0297	.0087	.0091
140000	.0486	.0502	.0282	.0369	.0082	.0088
160000	.0565	.0593	.0377	.0454	.0071	.0079
181000	.0647	.0698	.0489	.0533	.0052	.0069
192000	.0698	.0759	.0559	.0596	.0052	.0069
200500	.0751	.0833	.0640	.0655	.0043	.0062
215000	.0799	.0903	.0720	.0709	.0038	.0057
235000	.0889	.1057	.0898	.0815	.0018	.0044
245000	.0939	.1164	.1026	.0866	.0008	.0037
246000						

COLUMN 8011

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Transverse Deformation E. & W.	Transverse Deformation N. & S.
54.6	.0000	.000000	.000000	.000000
172.2	.0039	.000039	.000000	.000000
344.5	.0099	.000099	.000002	.000003
508.3	.0159	.000159	.000008	.000006
676.4	.0220	.000220	.000010	.000009
840.2	.0276	.000276	.000015	.000013
1012.4	.0339	.000339	.000020	.000016
1176.3	.0410	.000410	.000023	.000019
1344.3	.0497	.000497	.000032	.000026
1520.8	.0592	.000592	.000044	.000031
1613.2	.0653	.000653	.000048	.000034
1684.6	.0720	.000720	.000055	.000040
1806.4	.0783	.000783	.000060	.000044
1890.5	.0843	.000843	.000067	.000047
1974.5	.0915	.000915	.000076	.000055
2058.5	.0999	.000999	.000084	.000060
2066.9				


1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
2200
2100
2000
1900
1800
1700
1600
Transverse
Load in lb. per sq. in.
Longitudinal
Column 8011
Gauge Length = 100 inches
Circumference = 38.7 inches
Area = 119.0 sq. in.
Mixture = 1-1-2 Cement Universal
Age 14 Days
Max. Load = 246,000 lb.
Max. Unit Load = 2066.9 lb. per sq. in.
Unit Deformation in.'s per in.
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 8012

Observed Data

Length 10 ft. 0 in.
Gauge Length 100 in.
Diameter 12.18 in.

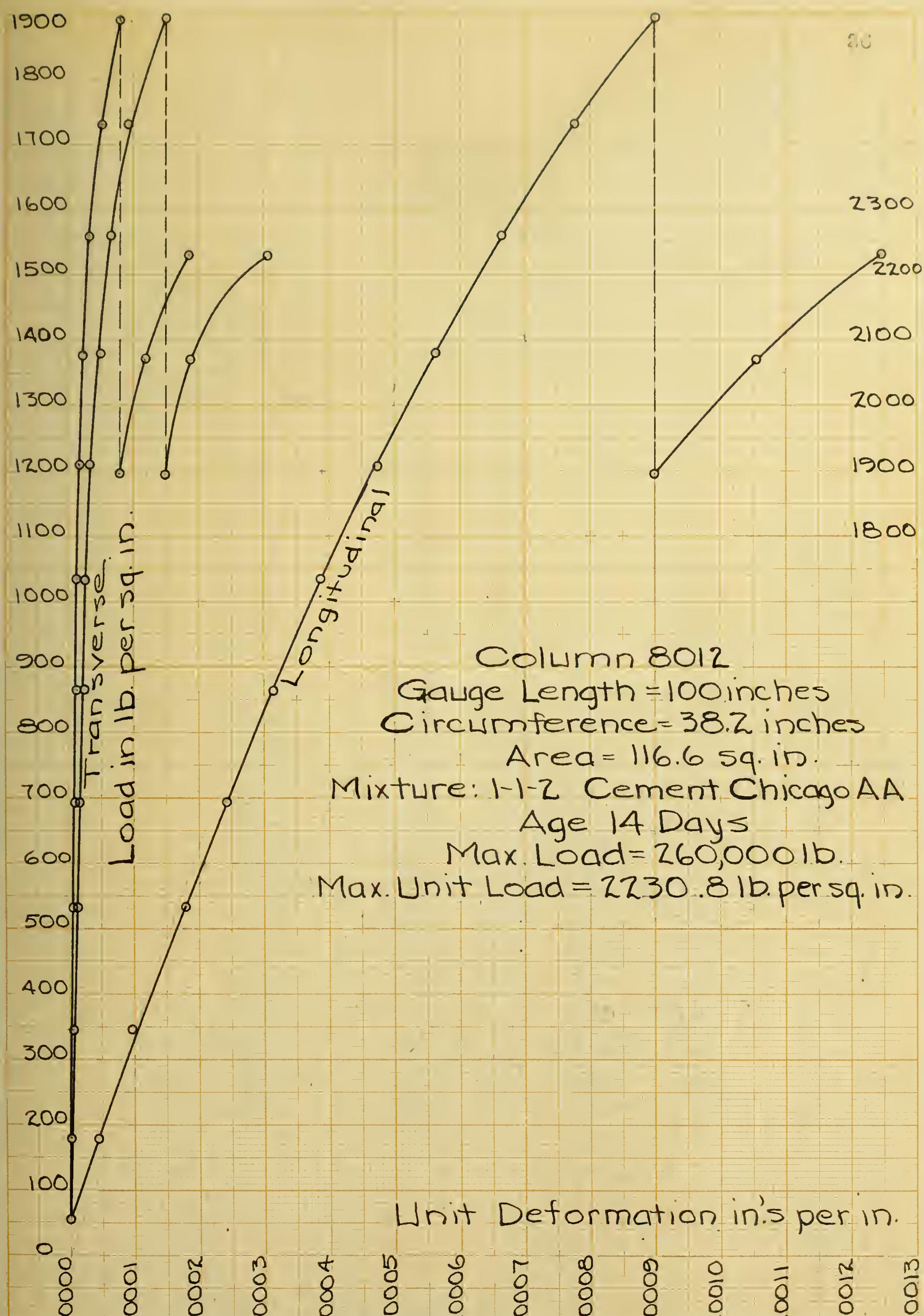
Mixture 1-1-2.
Age when tested, 14 days.
Cement, Chicago AA.

Load Pounds	Longitudinal Extensometer Readings 1	2	3	4	Transverse Extensometer Readings E. & W.	N. & S.
6500	.0000	.0000	.0000	.0000	.2169	.2664
21000	.0030	.0025	.0059	.0052	.2167	.2663
40500	.0082	.0080	.0100	.0120	.2160	.2659
62000	.0151	.0159	.0210	.0190	.2154	.2655
81000	.0218	.0229	.0269	.0248	.2148	.2651
101000	.0293	.0304	.0345	.0305	.2143	.2650
120500	.0377	.0388	.0408	.0371	.2139	.2648
141000	.0460	.0481	.0495	.0456	.2130	.2643
161000	.0552	.0571	.0582	.0544	.2109	.2634
182000	.0653	.0673	.0685	.0647	.2087	.2625
202000	.0765	.0796	.0795	.0756	.2057	.2603
221000	.0890	.0933	.0915	.0877	.1989	.2568
240000	.1039	.1101	.1058	.1019	.1939	.2520
260000	.1218	.1320	.1240	.1205	.1792	.2440

COLUMN 8012

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in	Transverse Deformation Total	Transverse Deformation Unit
53.8	.0000	.000000	.000000	.000000
180.2	.0042	.000042	.000002	.000001
347.5	.0096	.000096	.000007	.000004
532.0	.0178	.000178	.000012	.000007
695.0	.0241	.000241	.000017	.000011
866.6	.0312	.000312	.000021	.000012
1033.9	.0386	.000386	.000025	.000013
1209.8	.0473	.000473	.000032	.000017
1381.4	.0562	.000562	.000049	.000025
1561.6	.0665	.000665	.000067	.000032
1733.2	.0778	.000778	.000092	.000050
1896.2	.0904	.000904	.000148	.000079
2059.2	.1054	.001054	.000189	.000118
2230.8	.1246	.001246	.000309	.000184



Column 8012
Gauge Length = 100 inches
Circumference = 38.2 inches
Area = 116.6 sq. in.
Mixture: 1-1-2 Cement Chicago AA
Age 14 Days
Max. Load = 260,000 lb.
Max. Unit Load = 2230.8 lb. per sq. in.
Transverse
Longitudinal
Load in lb. per sq. in.
Unit Deformation in.'s per in.
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
1800
1900
2000
2100
2200
2300
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 8051

Observed Data

Length 6 ft. 0½ in.
Gauge Length 50 in.
Dimensions 12 in. x 11 3/4 in.

Mixture 1-1-2.
Age when tested, 14 days.
Cement, Chicago AA.

Load Pounds	Longitudinal Extensometer Readings 1	2	3	4
10500	.0000	.0000	.0000	.0000
25500	.0026	.0019	.0021	.0031
48000	.0066	.0052	.0062	.0086
72000	.0114	.0108	.0113	.0114
48000	.0100	.0080	.0076	.0091
26000	.0068	.0050	.0041	.0053
10500	.0030	.0025	.0016	.0020
28500	.0052	.0044	.0037	.0047
50600	.0089	.0082	.0077	.0086
72000	.0122	.0118	.0119	.0122
10500	.0035	.0029	.0019	.0024
72000	.0126	.0120	.0123	.0124
10500	.0040	.0031	.0022	.0025
72000	.0130	.0125	.0125	.0127
10500	.0042	.0033	.0024	.0028
72000	.0134	.0116	.0126	.0131
10500	.0042	.0037	.0026	.0030
73000	.0139	.0131	.0130	.0135
10500	.0045	.0038	.0028	.0030
73000	.0142	.0134	.0133	.0134
10500	.0046	.0040	.0030	.0033
72000	.0142	.0134	.0132	.0136
10500	.0047	.0042	.0031	.0034
72000	.0143	.0139	.0133	.0136
10500	.0052	.0044	.0032	.0035
26000	.0074	.0062	.0048	.0062
50000	.0112	.0100	.0091	.0103
77000	.0153	.0144	.0141	.0142
100000	.0208	.0195	.0192	.0190
124000	.0270	.0262	.0260	.0256
144000	.0336	.0330	.0332	.0334
118000	.0330	.0306	.0305	.0314
98000	.0308	.0280	.0275	.0286

COLUMN 8051

Observed Data

Continued

Load Pounds	Longitudinal Extensometer Readings 1	2	3	4
74000	.0275	.0240	.0233	.0248
51000	.0237	.0195	.0185	.0204
28000	.0189	.0144	.0131	.0148
10500	.0145	.0105	.0091	.0115
144000	.0370	.0365	.0369	.0389
10500	.0162	.0120	.0113	.0132
144000	.0389	.0381	.0394	.0404
10500	.0174	.0130	.0127	.0137
144000	.0401	.0394	.0412	.0415
10500	.0186	.0140	.0144	.0150
145000	.0416	.0410	.0436	.0429
10500	.0196	.0148	.0162	.0157
144000	.0424	.0419	.0450	.0434
10500	.0205	.0160	.0181	.0164
144000	.0434	.0426	.0469	.0445
10500	.0200	.0161	.0207	.0170
144000	.0446	.0440	.0504	.0454
10500	.0210	.0171	.0217	.0176
144000	.0452	.0448	.0513	.0460
10500	.0216	.0178	.0225	.0183
146000	.0460	.0450	.0526	.0418
10500	.0222	.0182	.0232	.0190
26500	.0244	.0201	.0250	.0216
51000	.0288	.0254	.0306	.0272
76000	.0325	.0311	.0371	.0327
101000	.0376	.0368	.0430	.0381
123000	.0421	.0415	.0481	.0427
144000	.0464	.0460	.0528	.0473
172000	.0532	.0530	.0602	.0544
213000	.1478	.1336	.1381	.1501

COLUMN 8051

Computed Data

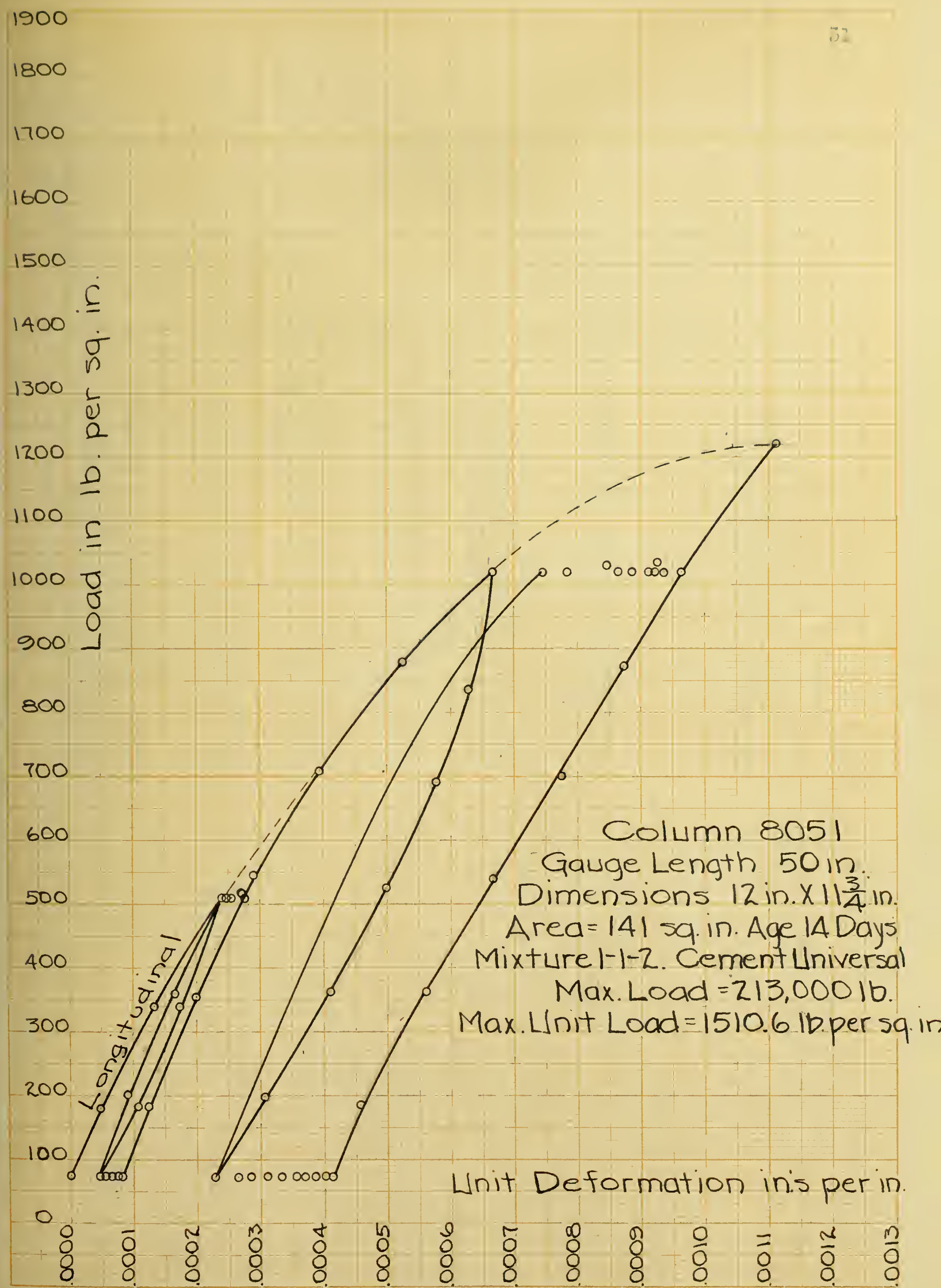
Unit Load Lbs. per sq. in.	Longitudinal Deformation 50 in's	1 in.
74.4	.0000	.000000
180.8	.0024	.000048
340.4	.0067	.000133
510.5	.0120	.000240
340.4	.0087	.000174
184.4	.0053	.000106
74.4	.0023	.000046
202.1	.0045	.000090
358.9	.0084	.000167
510.5	.0120	.000240
74.4	.0027	.000054
510.5	.0123	.000247
74.4	.0030	.000059
510.5	.0127	.000254
74.4	.0032	.000064
510.5	.0127	.000254
74.4	.0034	.000068
517.7	.0134	.000268
74.4	.0035	.000070
517.7	.0136	.000272
74.4	.0037	.000075
510.5	.0136	.000272
74.4	.0039	.000077
510.5	.0138	.000276
74.4	.0041	.000082
184.4	.0062	.000123
354.6	.0102	.000203
546.0	.0145	.000290
709.2	.0196	.000393
872.3	.0262	.000524
1021.2	.0335	.000666
836.9	.0314	.000628
695.0	.0287	.000575

COLUMN 8051

Computed Data

Continued

Unit Load Lbs. per sq. in.	Longitudinal Deformation 50 in's.	1 in.
534.8	.0249	.000498
361.7	.0205	.000411
198.6	.0153	.000306
74.4	.0114	.000228
1021.2	.0373	.000747
74.4	.0132	.000264
1021.2	.0392	.000784
74.4	.0142	.000284
1021.2	.0406	.000911
74.4	.0155	.000310
1028.3	.0423	.000846
74.4	.0166	.000332
1021.2	.0432	.000864
74.4	.0178	.000355
1021.2	.0444	.000887
74.4	.0185	.000369
1021.2	.0461	.000922
74.4	.0194	.000387
1021.2	.0468	.000937
74.4	.0201	.000401
1035.4	.0464	.000927
74.4	.0207	.000413
187.9	.0228	.000456
361.7	.0280	.000560
539.0	.0334	.000667
716.3	.0389	.000778
872.3	.0436	.000872
1021.2	.0481	.000963
1219.8	.0552	.001104
1510.6	.1424	.002848



Load in lb. per sq. in.
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Longitudinal
Column 8051
Gauge Length 50 in.
Dimensions 12 in. X 11 3/4 in.
Area = 141 sq. in. Age 14 Days
Mixture 1-1-2. Cement Universal
Max. Load = 213,000 lb.
Max. Unit Load = 1510.6 lb. per sq. in
Unit Deformation in's per in.
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 8013

Observed Data

Length 10 ft. 0 in.
Gauge Length 100 in.
Diameter 12.18 in.

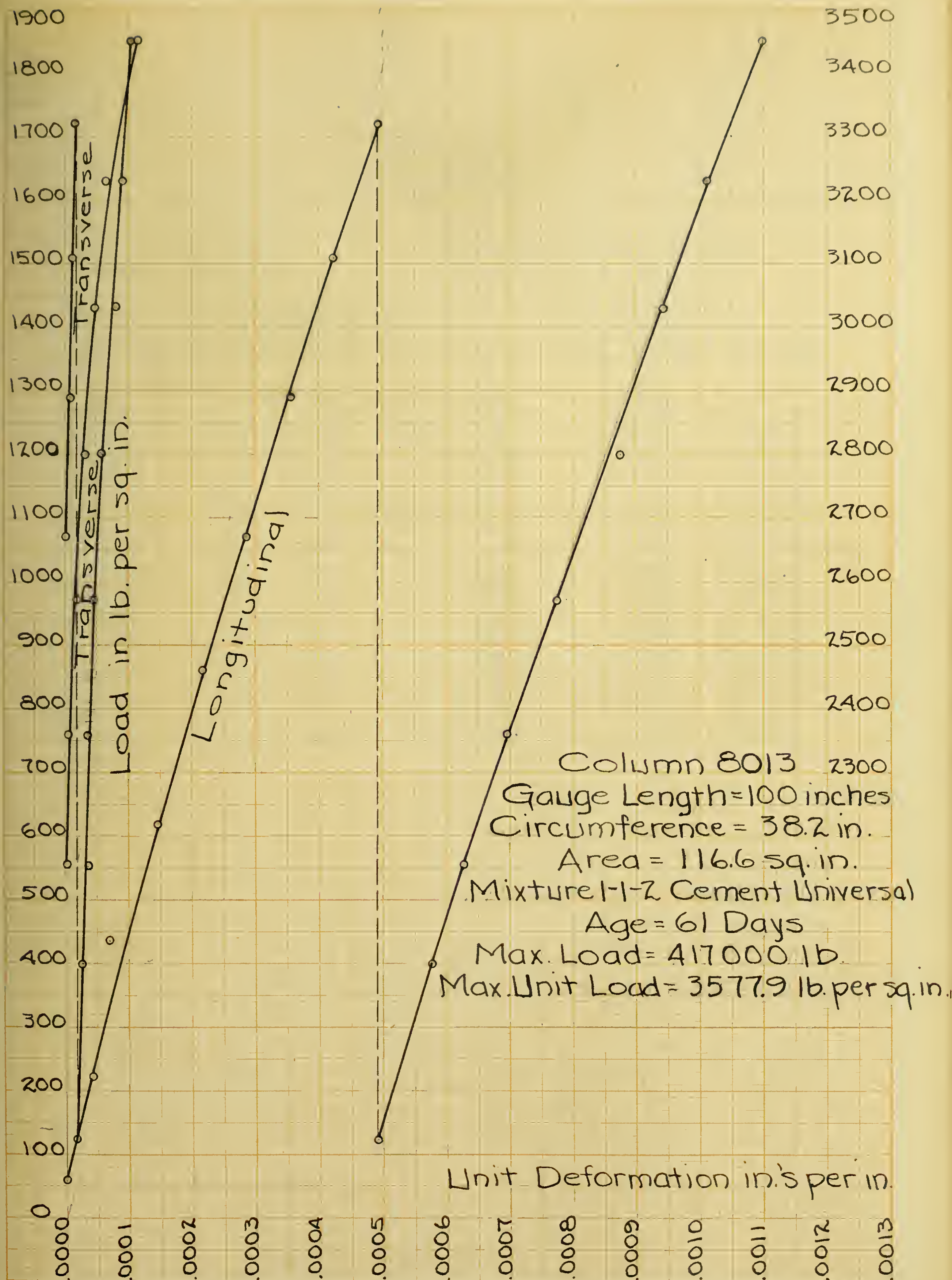
Mixture 1-1-2.
Age when tested, 61 days.
Cement, Universal.

Load Pounds	Longitudinal Extensometer Readings 1.	2.	3.	4.	Transverse Extensometer Readings E. & W.	N. & S.
6500	.0000	.0000	.0000	.0000	.2429	.2960
26000	.0050	.0035	.0023	.0058	.2433	.2965
51000	.0119	.0079	.0035	.0101	.2434	.2965
72000	.0190	.0130	.0142	.0152	.2435	.2961
100500	.0221	.0225	.0189	.0242	.2439	.2960
125500	.0258	.0320	.0230	.0341	.2440	.2957
150000	.0299	.0403	.0278	.0428	.2439	.2949
176000	.0342	.0502	.0321	.0521	.2438	.2944
201000	..0400	.0590	.0368	.0609	.2435	.2939
233000	.0471	.0701	.0426	.0723	.2431	.2927
251500	.0522	.0777	.0460	.0789	.2427	.2917
275000	.0582	.0860	.0520	.0871	.2423	.2915
300000	.0652	.0951	.0590	.0962	.2407	.2908
326000	.0686	.1061	.0674	.1072	.2389	.2890
353000	.0692	.1151	.0725	.1161	.2369	.2872
377000	.0695	.1243	.0761	.1260	.2347	.2848
401000	.0695	.1328	.0829	.1358	.2291	.2837
417000						

COLUMN 8013

Computed Data

Unit Load Lbs. per sq. in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Transverse Deformation E. & W.	Transverse Deformation N. & S.
55.8	.0000	.000000	..000000	.000000
223.1	.0041	.000041	-.000003	-.000004
437.6	.0068	.000068	-.000004	-.000004
617.8	.0147	.000147	-.000005	-.000001
862.3	.0216	.000216	-.000008	-.000000
1077.0	.0286	.000286	-.000009	.000002
1287.0	.0353	.000353	-.000008	.000009
1510.1	.0421	.000421	-.000007	.000013
1724.6	.0489	.000489	-.000005	.000017
1999.1	.0575	.000575	-.000002	.000027
2157.9	.0625	.000625	.000002	.000035
2359.5	.0696	.000696	.000005	.000037
2574.0	.0776	.000776	.000018	.000043
2797.1	.0873	.000873	.000033	.000058
3028.7	.0943	.000943	.000049	.000080
3234.7	.1011	.001011	.000067	.000092
3440.6	.1094	.001094	.000113	.000101
3577.9				


1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
3500
3400
3300
3200
3100
3000
2900
2800
2700
2600
2500
2400
2300
Transverse
Transverse
Load in lb. per sq. in.
Longitudinal
Column 8013
Gauge Length = 100 inches
Circumference = 38.2 in.
Area = 116.6 sq. in.
Mixture 1-1-2 Cement Universal
Age = 61 Days
Max. Load = 417000 lb.
Max. Unit Load = 3577.9 lb. per sq. in.
Unit Deformation in.'s per in.
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 2014

Observed Data

Length 10 ft. $0\frac{3}{4}$ in.
Gauge Length 100 in.
Diameter 12.25 in.

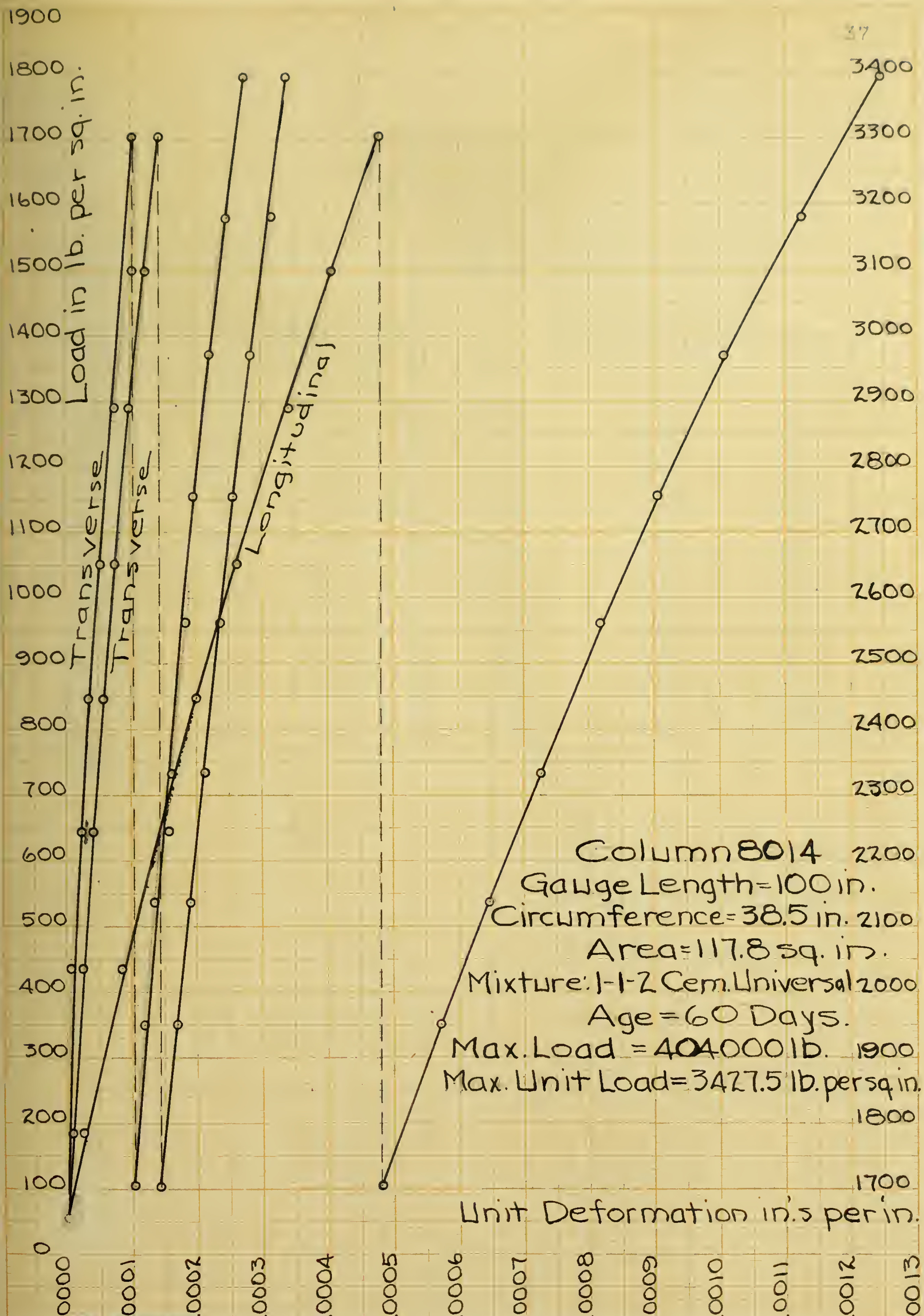
Mixture 1-1-2.
Age when tested, 60 days.
Cement, Universal.

Load Pounds	Longitudinal Extensometer Readings 1	2	3	4	Transverse Extensometer Readings E. & W.	N. & S.
6500	.0000	.0000	.0000	.0000	.2790	.2945
22000	.0025	.0012	.0021	.0037	.2780	.2937
51500	.0070	.0078	.0082	.0112	.2759	.2937
76000		.0142		.0170	.2740	.2917
100000	.0191	.0205	.0172	.0232	.2718	.2900
124000	.0272	.0258	.0218	.0305	.2695	.2878
152000	.0360	.0330	.0283	.0389	.2669	.2851
177000	.0432	.0392	.0343	.0468	.2640	.2820
201000	.0510	.0460	.0404	.0543	.2615	.2819
230000	.0608	.0548	.0487	.0642	.2582	.2800
252000	.0692	.0620	.0557	.0720	.2557	.2780
275000	.0774	.0698	.0631	.0800	.2530	.2748
302000	.0872	.0790	.0717	.0894	.2500	.2725
325000	.0964	.0868	.0798	.0999	.2475	.2703
350000	.1072	.0980	.0900	.1081	.2443	.2675
375000	.1202	.1108	.1009	.1183	.2405	.2642
400000	.1332	.1265	.1139	.1252	.2375	.2610
404000						

COLUMN 8014

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Transverse Deformation E. & W.	Transverse Deformation N. & S.
55.1	.0000	.000000	.000000	.000000
186.6	.0024	.000024	.000008	.000007
436.9	.0086	.000086	.000025	.000007
644.8	.0156	.000156	.000041	.000023
848.4	.0200	.000200	.000058	.000036
1052.0	.0263	.000263	.000077	.000054
1289.6	.0341	.000341	.000099	.000076
1501.7	.0409	.000409	.000122	.000102
1705.3	.0479	.000479	.000142	.000102
1951.3	.0571	.000571	.000170	.000118
2138.0	.0647	.000647	.000190	.000134
2333.1	.0726	.000726	.000212	.000161
2562.2	.0818	.000818	.000237	.000184
2757.3	.0907	.000907	.000257	.000197
2969.4	.1008	.001008	.000283	.000220
3181.5	.1126	.001126	.000314	.000247
3393.6	.1247	.001247	.000338	.000273
3427.5				


Load in lb. per sq. in.
Transverse
Transverse
Longitudinal
Column 8014
Gauge Length=100 in.
Circumference=38.5 in.
Area=117.8 sq. in.
Mixture: 1-1-2 Cem. Universal
Age=60 Days.
Max. Load = 404000 lb.
Max. Unit Load=3427.5 lb. per sq. in.
Unit Deformation in.s per in.
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 8015

Observed Data

Length 9 ft. $10\frac{1}{4}$ in.
Gauge Length 100 in.
Diameter 12.25 in.

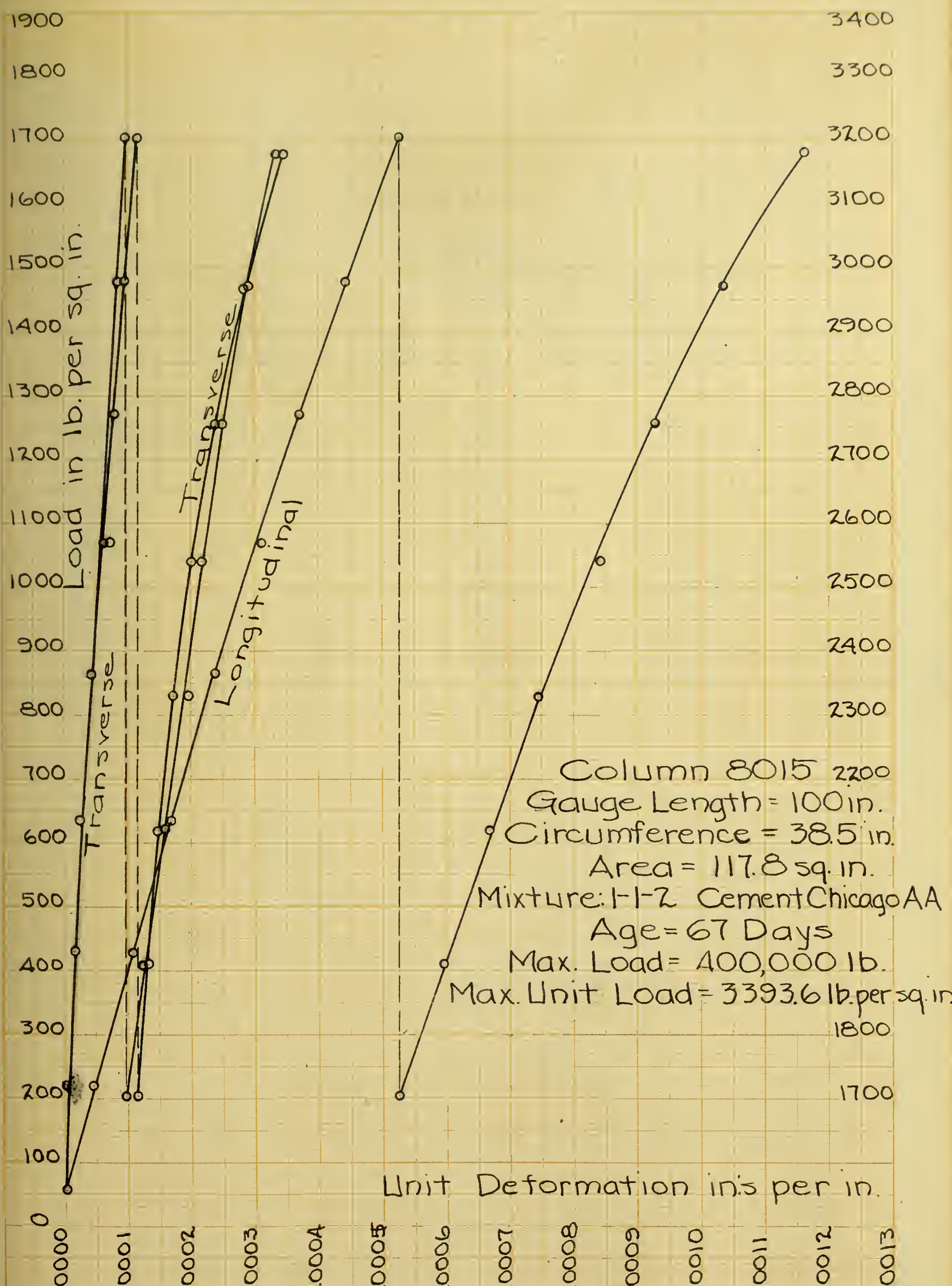
Mixture 1-1-2.
Age when tested, 67 days.
Cement, Chicago AA.

Load Pounds	Longitudinal Extensometer Readings 1	2	3	4	Transverse Extensometer Readings E. & W.	N. & S.
7000	.0000	.0000	.0000	.0000	.2305	.2555
26000	.0048	.0052	.0032	.0048	.2303	.2545
51000	.0091	.0122	.0105	.0110	.2285	.2537
75000	.0145	.0186	.0170	.0165	.2278	.2522
102000	.0208	.0260	.0250	.0232	.2251	.2504
126000	.0268	.0332	.0335	.0300	.2218	.2477
150000	.0330	.0402	.0400	.0362	.2210	.2459
175000	.0374	.0478	.0485	.0430	.2205	.2438
201000	.0445	.0562	.0572	.0515	.2187	.2416
225000	.0468	.0650	.0665	.0590	.2157	.2395
250000	.0474	.0738	.0780	.0678	.2111	.2375
275000	.0515	.0832	.0880	.0758	.2065	.2344
300000	.0560	.0940	.1015	.0850	.2038	.2308
325000	.0618	.1047	.1122	.0932	.1999	.2264
350000	.0638	.1170	.1285	.1040	.1951	.2206
375000	.0708	.1320	.1462	.1152	.1898	.2134
400000						

COLUMN 8015

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Transverse Deformation E. & W.	Transverse Deformation N. & S.
59.4	.0000	.000000	.000000	.000000
220.6	.0045	.000045	.000001	.000008
432.7	.0107	.000107	.000016	.000015
636.3	.0167	.000167	.000022	.000027
865.4	.0238	.000238	.000044	.000042
1069.0	.0309	.000309	.000071	.000064
1272.6	.0374	.000374	.000077	.000078
1484.7	.0442	.000442	.000082	.000095
1705.3	.0524	.000524	.000096	.000114
1908.9	.0593	.000593	.000121	.000131
2121.0	.0667	.000667	.000159	.000147
2333.1	.0746	.000746	.000196	.000172
2545.2	.0841	.000841	.000218	.000202
2757.3	.0929	.000929	.000250	.000238
2969.4	.1033	.001033	.000289	.000285
3181.5	.1160	.001160	.000332	.000344
3393.6				



Load in lb. per sq. in.
Transverse
Transverse
Longitudinal
Column 8015
Gauge Length = 100 in.
Circumference = 38.5 in.
Area = 117.8 sq. in.
Mixture: 1-1-2 Cement Chicago AA
Age = 67 Days
Max. Load = 400,000 lb.
Max. Unit Load = 3393.6 lb. per sq. in.
Unit Deformation in's per in.
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
1700
1800
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 8021

Observed Data

Length 10 ft. 1 in.
Gauge Length 100 in.
Diameter 12.36 in.

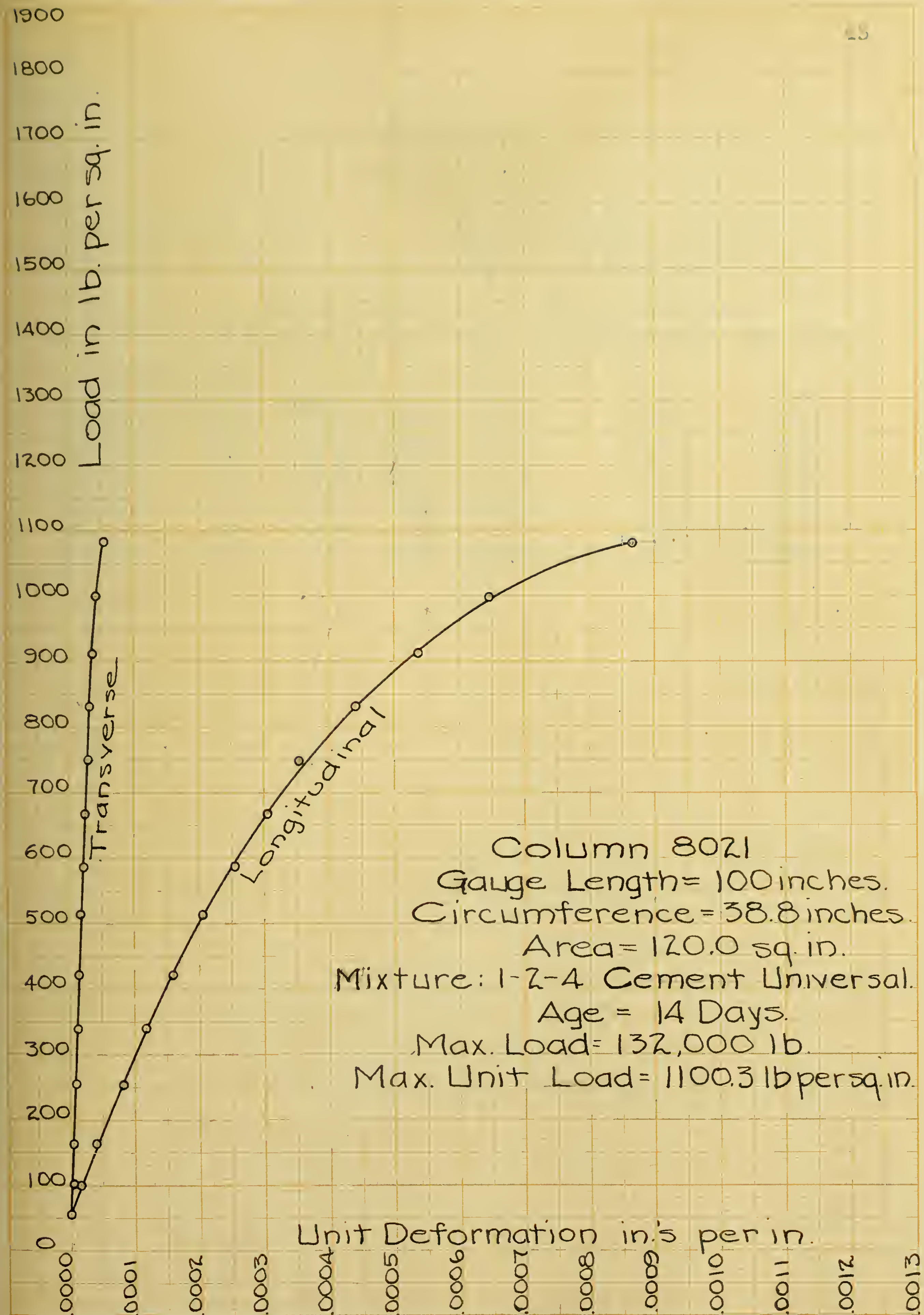
Mixture 1-2-4.
Age when tested, 14 days.
Cement, Universal.

Load Pounds	Longitudinal Extensometer Readings 1	2	3	4	Transverse Extensometer Readings E. & W.
6500	.0000	.0000	.0000	.0000	.0121
12000	.0018	.0023	.0005	.0010	.0119
20000	.0024	.0053	.0022	.0052	.0118
30600	.0068	.0100	.0052	.0102	.0116
41000	.0104	.0140	.0085	.0146	.0114
51500	.0158	.0175	.0123	.0192	.0113
61000	.0202	.0220	.0161	.0242	.0112
70600	.0256	.0264	.0204	.0294	.0109
80000	.0314	.0312	.0250	.0346	.0108
90300	.0384	.0362	.0255	.0420	.0106
100000	.0467	.0432	.0353	.0506	.0104
110000	.0570	.0523	.0425	.0624	.0102
120000	.0692	.0645	.0521	.0724	.0099
130000	.0902	.0855	.0690	.1026	.0092
132000					

COLUMN 8021

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Transverse Deformation Unit
54.2	.0000	.000000	.000000
100.0	.0014	.000014	.000004
166.7	.0038	.000038	.000006
255.1	.0081	.000081	.000010
341.7	.0119	.000119	.000013
424.3	.0162	.000162	.000015
514.4	.0206	.000206	.000017
588.5	.0255	.000255	.000022
666.8	.0306	.000306	.000025
750.2	.0355	.000355	.000029
833.5	.0440	.000440	.000032
916.9	.0536	.000536	.000036
1000.2	.0646	.000646	.000042
1083.6	.0868	.000868	.000055
1100.3			



Load in lb. per sq. in.
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Transverse
Longitudinal
Column 8021
Gauge Length = 100 inches.
Circumference = 38.8 inches.
Area = 120.0 sq. in.
Mixture: 1-2-4 Cement Universal.
Age = 14 Days.
Max. Load = 132,000 lb.
Max. Unit Load = 1100.3 lb per sq. in.
Unit Deformation in.'s per in.
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 8022

Observed Data

Length 10 ft. 1 in.
Gauge Length 100 in.
Diameter 11.78 in.

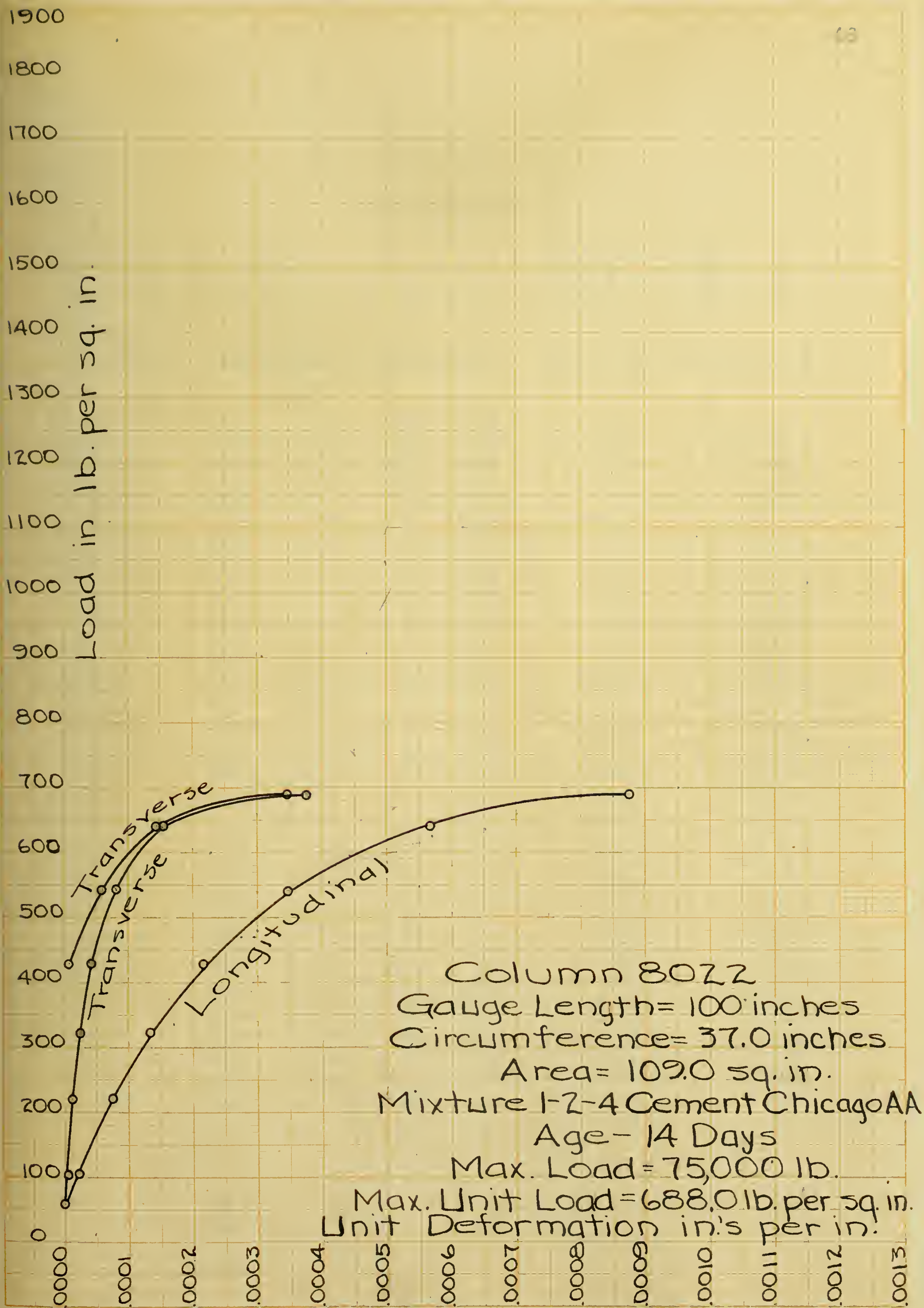
Mixture 1-2-4.
Age when tested, 14 days.
Cement, Chicago AA.

Load Pounds	Longitudinal Extensometer Readings				Transverse Extensometer Readings	
	1	2	3	4	E. & W.	N. & S.
6500	.0000	.0000	.0000	.0000	.2424	.2273
11700	.0040	.0018	.0012	.0014	.2443	.2265
24000	.0100	.0058	.0042	.0084	.2439	.2259
35500	.0175	.0120	.0068	.0160	.2431	.2246
47000	.0270	.0195	..0132	.0258	.2416	.2225
59000	.0410	.0305	.0254	.0414	.2354	.2177
70000	.0632	.0498	.0458	.0670	.2255	.2095
75000	.0950	.0760	.0758	.1022	.2013	.1830

COLUMN 8022

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Transverse Deformation Unit E.& W.	Transverse Deformation Unit N.& S.
59.6	.0000	.000000	.000000	.000000
107.3	.0021	.000021	-.000016	.000007
222.0	.0071	.000071	-.000013	.000012
325.7	.0131	.000131	-.000006	.000023
431.2	.0214	.000214	.000007	.000041
541.3	.0346	.000346	.000059	.000082
642.2	.0565	.000565	.000144	.000151
688.0	.0873	.000873	.000349	.000376


Load in lb. per sq. in.
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Transverse
Transverse
Longitudinal
Column 8022
Gauge Length = 100 inches
Circumference = 37.0 inches
Area = 109.0 sq. in.
Mixture 1-2-4 Cement Chicago AA
Age – 14 Days
Max. Load = 75,000 lb.
Max. Unit Load = 688.0 lb. per sq. in.
Unit Deformation in's per in.
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 8061

Observed Data

Length 6 ft. $0\frac{1}{2}$ in.
Gauge Length 50 in.
Dimension 11 3/16 in. x 12 1/8 in.

Mixture 1-2-4.
Age when tested, 14 days.
Cement, Chicago AA.

Load Pounds	Longitudinal Extensometer Readings 1.	2.	3.	4.	Transverse Extensometer Readings E. & W.	N. & S.
1600	.0000	.0000	.0000	.0000	.2441	.2716
11000	.0005	.0002	.0025	.0003	.2437	.2721
20000	.0021	.0022	.0048	.0017	.2434	.2714
30500	.0051	.0053	.0061	.0045	.2427	.2714
20000	.0049	.0046	.0054	.0036	.2431	.2714
11000	.0035	.0036	.0048	.0031	.2437	.2719
1000	.0014	.0003	.0028	.0003	.2440	.2719
30500	.0061	.0060	.0077	.0055	.2430	.2711
11000	.0035	.0030	.0051	.0033	.2434	.2713
1000	.0018	.0002	.0030	.0008	.2439	.2724
31000	.0068	.0061	.0072	.0061	.2424	.2708
1000	.0019	.0003	.0034	.0011	.2436	.2715
31000	.0072	.0069	.0078	.0075	.2423	.2705
1000	.0020	.0002	.0038	.0018	.2438	.2713
31000	.0078	.0068	.0079	.0072	.2421	.2708
1000	.0022	.0008	.0040	.0021	.2436	.2711
31500	.0079	.0070	.0084	.0074	.2425	.2707
1000	.0022	.0005	.0042	.0017	.2433	.2712
34000		.0072		.0081	.2419	.2706
1000	.0025	.0008	.0042	.0022	.2432	.2714
34000	.0090	.0078	.0091	.0083	.2416	.2706
1000	.0029	.0009	.0044	.0023	.2430	.2713
31000	.0089	.0070	.0089	.0081	.2418	.2707
1000	.0029	.0010	.0047	.0024	.2430	.2712
11000	.0039	.0021	.0062	.0039	.2424	.2709
19000	.0060	.0042	.0077	.0061	.2423	.2709
33000	.0091	.0075	.0093	.0085	.2421	.2704
51000	.0192	.0135	.0145	.0160	.2390	.2691
20000	.0154	.0090	.0101	.0115	.2411	.2694
1000	.0060	.0020	.0055	.0044	.2424	.2704
51000	.0212	.0142	.0155	.0176	.2383	.2687
1000	.0069	.0022	.0059	.0050	.2423	.2706

COLUMN 8061.

Observed Data

Continued.

Load Pounds	Longitudinal Extensometer Readings 1.	2.	3.	4.	Transverse Extensometer Readings E. & W.	N. & S.
51000	.0232	.0152	.0159	.0189	.2377	.2687
2000	.0091	.0038	.0063	.0062	.2417	.2703
51000	.0248	.0152	.0159	.0168	.2371	.2681
1000	.0102	.0041	.0065	.0070	.2413	.2702
51000	.0262	.0165	.0174	.0214	.2369	.2678
1000	.0105	.0042	.0067	.0071	.2416	.2700
51000	.0272	.0168	.0176	.0217	.2368	.2678
1000	.0110	.0040	.0069	.0073	.2415	.2700
52000	.0285	.0178	.0185	.0231	.2364	.2673
1000	.0119	.0042	.0073	.0074	.2417	.2699
51000	.0291	.0172	.0185	.0234	.2367	.2675
1000	.0121	.0042	.0074	.0081	.2420	.2699
52000	.0300	.0190	.0193	.0249	.2363	.2669
2000	.0142	.0048	.0080	.0086	.2419	.2696
11000	.0170	.0065	.0094	.0111	.2416	.2693
21000	.0220	.0102	.0118	.0151	.2409	.2690
31000	.0260	.0138	.0140	.0182	.2395	.2685
42000	.0279	.0160	.0172	.0221	.2381	.2678
52000	.0318	.0190	.0203	.0256	.2367	.2668
63000	.0382	.0230	.0245	.0304	.2340	.2658
39000	.0380	.0190	.0213	.0264	.2355	.2651
24000	.0329	.0158	.0173	.0242	.2387	.2663
2000	.0205	.0065	.0102	.0123	.2419	.2698
62000	.0432	.0242	.0268	.0342	.2332	.2652
1000	.0219	.0068	.0116	.0127	.2423	.2698
62000	.0462	.0261	.0294	.0361	.2326	.2649
2000	.0259	.0080	.0115	.0153	.2424	.2625
61000	.0490	.0262	.0312	.0370	.2321	.2646
2000	.0270	.0082	.0148	.0153	.2427	.2695
61000	.0514	.0270	.0334	.0404	.2319	.2643
1000	.0272	.0085	.0167	.0164	.2429	.2700
61000	.0530	.0289	.0369	.0421	.2312	.2637

COLUMN 8061

Observed Data

Continued

Load Pounds	Longitudinal Extensometer Readings 1	2	3	6	Transverse Extensometer Readings E. & W.	N. & S.
1000	.0298	.0088	.0191	.0177	.2428	.2691
62000	.0572	.0290	.0397	.0452	.2305	.2625
1000	.0312	.0091	.0215	.0193	.2428	.2683
61000	.0595	.0290	.0422	.0465	.2303	.2617
1000	.0340	.0095	.0241	.0209	.2429	.2679
61000	.0610	.0290	.0455	.0484	.2299	.2611
2000	.0368	.0108	.0271	.0234	.2433	.2673
61000	.0649	.0292	.0477	.0505	.2295	.2599
1000	.0390	.0112	.0285	.0246	.2421	.2673
61000	.0680	.0300	.0495	.0535	.2291	.2593
1000	.0425	.0120	.0310	.0268	.2418	.2659
61000	.0702	.0305	.0521	.0564	.2290	.2577
3000	.0452	.0132	.0332	.0295	.2411	.2646
12000	.0499	.0145	.0357	.0341	.2401	.2642
28000	.0600	.0209	.0412	.0423	.2365	.2610
46000	.0682	.0275	.0493	.0502	.2321	.2579
61000	.0735	.0315	.0542	.0581	.2279	.2563
70000	.0832	.0358	.0615	.0663	.2240	.2505
1000	.0510	.0151	.0388	.0347	.2390	.2639
68000	.1140	.0440	.0890	.0916	.2195	.2462

COLUMN 8061

Computed Data

Unit Load Lbs. per sq. in.	Longitudinal Deformation 50 in's.	Longitudinal Deformation 1 in.	Transverse Deformation E. & W.	Transverse Deformation N. & S.
11.8	.0000	.000000	.000000	.000000
81.1	.0009	.000018	.000003	-.000004
147.4	.0027	.000054	.000006	.000002
224.8	.0053	.000105	.000012	.000002
147.1	.0047	.000094	.000008	.000002
81.1	.0038	.000075	.000003	-.000003
7.4	.0012	.000024	.000000	-.000003
224.8	.0063	.000127	.000009	.000004
181.1	.0037	.000075	.000006	.000003
7.4	.0014	.000029	.000010	-.000007
228.5	.0065	.000131	.000014	.000008
7.4	.0017	.000034	.000013	.000000
228.5	.0074	.000147	.000015	.000009
7.4	.0020	.000040	.000003	.000003
228.5	.0074	.000149	.000017	.000007
7.4	.0023	.000046	.000004	.000004
232.2	.0077	.000154	.000013	.000008
7.4	.0022	.000043	.000007	.000004
250.6	.0077	.000153	.000018	.000008
7.4	.0024	.000049	.000008	.000002
250.6	.0086	.000171	.000021	.000008
7.4	.0026	.000053	.000009	.000003
228.5	.0082	.000165	.000019	.000008
7.4	.0028	.000055	.000009	.000003
81.1	.0040	.000081	.000014	.000006
140.0	.0060	.000120	.000015	.000006
243.2	.0086	.000172	.000017	.000010
375.9	.0158	.000316	.000043	.000021
147.4	.0115	.000230	.000025	.000018
7.4	.0045	.000090	.000014	.000010
375.9	.0171	.000343	.000048	.000024
7.4	.0050	.000100	.000015	.000008

COLUMN 8061

Computed Data

Continued

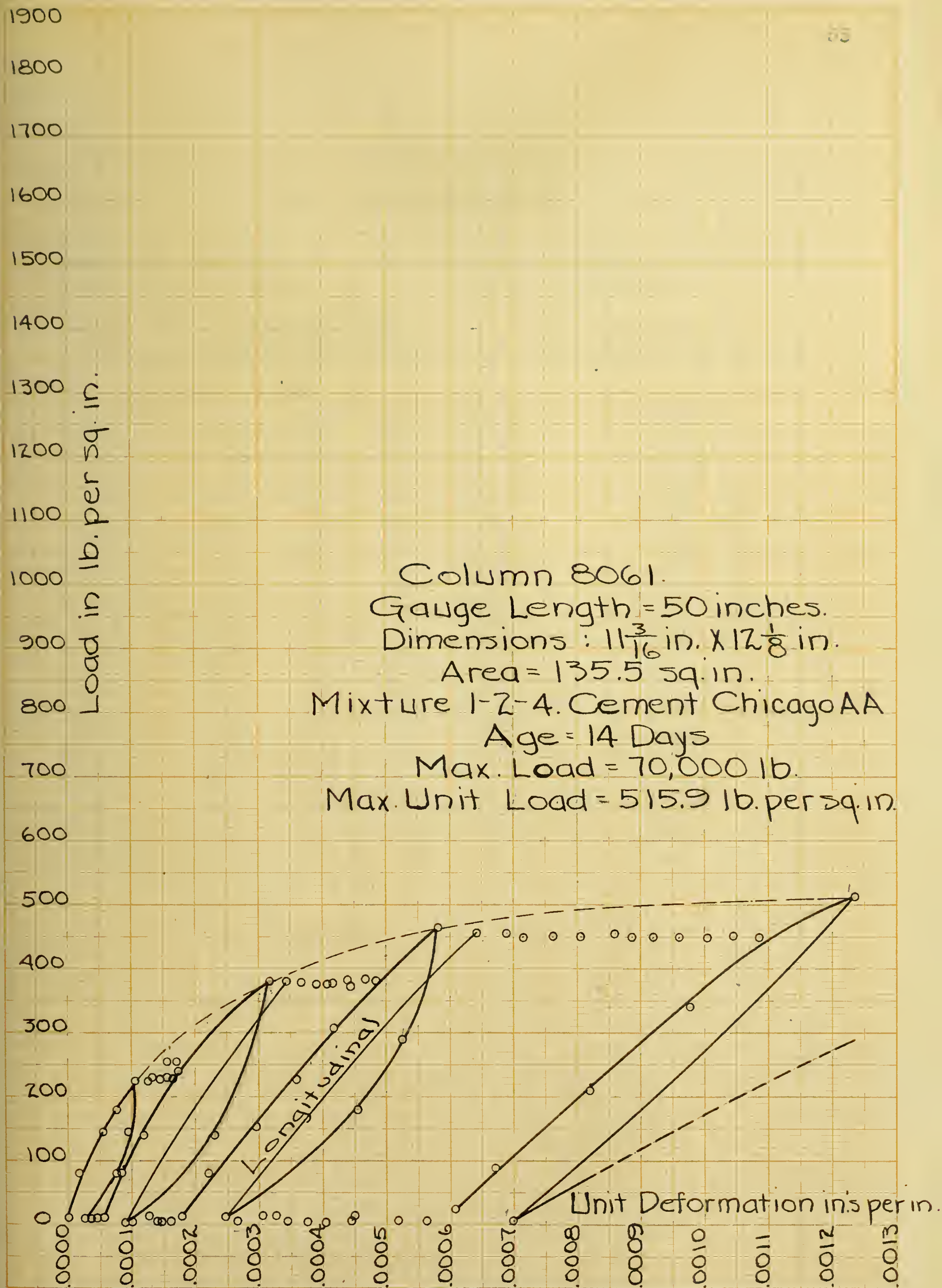
Unit Load Lbs. per sq. in.	Longitudinal Deformation 50 in's.	1 in.	Transverse Deformation E. & W.	N. & S.
375.9	.0183	.000366	.000053	.000024
14.7	.0064	.000127	.000020	.000011
375.9	.0195	.000391	.000058	.000029
7.4	.0070	.000139	.000021	.000012
375.9	.0204	.000408	.000060	.000032
7.4	.0071	.000143	.000021	.000013
375.9	.0208	.000417	.000060	.000032
7.4	.0073	.000146	.000022	.000013
383.2	.0220	.000440	.000064	.000036
7.4	.0077	.000154	.000020	.000014
375.9	.0221	.000443	.000062	.000034
7.4	.0080	.000159	.000017	.000014
383.2	.0233	.000466	.000065	.000039
14.7	.0089	.000178	.000018	.000017
81.1	.0110	.000220	.000021	.000019
154.8	.0148	.000296	.000027	.000022
228.5	.0180	.000360	.000038	.000026
309.5	.0208	.000416	.000050	.000032
383.2	.0242	.000484	.000062	.000040
464.3	.0290	.000581	.000084	.000048
287.4	.0262	.000524	.000072	.000054
176.9	.0226	.000451	.000045	.000044
14.7	.0124	.000249	.000018	.000015
456.9	.0321	.000642	.000091	.000053
7.4	.0132	.000265	.000015	.000015
456.9	.0345	.000689	.000096	.000056
14.7	.0152	.000304	.000014	.000076
449.6	.0352	.000717	.000100	.000058
14.7	.0163	.000327	.000012	.000018
449.6	.0381	.000761	.000102	.000061
7.4	.0172	.000344	.000010	.000013
449.6	.0402	.000805	.000108	.000066

COLUMN 8061

Computed Data

Continued

Unit Load Lbs. per sq. in.	Longitudinal Deformation 50 in's	1 in.	Transverse Deformation E. & W.	N. & S.
7.4	.0189	.000377	.000011	.000021
456.9	.0428	.000856	.000113	.000076
7.4	.0203	.000406	.000011	.000038
449.6	.0443	.000886	.000115	.000083
7.4	.0221	.000443	.000010	.000030
449.6	.0460	.000920	.000118	.000088
14.7	.0245	.000490	.000007	.000036
449.6	.0480	.000960	.000122	.000104
7.4	.0258	.000516	.000016	.000036
449.6	.0503	.001005	.000126	.000102
7.4	.0281	.000562	.000019	.000048
449.6	.0523	.001046	.000126	.000116
22.1	.0303	.000606	.000025	.000058
88.4	.0336	.000671	.000033	.000062
206.4	.0411	.000822	.000063	.000098
339.0	.0488	.000976	.000017	.000114
449.6	.0543	.001086	.000135	.000128
515.9	.0617	.001234	.000176	.000176
7.4	.0349	.000598	.000042	.000064
501.2	.0846	.001693	.000205	.000212



Column 8061.
Gauge Length = 50 inches.
Dimensions : 11 3/16 in. X 12 1/8 in.
Area = 135.5 sq. in.
Mixture 1-2-4. Cement Chicago AA
Age = 14 Days
Max. Load = 70,000 lb.
Max. Unit Load = 515.9 lb. per sq. in.
Load in lb. per sq. in.
Unit Deformation in's per in.
Longitudinal
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 8023

Observed Data

Length 9 ft. 9 in.
Gauge Length 100 in.
Diameter 12.19 in.

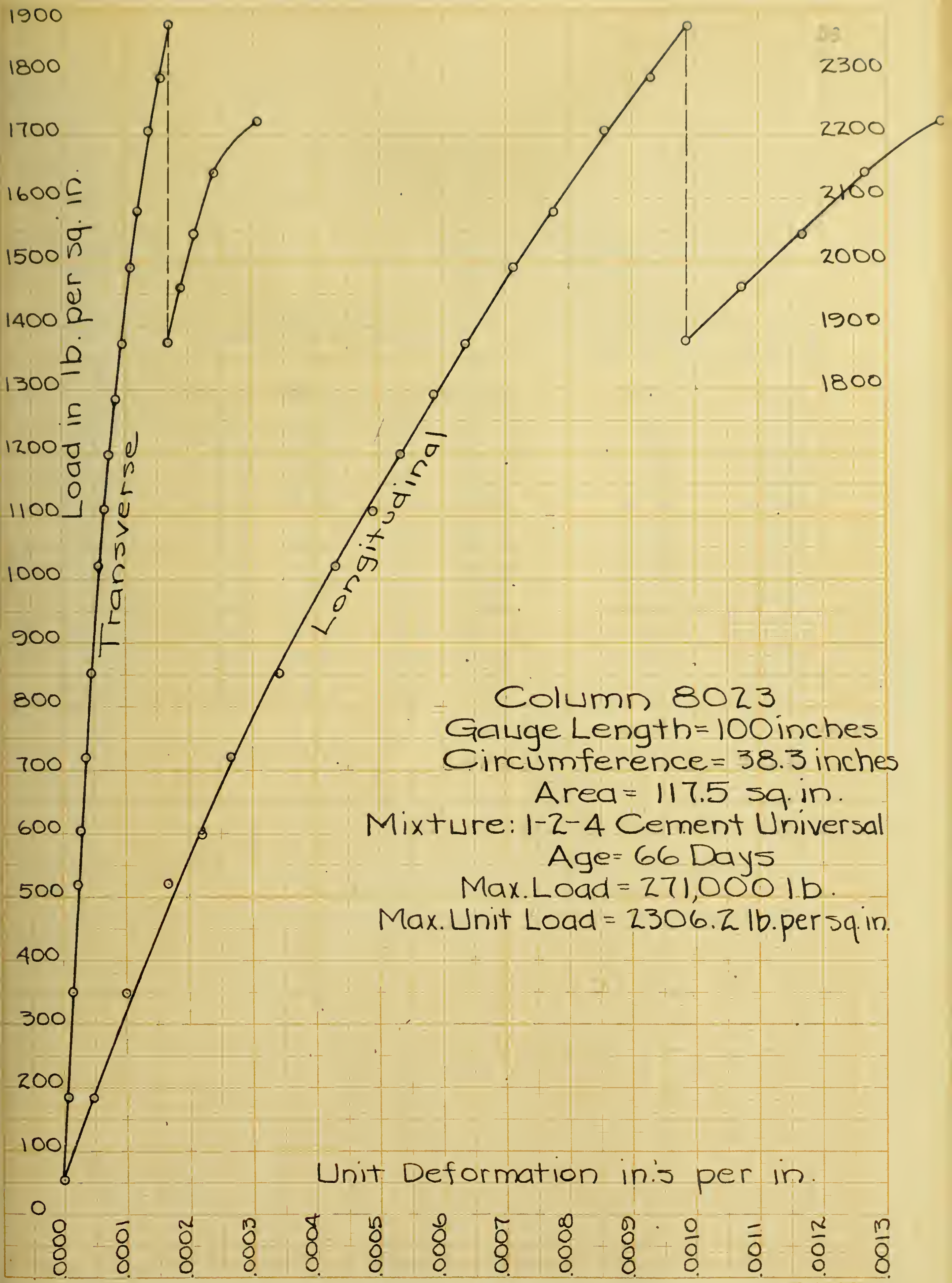
Mixture 1-2-4.
Age when tested, 66 days.
Cement, Universal.

Load Pounds	Longitudinal Extensometer Readings 1	2	3	4	Transverse Extensometer Readings E. & W.
6500	.0000	.0000	.0000	.0000	.0134
21600	.0069	.0031	.0030	.0057	.0126
41100	.0148	.0088	.0088	.0081	.0117
61000	.0194	.0149	.0138	.0188	.0109
71000	.0249	.0195	.0193	.0243	.0100
85000	.0252	.0257	.0253	.0294	.0090
100300	.0361	.0330	.0318	.0349	.0080
120000	.0462	.0430	.0400	.0433	.0065
130500	.0527	.0491	.0445	.0492	.0053
141000	.0577	.0539	.0483	.0538	.0042
151000	.0629	.0596	.0527	.0588	.0030
161000	.0688	.0649	.0569	.0639	.0020
175000	.0774	.0728	.0638	.0712	.0003
185600	.0838	.0790	.0697	.0771	-.0010
200500	.0928	.0874	.0766	.0851	-.0031
211000	.1011	.0955	.0830	.0924	-.0051
220500	.1088	.0977	.0890	.0993	-.0070
230500	.1173	.1108	.0964	.1070	-.0092
240500	.1269	.1201	.1048	.1157	-.0121
251500	.1371	.1316	.1134	.1252	-.0151
262000	.1485	.1420	.1234	.1360	-.0240
271000					

COLUMN 8023

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Transverse Deformation E. & W.
55.3	.0000	.000000	.000000
183.8	.0047	.000047	.000007
349.8	.0101	.000101	.000014
519.1	.0167	.000167	.000021
604.2	.0220	.000220	.000028
723.3	.0264	.000264	.000036
853.6	.0340	.000340	.000044
1021.2	.0431	.000431	.000057
1110.6	.0489	.000489	.000066
1199.9	.0534	.000534	.000075
1289.3	.0585	.000585	.000085
1370.1	.0636	.000636	.000094
1489.2	.0713	.000713	.000108
1579.5	.0774	.000774	.000118
1706.3	.0855	.000855	.000135
1795.6	.0930	.000930	.000152
1876.5	.0987	.000987	.000167
1961.6	.1079	.001079	.000185
2046.7	.1169	.001169	.000209
2140.3	.1268	.001268	.000233
2229.6	.1375	.001375	.000307
2306.2			


Column 8023
Gauge Length = 100 inches
Circumference = 38.3 inches
Area = 117.5 sq. in.
Mixture: 1-2-4 Cement Universal
Age = 66 Days
Max. Load = 271,000 lb.
Max. Unit Load = 2306.2 lb. per sq. in.
Load in lb. per sq. in.
Transverse
Longitudinal
Unit Deformation in.'s per in.
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 8024

Observed Data

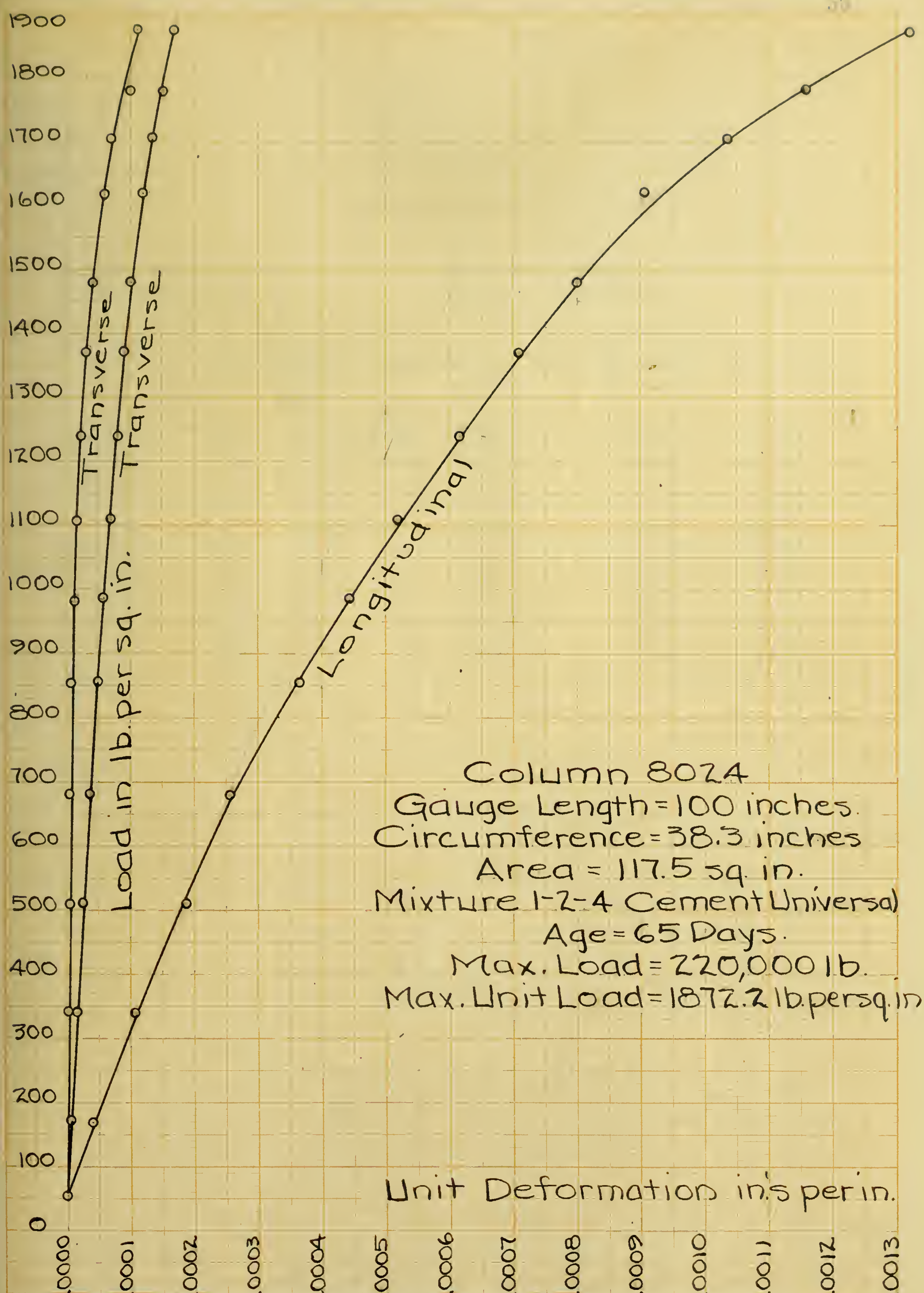
Length 10 ft 0 in. Mixture 1-2-4.
Gauge Length 100 in. Age when tested, 65 days.
Diameter 12.19 in. Cement, Universal

Load Pounds	Longitudinal Extensometer Readings 1	2	3	4	Transverse Extensometer Readings E. & W.	N. & S.
6500	.0000	.0000	.0000	.0000	.0074	.0050
20400	.0049	.0030	.0032	.0050	.0067	.0051
40000	.0120	.0100	.0097	.0111	.0055	.0048
60000	.0198	.0176	.0177	.0196	.0043	.0047
80000	.0264	.0243	.0214	.0296	.0028	.0044
100500	.0363	.0338	.0352	.0395	.0014	.0040
116000	.0443	.0413	.0432	.0481	.0002	.0034
130500	.0527	.0491	.0510	.0562	-.0010	.0029
146000	.0625	.0578	.0592	.0663	-.0022	.0021
160500	.0721	.0665	.0683	.0761	-.0036	.0012
174000	.0814	.0749	.0772	.0860	-.0051	.0000
190500	.0847	.0868	.0898	.1010	-.0073	-.0023
200000	.1066	.0966	.0999	.1124	-.0089	-.0036
210000	.1177	.1108	.1094	.1246	-.0109	-.0073
220000	.1395	.1217	.1209	.1442	-.0125	-.0085

COLUMN 8024

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Transverse Deformation Total	Transverse Deformation Unit
55.3	.0000	.000000	.000000	.000000
173.6	.0040	.000040	.000006	.000000
340.4	.0107	.000107	.000016	.000002
510.6	.0187	.000187	.000025	.000003
680.8	.0254	.000254	.000038	.000005
855.3	.0362	.000362	.000049	.000008
987.3	.0442	.000442	.000059	.000013
1110.6	.0523	.000523	.000069	.000017
1242.5	.0615	.000615	.000079	.000024
1365.9	.0708	.000708	.000090	.000031
1480.7	.0799	.000799	.000102	.000041
1621.2	.0906	.000906	.000120	.000060
1702.0	.1039	.001039	.000134	.000070
1787.1	.1156	.001156	.000150	.000100
1872.2	.1316	.001316	.000163	.000110



1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Load in lb. per sq. in.
Transverse
Transverse
Longitudinal
Column 8024
Gauge Length = 100 inches.
Circumference = 38.3 inches
Area = 117.5 sq. in.
Mixture 1-2-4 Cement Universal
Age = 65 Days.
Max. Load = 220,000 lb.
Max. Unit Load = 1872.2 lb. per sq. in.
Unit Deformation in's per in.
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 8025

Observed Data

Length 10 ft. 0 1/8 in.
Gauge Length 100 in.
Diameter 12.18 in.

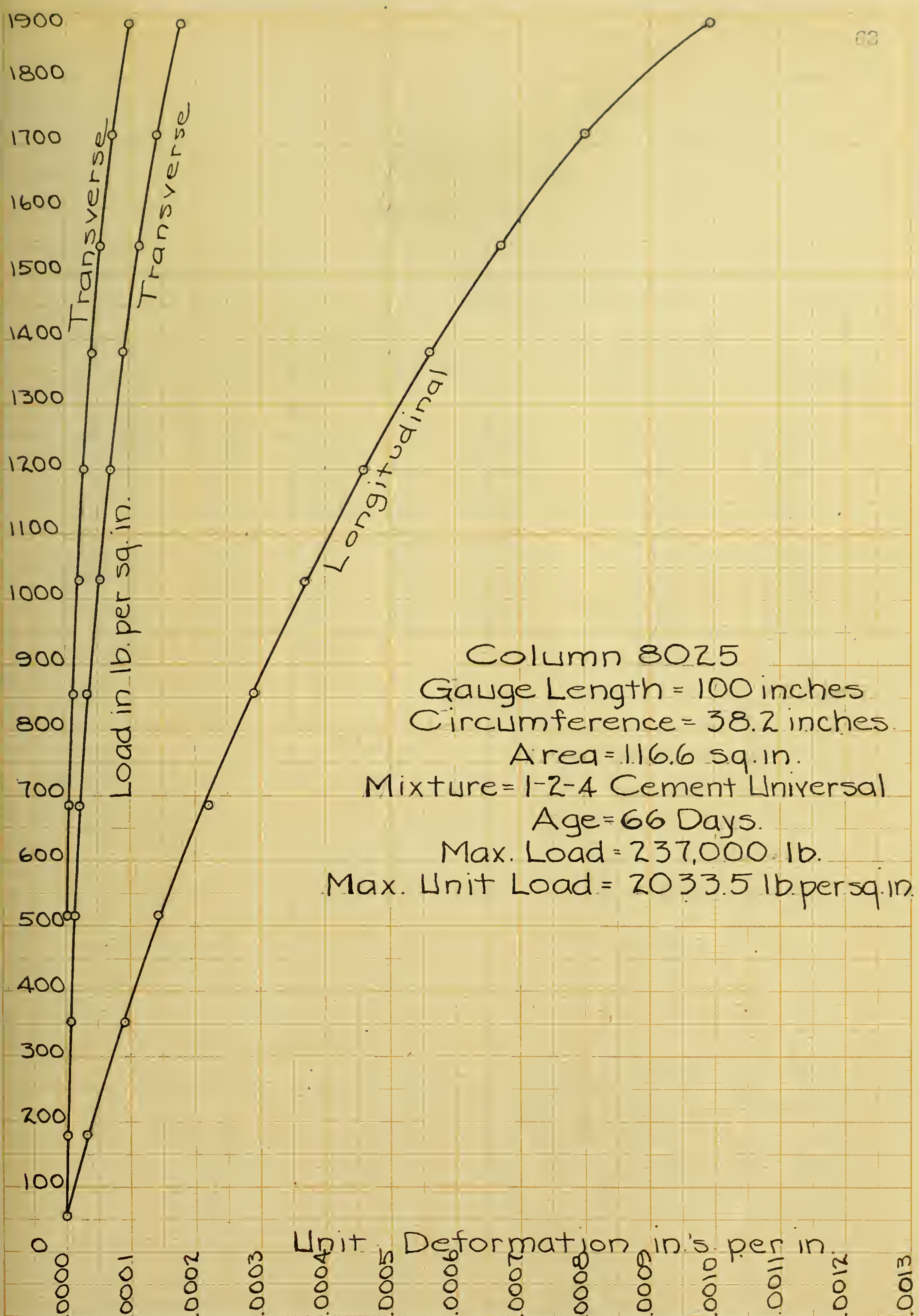
Mixture 1-2-4.
Age when tested, 66 days.
Cement, Universal.

Load Pounds	Longitudinal Extensometer Readings 1	2	3	4	Transverse Extensometer Readings E. & W.	N. & S.
6500	.0000	.0000	.0000	.0000	.2066	.2334
21000	.0026	.0038	.0032	.0028	.2063	.2337
41000	.0095	.0090	.0091	.0088	.2055	.2337
60500	.0170	.0110	.0157	.0135	.2049	.2332
80000	.0252	.0196	.0235.	.0195	.2039	.2326
100000	.0328	.0263	.0312	.0258	.2024	.2318
120000	.0404	.0350	.0399	.0326	.2002	.2307
140000	.0492	.0442	.0497	.0404	.1981	.2297
161000	.0582	.0548	.0609	.0506	.1956	.2282
180000	.0692	.0660	.0722	.0608	.1926	.2267
200000	.0820	.0800	.0867	.0728	.1895	.2246
220000	.0990	.1005	.1075	.0898	.1849	.2214
237000						

COLUMN 8025

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Transverse Deformation Unit E.& W.	Transverse Deformation Unit N.& S.
55.8	.0000	.000000	.000000	.000000
180.2	.0031	.000031	.000002	-.000002
351.8	.0091	.000091	.000009	-.000002
519.1	.0143	.000143	.000014	.000002
686.4	.0220	.000220	.000022	.000007
858.0	.0290	.000290	.000034	.000013
1029.6	.0370	.000370	.000053	.000022
1201.2	.0459	.000459	.000070	.000030
1381.4	.0561	.000561	.000090	.000043
1544.4	.0671	.000671	.000115	.000055
1716.0	.0804	.000804	.000140	.000072
1887.6	.0992	.000992	.000178	.000099
2033.5				



63
Column 8025
Gauge Length = 100 inches
Circumference = 38.2 inches
Area = 116.6 sq. in.
Mixture = 1-2-4 Cement Universal
Age = 66 Days.
Max. Load = 237,000 lb.
Max. Unit Load = 2033.5 lb. per sq. in.
Transverse
Transverse
Longitudinal
Load in lb. per sq. in.
Unit Deformation in's. per in.
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 107

Observed Data

Length 10 ft. $0\frac{1}{4}$ in.
Gauge Length 100 in.
Diameter 12.18 in.

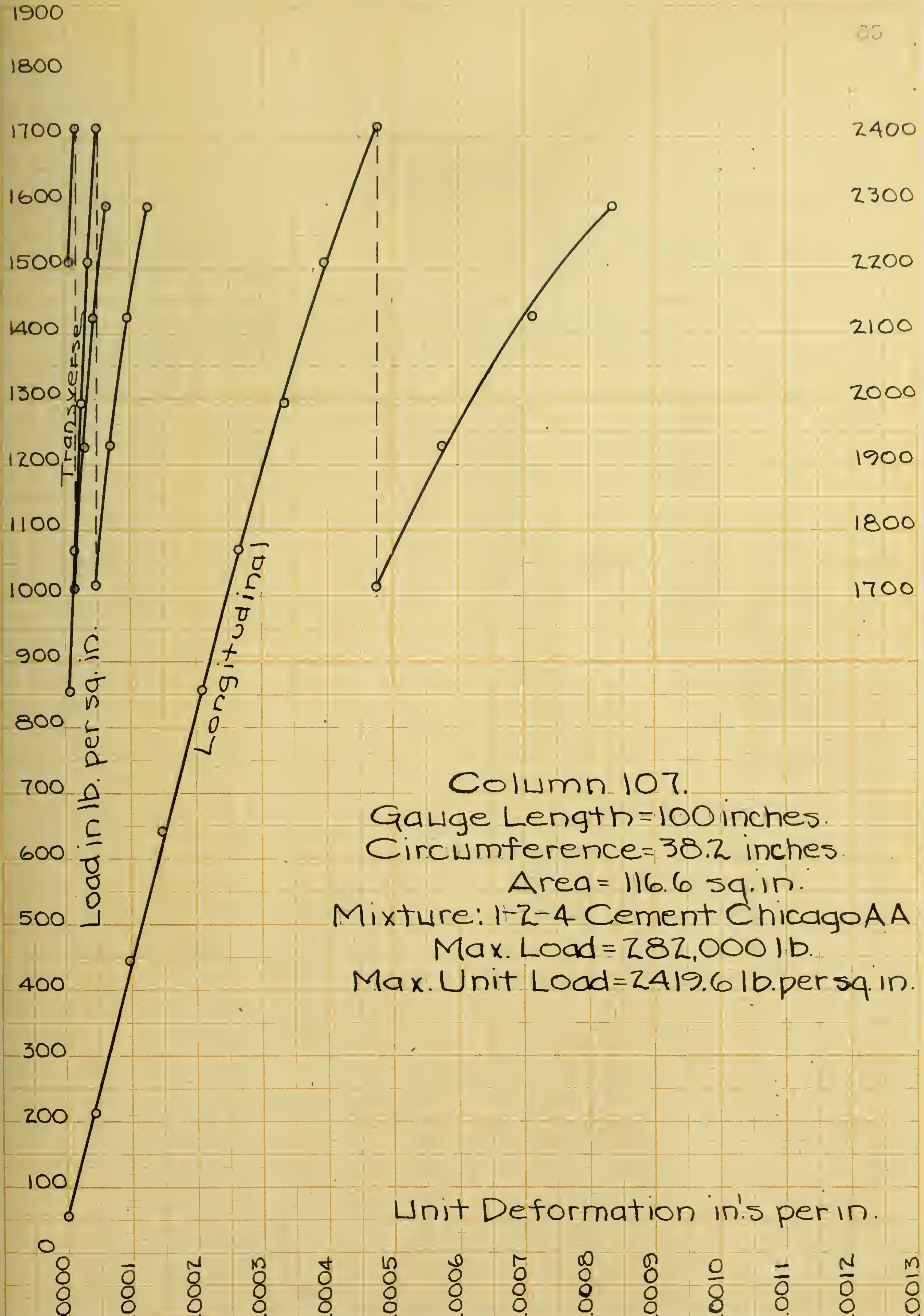
Mixture 1-2-4.
Age when tested, 379 days.
Cement, Chicago AA.

Load Pounds	Longitudinal Extensometer Readings 1	2	3	4	Transverse Extensometer Readings E. & W.	N. & S.
6500	.0000	.0000	.0000	.0000	.2689	.2704
25000	.0083	.0000	.0000	.0086	.2701	.2715
52000	.0156	.0048	.0025	.0164	.2697	.2723
75000	.0213	.0088	.0076	.0215	.2691	.2718
100000	.0279	.0144	.0136	.0277	.2682	.2724
125000	.0344	.0190	.0184	.0335	.2672	.2715
151000	.0430	.0258	.0224	.0418	.2661	.2705
176000	.0509	.0324	.0280	.0484	.2648	.2698
200000	.0605	.0398	.0328	.0574	.2629	.2686
225000	.0715	.0482	.0428	.0676	.2603	.2670
248000	.0846	.0578			.2571	.2652
267000	.0977	.0690			.2531	.2629
282000						

COLUMN 107

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Transverse Deformation Unit E.& W.	Transverse Deformation Unit N.& S.
55.8	.0000	.000000	.000000	.000000
214.5	.0042	.000042	-.000010	-.000010
446.2	.0098	.000098	-.000007	-.000015
643.5	.0148	.000148	-.000002	-.000011
858.0	.0209	.000209	.000006	-.000016
1072.5	.0263	.000263	.000014	-.000010
1297.6	.0333	.000333	.000023	-.000001
1510.1	.0399	.000399	.000034	.000005
1716.0	.0476	.000476	.000049	.000015
1930.5	.0575	.000575	.000071	.000028
2127.8	.0712	.000712	.000097	.000043
2290.9	.0834	.000834	.000129	.000061
2419.6				



Load in lb. per sq. in.
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
2400
2300
2200
2100
2000
1900
1800
1700
Transverse
Longitudinal
Column 107.
Gauge Length = 100 inches.
Circumference = 38.2 inches.
Area = 116.6 sq. in.
Mixture: 1-2-4 Cement Chicago AA
Max. Load = 282,000 lb.
Max. Unit Load = 2419.6 lb. per sq. in.
Unit Deformation in's per in.
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 161

Observed Data

Length 10 ft. 1 in.
Gauge Length 100 in.
Diameter 8.67 in.

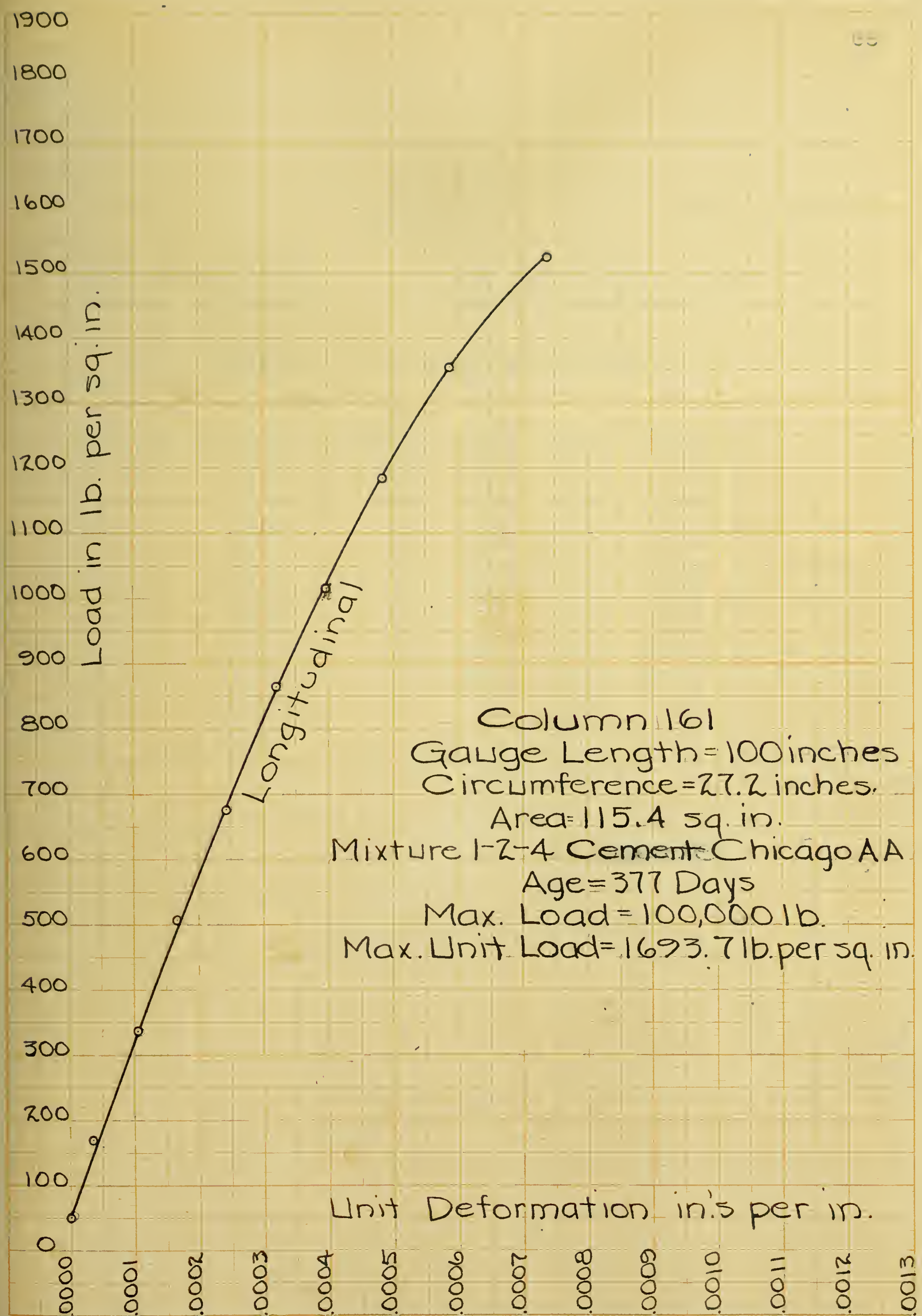
Mixture 1-2-4.
Age when tested, 1 year.
Cement, Chicago AA.

Load Pounds	Longitudinal Extensometer Readings			
	1	2	3	4
3000	.0000	.0000	.0000	.0000
10000	.0050	.0025	.0029	.0040
20000	.0129	.0090	.0089	.0114
30000	.0195	.0163	.0139	.0173
40000	.0273	.0260	.0206	.0230
51000	.0360	.0350	.0272	.0296
60000	.0450	.0445	.0341	.0357
70000	.0543	.0553	.0413	.0425
80000	.0625	.0700	.0511	.0516
90000	.0830	.0875	.0623	.0622
100000				

COLUMN 161

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	1 in.
50.8	.0000	.000000
169.4	.0036	.000036
338.8	.0106	.000106
508.2	.0168	.000168
677.6	.0242	.000242
863.9	.0320	.000320
1016.4	.0398	.000398
1185.8	.0484	.000484
1355.2	.0588	.000588
1524.6	.0738	.000738
1693.7		



Load in lb. per sq. in.
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Longitudinal
Column 161
Gauge Length = 100 inches
Circumference = 27.2 inches.
Area = 115.4 sq. in.
Mixture 1-2-4 Cement Chicago AA
Age = 377 Days
Max. Load = 100,000 lb.
Max. Unit Load = 1693.7 lb. per sq. in.
Unit Deformation in.'s per in.
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 162

Observed Data

Length 10 ft. 1½ in.
Gauge Length 100 in.
Diameter 8.83 in.

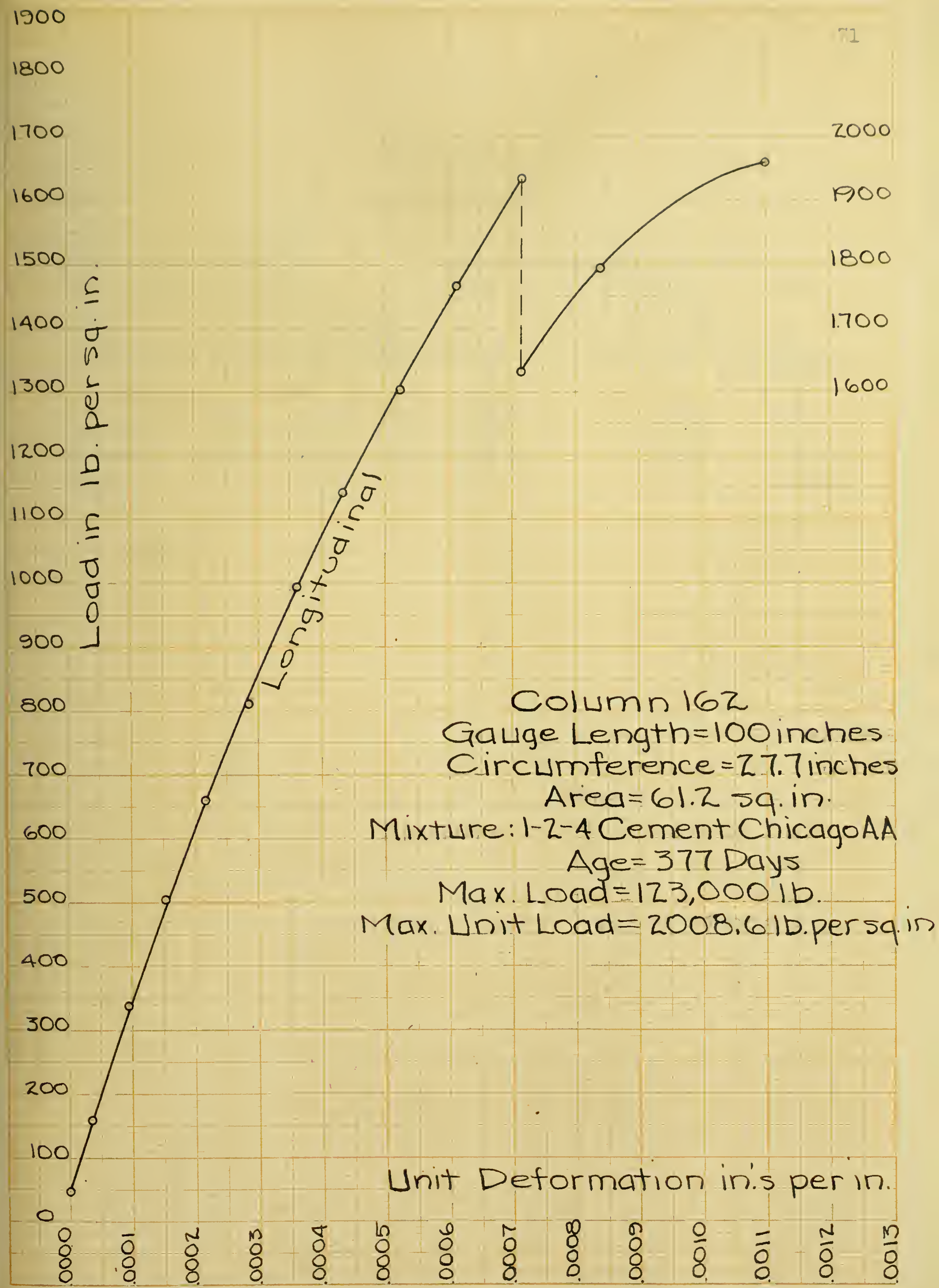
Mixture 1-2-4.
Age when tested, 1 year.
Cement, Chicago AA.

Load Pounds	Longitudinal Extensometer Readings 1	2	3	4
3000	.0000	.0000	.0000	.0000
9700	.0035	.0035	.0028	.0035
21000	.0092	.0082	.0093	.0112
31000	.0155	.0137	.0154	.0165
40500	.0228	.0190	.0216	.0236
50000	.0295	.0250	.0275	.0302
61000	.0372	.0325	.0355	.0382
70000	.0450	.0395	.0425	.0460
80000	.0545	.0485	.0513	.0552
90000	.0640	.0575	.0596	.0638
100000	.0762	.0685	.0708	.0704
110000	.0910	.0815	.0835	.0794
120000	.1210	.1080	.1055	.1051
123000				

COLUMN 162

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation Per 100 ins.	Per in.
49.0	.0000	.000000
158.4	.0033	.000033
342.9	.0095	.000095
506.2	.0153	.000153
661.4	.0218	.000218
816.5	.0281	.000281
996.1	.0359	.000359
1143.1	.0433	.000433
1306.4	.0524	.000524
1469.7	.0612	.000612
1633.0	.0715	.000715
1796.3	.0839	.000839
1959.6	.1099	.001099
2008.6		



Load in lb. per sq. in.
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
2000
1900
1800
1700
1600
Longitudinal
Column 162
Gauge Length=100 inches
Circumference=27.7 inches
Area=61.2 sq. in.
Mixture: 1-2-4 Cement Chicago AA
Age=377 Days
Max. Load=123,000 lb.
Max. Unit Load=2008.6 lb. per sq. in.
Unit Deformation in.'s per in.
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 8032

Observed Data

Length 10 ft. 0 in.
Gauge Length 100 in.
Diameter 12.01 in.

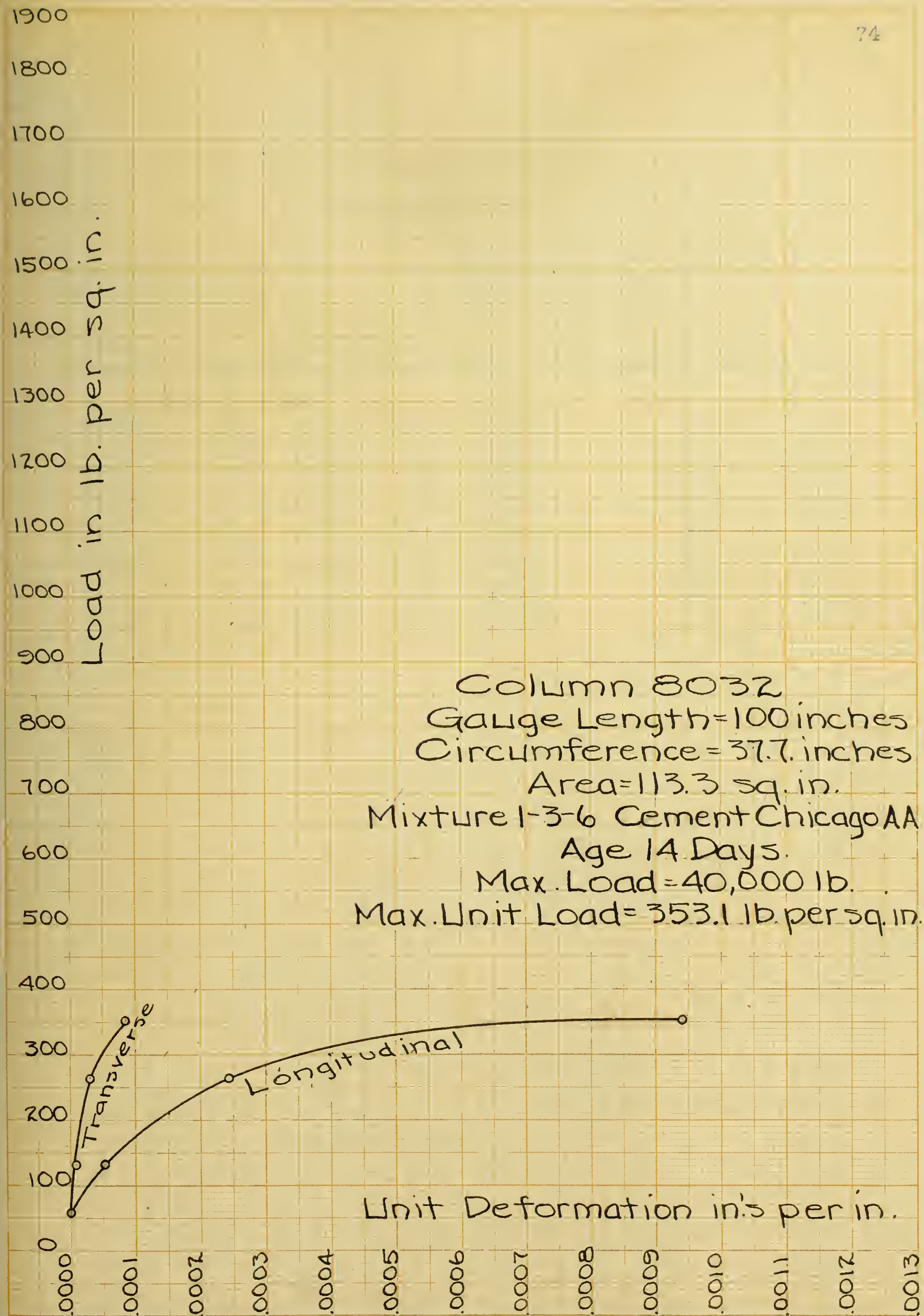
Mixture 1-3-6.
Age when tested, 14 days.
Cement, Chicago AA.

Load Pounds	Longitudinal Extensometer Readings				Traverse Extensometer Readings	
	1	2	3	4	E. & W.	N. & S.
6500	.0000	.0000	.0000	.0000	.2620	.2485
15000	.0058	.0042	.0056	.0054	.2609	.2475
30000	.0258	.0242	.0248	.0232	.2584	.2456
40000	.1020	.1090	.0910	.0726	.2519	.2385
40000						

COLUMN 8032

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in	Transverse Deformation Unit E.& W.	Transverse Deformation Unit N.& S.
57.4	.0000	.000000	.000000	.000000
132.4	.0053	.000053	.000009	.000008
264.8	.0245	.000245	.000029	.000024
353.1	.0937	.000937	.000084	.000083
353.1				



Column 8032
Gauge Length=100 inches
Circumference=37.7 inches
Area=113.3 sq. in.
Mixture 1-3-6 Cement Chicago AA
Age 14 Days.
Max. Load=40,000 lb.
Max. Unit Load=353.1 lb. per sq. in.
Load in lb. per sq. in.
Unit Deformation in's per in.
Transverse
Longitudinal
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 8033

Observed Data

Length 10 ft. 0 in.
Gauge Length 100 in.
Diameter 12.30 in.

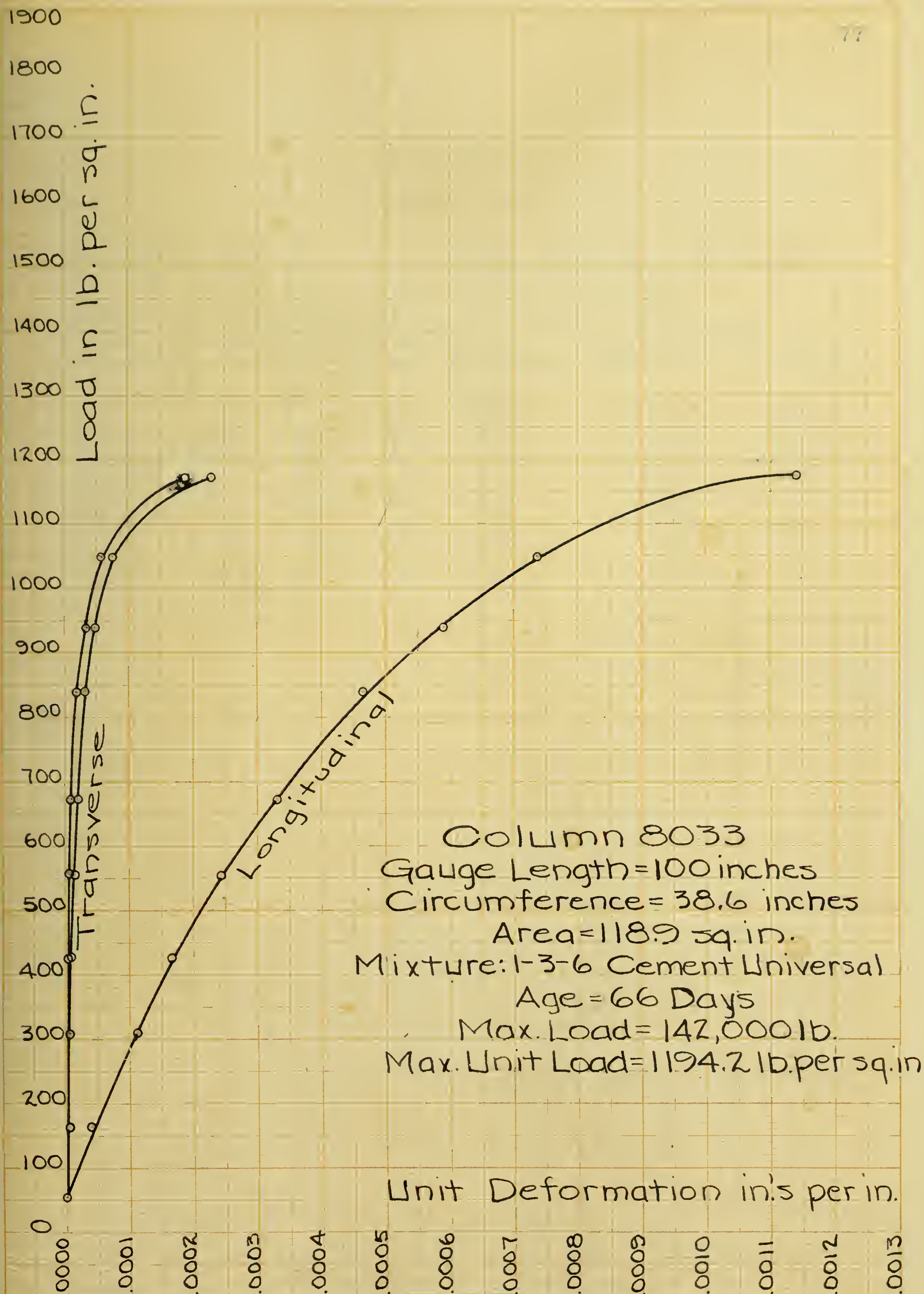
Mixture 1-3-6.
Age when tested, 66 days.
Cement, Universal.

Load Pounds	Longitudinal Extensometer Readings 1	2	3	4	Transverse Extensometer Readings E. & W.	N. & S.
6500	.0000	.0000	.0000	.0000	.1862	.2614
20000	.0030	.0036	.0053	.0039	.1855	.2609
37000	.0094	.0110	.0148	.0101	.1853	.2608
51000	.0150	.0170	.0188	.0160	.1850	.2608
66000	.0228	.0262	.0268	.0233	.1845	.2604
80000	.0302	.0362	.0353	.0301	.1839	.2602
100000	.0452	.0466	.0501	.0447	.1824	.2591
112000	.0578	.0620	.0600	.0560	.1805	.2572
125000	.0740	.0752	.0727	.0720	.1770	.2542
140000	.1132	.1098	.1130	.1208	.1579	.2374
142000						

COLUMN 8033

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Transverse Deformation Total	Transverse Deformation Unit
54.7	.0000	.000000	.000000	.000000
168.2	.0040	.000040	.000006	.000004
311.2	.0113	.000113	.000007	.000005
428.9	.0167	.000167	.000010	.000005
555.1	.0248	.000248	.000014	.000008
672.8	.0330	.000330	.000019	.000010
841.0	.0467	.000467	.000031	.000019
941.9	.0590	.000590	.000046	.000035
1051.3	.0735	.000735	.000075	.000059
1177.4	.1142	.001142	.000230	.000189
1194.2				


Load in lb. per sq. in.
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Transverse
Longitudinal
Column 8033
Gauge Length = 100 inches
Circumference = 38.6 inches
Area = 118.9 sq. in.
Mixture: 1-3-6 Cement Universal
Age = 66 Days
Max. Load = 142,000 lb.
Max. Unit Load = 1194.2 lb. per sq. in.
Unit Deformation in's per in.
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

COLUMN 8034

Observed Data

Length 10 ft. $0\frac{1}{2}$ in.
Gauge Length 100 in.
Diameter 12.25 in.

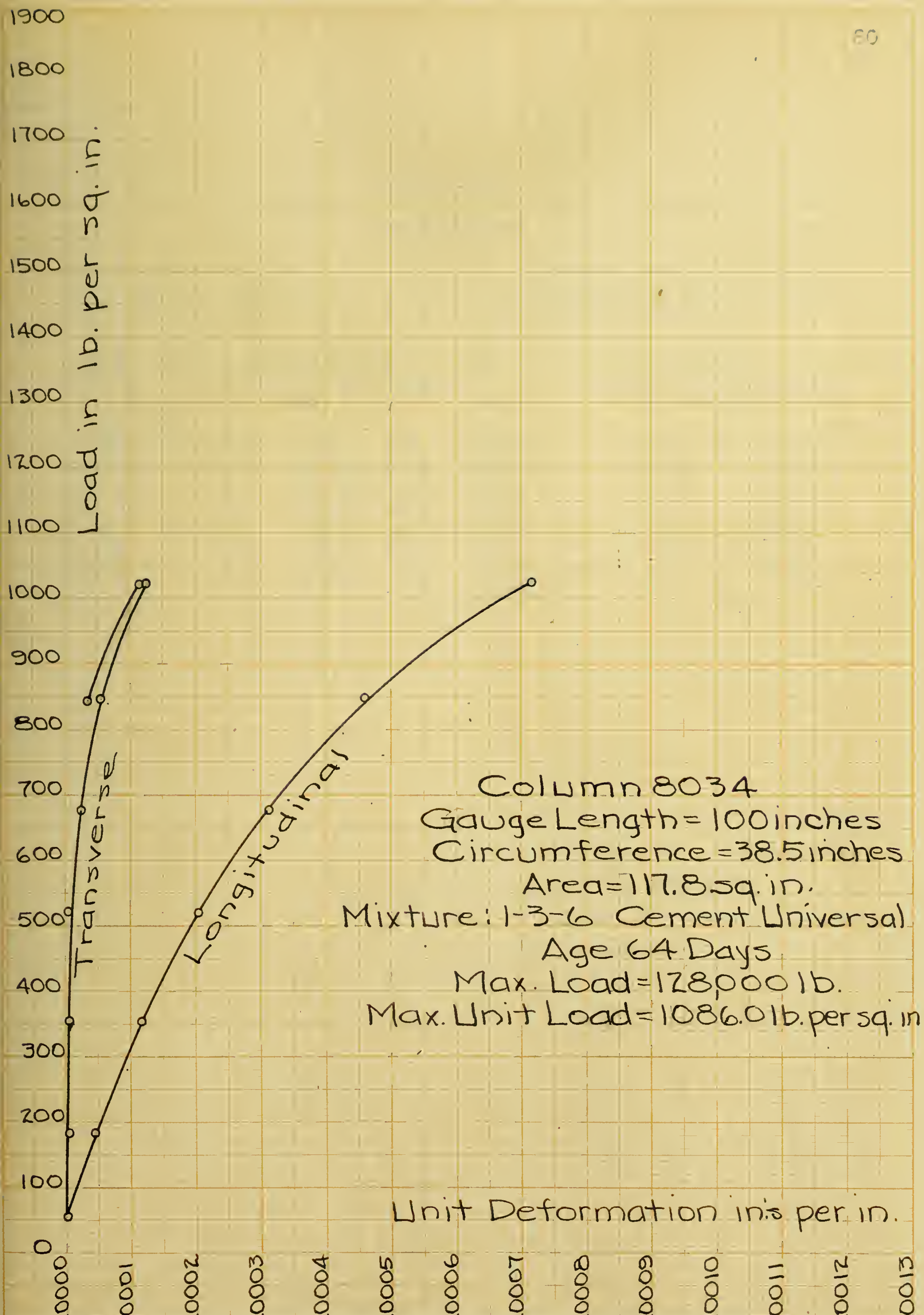
Mixture 1-3-6.
Age when tested, 64 days.
Cement, Universal.

Load Pounds	Longitudinal Extensometer Readings				Transverse Extensometer Readings	
	1	2	3	4	E. & W.	N. & S.
6500	.0000	.0000	.0000	.0000	.2393	.2491
21500	.0048	.0035	.0030	.0057	.2389	.2491
41500	.0122	.0108	.0100	.0136	.2390	.2493
61500	.0207	.0195	.0195	.0212	.2387	.2493
80000	.0305	.0325	.0318	.0299	.2364	.2498
100000	.0420	.0497	.0485	.0420	.2322	.2447
121000	.0641	.0758	.0782	.0684	.2241	.2350
128000						
90000	.1518	.1591	.1685	.1590	.2125	.2511

COLUMN 8034

Computed Data

Unit Load Lbs. per sq. in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in	Transverse Deformation Total	Transverse Deformation Unit
55.1	.0000	.000000	.000000	.000000
182.4	.0043	.000043	.000003	.000000
352.1	.0117	.000117	.000003	-.000002
521.8	.0202	.000202	.000005	-.000002
678.7	.0312	.000312	.000024	-.000005
848.4	.0458	.000458	.000058	.000036
1026.6	.0716	.000716	.000124	.000115
1086.0	.			
763.6	.1596	.001596	.000219	.000147


Load in lb. per sq. in.
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Transverse
Longitudinal
Column 8034
Gauge Length = 100 inches
Circumference = 38.5 inches
Area = 117.8 sq. in.
Mixture: 1-3-6 Cement Universal
Age 64 Days
Max. Load = 128,000 lb.
Max. Unit Load = 1086.0 lb. per sq. in.
Unit Deformation in's per in.
0.0000
0.0001
0.0002
0.0003
0.0004
0.0005
0.0006
0.0007
0.0008
0.0009
0.0010
0.0011
0.0012
0.0013

COLUMN 8035

Observed Data

Length 10 ft. 0 in.
Gauge Length 100 in.
Diameter 12.18 in.

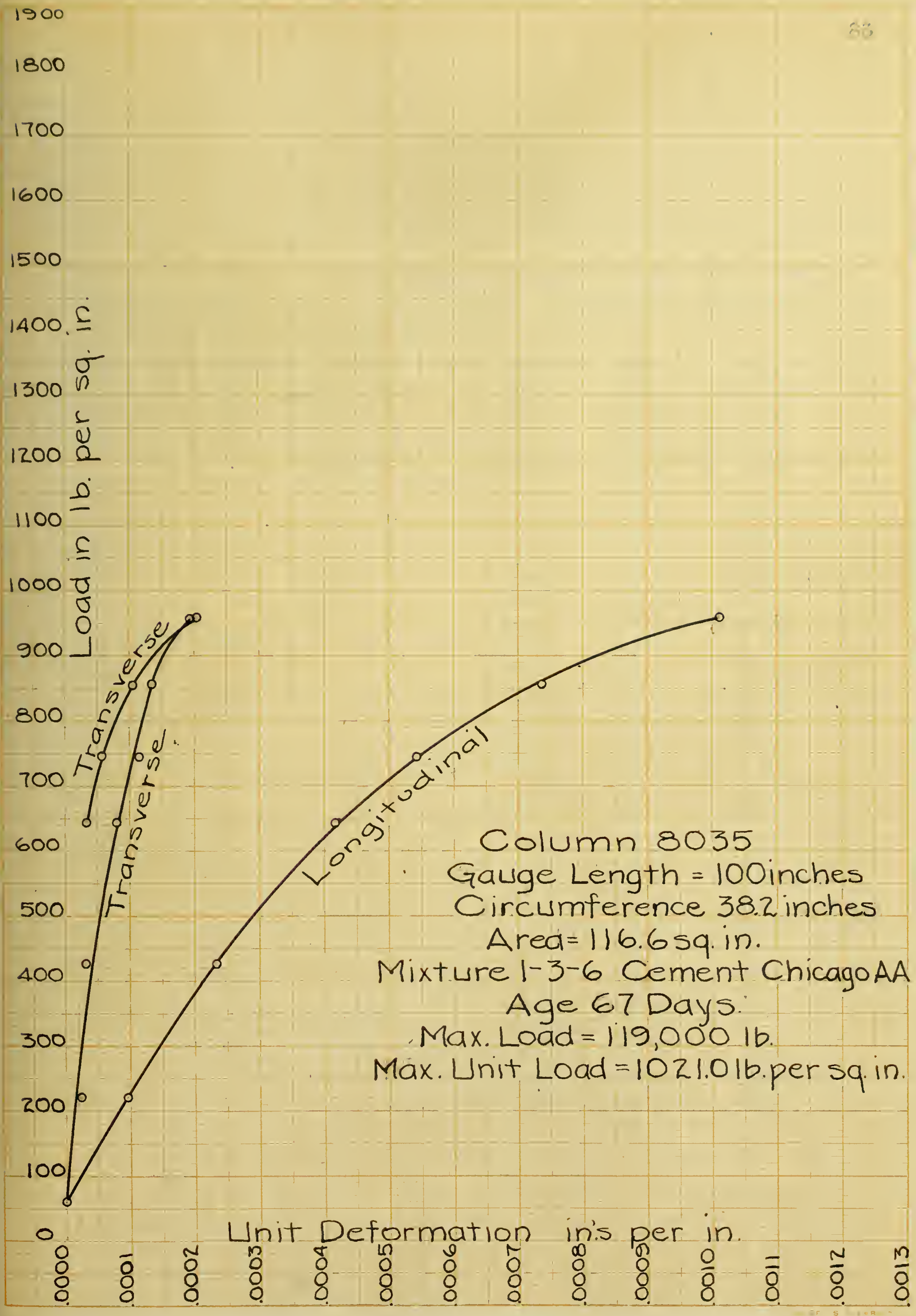
Mixture 1-3-6.
Age when tested, 67 days.
Cement, Chicago AA.

Load Pounds	Longitudinal Extensometer Readings 1	2	3	4	Transverse Extensometer Readings E. & W.	N. & S.
7000	.0000	.0000	.0000	.0000	.1880	.2335
26000	.0080	.0162	.0068	.0080	.1848	.2388
50000	.0214	.0290	.0200	.0218	.1845	.2348
75000	.0395	.0482	.0390	.0398	.1781	.2295
87000	.0514	.0615	.0518	.0515	.1740	.2266
100000	.0698	.0832	.0722	.0692	.1719	.2205
112000	.0946	.1158	.1008	.0932	.1641	.2093
119000						

COLUMN 8035

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins	1 in.	Transverse Deformation Total	Unit
60.1	.0000	.000000	.000000	.000000
223.1	.0098	.000098	.000025	-.000044
429.0	.0251	.000251	.000030	-.000010
643.5	.0416	.000416	.000081	.000033
746.5	.0541	.000541	.000115	.000057
858.0	.0736	.000736	.000132	.000107
961.0	.1011	.001011	.000196	.000199
1021.0				



Column 8035
Gauge Length = 100 inches
Circumference 38.2 inches
Area = 116.6 sq. in.
Mixture 1-3-6 Cement Chicago AA
Age 67 Days.
Max. Load = 119,000 lb.
Max. Unit Load = 1021.0 lb. per sq. in.
Load in lb. per sq. in.
Unit Deformation in's per in.
Transverse
Transverse
Longitudinal
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
.0000
.0001
.0002
.0003
.0004
.0005
.0006
.0007
.0008
.0009
.0010
.0011
.0012
.0013

TABLE 8

AUXILIARY SPECIMENS.

12 In. Cubes.

Cube Number	Kind of Cement	Mixture	Age Days	Weight in Lbs. At 7 days	Weight in Lbs. At test	Unit Load Lbs. per Sq. In.
8011	Chicago AA	1-1-2	14	149.5	148.8	3100
				151.2	149.1	3000
8012	Chicago AA	1-1-2	14	147.7	145.8	2300
				147.6	146.0	2410
8051	Chicago AA	1-1-2	14	148.6	148.4	2300
				147.7	147.0	2100
8013	Universal	1-1-2	61	147.6	146.5	4070
				147.7	147.2	4160
8014	Universal	1-1-2	60	-----	-----	-----
8015	Chicago AA	1-1-2	67	142.8	141.8	3550
				142.8	140.9	3640
8021	Universal	1-2-4	14	153	150.8	2080
				154.3	152.0	2170
8022	Chicago AA	1-2-4	14	146.3	146.1	1180
				145.7	145.5	1040
8061	Chicago AA	1-2-4	14	146.7	145.8	713
				147.0	145.4	760
8023	Universal	1-2-4	66	144.7	144.2	2940
				145.8	145.7	3110
8024	Universal	1-2-4	65	151.5	147.5	1900
				143.7	143.1	2900
8025	Universal	1-2-4	66	148.7	148.1	2260
				152.0	149.5	2870
107	Chicago AA	1-2-4	379	-----	-----	-----
161	Chicago AA	1-2-4	377	-----	-----	1910
						1660
162	Chicago AA	1-2-4	377	-----	-----	2150
						2320
8032	Chicago AA	1-3-6	14	149.5	147.5	932
				145.3	146.1	876
8033	Universal	1-3-6	66	147.7	145.8	1310
				148.5	145.0	1410
8034	Universal	1-3-6	64	152.5	148.4	2080
				151.8	148.7	3390
8035	Chicago AA	1-3-6	67	146.0	141.8	1300
				145.3	143.2	1470

TABLE 9.

AUXILIARY SPECIMENS.

6 In. Cubes.

Cube Number	Kind of Cement	Mixture	Age when tested Days	Unit Load Lbs. per sq. in.
8011	Chicago AA	1-1-2	14	2535
				3385
8012	Chicago AA	1-1-2	14	2140
				2310
				2070
8051	Chicago AA	1-1-2	14	2530
				2470
				2670
8015	Chicago AA	1-1-2	67	3560
				3880
				3760
8021	Universal	1-2-4	14	1550
				1355
				1410
8022	Chicago AA	1-2-4	14	1263
				1182
				1133
8061	Chicago AA	1-2-4	14	607
				505
				545
8023	Universal	1-2-4	66	2365
				2463
				2367
8024	Universal	1-2-4	65	2104
				1794
				2163
8025	Universal	1-2-4	66	2600
				2650
				2730
8032	Chicago AA	1-3-6	14	920
				884
				942
8033	Universal	1-3-6	66	1140
				1280
				1120
8034	Universal	1-3-6	64	1390
				1630
				1660
8035	Chicago AA	1-3-6	67	1610
				1470
				1490

TABLE 10

AUXILIARY SPECIMENS.

8 In. x 16 In. Cylinders.

Cylinder Number	Kind of Cement	Mixture	Age when Tested Days	Unit Load Lbs. per Sq. In.
8011	Chicago AA	1-1-2	14	1995
8012	Chicago AA	1-1-2	14	2125
8051	Chicago AA	1-1-2	14	----
8013	Universal	1-1-2	61	4240
8014	Universal	1-1-2	60	----
8015	Chicago AA	1-1-2	67	-----
8021	Universal	1-2-4	14	1150
8022	Chicago AA	1-2-4	14	954
8061	Chicago AA	1-2-4	14	-----
8023	Universal	1-2-4	66	1670
8024	Universal	1-2-4	65	760
8025	Universal	1-2-4	66	----
107	Chicago AA	1-2-4	379	----
161	Chicago AA	1-2-4	377	----
162	Chicago AA	1-2-4	377	----
8032	Chicago AA	1-2-4	14	299
8033	Universal	1-3-6	66	1350
8034	Universal	1-3-6	64	1030
8035	Chicago AA	1-3-6	67	----

TABLE II.

SUMMARY OF TESTS.

Column Number	Mixture	Age Days	Cement	Maximum Load Lb. per sq. in. Columns.	12 in. cubes	6 in. cubes	6 x 12 cylinders.
8011	1-1-2	14	Chicago AA	2067	3100 3000	2535 3385	1095
8012	1-1-2	14	Chicago AA	2231	2300 2410	2140 2310 2070	2125
8013	1-1-2	61	Universal	3576	4070 4160	4470 4760 4450	4240
8014	1-1-2	60	Universal	3427	-----	-----	-----
8015	1-1-2	67	Chicago AA	3394	3550 3640	3560 3880 3760	-----
8021	1-2-4	14	Universal	1100	2080 2170	1550 1355 1410	1150
8022	1-2-4	14	Chicago AA	688	1180 1042	1263 1182 1133	954
8023	1-2-4	66	Universal	2306	2940 3110	2365 2463 2367	1670
8024	1-2-4	65	Universal	1872	1900 2900	2104 1794 2163	760
8025	1-2-4	66	Universal	2234	2260 2870	2600 2650 2730	1705
107	1-2-4	379	Chicago AA	2420	-----	-----	-----
161	1-2-4	377	Chicago AA	1694	1910 1660	-----	-----
162	1-2-4	377	Chicago AA	2009	2150 2320	-----	-----

TABLE II.

SUMMARY OF TESTS.

Continued.

Column Number	Mixture	Age Days	Cement	Maximum Load Lb. per sq. in. Columns	12 in. cubes	6 in. cubes	8 x 16 cylinders.
8032	1-3-6	14	Chicago AA	853	932 876	928 884 948	809 Crush
8033	1-3-6	66	Universal	1194	1310 1410	1140 1280 1120	1350
8034	1-3-6	64	Universal	1086	2000 3390	1500 1630 1660	1030
8035	1-3-6	67	Chicago AA	1021	1300 1470	1610 1470 1490	-----
8051	1-1-2	14	Chicago AA	Repeat Load	2300 2100	2530 2470 2670	-----
8061	1-2-4	14	Chicago AA	Repeat Load	713 760	607 505 545	-----

TABLE 18.

SUMMARY OF COLUMN TESTS.

Column Number.	Mixture	Age Days	Cement	Maximum load Lbs. Sq. In.	Initial Modulus of Elasticity.	Ratio lateral to longitudinal deformation		Manner of Failure.
8011	1-1-2	14	Chicago AA	2067	3500000	------	----	crushed at top.
8012	1-1-2	14	Chicago AA	2231	3200000	1:10.0	1:50	crushing at top
8051	1-1-2	14	Chicago AA	Repeat	2500000	------	----	crush at middle
8013	1-1-2	30	Universal	3578	4300000	------	1:10.1	sheared began at top. Extended 3' down.
8014	1-1-2	60	Universal	3427	4700000	1:3.6	1:4.0	crush.
8015	1-1-2	60	Chicago AA	3394	3900000	------	----	shear at middle.
8021	1-2-4	14	Universal	1100	2800000	1:12.1	1:15.8	crush 2' from bottom.
8022	1-2-4	14	Chicago AA	688	2600000	1:5.2	1:2.4	crush
8061	1-2-4	14	Chicago AA	Repeat	3200000	------	----	shearing $1\frac{1}{2}$' from bottom.
8023	1-2-4	60	Universal	2306	2860000	------	----	shear middle
8024	1-2-4	60	Universal	1872	3200000	1:9.7	1:7.1	shear about 1' from top.
8025	1-2-4	60	Universal	2234	3900000	------	----	shear
107	1-2-4	365	Chicago AA	2430	3900000	1:18	1:6.5	shear 4' from bottom.
161	1-2-4	377	Chicago AA	1694	3000000	------	----	crush
162	1-2-4	377	Chicago AA	2009	3200000	------	----	crush
8032	1-3-6	14	Chicago AA	353	2000000	1:9.4	1:11.2	crush
8033	1-3-6	60	Universal	1194	2600000	1:22.5	1:5.4	sheared 3' from bottom.
8034	1-3-6	60	Universal	1086	3100000	1:40	1:5.7	crush 4' from bottom.
8035	1-3-6	60	Chicago AA	1021	2000000	1:7.3	1:5.2	shear at middle.

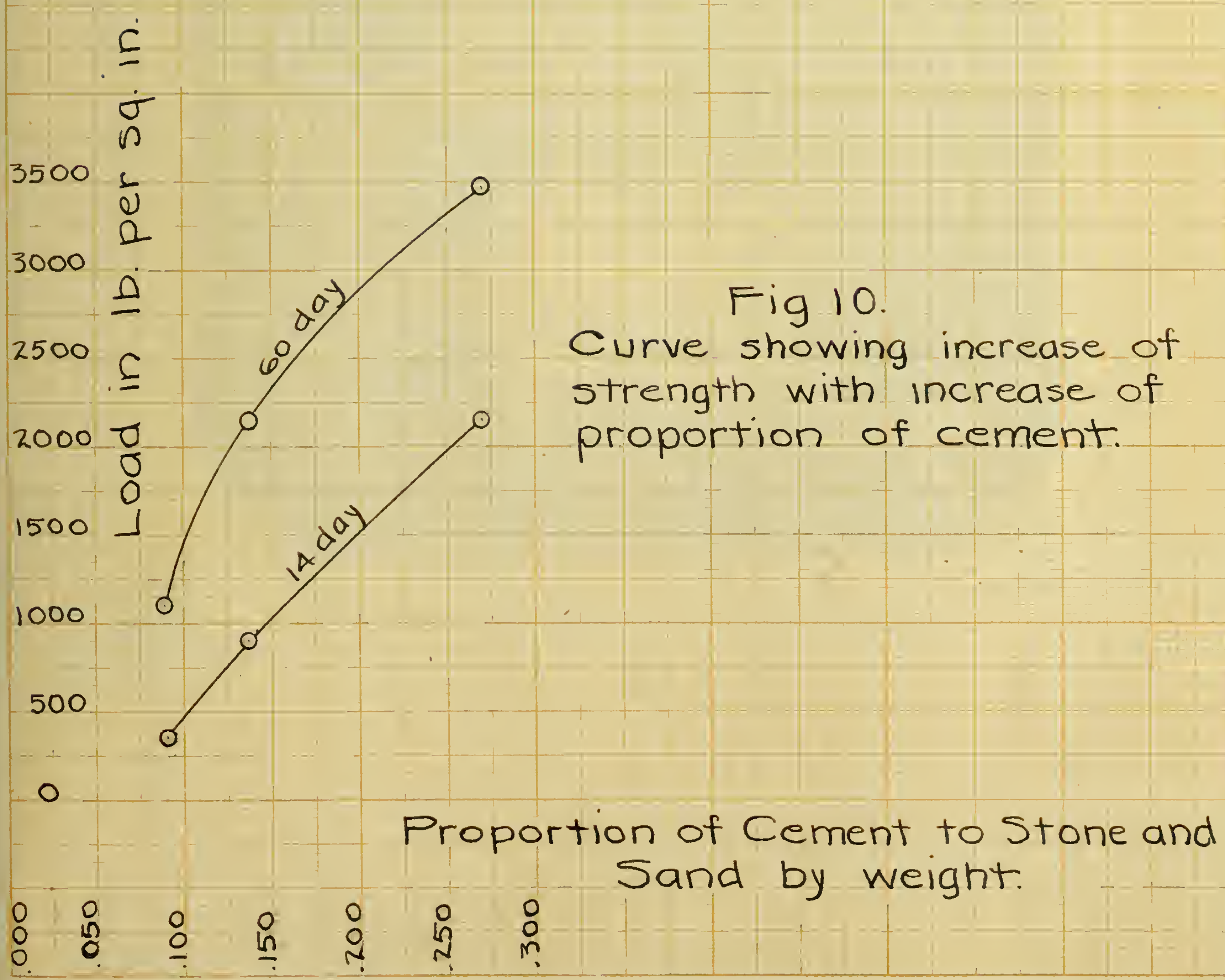
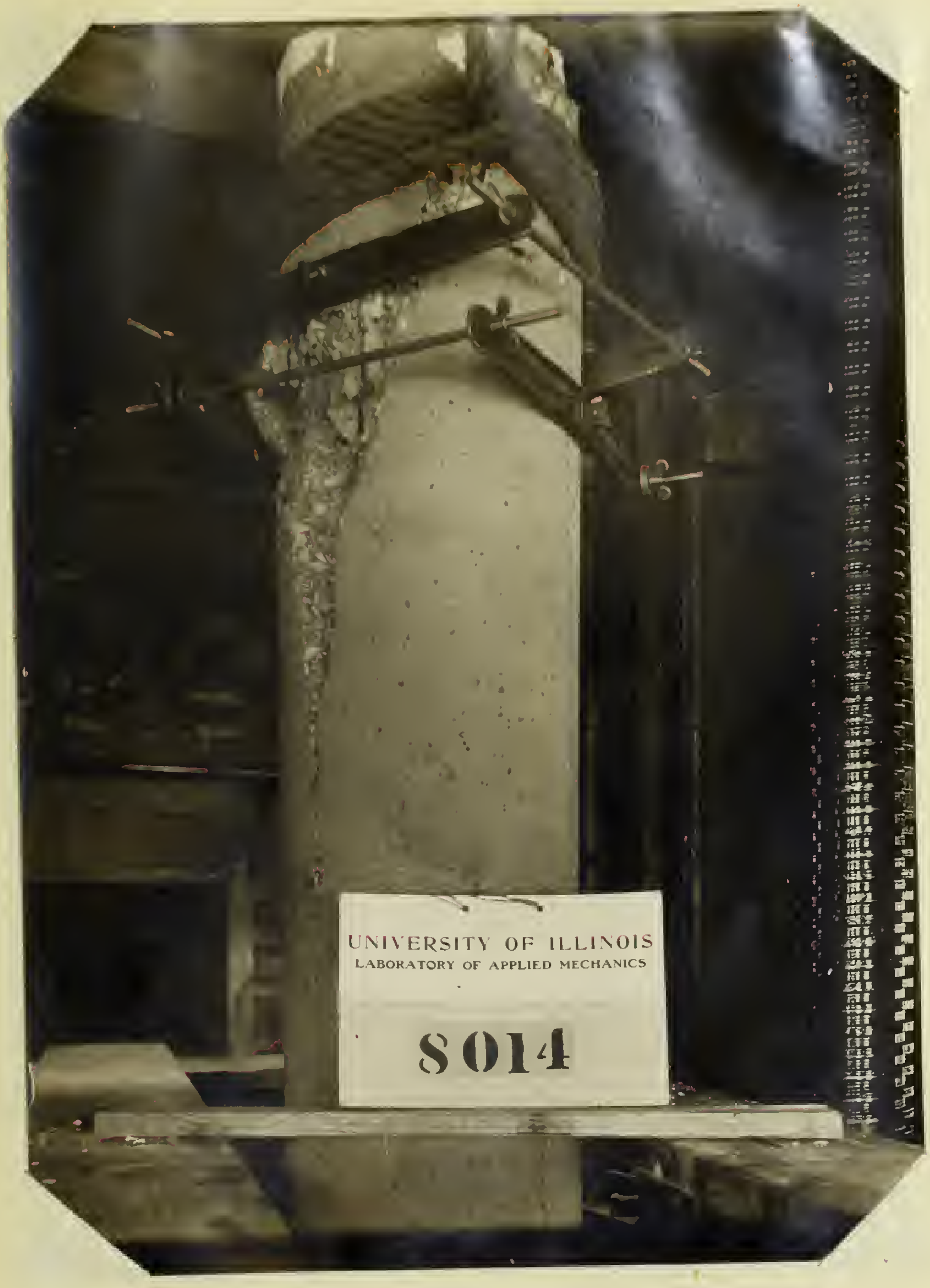


Fig 10.
Curve showing increase of strength with increase of proportion of cement.



VIEW SHOWING DIAGONAL SHEARING FAILURE.

Fig. 5.

View Showing Crushing in Connection
with Shearing Failure.

Fig. 6.

View Showing Typical Crushing Failure.

This Column was tested in the 1907 series.

Fig. 7.

View Showing Shearing Failure in Column
after being stripped of
Reinforcement.

Fig. 9.

DISCUSSION OF PLAIN COLUMN TESTS.

Methods of Failure:- In general there were two distinct forms of failure: (a) a failure by diagonal shearing and (b) a failure by general crushing. Fig. 5 is a view of a typical diagonal shearing failure, and Fig. 7 one of a simple compression failure. The 14-day columns generally failed by crushing near the top or bottom. The single exception to this was Column 3061 which failed under repeated loads by shearing about $1\frac{1}{2}$ feet from the bottom. This was perhaps due to the fact that the concrete was still green. In general the failures were gradual, and were not noted until the load began to decrease. The shortening in these columns was considerably greater than in the older columns of the same mixture. Furthermore, as a general rule, the failure was not accompanied by a loud report. The 60-day columns failed by crushing or shearing. In these tests the columns broke suddenly and without warning, and the failure was accompanied by a loud report. The manner of the failure in these tests differed from those of the year previous in that most of the failures were near the ends of the columns rather than near the middle. In nearly all cases the approach of the ultimate strength of the column might have been predicted from the increase in the rate of shortening.

Stress-Deformation Diagrams:- Stress-deformation diagrams are drawn for each column representing the observed unit loads and the corresponding unit deformations. The ordinates represent the load or pressure in pounds per square inch on the column, and the abscissae the unit deformations as determined from the extensometer readings for the gauged length used. These values are taken from the average of the readings on the four faces of the column. The amount of the deformation was calculated by using as the zero readings, the extensometer readingstaken at the original zero of load, or load at which the first reading was taken. This initial load varied from about 6000 to 11000 pounds. On the same curve sheet showing the stress-deformation diagram is a diagram showing the unit deformations along two perpendicular diameters at the middle of the column.

Strength of Plain Concrete Columns:- In Table 11 is given the ultimate unit load taken by the several columns. The average strengths of the 14-day columns are as follows: 1-1-2 concrete 2150 lb. per sq. in., 1-2-4 concrete 894 lb. per sq. in., 1-3-6 concrete 353 lb. per sq. in. The 60 day columns are as follows: 1-1-2 concrete 3465 lb. per sq. in,, 1-2-4 concrete 2140 lb. per sq. in., 1-3-6 concrete 1100 lb. per sq. in. Three columns, No.'s 107, 161, 162 of the series of 1907 were tested at the age of one year. For the purpose of comparison the average strengths of columns at the age

of 60 days and 200 days made of the same material will be taken from Bulletin No. 20 of the University of Illinois Engineering Experiment Station. These columns were of 1-2-4 concrete. The average unit strengths are as follows: 30 days 1740 lb. per sq. in., 200 days 2025 lb. per sq. in., 365 days 2040 lb. per sq. in.

In Fig. 10 the increased strength with an increased proportion of cement is shown graphically for the 14-day and 60-day columns, the weight of the cement being given in terms of the combined weights of sand and stone. It is quite readily seen that the addition of cement will give an additional strength much greater than the additional cost of material. Assuming the cost of cement at $2.00 per barrel, sand and stone at $2.00 per cu. yd. and taking the percentage of voids from the mechanical analysis of the stone and sand used in these tests which are 54.7 % and 28 % respectively, the cost of the materials in a cubic foot of concrete is as follows: 1-1-2 concrete 27½ cents per cubic foot, 1-2-4 concrete 22 3/10 cents per cubic foot, 1-3-6 concrete 19 6/10 ¢ per cubic foot. The increase of cost of the 1-1-2 concrete over the 1--2-4 and 1-3-6 concrete are 24 % and 41 % respectively. The increase of cost of the 1-2-4 concrete over the 1-3-6 concrete is 14 %. Taking the strengths of the 60-day columns because they are more nearly representative of actual conditions it is found that the increased strength of the 1-1-2 concrete over the 1-2-4 and 1-3-6 concrete are 62 % and 215 % respectively. The increased strength of the 1-2-4 concrete over the 1-3-6

concrete is 94 %. The 1-3-6 concrete has 2 % of voids after the sand and cement are added. The 1-2-4 has 8 % excess of mortar. The 1-1-2 concrete has 24 % excess of mortar. The theoretical mixture for concrete is understood to be just enough cement to fill the voids in the sand, and enough mortar to fill the voids in the stone. The 1-2-4 concrete is about the ideal mixture. The above data, if representative of actual conditions, indicates that from an economical standpoint the 1-1-2 concrete is the best, even though it has a considerable excess of mortar. The increase in strength of the 1-1-2 concrete over the 1-2-4 concrete is 250 % greater than the increase in cost.

A comparison of the strengths of the 1-2-4 concretes of the series of 1907 and 1908 at the ages of 60-days, 200-days, and 365-days, shows that the strength of the 200-day columns has increased in the interval about 15 %, while the 365-day columns show an increase of only about 1 %. The maximum unit strength for a single column was the 60-day 2210 lb. per sq. in. for 200-day 2680, and for the 365-day 2420 lb. per sq. in. It is seen by this data that no definite conclusions can be drawn, for there was not a sufficient number of test pieces of each age to eliminate, by taking an average, the accidental variations either of manufacture or of testing which enter into the strength of the columns. The strengths of the cubes in these tests is generally greater than that of the columns of the same mixture and age, but they show, as per example cubes

161 and 162, the difference in strength of properly mixed and improperly mixed concretes.

Modulus of Elasticity of Plain Concrete Columns: The modulus of elasticity of concrete varies with the stress in the concrete, as the deformation produced by a load is not proportional to the compressive stress. It has been found that the stress deformation relation of concrete closely approaches a parabola with its vertex at the ultimate load, and passing through the origin. As the ratio between the stress and deformation does not vary much for the first one-third of the strength of the concrete, the modulus of elasticity may be represented by the tangent to this parabola at this initial load. The tangent of the angle, which this tangent makes with the horizontal, is called the initial modulus of elasticity. The average moduli of elasticity for the 14-day tests are as follows: 1-1-2 concrete 3,350000 lb. per sq. in., 1-2-4 concrete 2,700000 lb. per sq. in., 1-3-6 concrete 2,000000 lb. per sq. in. The values for the 60-day tests are as follows: 1-1-2 concrete 4,300000 lb. per sq. in., 1-2-4 concrete 3,320000 lb. per sq. in., 1-3-6 concrete 2,560000 lb. per sq. in. The average for the 1-2-4 concrete at the age of 60 days is somewhat greater than the average for 1907 but a comparison of the columns shows that the maximum unit load was also greater. The 1-1-2 concrete 14-day old has about the same strength and the same modulus of elasticity as the 1-2-4 concrete at the age of

60 days, also the 1-2-4 concrete 14 days old has about the same strength and modulus of elasticity as the 1-3-6 concrete at the age of 60 days. The average of the 1-2-4 concrete of the 1907 series at the ages of 60 days, 200 days and 365 days are respectively: 3,040000 lb. per sq. in., 3,140000 lb. per sq. in., and 3,360000 lb. per sq. in. The data above shows that the richer the concrete the greater the modulus of elasticity. It is evident therefore that the addition of cement gives a much stiffer concrete. The results of the 365-day tests of 1908 give a slightly higher modulus of elasticity than the 200-day tests of 1907,and these in turn give a slightly higher modulus of elasticity than the 60-day tests of 1907. This difference is very small and might be attributed to difference of materials or manufacture. However it may indicate that the stiffness and rigidity of concrete increases with age but in a decreasing ratio after a certain length of time.

Poisson's Ratio:- When a load is applied to a column in compression the column shortens longitudinally,and at the same time expands laterally. Lateral expansion in plain concrete columns alone is of small importance,but in the study of plain columns in connection with columns having banded reinforcement, it is of the greatest importance as it shows the point at which the steel begins to take stress. The ratio between the lateral unit deformation and the longitudinal unit deformation is termed Poisson's Ratio. The apparatus used in measuring the

lateral deformation was experimental. A slight slip of the apparatus made a marked error in the readings, as the expansion is so minute that great care must be taken to obtain accuracy of readings. The results however show that for an increased load the lateral deformation increases faster than the longitudinal deformation. For 1-2-4 concrete at the age of 60 days, Poisson's ratio for $\frac{1}{4}$ load is about 1/9, for the half load about 1/7, and for the full load about 1/6.

Repetitive Loading:- In most of the tests the columns were loaded progressively to failure. Columns 8051 and 8061 were tested by repetitive loading. When a load is applied in any amount and released, the same load reapplied, and then released, and the operation continued, the longitudinal deformation for any given load increases, and there is also an increase in deformations due to the repetition of the load. The total deformation and resulting set soon becomes constant. For the higher loads the deformations and resulting set gradually increase with the repetition of the load, and finally failure occurs at a much smaller load than had the column been loaded progressively to failure. The two columns under consideration were square in cross section, being 12 inches on a side. The length of the columns was 6 feet. The gauge length used was 50 inches.

Column 8051 made of 1-1-2 concrete and 14 days old had a load of about 500 lb. repeated 10 times and the total deforma-

tion and resulting set approached a constant. The load was increased to about 1130 lb. per sq. in. and repeated 10 times. The total deformation and resulting set for this load again approached a constant, and it was evident from this that the column would not fail at this load no matter how often the load was applied and released. A third increment of load was then applied and the column failed on the first application at a unit load of 1230 lb. per sq. in.

Column 8061 was of 1-2-4 concrete and was 14 days old. An initial unit load of about 320 lb. per sq. in. was first applied 10 times, and then a unit load of 380 lb. per sq. in. applied 10 times. The unit load was then increased to 450 lb. per sq. in. This loading was repeated 13 times. The deformation and resulting set did not approach a constant, but the increase in deformation for each successive loading was about constant with the resulting set variable. It was evident that the column would fail under this loading if repeated a sufficient number of times as the unit deformation was approaching a maximum. After 13 applications of the load the unit load was increased to 510 lb. per sq, in. which showed a marked increase in the resulting deformation. The column failed at 500 lb. per sq. in. on the second application of the newly increased load.

When a certain load is repeated on a column and the load increased, the stress-deformation curve at once rises until it joins the general direction of the stress-deformation curve

for a single application of the load. If the points for the last repetition of each load be joined a curve will be obtained which has the same general form as the curve for a single application but with greater deformations. This is shown by dotted lines on the curve sheets of Columns 8051 and 8061.

SUMMARY.

The number of test specimens for each mixture and for each age is not large enough to form absolutely definite conclusions, but the following statement may be made some of these only as possibilities.

1. The average ultimate strength of plain concrete columns at 14 days of age are as follows: 1-1-2 concrete 2150 lb. per sq. in., 1-2-4 concrete 890 lb. per sq. in., 1-3-6 concrete 350 lb. per sq. in. The 60 day columns are as follows: 1-1-2 concrete 3460 lb. per sq. in., 1-2-4 concrete 2140 lb. per sq. in., 1-3-6 concrete 1100 lb. per sq. in. The effect of the amount of cement used is very marked, and this proves that for purely compressive stresses cement is an excellent reinforcing material.

2. The average unit stresses in the 1907 series of 1-2-4 concrete at different ages are as follows: 60 days 1740 lb. per sq. in., 200 days 2025 lb. per sq, in., 365 days 2041 lb. per sq. in. If this gradual increase is not a personal error, the data indicates that concrete gains strength slowly with age. This is of importance in that if the elements do not tend to combine chemically with the concrete and disintegrate it, that concrete is practically indestructible.

3. The average initial moduli of elasticity for 14-day concrete is as follows: 1-1-2 concrete 3,350000 lb. per sq. in., 1-2-4 concrete 2,700000 lb. per sq. in., 1-3-6 concrete

2000000 lb. per sq. in. The 60-day tests are as follows: 1-1-2 concrete 4,300000 lbs. per sq. in., 1-2-4 concrete 3,320000 lbs. per sq. in., 1-3-6 concrete 2,560000 lbs. per sq. in. This shows an increase in the 60-day 1-2-4 concrete over last year's test.

4. Poisson's ratio for concrete in compression is a variable quantity. The value varies with age, with the character of the material, and with the unit load.

5. The repetition of a load gives an increased amount of shortening and an increased set. For small loads the increase becomes smaller after a small number of repetitions. For the higher loads the effect of repetition is to gradually increase the deformations and the resulting set until the column fails.