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THE STRENGTH OF REINFORCED CONCRETE BEAMS;
RESULTS OF TESTS OF 333 BEAMS

(FIRST SERIES)

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PREFACE

The investigations herein reported were made by the Technologic Branch of the United States Geological Survey at the Structural Materials Testing Laboratories, St. Louis, Mo. When this work was transferred to the Bureau of Standards July 1, 1910, this manuscript was transmitted for publication.

of architectural and engineering structures. Studies have therefore been made near maximum load between external load conditions, as measured by the bending moment, and resistance of the beam as determined by the resisting moment. There is included the relation between the unit stress at maximum load and the yield point of the reinforcement.

Studies have been made for maximum load and for unit stresses of 16 000 and 32 000 pounds of the relation between the effective percentage of reinforcement and (1) the resistance of the beam as measured by $\frac{M}{bd^2}$, (2) percentage depth to the neutral axis, (3) unit compressive stress in the extreme upper fiber, (4) the deflection at the center of the beam. The results are presented diagrammatically and in greater detail in tabular form.

The change of such relation with age and the difference due to the nature of the aggregate have also been determined and are presented in the following pages.

The development and spacing of the tension cracks below the neutral axis for the various aggregates, ages, and percentages of reinforcement is plainly shown by photographs of the beams.

There is also included a study of plain concrete in direct compression. The growth in strength with age and the increase in stiffness, as measured by the initial modulus of elasticity, are clearly brought out. The variation with age of the ratio of the yield point to the ultimate strength for the different aggregates has been determined.

No extended discussion of the theory of reinforced concrete is attempted in this bulletin and theoretic formulas have been introduced only where necessary for the intelligent presentation of the data. The formulas used are, however, not original with this bulletin but are based on assumptions which are thought to approximate the truth.

IV. TESTS OF THE CONSTITUENT MATERIALS

1. CEMENT

The cement used in all the tests in these laboratories is known as typical Portland cement. It is prepared by thoroughly mixing together a number of Portland cements. The method of prepar-

ing the typical Portland cement that was used in the tests herein reported was as follows:

One thousand eight hundred sacks of cement, 200 from each of nine companies, were used. Two hundred sacks of one brand were spread over a concrete floor 25 by 40 feet in area and thoroughly mixed by hoeing from side to side. Two samples were then taken, a 50-pound sample for tests to be made by the constituent-materials section, and a smaller one for chemical tests. The cement was then resacked. When all the brands had been separately mixed in this way two sacks of each brand were spread on the floor in a layer about 3 inches thick. One brand was spread upon another in blanket form, making nine separate layers of cement for the nine brands used. The mass was mixed very carefully with shovels until a uniform mixture was obtained. A 10-pound sample was taken for physical tests and the cement was sealed in air-tight cans, two cans of 800 pounds capacity each being required to hold one mix.

Table 2 (p. 9) of the present bulletin contains the physical tests on the individual cans of cement which were used in the preparation of all concrete reported in this bulletin. The samples of cement on which these tests were made were taken at the time the typical Portland cement was prepared, just before the individual cans were sealed.

2. SAND

The sand used was what is known as Meramec River sand and was identical with that used in the series of plain concrete beams reported in Bulletin 344.⁴ The physical properties of this sand are given in Table 3 (p. 11).

3. AGGREGATES

With the exception of the cinders the aggregates used were practically identical with those used in the concrete beams reported

⁴U. S. Geological Survey.

Table 2.—Physical Properties of Cements Used in First Series

Reg. No.	Specific Gravity	Temperature, Fahrenheit		Water, Per Cent	Time of Set, Minutes				Fineness of Residue on Sieve		Tensile Strength, Age in Days					
					Vicat		Gilmore									
		Water	Air		I	F	I	F	100	200	1	7	28	90	180	360
387	....	...	...	20.75	240	445	285	480	5.25	21.75	375	669	747	875	695	...
392	3.165	75.2	87.0	21.00	130	298	213	365	5.20	21.50	402	685	814	774	723	793
397	3.162	80.0	95.0	21.00	140	299	236	366	5.00	21.65	460	711	722	780	748	779
399	....	...	...	21.00	193	385	252	480	5.10	21.60	277	665	735	899	748	...
400	....	...	...	21.00	193	406	257	483	5.30	21.75	277	656	721	807	754	...
402	3.163	79.0	86.0	21.00	161	310	227	379	5.20	21.65	416	689	811	783	827	803
406	3.165	79.0	86.0	21.00	157	310	225	385	5.00	21.60	427	659	828	795	809	823
419	3.165	79.0	86.0	21.00	177	310	239	393	5.00	21.40	440	688	741	790	789	802
427	3.166	77.0	85.0	21.00	168	342	221	397	5.50	22.00	447	691	790	797	813	803
443	3.164	79.0	86.0	21.00	...	310	230	387	4.90	21.50	427	685	786	791	776	832
451	3.164	75.2	87.0	21.00	137	303	211	366	5.45	22.80	416	690	795	784	799	823
453	3.163	77.0	82.0	21.00	142	305	282	358	5.25	21.70	460	675	751	778	778	814
456	....	77.0	85.0	21.00	188	343	226	395	...	....	455	695	690	779	843	778
463	....	...	...	21.00	...	335	247	455	5.55	21.75	224	641	727	876	770	...
478	3.157	75.2	87.0	21.00	134	303	210	369	5.00	21.80	422	684	798	787	805	811
485	3.167	68.0	71.0	20.75	...	395	266	457	5.55	22.25	290	688	680	786	860	904
487	3.165	68.0	73.0	20.75	207	387	263	453	5.35	22.30	301	693	789	798	853	861
5490	3.168	68.0	78.0	20.75	183	364	236	436	5.40	22.45	269	702	790	812	853	857

* In water and air warped one sixty-fourth of an inch around edge of pat.

Table 2.—Physical Properties of Cements Used in First Series—Continued

Reg. No.	Specific Gravity	Temperature, Fahrenheit		Water, Per Cent	Time of Set, Minutes				Fineness of Residue on Sieve		Tensile Strength, Age in Days					
		Water	Air		Vicat		Gillmore		100	200	1	7	28	90	180	360
					I	F	I	F								
492	3.162	80.0	89.0	21.25	148	336	230	406	---	----	451	695	783	779	748	753
6 493	3.172	78.8	92.0	21.00	133	276	204	346	5.15	20.95	450	698	786	769	772	883
494	3.167	80.6	94.0	21.00	103	267	191	----	5.20	21.60	420	724	759	746	754	752
498	3.160	77.0	95.0	21.00	125	285	202	346	4.80	21.30	460	671	754	760	756	791
501	3.172	80.6	98.0	21.00	127	277	204	346	4.85	21.60	465	672	763	771	778	820
503	3.163	80.0	85.0	21.25	142	296	217	352	5.10	21.65	431	692	753	757	740	819
504	3.163	77.0	89.0	21.00	135	287	194	335	---	----	455	655	775	762	790	814
513	3.165	68.0	71.0	20.75	---	382	271	466	5.30	22.20	321	684	802	813	863	871
516	....	68.9	89.0	20.75	155	339	214	383	5.40	22.35	326	673	784	807	863	898
518	3.163	80.0	85.0	21.25	160	335	264	413	4.80	22.50	468	679	702	765	767	800
519	3.166	80.0	89.0	21.25	162	334	230	411	5.01	20.90	440	686	753	778	744	813
520	3.165	79.0	82.0	21.00	164	379	247	440	5.30	22.65	453	676	775	773	763	788
7 523	3.160	68.0	73.0	20.75	208	405	282	454	5.30	22.40	311	690	774	827	865	854
526	3.165	68.0	78.0	20.75	---	344	239	429	5.40	22.35	287	697	799	797	860	910
Ave..	3.165	75.8	85.0	20.97	160	334	235	404	5.19	21.86	391	683	765	794	791	823

⁶ Steam warped one thirty-second of an inch around edge of pat.⁷ Air warped one sixty-fourth of an inch around edge of pat.

in above bulletin, Table 6, page 17. While the cinders were obtained from the same source as those previously used they came in a different car and were therefore treated as a separate sample. The physical tests on all the aggregates are given in Table 3.

Table 3. —Physical Properties of Sand and Other Materials Forming Aggregates Used in Beams

Kind of Material	Specific Gravity	Percent- age of Voids, Com- puted	Weight, Pounds Per Cubic Foot	Percentage Passing Sieve or Screen				
				200	100	80	50	40
Cinders.....	1.750	.....	.....	2.35	3.24	3.87	4.90	5.87
Granite.....	2.585	40.90	95.30	1.59	2.29	2.62	3.22	3.74
Gravel No. 1, Beams 333 to 388.....	2.450	33.00	102.40	0	0	0	0	0
Gravel No. 2, Beams 389 to 416.....	2.479	.....	.....	.....	.....	.....	.....	.....
Limestone.....	2.489	37.10	97.70	2.96	3.48	3.70	4.18	4.68
Meramec River Sand No. 1, Beams 162 to 197.....	2.597	37.90	100.60	.20	1.30	3.60	13.90	37.00
Meramec River Sand No. 2.....	2.619	33.89	107.91	.20	1.94	6.09	24.11	43.90

Kind of Material	Percentage Passing Sieve or Screen							
	30	20	10	$\frac{1}{4}$ inch	$\frac{1}{2}$ inch	$\frac{3}{4}$ inch	1 inch	1 $\frac{1}{2}$ inches
Cinders.....	7.10	9.13	14.15	21.58	77.06	93.23	96.50	100.00
Granite.....	4.38	5.45	8.50	19.88	57.54	99.25	99.71	100.00
Gravel No. 1, Beams 333 to 388.....	0	0	.95	43.00	79.30	95.20	98.50	100.00
Gravel No. 2, Beams 389 to 416.....	.....	.....	.....	.....	.....	.....	.....	.....
Limestone.....	5.23	6.21	10.69	28.71	60.86	96.04	99.37	100.00
Meramec River Sand No. 1, Beams 162 to 197.....	64.00	81.50	97.00	100.00	.....	.....	.....	.....
Meramec River Sand No. 2.....	60.28	74.64	88.96	100.00	.....	.....	.....	.....

4. REINFORCEMENT

The maximum load carried by a beam of given dimensions, which is insufficiently reinforced to develop failure by compression and in which the concrete is sufficiently strong to prevent failure by bond or diagonal tension, is proportional to the percentage and to the yield point of the reinforcement. The failure in this case will be caused by the unit stress in the reinforcement exceeding the yield point. If for a given percentage of reinforcement the yield point is low the maximum load carried will also be low as compared with that carried by a beam containing reinforcement having a higher yield point.

In order, however, to establish a consistent relation between the maximum load carried and the percentage of reinforcement, and in order to study the effect of the yield point of the reinforcement on the carrying capacity of the beam, the yield point of all the reinforcement used in a given beam should be identical. If the yield points of the reinforcement used in a given beam vary widely the failure of the beam, instead of being due to the simultaneous failure of all the reinforcement, will be caused by the failure in detail of the reinforcement. The coefficient of elasticity of the reinforcement being independent of the yield point, all the bars in the beam will elongate equally for a uniform, well-bedded vertically and axially loaded beam, for all stresses below that corresponding to the lowest yield point of the reinforcement in the beam. When this lowest yield point has been reached this particular bar will elongate much more rapidly and under a practically constant unit stress, thereby throwing much more of the load on the remaining bars. One would expect, therefore, that the increment of the elongation of the reinforcement for the same increment of load will now be greater than it was when the unit elongation was less than the lowest yield point of the reinforcement.

For bars of different yield points in the same beam the elongation curve of the reinforcement will suffer a change of direction as each bar fails, the curve becoming flatter as the load increases. Where there is considerable difference in the yield point of the reinforcement and for high percentages of reinforcement, this progressive flattening begins at some load prior to maximum load. If the yield point of the bars used is, however, practically identical,

the increments of deformation of the reinforcement should be proportional to the increments of load almost to the maximum load.

In order, therefore, to compare the maximum loads carried by identical beams or to study the effect of a change in the percentage of reinforcement the yield point of the reinforcement used in all the beams of a series should, as far as possible, be identical.

The reinforcement supplied to the laboratory was mild steel of presumably 55 000 to 65 000 pounds ultimate strength. It was thought, however, that in the steel as shipped there would be a greater variation in the yield point than should be permissible in a series of tests which it was hoped would furnish data for the conclusive investigation of reinforced concrete. It was therefore necessary to test a coupon from each bar to be used and then classify the steel according to the yield point.

(a) METHODS OF TESTING REINFORCEMENT

All the steel was tested, using the following method:

After the diameter of the 16-inch coupon had been determined at several points along its length and averaged, two punch marks were made, exactly 8 inches apart. The test piece was then placed between the flat wedges of the grips so that there was a space of about $1\frac{1}{2}$ inches between the punch marks on the test piece and the ends of the wedges. The surface of the steel around the lower punch mark was then whitened with a soapstone pencil. As the load was being applied one operator pivoted one point of a pair of dividers (whose points were firmly clamped 8 inches apart) in the upper punch mark and drew a line on the whitened surface of the steel at the other punch mark. As the steel elongated uniformly below the yield point a series of parallel lines was drawn by the lower divider point, their distance apart for equal load increments being approximately the same. To aid in distinguishing between these lines a magnifying glass was used. Near the yield point a sudden increase was noticed in the distance between these lines for the same increment of load. The unit stress in the steel at that point has been designated "elastic limit (by dividers)." At a somewhat higher unit stress there was a more or less sharp drop of the scalebeam. This unit stress has been called the "yield point." The "ultimate strength" is the maximum unit stress in the steel. The unit stress based on the load at rupture

and the original cross section has been called the "breaking strength."

After rupture the character of the fracture, whether silky or granular, was noted and the average diameter of the "neck" calipered. The pieces were then placed together and the percentage elongation read from a special rule. From the measured diameter of the neck the reduced cross section was determined, and the difference from the original cross section was calculated. The ratio of this difference to the original area has been called the "reduction in area."

(b) RESULTS OF TESTS OF REINFORCEMENT

The average results of the tests of the reinforcement in each beam have been compiled in Table 4 (p. 121).

Examining the values in column 6 it will be seen that the ultimate strength varies between 52 000 and 64 000 pounds, with the majority lying between 55 000 and 60 000 pounds. The steel therefore corresponds to what is known as "mild" steel.

The elastic limit by dividers varies between 33 000 and 41 000 pounds while the yield point lies between 35 000 and 43 000 pounds. The steel was classified on the basis of the elastic limit, each group differing by 2000 pounds.

The group 37 000 to 38 000 would be limited by unit stresses of 36 500 and 38 499 and similarly for all groups. The steel was first classified on this basis, but it was noticed that the values obtained for the elastic limit were subject to much more variation than was the case for the yield point. This was due to the fact that the operators found great trouble in fixing definitely the point at which the rate of change of the distance between the closely drawn parallel lines on the surface of the steel would change.

In all steel classified subsequently, the groups were based on the yield point, which, for mild steel at least, is a very definite point and independent of any personal equation of observation.

The average tests on reinforcement compiled in this table represent 1260 tests and furnish ample data for the study of the relation between the various qualities reported.

An examination of this table will show that for even the same or practically identical ultimate strengths there may be considerable variation in the elongation and in the reduction in area.

A considerable difference is noticeable in the yield point of steel having the same ultimate strength, the difference in some cases being as much as 5 000 pounds per square inch.

The change in the yield point and the ultimate strength do not necessarily go hand in hand, an increase in the ultimate strength not always being accompanied by an increase in the yield point.

A rough comparison showing the variation of the various qualities with a change in the ultimate strength can readily be made, and is summarized below:

Table 5.—Effect of Changes in Ultimate Strength of Reinforcement

(MILD STEEL)

Elastic Limit (Pounds Per Square Inch)	Yield Point (Pounds Per Square Inch)	Ultimate Strength (Pounds Per Square Inch)	Percentage Elongation in 8 Inches	Percentage Reduction in Area	Number of Tests Averaged
36 100	38 600	53 400	30.1	72.5	10
39 400	41 100	60 900	28.2	59.7	12
37 300	44 000	72 800	23.6	53.0	5

In comparing the values in these tables, however, it should be borne in mind that the extreme variation in the value of the ultimate strength occurs within comparatively narrow limits and that the tests were made on coupons tested just as they were cut from the bar and not on turned test pieces.

V. DETAILS OF TESTS

1. DESCRIPTION OF TEST PIECES

(a) BEAMS

The beams, 13 feet long, 8 by 11 inches in cross section, were tested on a 12-foot span by two equal loads applied at the third points. The cross sections of the various beams, giving the horizontal and vertical spacing of the reinforcement are shown in Fig. 1.

The reinforcement throughout consists of one-half inch round bars having a yield point of approximately 40 000 pounds. The percentage of reinforcement was varied by changing the number of bars. For all percentages above 1 the size of the beam

Fig. 1.—Distribution of Reinforcement

used made it impossible to place the reinforcement in a single layer. For these percentages the reinforcement was therefore placed in two layers, the depth from the top of the beam being $8\frac{1}{2}$ inches to the center of the top layer and 10 inches to the center of the bottom layer. The "nominal" percentages of reinforcement 0.5, 0.75, 1, 1.25, 1.50, 1.75, and 2, corresponding to 2, 3, 4, 5, 6, 7, and 8, one-half inch round bars respectively were based on the cross section of the beam above the lower layer of bars. The percentages thus obtained are not, however, the effective percentages that determine the resistance of the beam. The method of obtaining the "effective" percentages will be described in detail later.

(b) COMPRESSION TEST PIECES

The cylindrical test pieces were 8 inches in diameter by 16 inches in length while the cubes were 6 inches on the side.

(c) BOND TEST PIECES

For the bond test pieces a one-half inch round bar was embedded on the axis of a cylinder (8 inches in diameter and 6 inches in length) so that one end projected one-fourth inch beyond the cylinder and the other end projected sufficiently to permit gripping it in the jaws of the testing machine.

2. METHOD OF MAKING TEST PIECES

(a) PROPORTIONS

A 1 : 2 : 4 volume proportion was adopted for all the concrete used in the following tests. Since, however, the volume of a given weight of dry sand is greatly affected by the percentage of moisture present, it was thought best to do the actual proportioning by weight. The weight of 1 cubic foot of cement was assumed to be 100 pounds. The weight per cubic foot of the dry, loose sand and the dry, loose aggregate as determined by tests in the constituent-materials laboratory, was used in reducing the proportions by volume to the proportions by weight.

With this as a basis, the necessary weight of dry material for the desired batch was determined. Since the sand and stone, as stored in the bins, contained an appreciable amount of moisture, the dry weight of the material had to be increased by the weight of the moisture present before the batch could be weighed out.

The percentage of moisture was determined on a 500-gram sample of the sand and stone representing as nearly as possible an average of the material in the bin and this was then maintained constant.

(b) MIXING

All concrete was mixed in a motor-driven cubic-yard cube mixer, equipped with a charging hopper. All water used in mixing concrete was weighed and supplied to the mixer through a hose attached to a water barrel, mounted on a platform scale on a support above the mixer. To insure uniform conditions the interior of the mixer was wet down each morning before the first mix of the day. All concrete was mixed two minutes dry and three minutes wet, after which it was dumped on the cement floor, shoveled in wheelbarrows and wheeled to the molding floor. Sufficient material was charged into the mixer to make three beams, three cylinders, and three cubes from the same batch of concrete.

In order to eliminate the personal equation as far as possible, the amount of water required to bring the batch to the desired consistency for a particular aggregate was carefully determined by trial before the test pieces were molded. Thereafter the weight of water to be used with each aggregate for that consistency could be obtained by making a simple correction, depending upon the percentage of water contained in the aggregate as it came from the bins. The total amount of water, including moisture, was expressed as a percentage of the total weight of the dry material and was maintained constant.

Concrete of medium consistency had a smooth appearance in the mixer, but showed a tendency to lump. When dumped, it stood in a pile with steep slopes, exhibiting a somewhat lumpy appearance and showing individual stones, but no voids. The stones showed an even coating of mortar. No water collected on the surface of the beam in the mold. The surface was easily finished with a trowel.

(c) MOLDING

The beam molds consisted of three long steel channels with flanges turned outward, forming the sides and bottom of the mold.

The ends were closed by short pieces of channels. The side and end pieces were removable. The molds were oiled before the concrete was placed, to prevent adhesion to the surface of the steel. In molding reinforced concrete beams two methods were used, depending upon whether the reinforcement was placed in one or two layers.

Where the reinforcement was in one layer it was placed 1 inch from the bottom of the beam. Sufficient concrete was first placed in the bottom of the mold to bring the surface of the layer a little above the center of the reinforcement. After this layer had been tamped once with a hand tamper, the reinforcement was placed upon it and held in the proper position by slotted wooden templets. The reinforcement was then tamped down into the concrete the required depth; the distance from the top being gauged by means of a T-shaped templet, the arms of which rested on the top of the sides of the mold and the end of the leg on the reinforcement. The concrete was then placed in three equal layers, each layer being tamped once, then spaded back from the surface of the mold and tamped again. The tamping was done by a pneumatic tamper working under 60 pounds pressure and having a 3 by three-fourths inch rectangular head.

Where the reinforcement was in two layers the manner of placing the first layer of concrete and the bottom layer of reinforcement was identical with that followed when there was but one layer of reinforcement. When the lower layer of reinforcement had been placed a layer of concrete was added of such a thickness that, when tamped, its surface came almost to the depth of the center of the upper layer of reinforcement which was placed $2\frac{1}{2}$ inches from the bottom of the beam. This layer of reinforcement was then placed in the same manner as the first layer. The concrete in the remainder of the beam was placed in three layers in the usual manner and the top troweled.

The molds were removed at the end of 24 hours and the beams covered with burlap until, at the end of from two to three weeks, they were moved into the damp closet. Both before and after being placed in damp closet they were sprinkled every eight hours. The temperatures on the molding floor and in the damp closet were maintained as near 70° F as possible.

3. METHODS OF TESTING TEST PIECES

(a) BEAMS

The method of testing reinforced beams has been described in a previous bulletin⁸ but it is thought best to repeat some of this information for the purpose of facilitating the study of the results.

Fig. 2 shows a reinforced beam under load with all the attachments. The construction of the box girder, through which the load is transmitted to the beam, and the deformer are fully described in Bulletin 329.⁸ While the gauge length, 29.25 inches, was the same as that used in the tests on plain beams, the vertical spacing of the contact points was different, the upper point being 0.5 inch below the top, while the lower one was placed 1 inch above the bottom of the beam on the plane of the lower layer of reinforcement. By this arrangement the elongation of the reinforcement in the lower layer was read directly, no error due to the reduction of the readings from one horizontal plane to another being possible. The only source of error with this arrangement would be the irregularity in the vertical position of the reinforcement and on the assumption that the elongation read by the micrometers is the uniform lengthening of the reinforcement in the gauge length, uninfluenced by the incasing concrete and free of any comparatively large local elongations where the reinforcement spans a crack in the concrete.

Since the upper contact point is placed 0.5 inch below the top surface of the beam it does not record the exact total deformation of the extreme outer fiber, at which crushing will first appear. With the usual arrangement of deformers in which the contact points are clamped against the sides of the beam this is the only method possible and it therefore becomes necessary to reduce the readings of the upper micrometer to the outer fiber, making the usual assumption of conservation of plane section.

The deflections were read directly to the nearest 0.005 inch by a wire fastened at each end of the beam, at a point 4 inches below the top surface, and passing in front of a mirror and scale fastened to the center of one face of the beam. The scale was graduated to 0.01 inch, but by reading always the same part of the top or bottom

⁸ U. S. Geological Survey.

Fig. 2.—Beam with Electric Contact Deformers

of the wire when it coincided with its image in the mirror 0.005 inch could be easily and accurately measured.

In order to measure any slip that might occur between the end of the reinforcement and the adjacent concrete, a stirrup (Fig. 3) was clamped to the beam, with the contact points in the plane of the reinforcement. This stirrup carried a micrometer screw reading directly to 0.0001 inch, which bore against the smoothed end of one of the reinforcing bars in the lower layer. Since if a slip occurs it is usually an appreciable quantity the readings for these micrometers were thought sufficiently accurate if read by manual contact, and consequently no electric circuit was used.

The electric-contact deformeters were used on all beams with the exception of a few of the 13 and 26 week tests on which Johnson deformeters (Fig. 3) were used. In this type of instrument the rod extending from one yoke to the other is pivoted at one end similarly to that for the electric-contact deformeters. To the other end of the rod is fastened a slip of metal, which rests lightly on a small drum fastened to a little shaft, to one end of which a pointer is attached. One end of the pointer carries a vernier which travels along a circular scale on the circumference of a dial in which the pointer moves. By means of the vernier, deformations can be read to 0.0001 inch.

In order to trace the development of cracks on the surface of the beam it was necessary to examine it with magnifying glasses. In examining the surface of the beam within the gauge length it was almost impossible to avoid disturbing the rods extending across the surface from one deformer yoke to another. In the case of the Johnson deformeters this was a very serious matter, for any movement or jarring of the rod would result in a permanent movement of the indicating pointer over the face of the dial so that the reading of any dial in this case would be the legitimate movement due to the deformation of the concrete between the contact points, plus or minus the movement caused by any disturbance to the rods.

A disturbance of the rods where the electric-contact deformeters were used made no material difference, since a reading of the micrometers could be only taken when the end of the micrometer screw bore against the end of the rod and caused the closing of an

electric circuit. After this reading was taken the screws would, in any case, be turned back a little, in order to prevent the end of the micrometer screw jamming against the end of the rod when load was being applied. What happened to the rod between readings was comparatively unimportant; provided, always, that the fixed end of the rod was always pressed home snugly and the free end returned to its position in the grooved roller when being replaced.

When, therefore, the surface of the beam was being examined for cracks the lower rod would be removed, and replaced when more load was being applied.

The method of "zero moments" described in detail in Bulletin 344⁹ was used on the reinforced beams. While this method seems warranted for the deformations it has no rational basis for the deflections. Since, however, the deflection curve for loads below that which causes the concrete to crack on the tension side is practically a straight line the position of the deflection due to the weight of the beam could be estimated on this assumption with but little error.

While in the majority of cases load increments of 1000 pounds were used throughout the greater part of a beam test, no arbitrary set of loads was adopted and used. The increments of load applied were determined largely by the aggregate and percentage reinforcement as well as the behavior under load. In all cases the attempt was made to so choose the loads that the greater number of points would be obtained where the deformation curves suffered a change of direction. Such points would occur when the beam first commenced cracking and for some little time after that, depending on the percentage of reinforcement. Near maximum load and particularly for the higher percentages of reinforcement and the weaker aggregates the deformation curves would in many cases again change their direction, making a greater number of points desirable in order to accurately define the curve.

In some cases, with the low percentages of reinforcement in the four-week tests, the increments of load were as low as 250 to 500 pounds while for higher percentages and greater ages 1000-pound increments could be used throughout.

⁹ U. S. Geological Survey.

Fig. 3.—Beam with Johnson Deformers

In the earlier tests, in order to more definitely fix the load at which the first crack appears, the surface of the beam was examined after the application of each increment of load succeeding that at which the rate of change of the deformations was seen to increase. It was soon noticed, however, that a beam at this stage could not be permitted to rest under load for the time necessary to hunt for cracks, since a noticeable flattening of the deformation curves would occur due to this rest. In order to prevent this the surface of the beam was examined only after each 1000-pound increment during this period of the test, although deformations might have been read for every 250 or 500 pounds. In many cases there is, therefore, an apparent discrepancy between the loads at which the first crack appears in three identical test pieces. If the development of cracks is traced only after each 1000-pound increment of load and in one case a crack appears between 2750 and 3000 pounds load, while in another identical test piece it occurs between 3000 and 3250 pounds, in the first instance the first crack would be recorded at 3000 pounds, while in the latter it would be reported for 4000 pounds. Under these conditions a total maximum apparent discrepancy of nearly 1000 pounds could be reported.

The frequency with which the development of cracks was traced was governed entirely by the behavior of the beam under load. If it was noticed that the cracks increased in height very slowly between successive load increments, cracks would be traced every other load or even less frequently if the case would warrant it.

The endeavor was made in each case to trace the essential development of the cracks but not every detailed change. It is not possible to obtain a detailed history of the development of the cracks and an accurate set of deformation readings from the same beam, since, in order to trace the cracks, the beam must remain under load for a considerable time and the deformation readings are consequently affected.

For each increment of load there were four micrometers to be read. It was desirable to read these simultaneously at all times but particularly so near maximum load to eliminate the effect of rest on the concrete for those beams that failed by compression, and in order to obtain the exact elongation of the reinforcement

for those that failed by tension to compare it with that corresponding to the yield point.

When, therefore, the rapid increase of the readings of the upper micrometers indicated the proximity of a compression failure, these were read first while, if the elongation of the steel approached that for the yield point, the lower micrometers were not only read first but read continuously as the load was applied. This was made necessary by reason of the fact that, when approaching maximum load, the elongations are increasing regularly, the increment of deformation being proportional to the increment of load. At the instant that maximum load is reached, there is a sudden sharp drop of the scalebeam and a correspondingly sudden large increase in the elongation of the reinforcement. This behavior necessitates reading both lower micrometers simultaneously and continuously and recording the last reading previous to the sudden increase in the deformation.

The time required to take the four micrometer readings and the deflection varies from 30 to 45 seconds so that the effect of rest between the separate micrometer readings may be considered negligible.

As the cracks developed their course was traced with a lead pencil on the surface of the beam, a short line being drawn across the crack at the point where it became invisible. At this point the applied load at that particular time is marked on the beam. After testing, the beams (piled in groups of three identical test pieces, with the cracks and numbers marked with black paint) were photographed. These photographs, giving a complete history of the development of the cracks, are shown in Figs. 22 to 30, facing page 96.

(b) COMPRESSION TEST PIECES

The cylinders and cubes are tested on a four-screw 200 000-pound machine. To insure an even distribution of load over the entire cross section the ends of the cylinders are bedded in plaster of Paris to a thickness of about one-half inch on a piece of plate glass (previously oiled to prevent adhesion of the plaster). The bearing surfaces are made normal to the axis of the cylinder by means of a spirit level applied to its sides. The cubes are not

capped with plaster of Paris, but a thin piece of asbestos is placed on a spherical bearing plate when under test, in order to take up all nonparallelism of the ends.

The load is in each case carried to failure, being applied continuously to rupture in the case of the cubes and in increments of 5000 pounds, or approximately 100 pounds per square inch, for the cylinders. For each increment gross deformations are read on two opposite sides of the cylinder over a gauge length of 12 inches.

4. METHODS OF COMPUTATION

(a) BEAMS

Throughout this Bulletin a "parabolic formula" has been used in discussing the resistance of reinforced concrete to flexure. This was thought necessary, as it was desired to have a close agreement between the external bending moment, based on the loading and dimensions, and the internal resisting moment, based on the stresses and position of the neutral axis. In the formulas used, the character of the deformation curve of the concrete in compression is determined by the percentage of the ultimate compression deformation which has been developed for that particular concrete in the beam under discussion. Even if there were but little difference in the stress deformation curve in compression for different materials (which is not the case), the varying percentages of reinforcement used in the beams develop widely different compressive deformations at maximum load and consequently different distribution of the compressive stresses. For working stresses, the differences are probably small. For some of the beams one would expect considerable variation in the results obtained with different assumptions as to the distribution of the stress, particularly those with the higher percentages of reinforcement and all the cinder concrete. While it would have been very desirable to use the actual percentage of the ultimate compressive deformation that was developed in each beam in the computations, the large number of beams to be reviewed made necessary the assumption of some average stress deformation relation, to be kept constant throughout all computations. It was therefore assumed that one-half the ultimate deformation of the concrete in compression

was developed in the upper fiber of the reinforced concrete beams. For independent analysis of the results of this series, the logs of the tests are given on pages 142 to 200.

The symbols and the formulas used in these tests are the same as those used in Bulletin No. 4 of the University of Illinois Engineering Experiment Station¹⁰ and their derivation will therefore not be repeated here. The formulas there given, however, are applicable only to reinforcement placed in one layer and the modification necessary to adapt them to reinforcement in two layers will therefore be given.

Fig. 4.—Illustration of Symbols

(1) Definition of Symbols Used.—

b = breadth of beam, in inches.

d = depth of beam, in inches, to center of lower layer of reinforcement.)

e = distance, in inches, between center of lower and center of upper layer of reinforcement.

z = distance, in inches, from top of beam to the center of gravity of the compressive stresses.

¹⁰ Talbot, A. N., Tests of Reinforced Concrete Beams, Series of 1905, University of Illinois Bulletin, vol. 3, No. 14, 1905.

(1) **Definition of Symbols Used**—Continued.

Kd = distance, in inches, from the top of the beam to the neutral axis. (The distance is obtained directly from the measured deformations of the concrete and the reinforcement.)

A = total area, in square inches, of reinforcement in lower layer.

A_1 = total area, in square inches, of reinforcement in upper layer.

q = ratio of the unit compressive deformation of the concrete developed in the beam for any given load to the ultimate compressive deformation of that concrete.

m = number of bars in lower layer of reinforcement.

o = circumference of each bar.

Σo = sum of circumferences of all bars.

p = "nominal" percentage of reinforcement based on the area of the concrete above the center of the lower layer of steel.

f_s = unit stress in lower layer of reinforcement.

f_{s1} = unit stress in upper layer of reinforcement.

f_c = unit compressive stress on extreme fiber of beam.

M = total bending moment or total resisting moment, in inch pounds.

V = total vertical shear in pounds.

u = bond stress per unit area of surface of bar.

The general formula for the resisting moment of beams containing but one layer of reinforcement expressed in terms of the unit stress in the reinforcement, and neglecting all tensile stresses in the concrete is

$$M = Af_s (d-z).$$

In Bulletin No. 4 above referred to it has been shown that z varies with the different assumptions made as to the shape of the stress deformation diagram for concrete in compression and with the magnitude of the stress. For a straight line stress deformation diagram for concrete in compression $z = \frac{1}{3}Kd$ while for $q = 1$, i. e., for a beam that fails in compression, $z = 0.375 Kd$. For beams in which the compressive strength of the concrete is not

developed z lies between $0.33 Kd$ and $0.375 Kd$. For our case q has been made equal to one-half and is kept constant throughout all computations.

(2) **Formulas for Reinforcement in One Layer.**—The formulas given in Bulletin No. 4 of the University of Illinois Engineering Experiment Station were used directly and are given below:

$$M = A f_s (d - 0.35 Kd) \dots\dots\dots (1)$$

$$f_c = \frac{2 p f_s}{K} \times \frac{1 - \frac{1}{2} q}{1 - \frac{1}{3} q} \dots\dots\dots (2)$$

$$u = \frac{V}{om(d - 0.35 Kd)} \dots\dots\dots (3)$$

for

$q = \frac{1}{2}$, equation (2) becomes

$$f_c = \frac{1.8 p f_s}{K} \dots\dots\dots (4)$$

While equation (4) was used throughout all the computations it was thought advisable to give equation (2) from which it is derived. Whether a straight line stress deformation diagram or a parabola with the apex at the extreme fiber is chosen makes very little difference in the values of M or u . This is not the case, however, with the values of f_c . While for a straight line formula the resisting moment will differ but little from that when the parabola is used, the unit compressive stress for the former case will be 33 per cent higher than in the latter. This difference will become smaller and smaller as the ratio of the compressive deformation developed in a given beam to the ultimate compressive deformation of the concrete decreases. It should, therefore, be realized that the unit compressive stress in the extreme fiber of those beams having a high percentage of reinforcement, particularly for the cinders and perhaps the majority of the four week tests, may be as much as 20 per cent high.

With equation (2), however, any one who cares to do so can analyze the results using the actual values of q .

(3) **Formulas for Reinforcement in Two Layers.**—For any given distribution of reinforcement and a given fraction of the ultimate deformation of the concrete developed, the position of

the center of the compressive stresses is fixed. It has been indicated above that the variation in the position of the center of the compressive stresses, for varying intensities of stress in the concrete, is very small, and that the position as governed by this variable can be considered constant.

The theoretical influence on the position of the neutral axis of a distribution of the reinforcement in more than one layer has not been determined, since the position of the neutral axis that is used in the computations is determined directly from the measured deformations assuming conservation of plane section.

(4) **Formula for Unit Stress in Lower Layer of Reinforcement.**—If, then, we may consider the position of the center of compressive stresses as known for a particular case, we may write the following expression for the total bending moment at the center of the beam:

$$M = A_1 f_{s1} (d - 0.35 Kd - e) + A f_s (d - 0.35 Kd) \quad (5)$$

Within the elastic limit of the steel

$$\frac{f_{s1}}{f_s} = \frac{d - Kd - e}{d - Kd}$$

Substituting this value of f_{s1} in (5)

$$M = \frac{A_1 f_s^* (d - 0.35 Kd - e) (d - Kd - e)}{d - Kd} + A f_s (d - 0.35 Kd) \quad (6)$$

This formula gives the unit stress in the lower layer of reinforcement, provided the elastic limit of the reinforcement is not exceeded.

(5) **Formula for Unit Compressive Stress in Extreme Fiber of Beam.**—For the reinforcement arranged in two layers equation (2) must be modified as follows:

The sum of all the tensile stresses is now $A_1 f_{s1} + A f_s$

but

$$\frac{f_{s1}}{f_s} = \frac{d - Kd - e}{d - Kd}$$

Making these changes in equation (2) we obtain

$$f_c = \frac{2 f_s [A_1 (d - Kd - e) + A (d - Kd)]}{Kbd (d - Kd)} \times \frac{1 - \frac{1}{2} q}{1 - \frac{1}{3} q} \quad (7)$$

For the approximate formula $q = \frac{1}{2}$ we obtain

$$f_c = \frac{1.8 f_s [A_1 (d - Kd - e) + a (d - Kd)]}{Kbd (d - Kd)}. \quad (8)$$

(6) **Formula for Unit Bond Stress.**—For the reinforcement placed in two layers, it has been proven (6)

$$M = \frac{A_1 f_s (d - 0.35 Kd - e) (d - Kd - e)}{d - Kd} + A f_s (d - 0.35 Kd)$$

Differentiating

$$\frac{\delta M}{\delta x} = \left[\frac{A_1 (d - 0.35 Kd - e) (d - Kd - e)}{d - Kd} + A (d - 0.35 Kd) \right] \frac{\delta f_s}{\delta x}$$

But
$$\frac{\delta M}{\delta x} = V$$

Therefore

$$V = \left[\frac{A_1 (d - 0.35 Kd - e) (d - Kd - e)}{d - Kd} + A (d - 0.35 Kd) \right] \frac{\delta f_s}{\delta x} \quad (9)$$

But
$$A \delta f_s = \Sigma_0 u \delta x$$

Therefore
$$\frac{\delta f_s}{\delta x} = \frac{u \Sigma_0}{A}$$

Substituting this value of $\frac{\delta f_s}{\delta x}$ in equation (9) and solving for u

$$u = \frac{VA (d - Kd)}{\Sigma_0 [A_1 (d - 0.35 Kd - e) (d - Kd - e) + A (d - 0.35 Kd) (d - Kd)]} \quad (10)$$

If in equation (10) A_1 is made zero

$$u = \frac{V}{\Sigma_0 (d - 0.35 Kd)}$$

which is the formula for reinforcement in one layer.

(b) COMPRESSION TESTS

The compression tests reported in this paper were made primarily with a view of determining the elastic behavior and the ultimate strength of the concrete that was used in the correspond-

ing reinforced beams. While it was thought necessary to have the ultimate strength of the concrete as given by a compression test in order to compare with the computed extreme fiber stress of any beams that might fail by the compression of the concrete in the upper fiber, it is also thought extremely desirable to have a complete record of the elastic behavior of the concrete under pure compression. By comparing the extreme fiber stress, as computed from the bending moment for a given load, with the unit compressive stress for the same unit deformation of the cylinder, the relation between the behavior of concrete in direct compression and in compression in a beam may be established.

The stress deformation curve of the cylinders is further useful in determining the character of the stress deformation curve of the concrete in compression in the beam.

No study of the possible influence of the initial modulus of elasticity of the concrete upon the position of the neutral axis, as given by a theoretical formula, can be made, unless this quantity is observed in a compression test.

Considered apart from their value in aiding in the interpretation of the tests on the reinforced beams, these tests in themselves form a very complete investigation of the compressive strength of concrete.

For each age and aggregate 21 beams were molded, three each for seven percentages of reinforcement. For each beam one cylinder and one cube were molded, making 21 identical test pieces of each. It seems reasonable to believe therefore that the accuracy of any relations brought out by the average of such a large number of tests will have sufficient weight to warrant the almost self-evident conclusions that have been arrived at by a study of the present tests.

(1) **Definition of Terms and Symbols.**—While the significance of the terms and symbols used in these tests is similar to those used in other investigations, it is thought advisable to define them briefly here.

Weight in Pounds per Cubic Foot.—This was computed from the weight as obtained for the cylinder or cube as it was brought from

the damp closet and the volume as given by the measured dimensions.

Ultimate Strength.—The ultimate strength was obtained by dividing the maximum load carried by the test piece by the actual sectional area as given by the measured dimensions.

Initial Modulus of Elasticity.—This term is defined as the ratio of the unit stress to the unit gross deformation, as given by the ordinate and abscissæ of a point on a line drawn tangent to the initial part of the curve, or coincident with it when there is straight line variation. The direction in which this line is to be drawn is determined by eye on the plotted curve, the aim being to draw a straight line through as many points as possible even if by so doing it will not pass through the origin.

Yield Point.—At some unit stress, which differs with the material and age, the curve showing the relation between the unit stresses and the corresponding unit gross deformations will turn from the line of the initial modulus of elasticity. Below this point, which is herein called the "yield point," the unit stresses are directly proportional to the unit deformations.

Stress Ratio of Cylinders to Cubes.—This ratio is obtained by dividing the ultimate strength of the cylinders by the ultimate strength of the cubes.

VI. RESULTS OF TESTS

1. BEAMS

The complete log of all beam tests is given in Appendix II, page 142.

Some of the results of the tests of reinforced concrete beams are summarized in Tables 6 to 21, facing page 128, and typical curves are shown in Figs. 41 to 45.

It is not the aim of these tables to present the results of a detailed study of the tests, but rather the values that are usually used in the design of a beam. The greater part of each table has therefore been devoted to a comparison of the resisting moment with the bending moment, and the relation between the unit stress in the reinforcement at the failure of the beam and the yield point of the reinforcement used. The unit compressive stress in the extreme fiber of the beam, as figured from the bending moment

Fig. 41.—Stress Deformation Curves of Granite Concrete 0.98 per cent Reinforcement, Ages 4 Weeks and 52 Weeks

4672°—12 (To face page 32.) No. 1

Fig. 42.—Stress Deformation Curves of Cinder Concrete 0.98 per cent Reinforcement, Ages 4 Weeks and 52 Weeks

Fig. 43.—Stress Deformation Curves of Different Aggregates at 4 Weeks with .49 and 1.96 per cent Reinforcement
4672°—12 (To face page 32.) No. 2

Fig. 44.—Stress Deformation Curves of Limestone Concrete at Different Ages with .49 and 1.96 per cent Reinforcement

Fig. 43.—Stress Deformation Curves of Different Aggregates at 4 Weeks with .49 and 1.96 per cent Reinforcement

4672°—12 (To face page 32.) No. 2

Fig. 44.—Stress Deformation Curves of Limestone Concrete at Different Ages with .49 and 1.96 per cent Reinforcement

Fig. 45.—Stress Deformation Curves of 4-Weeks Limestone Concrete with Different Percentages of Reinforcement

4672°—12 (To face page 32.) No. 3

Fig. 45.—Stress Deformation Curves of 4-Weeks Limestone Concrete with Different Percentages of Reinforcement

and also the resisting moment, has been compared with the unit stress taken from the gross deformation curve of the cylinder for a unit deformation equal to that in the beam. The computed unit bond stress of the reinforcement in the lower fiber has also been given.

(a) EXPLANATION OF TABLES 6 TO 21

Column 1.—The register number of the beam which is the same as that of the corresponding cylinder and cube.

Column 2.—The weight of the beam within 5 pounds.

Column 3.—The weight per cubic foot of the concrete.

Column 4.—Number of one-half inch round bars used.

Column 5.—Nominal percentage of reinforcement.

Column 6.—Effective percentage of reinforcement.

Column 7.—Total area of reinforcement, in square inches, based on a diameter of one-half inch.

Column 8.—Applied load at the first crack.

Column 9.—Unit elongation of the lower fiber at first crack.

Column 10.—Maximum applied load, in pounds.

Column 11.—Deflection of the beam, in inches, at maximum load.

Column 12.—Unit elongation of reinforcement at maximum load.

Column 13.—Unit stress in reinforcement at maximum load.

Column 14.—Average yield point of reinforcement used in each beam.

Column 15.—Ratio of unit stress in reinforcement at maximum load to yield point.

Column 16.—Applied load carried by the beam at the time moments were compared. This load has been so chosen that the unit elongation of the reinforcement will be below that corresponding to the yield point of the reinforcement.

Column 17.—The unit elongation of reinforcement for the load chosen.

Column 18.—Unit stress corresponding to this load.

Column 19.—Depth of neutral axis below top of the beam.

Column 20.—The lever arm of the reinforcement. This is the distance, in inches, between the center of gravity of the compressive stresses and the tensile stresses in the lower layer of reinforcement.

ment which is necessarily lower than the center of gravity of the total tensile stress in all the reinforcement.

Column 21.—The resisting moment, in inch pounds, as computed by equation (1), page 28, for the reinforcement in one layer and by equation (6), page 29, for the reinforcement in two layers.

Column 22.—External bending moment, in inch pounds, due to the applied load, the weight of the beam, and that of the deformer.

Column 23.—Comparison of external bending moment with the resisting moment, based on the unit stress in the reinforcement.

Column 24.—Unit deformation of the upper fiber of the beam.

Column 25.—Unit compressive stress as read from the individual compressive stress gross deformation diagram of the cylinders.

Column 26.—Unit compressive stress in extreme upper fiber based on stress in reinforcement.

Column 27.—Unit compressive stress in extreme upper fiber as computed from bending moment.

Column 28.—Comparison of compressive stress, read from individual compressive stress gross deformation diagrams and compressive stress in extreme upper fiber, based on stress in reinforcement.

Column 29.—Comparison of compressive stress, read from individual compressive stress gross deformation diagrams and compressive stress in extreme upper fiber, as computed from bending moment.

Column 30.—The unit bond stress as computed from equation (3) page 28 for the applied load shown in column 16.

(b) DISCUSSION OF TABLES 6 TO 21

In computing the weight per cubic foot the following formula was used:

$$\text{Weight per cubic foot} = \frac{W - w}{V - v}.$$

W = total weight of beam, in pounds.

w = weight of reinforcing bars, in pounds, for the beam under consideration.

V = volume of beam, in cubic feet, based on the measured breadth, depth, and length.

v = volume of reinforcing bars, in cubic feet.

The average of these columns for each particular aggregate compares very closely with the average weight per cubic foot as obtained from the weight of the cylinders and cubes.

As in the case with the cylinders and cubes, there is no increase in the weight per cubic foot with age.

The average weights per cubic foot for the beams, cylinders and the cubes for the ages of 4, 13, 26 and 52 weeks have been compiled in the following table and unless otherwise indicated is the average of 21 tests.

Table 22.—The Average Weight Per Cubic Foot of the Concrete

Age, in Weeks	Granite			Limestone		
	Beams	Cylinders	Cubes	Beams	Cylinders	Cubes
4	147.9	149.4	147.1	147.1	145.8	144.9 (18)
13	148.5	147.7	146.4	146.9	146.0 (20)	142.4
26	148.2	148.2	147.8 (20)	145.9	147.6 (20)	147.4
52	147.2	148.9	148.1	146.6	147.4	147.9
Average	148.0	148.6	147.4	146.6	146.7	145.7

Age, in Weeks	Gravel			Cinders		
	Beams	Cylinders	Cubes	Beams	Cylinders	Cubes
4	144.5	144.0	142.0 (12)	119.0	118.4	116.6 (15)
13	145.2	144.2	143.2	120.1	119.4	117.9
26	143.0	144.9	144.8 (20)	118.9	119.5	118.7
52	143.5	145.9	145.9	118.1	119.7	119.2
Average	144.1	144.8	144.0	119.0	119.3	118.1

Column 5, Tables 6–21, contains the “nominal” percentage of reinforcement. The “nominal” percentage of reinforcement is that obtained by dividing the total sectional area of the reinforcement in the beam, calling the diameter of all bars one-half inch, by the area of the cross section of the beam above the center of the lower layer of reinforcement, assuming this to be 8 by 11 inches.

Where the reinforcement is in but one layer the resistance of the beam to the flexure is proportional to this "nominal" percentage, but where the reinforcement is arranged in two or more layers this is no longer the case. For such a condition, for two equal areas of reinforcement placed at different distances below the neutral axis, that farthest away is the more effective in resisting flexure. The effect of placing the reinforcement in two layers is equivalent to reducing the percentage of reinforcement, and all comparisons between the beams of a given series must be based on this reduced or "effective" percentage and not on the "nominal" percentage which is shown in these tables. The manner of computing this "effective" percentage of reinforcement, as well as the use that is made of it, will be shown later in connection with a discussion on the effect of a variation in "effective" per cent on the behavior of a beam, page 54.

(1) **Analysis at First Crack.**—Column 8 gives the applied load at the first crack, while column 9 contains the unit elongation of the lower fiber at first crack. While a beam was being tested the surface was carefully examined with a magnifying glass in order to detect the first crack; the applied load on the beam at that time was noted and has been called the "applied load at first observed crack," and is the value reported on the log sheets, following page 128.

It should be recognized, however, that the crack was not detected until it became of such a size as to be visible to the eye through a magnifying glass. It may, however, have existed in the beam for a short time previous to this, and the load at which it occurred may be approximated as follows: Before the unit elongation of the lower fiber of the beam has exceeded the ultimate unit elongation for that particular concrete the beam acts as a homogeneous material the deformations of the upper fiber and the deflections being practically independent of the percentage of reinforcement. During this period the fiber deformations, as well as the deflections, are closely proportional to the load carried. At some load, however, which varies somewhat with the percentage of reinforcement, the unit elongation of the lower fiber exceeds the ultimate unit elongation for the concrete. The concrete below the neutral axis, beginning at the outer surface, will now fail in tension,

and will cause a portion of the weight of the beam, together with that part of the applied load which was taken care of by the tensile strength of the concrete to be thrown on the reinforcement. The increments of deformation will now no longer be proportional to the increments of load, and the curve showing the relation between the $\frac{M}{bd^2}$ and the unit elongation of the reinforcement will undergo a change of direction. The abruptness of this change depends entirely on the percentage of reinforcement, the lower the percentage the greater the change.

Since this abrupt change is due only to the cracking of the concrete in tension below the neutral axis these curves form a ready means of determining the $\frac{M}{bd^2}$ and consequently the applied load at which this cracking took place.

For some of the higher percentages that were used in this series, the change of direction took place very gradually and over a comparatively large field, so that it became rather difficult to say at what $\frac{M}{bd^2}$ the curvature started. For the lower percentages, however, no difficulty was experienced, as the curvature took place very suddenly, forming an abrupt break in the "steel curve," for which point the $\frac{M}{bd^2}$ was easily obtainable.

The applied loads corresponding to these $\frac{M}{bd^2}$ are shown in column 8, being recorded to the nearest 500 pounds applied load.

These values, however, do not correspond to the "applied load at first *observed* crack," but are in many cases considerably less. The values in column 8 are practically constant and independent of the percentage of reinforcement which is not true for the first *observed* crack. This latter value increases with the percentage of reinforcement, varying on an average from about 4000 pounds for a "nominal" percentage of reinforcement of 0.5 per cent to 7000 to 9000 pounds for one of 2 per cent.

This difference is largely due to the fact that for the greater percentages which were obtained by putting in a larger number of bars of the same diameter, a better distribution of reinforcement is

obtained than is the case with fewer bars. An inspection of the photographs of the beams showing the development of cracks will show that for the higher percentages of reinforcement the cracks are closer together, and consequently not as wide as for lower percentages. This means that the applied load that will render them visible in the case of the higher percentages will be greater than that necessary with the lower percentages of reinforcement.

The unit elongation of the lower fiber, which is given in column 8, is obtained from the unit elongation of the reinforcement corresponding to the $\frac{M}{bd^2}$, obtained as already described, by multiplying by the ratio of the distance from the neutral axis to the lower outer fiber to the distance from the neutral axis to the center of the lower layer of reinforcement.

The value for the ultimate unit elongation of the lower fiber, as obtained above, should be the same as the unit elongation at rupture of beams without reinforcement made of the same aggregate and having the same proportions and consistency as were used in the present series.

It is possible to make such a comparison with the results of the tests reported in Bulletin 344.¹¹ With the exception of the cinders, the material used in the series of beams without reinforcement and in that of the reinforced beams of the present Bulletin was not only from the same source but was practically identical, since it was taken from the same storage bin.

As was explained in the above bulletin it was found impossible to obtain the unit elongation of the lower fiber at the instant the beam without reinforcement broke, owing to the difficulty of reading the micrometers when the elongations were increasing so rapidly. The exact value for the ultimate-unit elongation could consequently not be obtained. The value that has been reported is that obtained from the complete set of micrometer readings taken at the last load increment preceding maximum load. This value is, therefore, less than the ultimate unit elongation by a varying amount, depending upon whether the maximum load corresponded to the load for which the last full set of readings had been

¹¹ U. S. Geological Survey.

taken, or was more nearly equal to this load, increased by the usual load increment for which readings were being taken in that particular test.

The values for the 13-foot beams of medium consistency have been taken from Bulletin 344¹² and are summarized in Table 23, each value being the average of three tests.

Table 23.—Unit Elongation in Lower Fiber of Concrete Beam Without Reinforcement, as Taken from Bulletin 344¹²

Age, in Weeks	Granite	Limestone	Gravel	Cinders
4	0.000115	0.000117	0.000095	0.000335
13	.000109	.000121	.000100	.000288
26	.000132	.000120	.000104	.000267
52	.000109	.000116	.000120	.000334
Average	.000116	.000119	.000105	.000306

For convenience of comparison it seems warranted to average the four values for each aggregate.

Table 24 contains the average of the unit elongation of the extreme lower fiber at first crack, as given in column 9, Tables 6 to 21, following page 128, for each age and aggregate. Each figure is the average of from 19 to 21 tests.

Table 24.—Unit Elongation of Lower Fiber of Reinforced Concrete Beams at First Crack

Age, in Weeks	Granite	Limestone	Gravel	Cinders
4	0.000130	0.000126	0.000103	0.000180
13	.000117	.000132	.000107	.000163
26	.000107	.000115	.000109	.000180
52	.000102	.000101	.000112	.000192
Average	.000114	.000119	.000108	.000179

In this table, also, the apparent independence of the results from the influence of age seems to warrant the averaging of the four values for each aggregate.

¹² U. S. Geological Survey.

When the method of obtaining the values that have been used in the preparation of Tables 23 and 24 are considered, the agreement between the average ultimate unit elongation of the lower fiber for each aggregate is remarkably close.

The values of the stone and gravel concrete are about the same, while that for cinders is somewhat larger, as given in Table 24, and considerably greater in Table 23. The difference between the value for the ultimate-unit elongation for the cinders of the beam series without reinforcement and that of the reinforced beam series can be satisfactorily explained. As has already been pointed out, the granite, gravel, and limestone used in the two series were almost identical, and the same 1 : 2 : 4 volume proportion was used for each. Since, however, there was not a sufficient amount of the cinder used in the first series to complete the tests to be made in the second more had to be obtained. While comparison of the physical tests for these two samples will show no considerable difference, the weight per cubic foot of that used in the plain beam series was 47, while that used in the reinforced series was 49.3, but as was pointed out in Bulletin 344,¹³ the cinder concrete there used was more nearly a 1 : 2 : 5 volume proportion than a 1 : 2 : 4 mixture, and this is the probable explanation of the different values for cinder concrete in Tables 23 and 24. It is believed, however, that a study of the values of these two tables will indicate conclusively that the point at which the curve plotted between $\frac{M}{bd^2}$ and unit elongations of the reinforcement, first changes its direction corresponds closely to the occurrence of the first crack in the concrete.

(2) **Analysis at Maximum Load.**—The failure of all the beams, reported in the present Bulletin, was due to the failure of the reinforcement. The strength of the concrete did not influence the character of the failure of the beam in any way, although the load carried when the beam failed did vary slightly with the material, due to the difference in the position of the neutral axis.

Since the failure of the beam was caused by the failure of the reinforcement, a comparison of the yield point of the reinforce-

¹³ U. S. Geological Survey.

ment, used in the beam, with the unit stress, based on the elongation of the reinforcement at maximum load, should be of interest.

These "maximum load" conditions have been summarized in columns 10, 11, 12, 13, 14, and 15, Tables 6 to 21, following page 128. Column 10 contains the maximum applied load in pounds.

If the fact that the yield point of the reinforcement used in the beams of this series varied from 36 000 to 43 000 pounds is taken into consideration, the results, particularly at 26 weeks, may be considered independent of the aggregate considered.

This, however, is not strictly true, particularly at the ages of 4 and 13 weeks, since the lower modulus of elasticity of the cinders will give a shorter moment arm for the same unit elongation of the reinforcement, and consequently a less load carried at the yield point of the reinforcement, than is the case for a concrete having a higher modulus of elasticity. For these ages, the aggregates can be separated into the stone and gravel concretes on one hand, and the cinder on the other. Examining the curves for the cinder beams and more particularly those for the beams containing a high percentage of reinforcement, facing page 32, it will be noticed that the curve for the upper fiber is very flat, even under the low loads at which the concrete first starts cracking. The slope of this curve with the horizontal decreases very rapidly as the load increases, the curve being almost horizontal for quite a while before the maximum load is reached. The reinforcement is affected similarly near maximum load, there being large increases in the elongation for very slight increases in the applied load.

This behavior in every case is the sign of a compression failure, the proximity to which is indicated by the degree of the slope of the upper fiber curve. In the case of the four-week cinder beams with 2 per cent "nominal" reinforcement there was probably simultaneous failure of the reinforcement in tension and the concrete in compression. The failure of these beams was not marked by a sudden increase in the readings of the lower micrometers, followed immediately by a sharp drop of the scalebeam as is the case with a typical tension failure.

For these compression failures and even, although to a less extent, for the four-week cinder beams having 1.50 and 1.75 per

cent "nominal" reinforcement, the weighing beam rose very slowly as load was being applied for some time before maximum load was reached and there was no definite indication of the failure of the reinforcement. The relation between the percentage of reinforcement and the resistance of the beam, as measured by the applied load carried, can be obtained from these tables.

When the reinforcement is arranged in one layer, as is the case for 0.5, 0.75, and 1 per cent, this comparison will lead to results that are quite near the truth. When, however, the bars are arranged in two layers the results as given in this table require considerable modification. The "nominal" percentage of reinforcement has first to be reduced to "effective" percentage and for theoretical considerations a correction applied for the varying yield point of the reinforcement, an increase in the yield point for the same sectional area of bar being equivalent to an increase in the percentage of reinforcement. Instead of making this comparison on the basis of applied loads, a better method is to reduce all values to $\frac{M}{bd^2}$: A study of the tests on this basis has been made on page 72.

The deflections, in inches, of the beams at maximum load are given in column 11.

The increase in the deflection with percentage of reinforcement is brought out in a general way by these values, but the deflection is not strictly proportional to the "nominal" percentages shown.

As was the case in comparing the maximum values of $\frac{M}{bd^2}$, the deflections must also be compared on the basis of the effective percentage of reinforcement. In making this comparison, however, the method of measuring the deflection at maximum load must not be lost sight of. As has been indicated, the failure of the beam causes an abrupt and large increase in the elongation of the reinforcement. The deflection is affected similarly, though apparently to a somewhat less degree, and consequently the values reported are liable to be somewhat in error. The deflection at maximum load is, of course, the last reading immediately preceeding the sudden increase in the deflection. If this value is obtained, the deflection is correct, but if obtained a moment later it is too large

by what, in many cases, is an appreciable amount. A comparison of the deflections for maximum load will, therefore, not lead to as consistent conclusions as to the effect of an increase in the percentage of reinforcement as will a similar comparison made at some point below the maximum load for which the deflections are definitely known. A study of the influence of an increase in the amount of reinforcement on the deflection for stresses of 32 000 and 16 000 pounds per square inch in the reinforcement has been made on page 82. These tables further bring out the fact that while the load carried at the failure of the beam may differ but little for the ages of 4, 13, 26, and 52 weeks as long as the yield point of the reinforcement is the governing factor, there can nevertheless be a considerable increase in stiffness, as measured by the decreased deflections.

Column 12, Tables 6 to 21, contains the unit elongation of the reinforcement at maximum load. This was obtained by dividing the average total deformation of the reinforcement by the gauge length, 29.25 inches. With the arrangement of the deformeters that was used on the four-week tests it was not possible to read both lower micrometers of the deformer simultaneously. The two vertical longitudinal halves of the deformeters were not insulated from each other, so that with two observers reading the lower micrometers at the same time it was impossible for either to distinguish between the click in the telephone receiver that was caused by the closing of the electric circuit through his micrometer or through that of the other observer. With this arrangement it was therefore possible to read but one lower micrometer at one time. For reasons, however, that have already been mentioned it was very important that these readings be taken simultaneously at the moment the beam fails. In order to make this possible the deformer was altered by the introduction of a hard rubber bushing which made it possible to take simultaneous readings of the lower micrometers. In obtaining the unit elongation of the reinforcement at maximum load for the earlier tests, the following approximation was used with what are believed to be satisfactory results. Assume, first, the following data, the columns E and W

giving the total deformations of the reinforcement for each side of the beam:

Applied Load, Pounds	Total Deformation of Reinforcement	
	Deformeter E	Deformeter W
16 000	280	356
17 000	304	390
18 000	333	427
19 000	410	517
19 150 M. L.	....	533

The deformations in column E have been increasing at the rate of from 24 to 77 points for the same increment of load, while the values in column W for the same additions of load have increased by from 26 to 90 points. It has been assumed that the ratio of any increase in the total deformation in column E to the increase in column W for a given load increment is equal to the ratio of the increase in E and W for the preceding increment of load. In the data shown above the reading of the lower micrometer at maximum load was not obtained and the increase (X) of the deformation must be estimated as follows:

$$X = \frac{77}{90} \times 16 = 14$$

The lower total deformation is therefore 424, which, averaged with 533, gives the average total deformation of the reinforcement. Since, however, this is not an observed value, it was thought advisable to make a distinction in the table, so whenever the unit deformation of the reinforcement is based on an approximated average total deformation it has been inclosed in parentheses.

While the method outlined is an approximation, and introduces an error in the unit deformation of the reinforcement at maximum load, the magnitude of the error is probably small. Assume, for instance, that the error made in estimating the increment "14" for deformeter E may be either 25 per cent too large or too small, which is believed to be an extreme case. The greatest error in the average increment will then be 13 per cent while the error in the average total deformation will be less than 0.5 per cent.

The closeness of this approximation may be seen by an inspection of the deformation curves of those beams for which this method had to be used. It will be seen that the maximum load point lines up very satisfactorily with the preceding portion of the curve.

Given the unit elongation of the reinforcement and assuming a coefficient of elasticity of 30 000 000 the unit stress is easily obtained. It must be borne in mind, however, that the proportionality of stress and strain holds only within the elastic limit of the material. If, therefore, the unit elongation given in column 12 is greater than the unit elongation which corresponds to the yield point of the reinforcement, which is given in column 14 for each beam, the unit stress in the reinforcement based on this elongation will be incorrect. The computed unit stress in the reinforcement will be too great by an amount which will depend upon the difference between the observed unit elongation and the unit elongation at the yield point. While the unit stresses of column 13 have been obtained as described above, it must be remembered that the values there given are, in most cases, much too large. It is believed that the true stress in the reinforcement differs but little from the yield point, for it is a known peculiarity of reinforcement that it suffers a large increase in elongation at the yield point with but little if any increase in stress. Excepting high carbon steel, for which the yield point is not so well defined, the increase in elongation from the time the reinforcement reaches the yield point, until it again takes load, is almost without exception much greater than the whole elongation below the yield point.

That, for a tension failure, the reinforcement acts thus in a beam seems to be indicated by the fact, that after the sharp drop of the scalebeam and the sudden increase of the lower micrometer readings at maximum load, the beam will continue to deflect and the elongations of the reinforcement increase under a load several thousand pounds less than that at which the beam failed. This action will continue until the concrete begins to spall on the compression side of the beam when a more or less sudden collapse of the beam takes place.

Column 14 contains the average yield point of the reinforcement used in each beam. The values have been taken from Table 4,

p. 121, which give a summary of the physical tests of the reinforcement used in this series.

Column 15 gives the ratio of the unit stress in the reinforcement at maximum load, as computed from the measured elongation in column 12 to the yield point of the reinforcement. In no case is the unit stress in the reinforcement exactly equal to the yield point, the ratio varying from about 83 per cent for 0.5 per cent "nominal" reinforcement to about 1.30 for 2 per cent "nominal" reinforcement. In a general way, the ratio is less than 1 for percentages of reinforcement up to and including 1 per cent, and greater than 1, for all higher percentages.

Age seems to have little effect on the ratio and leads to the belief that the increase in the tensile strength of the concrete below the neutral axis, as well as the change in position of the neutral axis due to the increased stiffness of the concrete in compression, have little influence on this ratio.

Since age seems to have so little influence on this ratio the values given in column 15 have been averaged for all ages for each aggregate and are tabulated in Table 25.

Table 25.—Average Ratio of Unit Stress in Reinforcement to Yield Point at Maximum Load

Cinder		Granite		Gravel		Limestone		Grand Average	
Effective Percent- age of Rein- forcement	Ratio	Effective Percent- age of Rein- forcement	Ratio	Effective Percent- age of Rein- forcement	Ratio	Effective Percent- age of Rein- forcement	Ratio	Effective Percent- age of Rein- forcement	Ratio
0.49	0.86	0.49	0.83	0.49	0.82	0.49	0.79	0.49	0.83
0.74	0.93	0.74	0.89	0.74	0.95	0.74	0.89	0.74	0.92
0.98	0.99	0.98	0.97	0.98	1.04	0.98	0.93	0.98	0.97
1.08	1.13	1.11	1.08	1.12	1.12	1.11	1.05	1.11	1.09
1.24	1.24	1.30	1.06	1.30	1.20	1.30	1.17	1.28	1.17
1.48	1.35	1.54	1.13	1.54	1.22	1.53	1.10	1.52	1.20
1.62	1.38	1.71	1.17	1.72	1.29	1.71	1.28	1.69	1.28

For a ready comparison, these average values have again been averaged in Table 26. These values are shown graphically in Fig. 5, an inspection of which will show that as a general proposition it may be stated that the ratio of the unit stress in the reinforcement at maximum load to the yield point varies with the percentage of reinforcement.

(3) Analysis of conditions in a beam at a load preceding maximum load for which the unit elongation in the reinforcement is less than that at the yield point.—One of the most pertinent questions that can be asked in regard to any series of tests of reinforced concrete beams is that bearing on the relation of the internal resisting moment to the external bending moment. The external

Fig. 5.—Ratio of Unit Stress at Maximum Load to the Yield Point as a Function of the Effective Percentage of Reinforcement

bending moment represents outside load conditions which must be met and resisted by the stresses set up in the beam. The magnitude and distribution of the load to be carried and the size of the span determine the external bending moment and are themselves determined largely by the use to which the structure is to be subjected.

The resisting moment, while depending also on the dimensions—i. e., the breadth and depth of the beam—is affected by the quality of the material used in making the beam, the care used in mixing and placing the concrete, and the age at which it is subjected to load.

If the weight of the beam and any attached test apparatus, the applied load when the beam failed, and the span are known, the

bending moment can easily be computed. The bending moment thus computed should theoretically be equal to the resisting moment of the beam.

The flexure of a simple beam develops within it two groups of horizontal stresses, one of which is above the neutral axis and is entirely compressive, while the other is below the neutral axis and is tensile. A necessary condition of equilibrium requires that the summation of the horizontal tensile stresses be equal to the horizontal compressive stresses. For a beam which contains no horizontal reinforcement above the neutral axis, all the compressive stresses that are developed are taken by the concrete alone. Below the neutral axis, the distribution of stress is, however, different. When horizontal reinforcement is used, the tensile stresses are divided between it and the concrete. As long as the unit elongation of the lower fiber is less than the unit ultimate elongation of concrete without reinforcement the division of the total tensile stress between the concrete and the reinforcement is determined by their respective coefficients of elasticity, the unit stress in the concrete at the level of the reinforcement and in the reinforcement where both have the same elongation, being directly proportional to these coefficients. When, however, the concrete cracks, these conditions begin to change; the nearer the load at a particular instant approaches the maximum load, for that beam, the greater the change. The cracks can in no case extend through to the neutral axis for below it there must always be a point at which the unit elongation is equal to the unit ultimate elongation of the concrete so that immediately above this fiber the concrete will be at the point of breaking while below it, it will just have broken. There must, therefore, be in every cross section of a beam, no matter to what extent the cracks are developed, a portion furnishing a source of tensile resistance, which would otherwise have to be provided by the reinforcement. If the concrete did not carry some tension the total tensile stresses that must be developed in a beam for equilibrium, could only be provided by an increase in the deformation of the reinforcement.

In all formulas, that are in use in the design of reinforced concrete, however, the reinforcement is assumed to carry all the

tensile stresses and this uncertain resistance of the concrete in tension is neglected.

While it is entirely warranted to neglect so uncertain an element in all formulas intended for design, it should nevertheless be included in a discussion of theoretical results. If it is not included, the effect of its neglect on any results, that may be compared with theory, should be recognized, for in many instances this is the only influence whose exclusion would account for the apparent discrepancies in some of the tabulated ratios.

A comparison of the resisting and bending moments will show, for instance, that whenever the resisting moment of the beam is based on the stress in the reinforcement, as computed from its measured deformation, it will theoretically fall below the bending moment obtained from the external loading and dimensions of the beam, since the elongation of the reinforcement, on which it is based, is smaller than what it would be if there were no tensile resistance in the concrete below the neutral axis.

Reversing this process and figuring the stress in the reinforcement from the bending moment, the values will theoretically, always be too great, for we now assume that the entire bending moment to be carried by the reinforcement, which is never the case even at maximum load.

All methods for computing the resisting moment have, heretofore, been based on the tensile stress in the reinforcement. Neglecting the effect of the tensile stress of the concrete in adding to the resisting moment of the reinforcement, the quantities involved, when this method is used, are the unit stress in the reinforcement, the percentage of reinforcement, the position of the neutral axis and the character of the stress deformation diagram of concrete in compression, as affecting the position of the center of gravity of the compressive stresses. Theoretical discussions indicate however, that the various assumptions as to the character of this curve have very little effect on the position of the center of the compressive stresses, although it does affect the extreme fiber stress of the concrete in compression.

In the discussion of all tests that have been made up to the present time, the resisting moment has been thus based on the

measured stress in the reinforcement, and while it does not lead to results that are strictly comparable to the bending moment it has nevertheless the sanction of wide usage. A further reason for the use of this method has been the supposedly greater reliability of data which is based on the properties of steel. As steel is manufactured in a mill with what is believed to be greater care than is exercised in the mixing and molding of concrete, the belief that it is more homogeneous and reliable is perhaps not altogether unfounded.

For stresses below the yield point, steel has, further, a constant coefficient of elasticity, which is unaffected by variations in either the yield point or the ultimate strength. For a given elongation in the steel, the unit stress is, therefore, easily obtained for all elongations below that corresponding to the yield point. When the failure of a beam is due to the failure of the reinforcement, the unit stress in the reinforcement is usually very little above the yield point, while for those cases in which the failure of the beam is by compression, diagonal tension or bond—i. e., a failure caused by some weakness of the concrete—the unit stress in the reinforcement at maximum load is always well below the yield point.

In no case, however, not even for the beams failing by tension, is the ultimate strength of the reinforcement approached, so that as far as the initial failure of the beam is concerned the ultimate strength is unimportant.

While the above method of computing the resisting moment makes use of the greater portion of the tensile stresses below the neutral axis, another method, based on the compressive stresses above the neutral axis should, theoretically, lead to better results, since the action of no stresses is neglected.

That concrete under compression in a beam acts in an identical manner with concrete in pure compression is the fundamental assumption on which this method is based. While this assumption may be a debatable question a majority hold that, at the moment of failure in compression, the only portion of the concrete, that is seriously affected, is the extreme outer fiber; for, considering the fibers above the neutral axis, each is adjacent to one which is stressed higher and to another which is stressed lower than itself.

The latter helps to aid or reinforce the fiber in question, while the former will itself be aided by it. If, however, we consider, as is nearly always done, all the horizontal compressive forces applied at a point one-third of the distance to the neutral axis below the top of the beam, we would have conditions which would approximate those in a horizontal strut loaded at the upper limit of the middle third. In this case, we would have zero stress in the extreme lower fiber of this imaginary strut, and this would correspond to the zero stress at the neutral axis of the beam. It would seem that the two cases are almost parallel, particularly over the middle third of the beam where the shear is practically zero. While the ultimate micrometer reading on either side of one of the regular cylindrical compression pieces is in no case zero, it frequently happens that the ultimate deformation of one side is as much as twice that of the other. This would indicate that the load is eccentrically applied to the cylinder and while it never gets out to the limit of the middle third, the conditions nevertheless approximate those assumed above for a beam. The results arrived at by the use of this method would further appear to warrant the correctness of the assumption that the concrete in compression in a beam acts similarly to that in a simple compression test.

The physical properties of concrete, while paralleling, in a general way, those of steel, are much more sensitive to external influences. From a discussion of the compression tests on pages 98 to 109 it may be concluded, in a very general way, that concrete in compression has a yield point, which is fairly well defined, and below which the relation between unit stress and unit strain can be represented by a straight line whose slope is the initial coefficient of elasticity. The unit stress for any deformation below this yield point can, therefore, readily be obtained when the coefficient of elasticity is known.

This coefficient of elasticity, unlike that for steel, which is fairly constant, is subject to considerable variation. It varies with material and proportions; it increases somewhat with age, and decreases as the concrete is made of wetter consistency. While the increase with age is slight and could be neglected, the variation due to material, proportions, and consistency must be considered.

Unfortunately, this is not all that must be taken into account, for in all beams that fail by the compression of the concrete, and in many that fail by the tension of the reinforcement, the unit stress in the concrete is above the yield point. The unit stress can not, therefore, be obtained directly from the elongation and the initial coefficient of elasticity, as was the case for unit stresses below the yield point. A study of the compression tests shows, however, that the stress gross deformation curves for the individual cylinders differ in but few instances more than is permissible from the average curve of a group, so that we may assume that any material used in concrete of a given proportion, age, and consistency is sufficiently homogeneous to yield practically identical results on similar test pieces. With the aid of this curve, the unit stress for any given deformation is easily obtainable, whether it be above or below the yield point of the concrete.

Since this is the case, we are furnished with a method of computing the resisting moment of the beam which does not, as does the method based on the unit stress in the reinforcement, neglect a portion of the horizontal stresses in the beam. It does, however, introduce a source of error, in necessitating an assumption as to the character of the stress deformation diagram above the neutral axis. Yet, even with the assumption that has been made in this bulletin, and which has been maintained constant for all degrees of loading and all aggregates, the results obtained by this method are more nearly comparable with the external load conditions than are those which are based on the reinforcement, and which neglect the tensile stresses in the concrete.

Theoretically, this method would be applied in the following manner: The average stress gross deformation diagram of the concrete under consideration would be entered, with the unit deformation of the extreme upper fiber of the reinforced beam at the $\frac{M}{bd^2}$ for which the resisting and the bending moment were to be compared. With this unit compressive stress column 25, tables 6 to 21 as a basis, the total compressive stress would be computed, making use of the particular stress deformation diagram above the neutral axis which has been assumed in this bulletin. The resisting moment would then follow, by multiplying by the

distance from the center of gravity of the compressive stresses to that of the tensile stresses in the reinforcement.

The ratio of the resisting moment thus computed, to the bending moment could then be obtained. Since, however, we already have in column 26 the unit compressive stress in the extreme upper fiber, based on the tensile stress in the reinforcement, and in column 25 the unit compressive stress, taken from the compressive stress gross deformation diagram for the compressive cylinder, paralleling the beam under consideration it has been thought advisable to reverse the process outlined above, and compute the extreme fiber stress from the bending moment. This has been done and the values entered in column 27.

Making use of the necessary condition of equilibrium, that the sum of all the horizontal forces must be equal to zero, it is possible to figure the unit compressive stress of the extreme upper fiber of the beam from the tensile stress below the neutral axis. If, as a basis for this computation, the total tensile stress—i. e., the total tensile stress in the reinforcement plus the total tensile stress in the concrete—is used, the value obtained for the unit compressive stress in the extreme upper fiber of the beam should be the same as that which would be obtained if it had been computed directly from the bending moment.

If, however, as was done for the values in column 26, it is based on the total tensile stress in the reinforcement alone, the values obtained for the unit compressive stress will be smaller than that obtained from the bending moment, due to the neglect of the tensile stresses in the concrete below the neutral axis.

The values given in column 26 will, therefore, be found to be smaller than if computed from the bending moment, making use of the known position of the neutral axis.

Column 26 contains the unit compressive stress in the upper fiber of the beam as it would be computed from the bending moment, using the position of the neutral axis as given in column 18, the compressive stress deformation diagram with $q = \frac{1}{2}$, as has been assumed throughout this bulletin, and the external bending moment as given in column 22. Theoretically the values in column 27 would be obtained in this manner, but since, in column 26, we already have the unit compressive stress in the upper fiber,

based on the total tensile stress in the reinforcement, and in column 22 the ratio of the resisting moment, based on the tensile stresses in the reinforcement, to the bending moment it was only necessary to divide the values in column 26 by those in column 23.

Examining the values of $\frac{M_r}{M_b}$ given in column 23, we find, as might have been expected, that the ratio more nearly approaches unity as the percentage of reinforcement increases, due to the relatively greater importance of the neglect of the tensile resistance of the concrete below the neutral axis for the lower percentages.

As might be expected, the same behavior is indicated by the ratio in column 28, which is more nearly equal to unity, the higher the percentage of reinforcement.

The values of the ratio of the unit compressive stress in the upper fiber, as figured from the bending moment to the unit compressive stress, taken from the cylinders, is given in column 29 and is, as it should be, more nearly independent of the percentage of reinforcement than are the values in column 28, although the ratio does increase somewhat with the percentage of reinforcement.

The value of the computed unit bond stress, column 30, is seen to be entirely independent of the percentage of reinforcement, and has therefore been averaged for each age and aggregate. Under the heading of "Remarks" is given the unit bond stress at maximum load for tests on bond test pieces, the details of which have been given on page 17, and also the ratio of this unit bond stress to the average computed unit bond stress in the reinforced beams given in column 30. An examination of this ratio will show that in no case was the beam in danger of failure due to the slipping of the bars since the value of the ratio was in no case less than 3.

(c) THE EFFECT OF VARIATIONS IN THE PERCENTAGE OF REINFORCEMENT ON THE BEHAVIOR OF THE BEAM

The influence of treatment and environment is of great importance in the case of concrete. Concrete is in a state of change for a long time after it has been placed, a continual though slow increase in strength being accompanied by a corresponding increase in stiffness. For a given age, aggregate, and consistency its

strength varies almost directly as the percentage of cement, while a change in consistency causes a marked change in the ultimate strength for periods even up to one year. The strength of the concrete is greatly affected by the kind of aggregate used, and when this is kept constant, it is again affected by the uniformity of the grading, and, for the same grading, whether it grades down from a large or a comparatively small size. Even for a good hard stone, the fact that it was crushed and screened dry or wet exerts a marked influence on the strength and stiffness, while the character and amount of sand used in the concrete introduces another variable whose importance must not be overlooked.

When, therefore, concrete is combined with steel in a reinforced beam the behavior of the beam under load depends largely on the quality of the concrete used. The behavior of the beam, particularly one in which the percentage of reinforcement is comparatively high, is also slightly influenced by a peculiarity, which is common to all qualities of concrete, though in a different degree, in the following manner:

As was seen by an inspection of the diagrams giving the average compressive stress gross deformation curves for the concrete used in the present series, the maximum unit stress within which the relation of stress to deformation can be accurately represented by a straight line varies from 30 to 40 per cent of the ultimate strength. Even at a unit stress 50 per cent in excess of this amount, the variation from a straight line is but between 4 and 5 per cent. That is, the unit stress as given for a certain deformation on the curve is 4 or 5 per cent less than that computed from the given deformation using the initial coefficient of elasticity.

If, in a given series of beams in which the concrete is identical, we arbitrarily fix certain intensities of stress in the lower layer of the reinforcement, the behavior of the beam will, for all intensities of unit compressive stress in the extreme upper fiber which are greater than that corresponding to the limit of the straight-line variation, be governed largely by the character of the compressive stress gross deformation diagram. For this case, therefore, the behavior of the beam will not be in a direct relation to the percentage of reinforcement. For all unit compressive stresses in the extreme upper fiber which are below this value the behavior

of the beam will be a direct function of the percentage of reinforcement.

With these peculiarities in mind a study has been made of the relation between the percentage of reinforcement and the strength and the stiffness of the reinforced beams.

Nearly all building laws and specifications prescribe an allowable working stress of 16 000 pounds per square inch in the reinforcement. It is a matter of interest, therefore, to know exactly (1) how an actual beam for which this stress has been developed in the reinforcement would behave under load; (2) the load carried, and its variation with the amount of reinforcement; (3) the position of the neutral axis; (4) the effect of an increase or decrease of the area of the reinforcement; (5) the relation of the unit compressive stress in the extreme upper fiber to the unit tensile stress in reinforcement.

The questions are often asked (1) to what extent have the cracks developed below the neutral axis when the beam is subject to working loads; (2) does the deflection vary with the percentage of reinforcement; (3) does the allowable deflection increase directly with the span for a given concrete and percentage of effective reinforcement; (4) what is the effect of variations in the unit stress of the reinforcement; (5) what is the effect of an extreme variation in the yield point of the reinforcement.

While undoubtedly other studies leading to interesting results can be made from the data herein presented, it is thought that some of the principal points of interest in reinforced concrete have been covered and are summarized as follows.

Principal Considerations in Design of Reinforced Concrete Beams

With a view to furnishing information on these points, the following studies (for a maximum load and a unit stress of 16 000 and 32 000 pounds per square inch in the lower layer of reinforcement) have been made, involving the influence of the character of the aggregate and age of the concrete in the relation of the effective percentage of the reinforcement to:—(1) the position of neutral axis, (2) value of $\frac{M}{bd^2}$, (3) compressive stress in extreme upper fiber, (4) deflection.

As has already been indicated, it is necessary to use from two to eight, one-half inch round bars in order to bring about the desired variation in the nominal percentage of reinforcement. As the test beams were only 8 inches wide, it would probably not have been possible to place more than four bars in one layer and prevent the splitting of the concrete in the plane of the reinforcement. When, therefore, more than four bars were used they had to be arranged in two layers as shown in Fig. 1.

For those cases in which the reinforcement consisted of two, three, or four bars the entire area of reinforcement was effective in the same degree in resisting flexure. When, however, more than four bars were used, and it became necessary to place the reinforcement in two layers, this was no longer true. A square inch of reinforcement in the lower layer becomes now more effective than a square inch in the upper layer, in resisting flexure, in proportion to the distance from the neutral axis to the center of the lower layer of reinforcement and from the neutral axis to the upper layer of reinforcement.

If, therefore, the area of the reinforcement in the upper layer were multiplied by the ratio between the distance from the neutral axis to the upper layer and the distance from the neutral axis to the lower layer, an area would be obtained which, when added to the area of the reinforcement in the lower layer, would give a new area of reinforcement concentrated in the lower layer and causing the beam to duplicate its behavior for the original arrangement of the reinforcement in two layers.

While it was thought unnecessary to give in detail all the computations required in the preparation of Figs. 6 to 21, it was thought best to include the computation sheet for one set of beams in order that the basis underlying Figs. 6 to 21 might be clearly understood.

Table 26, p. 60, shows, therefore, the computation sheet for beams of 1 : 2 : 4 granite concrete tested at the age of 13 weeks.

Column 1 contains the register number of the beam, while column 2 contains the number of one-half-inch round bars with which each beam was reinforced.

Column 3 contains the maximum value of $\frac{M}{bd^2}$. For those

beams for which the maximum load was observed, this value could be figured directly from the maximum applied load, the weight of the deformer, and that of the beam. In computing bd^2 the nominal dimensions, 8 inches wide, 10 inches to the center of the lower layer of reinforcement were adhered to. Whenever the tabulated values have been followed by an asterisk, they are based on actual measured values.

The unit deformation of the upper fiber at maximum load is given in column 4. In but a few instances was this quantity measured directly. Since the failure of all the beams was due to the tension in the reinforcement the readings of the lower micrometers at maximum load were far more important than those at the top of the beam. The observer on each side of the beam therefore concentrated his attention on the lower micrometer when maximum load was being approached, in order to detect the first sign of failure in the reinforcement. In order, therefore, to approximate the unit deformation of the upper fiber at maximum load it was necessary to produce the upper fiber curve (Figs. 41 to 45, facing p. 32) beyond the $\frac{M}{bd^2}$ corresponding to the last load increment preceding maximum load until it intersected a horizontal line through the maximum value of $\frac{M}{bd^2}$. The values thus obtained were entered in column 4.

In a few instances the beam failed just after a full set of readings had been taken, and before any additional load had been applied. The values thus obtained by direct measurement have been followed by an asterisk in column 4.

In column 5 is given the unit deformation of the reinforcement. These values were obtained, as already indicated, from the reading of the lower micrometer just previous to the sudden increase in the readings which indicated that the yield point of the reinforcement had been reached. Since this reading was considered one of the most important in the entire test it was always observed and therefore all the values in the column have been followed by an asterisk.

The percentage depth of the neutral axis below the top of the beam is given in column 6, and is based on the usual assumption

that the deformations are proportional to the distance from the neutral axis. Since these values have been obtained from those in columns 4 and 5, they involve in many cases an approximate value, particularly of the unit deformation of the upper fiber.

Column 7 contains the average yield point of the reinforcement used in each beam and are the averages of the individual values given in the summary of the tests on the reinforcement. (Table 4.) The usual percentage of reinforcement is obtained by dividing the total sectional area of the reinforcement by the cross section of the beam above the center of the lower layer of reinforcement.

The values in column 8 have been obtained in this way, and are based on bars of one-half inch nominal diameter, a constant breadth of 8 inches and a constant depth to the center of the lower layer of reinforcement of 10 inches. In all discussions that follow, this percentage of reinforcement will be referred to as the "nominal" percentage.

In order to obtain the "effective" percentage at maximum load, which is the percentage of reinforcement which, when concentrated in the plane of the lower layer of reinforcement, will cause identical behavior under load, it is necessary to multiply the area of the reinforcement in the upper layer by the ratio between the distance from the neutral axis to the upper layer of the reinforcement and the distance from the neutral axis to the lower layer of reinforcement. This reduced area is added to the cross section of the lower layer, and the sum divided by the cross section of the beam above the lower layer. Since the final study was to be made on average values, this reduction was made only for the average values of the position of the neutral axis as given in column 6.

The values thus obtained for the "effective" percentage, theoretically, still require modification at maximum load, due to the fact that the average yield point of the reinforcement used in the different beams is not the same. An increase in yield point is equivalent to an increase in the percentage of reinforcement, and in order to reduce all sets of beams to the same basis, the "effective" percentages of column 9 have been altered to correspond to

a yield point of 40 000 pounds per square inch, the approximate average yield point of all the reinforcement used, and are given in column 10.

The value of the deflection, in inches, at maximum load is shown in column 11. With the exception of the values in columns No. 1, 2, and 8 all values, that have been mentioned up to this point, refer to maximum load conditions only.

The next five columns give conditions in the beam at a unit stress of 32 000 pounds per square inch in the lower layer of the reinforcement. Assuming a modulus of elasticity of 30 000 000, the unit deformation corresponding to a stress of 32 000 pounds per square inch is 0.001067. With this as a basis, the values in columns 12 to 16, inclusive, were obtained as follows: Figs. 41 to 45, facing page 32, for the above unit deformation for the lower fiber the corresponding $\frac{M}{bd^2}$ was read from the steel curve and entered in column No. 12.

With the value of $\frac{M}{bd^2}$ corresponding to a unit deformation in the reinforcement of 0.001067 known, the unit deformation of the upper fiber was read from the upper curve and entered in column 13.

The percentage depth of the neutral axis below the top (column 14) and the deflection, in inches, at the center of the beam (column 15) were obtained in the same manner.

The "effective" percentage in column 16, and also the values in column 9, were obtained from the known distribution of the reinforcement in the beam and the known position of the neutral axis.

Columns 17 to 21, inclusive, contain the same information for a unit stress of 16 000 pounds per square inch in the lower layer of the reinforcement as is given in columns 12 to 16 for a unit stress of 32 000 pounds per square inch.

An inspection of columns 16 and 21 will indicate that the higher the unit stress in the lower layer of reinforcement the higher the neutral axis, and therefore the greater the "effective" percentage of reinforcement.

1	2	3
Beam No.	Num- ber of 1-Inch Round Rods	Maxi- mum Value of M bd ²
165	2	¹ 229.47
166	2	¹ 220.26
167	2	¹ 223.68
Average		224.47
177	3	¹ 301.77
178	3	¹ 325.47
179	3	¹ 320.67
Average		315.97
189	4	¹ 407.29
190	4	¹ 402.06
191	4	¹ 378.87
Average		396.07
201	5	¹ 433.68
202	5	¹ 435.18
203	5	¹ 451.08
Average		439.98
213	6	¹ 522.59
214	6	¹ 529.68
215	6	¹ 521.29
Average		524.52
225	7	¹ 573.38
226	7	¹ 584.69
227	7	¹ 589.69
Average		582.59
243	8	¹ 665.29
244	8	¹ 665.11
245	8	¹ 690.10
Average		673.50

Table 26.—Computation Sheet for Beams of 1 : 2 : 4 Granite Concrete Tested at 13 Weeks

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Beam No.	Number of 1-Inch Round Rods	Maximum Value of M lb-ft	Unit Deformation Upper Fiber at Maximum Load	Unit Deformation of Reinforcement	Percentage Depth of Neutral Axis Below Top Beam	Average Yield Point of Reinforcement Used	Nominal Percentage of Reinforcement	Percentage of Effective Reinforcement	Uniform Percentage of Reinforcement	Deflection in Inches at Maximum Load	Conditions in the Beam at a Unit Stress of 32 000 lbs. per sq. in. in the Lower Layer of Steel					Conditions in the Beam at a Unit Stress of 16 000 lbs. per sq. in. in the Lower Layer of Steel				
											M lb-ft	Unit Deformation Upper Fiber	Percentage Depth Neutral Axis Below Top	Deflection in Inches	Effective Percentage Reinforcement	M lb-ft	Unit Deformation Upper Fiber	Percentage Depth Neutral Axis Below Top	Deflection in Inches	Effective Percentage Reinforcement
165.....	2	1 229.47	0.000480	1 0.001138	29.5	42 230				1 0.350	223.5	0.000460	30.5	0.323		180.0	0.000322	37.5	0.170	
166.....	2	1 220.26	1 418	1 1176	26.2	42 200				1.325	209.0	393	27.0	.296		165.5	276	34.8	.156	
167.....	2	1 223.68	464	1 1164	28.3	41 910				1.345	210.0	428	28.8	.292		165.0	280	35.1	.138	
Average.....		224.47	.000454	.001159	28.0	42 110	0.49	0.49	0.517	.340	214.2	.000427	28.8	.304	0.491	170.2	.000293	35.8	.155	0.491
177.....	3	1 301.77	.000544	1.001215	31.2	41 940				1.410	1 280.5	.000490	1 31.5	1.340		197.0	.000305	36.9	.158	
178.....	3	1 325.47	1 560	1 1248	31.0	43 390				1.410	298.5	503	32.1	.353		210.0	326	38.1	.172	
179.....	3	1 320.67	564	1 1070	33.0	43 470				1.390	1 320.7	564	34.0	1.390		226.5	333	39.0	.182	
Average.....		315.97	.000556	.001178	31.7	42 930	.74	.74	.790	.403	299.9	.000519	32.5	.361	.736	211.2	.000321	38.0	.171	.736
189.....	4	1 407.29	.000695	1.001226	36.2	41 950				1.455	372.0	.000626	37.0	.379		251.0	.000371	41.3	.203	
190.....	4	1 402.06	690	1 1374	33.6	42 480				1.475	343.0	568	34.7	.351		245.0	375	41.6	.187	
191.....	4	1 378.87	634	1 1176	36.7	40 670				1.400	363.0	603	36.4	.365		254.5	388	42.6	.186	
Average.....		396.07	.000673	.001259	35.5	41 700	.98	.98	1.024	.443	359.3	.000599	36.0	.365	.982	250.2	.000378	41.8	.192	.982
201.....	5	1 433.68	.000689	1.001443	36.0	40 920				1.430	390.0	.000608	36.3	.333		262.0	.000368	41.0	.172	
202.....	5	1 435.18	713	1 1323	35.2	41 460				1.435	380.5	596	35.9	.344		258.0	361	40.7	.176	
203.....	5	1 451.08	725	1 1479	35.0	40 410				1.465	390.0	589	35.6	.352		1 265.7	1 363	40.5	.185	
Average.....		439.98	.000709	.001415	35.4	40 930	1.23	1.11	1.139	.443	386.8	.000598	35.9	.343	1.112	261.9	.000364	40.7	.178	1.103
213.....	6	1 522.59	.000819	1.001321	37.8	41 460				1.470	1 446.1	.000670	38.7	.365		290.0	.000405	43.4	.179	
214.....	6	1 529.68	845	1 1494	37.7	41 230				1.525	437.0	667	38.4	.381		290.0	410	43.5	.203	
215.....	6	1 521.29	837	1 1422	36.8	41 080				1.495	422.0	631	37.2	.355		276.0	376	41.6	.173	
Average.....		524.52	.000834	.001412	37.4	41 260	1.47	1.30	1.337	.497	435.0	.000656	38.1	.367	1.294	285.3	.000397	42.8	.185	1.279
225.....	7	1 573.38	.000933	1.001503	40.3	41 180				1.510	479.5	.000741	40.9	.379		312.0	.000444	45.0	.192	
226.....	7	1 584.69	865	1 1694	38.3	42 110				1.505	490.0	691	39.3	.360		314.0	403	43.2	.174	
227.....	7	1 589.69	890	1 1443	39.1	40 750				1.495	494.0	723	40.4	.362		320.5	428	44.7	.185	
Average.....		582.59	.000896	.001547	39.2	41 350	1.72	1.54	1.588	.503	487.8	.000718	40.2	.367	1.533	315.5	.000425	44.3	.184	1.520
243.....	8	1 665.29	.001115	1.001706	40.0	41 790				1.615	546.0	.000822	43.6	.414		346.5	.000487	47.9	.217	
244.....	8	1 665.11	950	1 1405	40.1	41 780				1.530	556.0	734	40.8	.386		1 356.7	1 427	1 44.5	1.195	
245.....	8	1 690.10	1062	1 1831	38.3	41 400				1.595	548.0	725	40.5	.382		343.0	414	44.0	.189	
Average.....		673.50	.001042	.001647	39.5	41 660	1.96	1.72	1.791	.580	550.0	.000760	41.6	.394	1.712	348.7	.000443	45.5	.200	1.694

1 Actual measured values, or computed from actual measured values.

While Table 26 has been given as an illustration of the basis of the tabulated values, and as furnishing in detail the method of calculation that was used, like all tabulated values they are unsatisfactory for the purpose of comparing a large number of results. Therefore but one set of computations has been published and the remainder of the data presented graphically in Figs. 6 to 21, pages 62 to 95, which will now be discussed.

(1) **Variation in the Position of the Neutral Axis with the "Effective" Percentage of Reinforcement.**—An accurate knowledge of the position of the neutral axis is one of the first requisites in determining the resistance of a beam to flexure. It seems logical, therefore, to discuss the change in the position of the neutral axis when the amount or disposition of the reinforcement is altered, before taking up the resistance of the beam to flexure.

Figs. 6 to 9, pages 62 to 65, have therefore been prepared to show the change in the position of the neutral axis with change in percentage of reinforcement. Each point in the figures is the average of three tests and every figure gives the results of the tests on a given aggregate made at a particular age. On each figure three curves have been drawn. One shows the relation between the variables under consideration for a unit stress in the lower layer of steel equal to 16 000 pounds per square inch, one for a unit stress of 32 000 pounds, and one has been drawn for maximum load conditions.

A general inspection of these curves will show that if we except the points observed for limestone concrete beams which were reinforced with two, one-half inch round bars or 0.5 per cent reinforcement, the curves are all very uniform, and all sets seem to have the same general shape irrespective of the aggregate considered.

What difference there is in the uniformity seems to be in favor of the 16 000 pounds stress curve, while that for maximum load conditions is the most irregular of the three.

The curve for maximum load conditions is perhaps even more regular than might be expected when the various reductions that have been made in the preparation of these figures is taken into consideration.

Fig. 7.—Relation Between Position of Neutral Axis and Effective Percentage of Reinforcement for Limestone Concrete

Fig. 8.—Relation Between Position of Neutral Axis and Effective Percentage of Reinforcement for Gravel Concrete

Fig. 9.—Relation Between Position of Neutral Axis and Effective Percentage of Reinforcement for Cinder Concrete

As was the case for the other curves, any error in the vertical placing of the bars in the beam as well as any instrumental errors in the deformeters inasmuch as it affects the position of the neutral axis influences the "effective percentage" of reinforcement.

Since, however, the yield point of the reinforcement used in the beams varied from 35 000 to about 42 000 pounds per square inch, the possibility of another error was introduced at maximum load when the "effective" percentage was reduced to correspond with a yield point of 40 000 pounds.

As might be expected from the upward bend of the neutral axis curves in Figs. 6 to 9, pages 62 to 65, the 32 000 pounds curve is in all cases well above the 16 000 pounds curve for 0.5 per cent reinforcement.

For the gravel and stone concrete having 1.6 per cent reinforcement the 4-week tests appear in one group and the 13, 26, and 52 week tests in another. For the 4-week tests the change in the position of the neutral axis when the stress in the reinforcement increases from 16 000 to 32 000 pounds per square inch is appreciably less than for ages of 13, 26, and 52 weeks. A reference to the average compressive stress gross deformation curves for the cylinders (Figs. 37 to 40, pp. 111 to 114) and the ultimate compressive strength at the age of 4 weeks as contrasted with that at 13, 26, and 52 weeks, Tables 33 to 36, pages 129 to 136, will furnish an explanation for this behavior. As may be seen, the increase in strength and stiffness from 4 to 13 weeks is quite appreciable, while the increase after 13 weeks is much less.

The tendency of the neutral axis to rise with the increasing development of cracks below the neutral axis as the unit stress in the reinforcement changes from 16 000 to 32 000 pounds per square inch is therefore partly counteracted by the lowering of the neutral axis, due to the uniformly changing stress conditions above the neutral axis, after the yield point of the concrete in compression has been reached.

When the age of 13 weeks is reached the concrete above the neutral axis has apparently increased sufficiently in strength and stiffness to make the development of cracks below the neutral axis the only factor in determining the change in its position.

This action is even more clearly brought out by the tests on the cinder concrete. For example, the 4-week tests on cinder concrete, below an effective percentage of about 1.1, shows that the neutral axis rises as the unit stress in the reinforcement increases from 16 000 to 32 000 pounds, the amount of the rise, however, steadily decreasing to zero at this percentage. For percentages of reinforcement above 1.1 the distance of the neutral axis below the top of the beam increases when the stress in the reinforcement changes from 16 000 to 32 000 pounds per square inch—the amount of the change increasing regularly as the percentage of reinforcement increases.

This lowering of the neutral axis above a reinforcement of 1.1 per cent is quite noticeable at maximum load, and would indicate that the ultimate compressive strength of the concrete has been almost developed. The individual tests at four weeks on cinder concrete having 1.50, 1.75 and 2 per cent nominal reinforcement present all the characteristics of the proximity or presence of a compression failure, becoming more marked as the percentage of reinforcement increases. From an examination of representative deformation curves for cinder concrete for the upper fiber it is seen that the abrupt change in direction at maximum load, which is always indicative of a tension failure, is absent. The curves, on the contrary, are very regular, although the deformations increase rapidly near the maximum load. The deformations of the upper fiber, as might be expected when the low modulus of elasticity (1 610 000) is taken into consideration, are very large even for comparatively low loads and continue to increase until near maximum load the increase in deformation is so great, for a small increase in load that the curves are practically horizontal.

Table 36, page 136, shows that the ultimate strength of cinder concrete at the age of 4 weeks as based on the tests of the cylinders is 1647 pounds per square inch.

Fig. 21, page 95, showing the relation between the “effective” percentage of reinforcement and the unit compressive stress in the extreme upper fiber, gives a unit compressive stress equal to 1750 pounds per square inch for 1.6 per cent reinforcement. This figure also indicates that at maximum load the unit compressive

stress in the extreme upper fiber for all percentages of reinforcement greater than 1 per cent is nearly equal to the ultimate strength of the concrete.

Fig. 9, page 65, showing the variation of position of the neutral axis with the "effective" per cent at the age of 13 weeks, brings out clearly the effect of the increase in strength and stiffness with age. At the age of 4 weeks it is seen that the depth of the neutral axis below the top of the beam remains constant for all intensities of loading for a percentage of reinforcement of 1.1.

For the 13-week tests this same condition is seen to occur at about 1.6 per cent, while for all percentages below this amount the distance of the neutral axis below the top of the beam decreases as the unit stress in the reinforcement increases.

Examining Table 36, page 136, and Fig. 21, page 94, it is seen that even at the age of 13 weeks the ultimate strength of the concrete in compression is approached when the amount of the reinforcement is 1.6 per cent.

All data illustrated in part by representative curves (Figs. 41 to 45, facing page 32) show the concrete still increasing in strength and stiffness for ages of 26 and 52 weeks, the latter figure being nearly similar in outline to those for the stone and gravel concretes at an age of 4 weeks, although the neutral axis for the cinder concrete is, of course, lower, due to the lower modulus of elasticity.

Table 27 has been prepared to show the distance of the neutral axis below the top of the beam for every age and aggregate and for 0.5 and 1.6 per cent "effective" reinforcement with stresses of 16 000 and 32 000 pounds per square inch respectively. These percentages read directly from the figures were chosen since they are the maximum values and minimum values that are common to all of Figs. 6 to 21, pages 62 to 95, and permit rough comparison of the tests to be made.

While it appears that age has an influence on the absolute position of the neutral axis for the purpose of comparison the percentage distance below the top of the beam has been averaged for all four ages and tabulated in Table 27, since the difference between stone and gravel concretes and cinder concrete is quite marked.

Table 27.—Percentage Depth of Neutral Axis Below Top of Beam, Based on Effective Depth

Unit Stress in Lower Layer of Reinforcement, 16 000 Pounds

Age, in Weeks	Granite		Gravel		Limestone		Cinders	
	Effective Percentage of Reinforcement		Effective Percentage of Reinforcement		Effective Percentage of Reinforcement		Effective Percentage of Reinforcement	
	0.5	1.6	0.5	1.6	0.5	1.6	0.5	1.6
4	34.5	46.5	32.5	44.0	33.5	48.0	45.5	60.0
13	35.5	45.0	32.5	43.0	34.5	46.0	45.0	57.0
26	32.0	44.0	33.0	42.0	33.5	44.0	43.5	57.0
52	32.5	44.5	33.0	44.0	31.0	44.5	46.0	57.5
Average	33.6	45.0	32.8	43.2	33.1	45.9	45.0	57.9

Unit Stress in Lower Layer of Reinforcement, 32 000 Pounds

4	29.0	45.0	29.0	42.0	29.0	46.0	41.0	61.5
13	29.0	40.5	26.5	39.0	28.5	43.0	38.0	57.0
26	27.0	40.0	26.0	38.0	28.0	40.0	37.5	55.0
52	27.5	40.0	26.5	39.0	25.0	41.0	38.0	55.0
Average	28.1	41.4	27.0	39.5	27.6	42.5	38.6	57.1

Table 28.—Relation Between Distance of Neutral Axis Below Top of Beam and Relative Value of Modulus of Elasticity

Kind of Aggregate	Average Ratio of Moduli of Elasticity Cinders=Unity	Stress in Reinforcement 16 000 Pounds Per Square Inch		Stress in Reinforcement 32 000 Pounds Per Square Inch	
		Effective Percentage of Reinforcement		Effective Percentage of Reinforcement	
		0.5	1.6	0.5	1.6
Gravel.....	2.63	32.8	43.2	27.0	39.5
Granite.....	2.37	33.6	45.0	28.1	41.4
Limestone.....	2.13	33.1	45.9	27.6	42.5
Average.....	2.38	33.2	44.7	27.6	41.1
Cinders.....	1.00	45.0	57.9	38.6	57.1
Ratio cinders to rock.....		1.36	1.30	1.40	1.39

The values in column 2 of this table were obtained from Tables 33 to 36, pages 129 to 136, by averaging the ratios of the moduli of elasticity calling that of cinders which is the lowest equal to unity. The change in the position of the neutral axis below the top of the beam is not influenced in direct proportion to the modulus of elasticity, the neutral axis for different concretes changing much less rapidly than the corresponding moduli of elasticity.

The values in this table have been arranged in decreasing order of the magnitude of the ratio of the moduli of elasticity, the stone and gravel concretes being grouped together, while the cinder concrete is shown separately.

The average ratio for stone and gravel concrete to cinder concrete is 2.38, which is about 4.5 times the change in that of the stone and gravel concrete. Bearing this in mind, it may reasonably be expected that the difference between the distance of the neutral axis below the top of the beam for cinder concrete and that for stone and gravel concrete is greater than that found in the stone and gravel concrete group. From the table this is seen to be the case, the ratio of the depth to the neutral axis for cinder concrete to that for stone and gravel concrete varying from 1.30 to 1.40, with an average value of 1.36.

Table 29.—Comparison of Computed and Observed Values of K for 0.5 Per Cent and 1.6 Per Cent "Effective Reinforcement."

Age in Weeks	Granite					Gravel					Limestone					Cinders				
	K in Per Cent for the Following Percentage of Reinforcement					K in Per Cent for the Following Percentage of Reinforcement					K in Per Cent for the Following Percentage of Reinforcement					K in Per Cent for the Following Percentage of Reinforcement				
	14N					N					N					N				
	0.5		1.6			0.5		1.6			0.5		1.6			0.5		1.6		
	Computed	Observed	Computed	Observed		Computed	Observed	Computed	Observed		Computed	Observed	Computed	Observed		Computed	Observed	Computed	Observed	
4	6.99	25.0	29.0	40.0	45.0	6.52	24.0	29.0	39.0	42.0	8.36	27.0	29.0	43.0	46.0	18.63	37.0	41.0	56.0	62.0
13	6.77	25.0	29.0	40.0	41.0	6.49	24.0	27.0	39.0	39.0	7.88	26.0	29.0	42.0	43.0	16.48	36.0	38.0	54.0	57.0
26	6.70	25.0	27.0	39.0	40.0	5.73	23.0	26.0	37.0	38.0	6.96	25.0	28.0	40.0	40.0	14.15	34.0	38.0	52.0	55.0
52	6.29	24.0	28.0	39.0	40.0	5.56	23.0	27.0	37.0	39.0	6.59	24.0	25.0	40.0	41.0	14.22	34.0	38.0	52.0	55.0
Average		24.7	28.2	39.5	41.5		23.5	27.2	38.0	37.0		25.5	27.8	41.2	42.5		35.2	38.7	53.5	57.2

¹⁴N=Ratio of modulus of elasticity of steel (30 000 000) to the average initial modulus of elasticity of concrete. (Tables 33 to 36.)

While it is somewhat foreign to the purpose of this bulletin to enter into any theoretical discussions, and while it has been the aim to adhere strictly to a presentation and discussion of experimental results, the preceding table giving the computed and experimental position of the neutral axis is of interest.

The experimental or observed value of the depth of the neutral axis below the top of the beam has been read from the 32 000 pounds stress curve. (Figs. 6 to 9.) Since the formula, by which the computed values of the neutral axis were obtained, is based in part on the assumption that the concrete below the neutral axis has no tensile resistance, the observed values, with which the computed values are to be compared, should be obtained at a stage during the test when the beam most nearly approximates the conditions assumed in the formula. Since the maximum load values are in no case as accurate as could be desired, the computed values have been compared with the observed values for a stress of 32 000 pounds per square inch in the lower layer of the reinforcement.

The general formula for proportionate distance of the neutral axis below the top of the beam is as follows:

$$K = \sqrt{\frac{2 p n}{1 - \frac{1}{3}q} + \left[\frac{p^2 n^2}{1 - \frac{1}{3}q} \right]^2} - \frac{p n}{1 - \frac{1}{3}q}$$

K = proportionate depth of the neutral axis below top of beam.

P = "Effective" percentage of reinforcement.

n = ratio of the modulus of elasticity of the reinforcement to the initial modulus of elasticity of the concrete.

q = ratio of unit compressive deformation developed in the upper fiber of the beam to the ultimate unit compressive deformation of the concrete.

In this formula, as in others, q has been made equal to $\frac{1}{2}$.

The values for the four ages have been averaged. The computed value is in all except one case less than the observed value. In examining this table it should be remembered that in the theoretical formula q has been retained equal to $\frac{1}{2}$, irrespective of the kind of concrete, and further that the assumed condition of total absence of tensile resistance below the neutral axis is not true.

(2) Variation of $\frac{M}{bd^2}$ with "Effective" Percentage of Reinforcement.—The data plotted in Figs. 10 to 13 was obtained in tables similar to Table 27, page 69. An inspection of these diagrams shows that the variation of $\frac{M}{bd^2}$ with "effective" per cent of reinforcement can be represented sufficiently well by a straight line. A straight line has therefore been drawn through every group of points, one for a unit stress in the lower layer of reinforcement equal to 16 000 pounds, another for 32 000 pounds, and a third at maximum load. The curve for 32 000 pounds per square inch is always well above that for 16 000 pounds, and the direction of both is such that they would converge at about the same point for zero percentage of reinforcement. This is, however, not the case for the line drawn at maximum load. In many cases the line crosses that for 32 000 pounds stress in the reinforcement, seeming to indicate that the $\frac{M}{bd^2}$ or load carried at "maximum" load was actually less than that carried for a stress of 32 000 pounds per square inch in the reinforcement. As was pointed out in the preparation of Table 27, page 69, the "effective" percentage of reinforcement at maximum load had to be modified, due to the fact that the yield point of the reinforcement used varied from 35 000 to 42 000 pounds per square inch. Since a unit stress of 40 000 pounds was taken as a basis for comparison, the effective per cent of all beams having reinforcement of a higher yield point was increased, when corrected, above what it would be if based only on the position of the neutral axis, while if the reinforcement were of lower yield point it would be decreased. The effect of such an increase in percentage is to move the plotted point over horizontally a distance which is in several cases great enough to cause the maximum load line to intersect that for a stress of 32 000 pounds in the reinforcement.

This behavior would seem to throw suspicion on the correctness of the assumptions made in the preparation of the data used in plotting this line. In studying any of these diagrams, too much emphasis can not be laid on the necessity for remembering how

Fig. 11a.—Relation Between $\frac{M}{bd^2}$ and Effective Percentage of Reinforcement for Limestone Concrete

Fig. 11b.—Relation Between $\frac{M}{bd^2}$ and Effective Percentage of Reinforcement for Limestone Concrete

Fig. 13a.—Relation Between $\frac{M}{bd^2}$ and Effective Percentage for Reinforcement of Cinder Concrete

the various values used were obtained. The value of $\frac{M}{bd^2}$ is, of course, almost correct since it is based on a load which could be accurately determined and on dimensions, span, position of load points, breadth, and depth, all of which can be accurately measured.

As has already been pointed out this was not the case in determining the "effective" percentage of reinforcement. There is also the possibility that for the same "effective" percentage all concentrated in the lower layer in one case and in another distributed in two layers, there may be sufficient difference in behavior in the action of the beam under load, to cause some of the more or less erratic values that are noticeable.

The lines for 16 000 and 32 000 pounds per square inch in the reinforcement are therefore in one group and are comparable among themselves, while the line for maximum load can only be compared with other maximum load lines.

Examining the values for $\frac{M}{bd^2}$ at an "effective" percentage of reinforcement of 0.5 and 1.6 per cent and for a stress of 16 000 and 32 000 pounds per square inch in the reinforcement and contrasting the 4-week with the 13-week tests the effect of the character of the compressive stress gross deformation curve on the resistance of the beam is very generally brought out. At a reinforcement of 0.5 per cent for which the intensity of loading does not cause compressive stresses in the concrete much above the yield point, at the age of 4 weeks, the increase in $\frac{M}{bd^2}$ at 13 weeks is less than for 1.6 per cent reinforcement for which in many cases the compressive stress developed in the upper fiber was considerably greater than the yield point. This is particularly true for a unit stress in the steel of 32 000 pounds per square inch.

The $\frac{M}{bd^2}$ for 32 000 pounds per square inch is not exactly twice that for a stress of 16 000 pounds per square inch. This is probably due to the fact that a beam without reinforcement, 8 by

11 inches in section, has itself considerable resistance to flexure, which must be added to that due to the introduction of reinforcement.

Bulletin 344¹⁵ gives tests on concrete beams without reinforcement, having the same gross 8 by 11 inch section that was used in the reinforced beam series reported in this bulletin. A portion of the tests of the first series was of beams of a constant 12-foot span, while a secondary portion included beams of variable spans which consisted of the larger portion of the 12-foot span after rupture. A summary of the results of the tests on the 12-foot beams is given in Table 8, pages 36-40, while that for the beams of variable span is given in Table 9, pages 42-46 of the above bulletin. Column 19, Table 8, contains the maximum total $\frac{M}{bd^2}$ for the 12-foot beams, while column 20, Table 9, gives the same information for the variable beams. Since the value of $\frac{M}{bd^2}$ is independent of the span and the conditions of loading these values have been averaged.

Since a medium consistency was used in the reinforced beams, only the $\frac{M}{bd^2}$ for the beams without reinforcement of medium consistency has been used. As was previously indicated the value of $\frac{M}{bd^2}$ for these beams was based on a depth of 11 inches, for which $bd^2 = 968$. The $\frac{M}{bd^2}$ which is plotted on Figs. 6 to 21, pages 62 to 95, has, however, been based on the depth to the reinforcement which is 10 inches, making $bd^2 = 800$.

The value of $\frac{M}{bd^2}$ as given in Tables 8 and 9, Bulletin 344¹⁵ should therefore be multiplied by $\frac{968}{800} = 1.21$ to make them directly comparable with the values plotted in the figures.

Where the gravel and stone concretes were identical in both beam series, there is a tendency which seems to indicate that the three lines should meet the common point of zero reinforcement.

¹⁵ U. S. Geological Survey.

If we use this line as a datum, the resistance of the beam to flexure is nearly proportional to the stress in the reinforcement—that is, the distance on the ordinate from the datum line to the 32 000-pound line is nearly equal to twice the distance to the 16 000-pound line.

It has already been pointed out in Bulletin 344,¹⁵ and called attention to in the present bulletin, in discussing the elongation of the lower fiber at first crack, that the proportion of the cinder concrete was a 1 : 2 : 5 volume proportion instead of 1 : 2 : 4. The influence of this difference is clearly seen in the position of the line for the cinder concrete in beams without reinforcement in Figs. 10 to 13, pages 73 to 80.

These figures again bring out clearly the fact, to which attention has already been called, in discussing the ratio of the external bending moment and the internal resisting moment, based on the measured stress in the reinforcement (Tables 6 to 21, column 22, following page 128), that the strength of the concrete in tension below the neutral axis has an appreciable effect on the resistance of the beam.

(3) Variation of the Deflection at Center of Span with Effective Percentage of Reinforcement.—Figs. 14 to 17, pages 86 to 90, showing the relation existing between the deflection of the center of the beam, in inches, and the effective percentage of reinforcement for maximum load, and for stresses of 16 000 and 32 000 pounds per square inch, have been prepared from tabulated data similar to that shown in Table 45, columns 10, 11, 15, 16, 20 and 21.

With the explanation of the method of preparation of similar diagrams that has already been given, any further comments on these figures seem unnecessary. An interesting check on the accuracy of the measured deflections, as well as the deformation of the upper and the lower fiber, and consequently the position of the neutral axis, which is obtained directly from the last two, can be obtained by computing the deflection for a stress of 16 000 and 32 000 pounds in the reinforcement. The formula used neglects the weight of the beam, and is based on a beam loaded at the third

points only. The deflection at the center is obtained from the elastic curve, in the derivation of which the usual assumptions are made. The formula reduces to—

$$\Delta = \frac{220.8 S}{E (1 - k)}$$

Where Δ = deflection, in inches, at center of beam.

E = modulus of elasticity of reinforcement.

S = unit stress in reinforcement.

k = proportionate depth to neutral axis.

$$\text{For } S = 32\ 000 \quad \Delta = \frac{0.235}{1 - k}$$

$$S = 16\ 000 \quad \Delta = \frac{0.118}{1 - k}$$

With these formulas and the values of ' k ' as given by Figs. 6 to 9, pages 62 to 65, as a basis, the following table has been prepared for percentages of 0.5 and 1.6 "effective" reinforcement.

The deflections are paralleled by those containing the values obtained from Figs. 14 to 17, which are based on the observed deflections. As will be seen there is a very satisfactory agreement between the observed and the computed values, which not only checks the observed values but also throws light on the degree of accuracy of the deformations.

An inspection of this table will show that for a given stress in the reinforcement the deflection is independent of the age. Since there is no apparent relation between deflection and age, the values in the above table have been averaged, and the average deflection for 32 000 pounds in the reinforcement compared with that for 16 000 pounds per square inch, in the last line of the table. The deflection is apparently not quite doubled, when the stress in the reinforcement is doubled. The average deflections for the stone and gravel concretes, and that for the cinder concrete, for 0.5 and 1.6 per cent reinforcement, have been roughly expressed in terms of the span in the following table.

Table 30.—Approximate Deflections, in Terms of the Span Length

Kind of Concrete	Stress in Reinforcement 16 000 Pounds		Stress in Reinforcement 32 000 Pounds	
	Effective Percentage of Reinforcement		Effective Percentage of Reinforcement	
	0.5	1.6	0.5	1.6
Stone and gravel	$\frac{1}{1000}$	$\frac{1}{720}$	$\frac{1}{500}$	$\frac{1}{360}$
Cinder	$\frac{1}{1000}$	$\frac{1}{600}$	$\frac{1}{500}$	$\frac{1}{300}$

Table 31.—Computed and Measured Deflection, in inches, at the Center of the Beam

Unit Stress in Lower Layer of Reinforcement 32 000 Pounds per Square Inch

Age, in Weeks	Granite				Gravel				Limestone				Cinders			
	Effective Percentage of Reinforcement				Effective Percentage of Reinforcement				Effective Percentage of Reinforcement				Effective Percentage of Reinforcement			
	0.5		1.6		0.5		1.6		0.5		1.6		0.5		1.6	
	Deflection															
	Computed	Observed	Computed	Observed	Computed	Observed	Computed	Observed	Computed	Observed	Computed	Observed	Computed	Observed	Computed	Observed
4	0.33	0.30	0.43	0.40	0.33	0.31	0.41	0.39	0.33	0.30	0.44	0.41	0.40	0.37	0.60	0.56
13	.33	.31	.40	.38	.32	.29	.39	.38	.33	.32	.41	.40	.38	.34	.55	.51
26	.32	.31	.39	.40	.32	.28	.38	.37	.33	.31	.39	.38	.38	.34	.53	.51
52	.32	.29	.39	.39	.32	.28	.39	.39	.31	.29	.40	.38	.38	.33	.51	.52
Average	.33	.30	.40	.39	.32	.29	.39	.38	.33	.31	.41	.39	.39	.35	.55	.53

Unit Stress in Lower Layer of Reinforcement 16 000 Pounds per Square Inch

4	0.17	0.16	0.22	0.19	0.18	0.16	0.21	0.19	0.18	0.14	0.23	0.20	0.22	0.19	0.30	0.26
13	.18	.16	.21	.19	.18	.15	.21	.19	.18	.14	.22	.20	.21	.20	.27	.26
26	.17	.17	.21	.21	.18	.15	.20	.19	.18	.15	.21	.20	.21	.19	.27	.27
52	.18	.20	.21	.20	.18	.16	.21	.20	.17	.16	.21	.20	.22	.20	.27	.27
Average	.18	.17	.21	.20	.18	.16	.21	.19	.18	.15	.22	.20	.22	.20	.28	.27
Ratio $\frac{32\ 000}{16\ 000}$	1.83	1.76	1.90	1.95	1.78	1.81	1.86	2.00	1.83	2.06	1.86	1.95	1.77	1.75	1.96	1.96

(4) **Variation of Compressive Stress in Extreme Upper Fiber with "Effective" Percentage of Reinforcement.**—The data given in Table 26, columns 4, 10, 13, 16, 18 and 21, furnishes the basis for determining the relation between the unit compressive stress in the extreme upper fiber for maximum load, 16 000 pounds and 32 000 pounds per square inch in the lower layer of the reinforcement.

As has already been pointed out in explaining the preparation of Table 27, page 69, the unit deformation of the upper fiber could in but few cases be observed directly, and the values tabulated had therefore to be estimated from the upper fiber curves.

The average compressive-stress gross-deformation curves, Figs. 37 to 40, pages 111 to 114, are entered with the values of the unit compressive deformation, columns 4, 13, and 18, Table 26, and the corresponding unit compressive stress determined. This was plotted against the "effective" percentage of reinforcement, columns 10, 16, and 21, Table 26, in Figs. 18 to 21, pages 92 to 95.

An inspection of these figures will show that the group of points for each intensity of loading can be represented with sufficient accuracy by a straight line.

A summary of the unit compressive stress in the upper fiber for 0.5 and 1.6 per cent "effective reinforcement" and at a unit stress in the lower layer of reinforcement of 16 000 and 32 000 pounds has been made in the following table:

An inspection of this table will show the fallacy of the usual assumption, made in specifications, of the simultaneous occurrence of a unit compressive stress of 500 to 800 pounds per square inch in the upper fiber and a unit stress of 16 000 pounds in the reinforcement. A beam of cinder concrete with 0.5 per cent reinforcement and 4 to 13 weeks old is the only case which even approximates the assumed conditions. For all other aggregates and ages the unit stress in the upper fiber is from about two to four times as great as that assumed.

It should be noted, therefore, that if under actual conditions of loading a unit stress of 16 000 pounds is really developed in the reinforcement the stress in the upper fiber is at least 1000 pounds per square inch and in many cases is considerably greater.

Table 32.—Summary of unit Compressive Stress in the Upper Fiber of Beam for Stresses of 16 000 and 32 000 Pounds per Square Inch in Lower Fiber

Unit Stress in Lower Layer of Reinforcement 16 000 Pounds per Square Inch

Age, in Weeks	Granite		Gravel		Limestone		Cinders	
	0.5	1.5	0.5	1.6	0.5	1.6	0.5	1.6
4	1270	1775	1300	1760	1030	1500	730	1060
13	1300	1850	1210	1800	1050	1680	800	1240
26	1200	1830	1440	2025	1200	1700	925	1400
52	1420	1980	1470	2225	1120	1950	1050	1475

Unit Stress in Lower Layer of Reinforcement 32 000 Pounds Per Square Inch

4	1850	2520	1850	2630	1480	2030	1040	1550
13	1950	2850	1820	2880	1600	2550	1140	1870
26	1860	3000	1940	3300	1650	2670	1260	2110
52	1950	3250	2110	3500	1630	2950	1410	2300

(d) DISCUSSION OF PHOTOGRAPHS OF BEAMS.

As was described on page 21, the development of the cracks, which were visible on the surface of the concrete, was in a majority of cases traced at intervals throughout the test. At the age of 4 weeks, the development of cracks was traced for each of a set of three identical beams, and this method was also followed in some of the 13-week beams. Since all the beams tested at the age of 4 weeks failed in tension, those at succeeding ages were even more certain to fail in this way, and it was suspected that the change in the beam with age would be insufficient to cause much, if any, change in the time of appearance of the first crack, their development during the test, or their height at maximum load.

In order to save time on tests subsequent to those at the age of 4 weeks, without sacrificing any test data of importance, it was thought best to trace the cracks, at the end of the test, on two beams of a set, and to trace them at various loads throughout the test on the third beam.

Fig. 22.—Granite Concrete, Age 4 Weeks, Showing Variation in Position of Cracks with Variation in Percentage of Reinforcement

Fig. 23.—Limestone Concrete, Age 4 Weeks, Showing Variation in Position of Cracks with Variation in Percentage of Reinforcement

Fig. 24.—Gravel Concrete, Age 4 Weeks, Showing Variation in Position of Cracks with Variation in Percentage of Reinforcement

Fig. 25.—Cinder Concrete, Age 4 Weeks, Showing Variation in Position of Cracks with Variation in Percentage of Reinforcement

Fig. 26.—Granite Concrete, Showing Beams with 0.49 and 1.96 Percentages Reinforcement

Fig. 27.—Limestone Concrete, Showing Beams with 0.49 and 1.96 Percentages Reinforcement

Fig. 28.—Gravel Concrete, Showing Beams with 0.49 and 1.96 Percentages Reinforcement

Fig. 29.—Cinder Concrete, Showing Beams with 0.49 and 1.96 Percentages Reinforcement

Cinder concrete.
Age 4 weeks.
1.96% reinforcement.

Cinder concrete.
Age 13 weeks.
1.96% reinforcement.

Cinder concrete.
Age 26 weeks.
1.96% reinforcement.

Cinder concrete.
Age 52 weeks.
1.96% reinforcement.

Fig. 30.—Showing Similarity of Cracking in Similar Beams

The determination of the loads, at which cracks were traced, was based entirely on the rate at which cracks developed during the test. If the cracks showed an appreciable increase in height, the loads at which cracks were traced were taken closer together, while if their development was slow, the cracks were not traced for every load increment.

With low percentages of reinforcement, cracks developed so rapidly that in many cases the surface was examined after every 500-pound load increment was applied, while with the higher percentages the interval was sometimes as much as 2000 to 3000 pounds.

At that point of the beam at which for a given applied load the crack became invisible the magnitude of the load was marked. After the test was completed the cracks were outlined and the applied loads indicated with black paint showing the height of the crack during different stages of the test. The three identical beams for a given age were then piled one on top of another and the group photographed.

Representative photographs have been reproduced in Figs. 22 to 30.

An examination of these photographs will bring out the following facts:

1. The spacing of the cracks is independent of the kind of aggregate and the age of the concrete.
2. The spacing varies with the percentage of reinforcement, being about 7 inches for 0.5 per cent nominal reinforcement for all aggregates, and varies from about 3 inches for stone aggregates to $3\frac{1}{2}$ inches for cinders with 2 per cent nominal reinforcement.
3. While the difference is in all cases slight, the cracks seem to extend up higher with stone and gravel concrete than with cinder concrete. The cracks as a rule are approximately vertical, with the exception of those outside the load points, for a high percentage of reinforcement and with cinder concrete.
4. The fact that the first visible crack occurs at higher loads, as the percentage of reinforcement is increased, may be due either to the lowering of the neutral axis, as influencing the height of the cracks, or upon the larger number of cracks in a given length of beam, which for the same total deformation must cause the indi-

vidual cracks to be smaller than is the case for lower percentages of reinforcement.

5. For a nominal reinforcement of 0.5 per cent the applied load at first *visible* cracks varies from 3250 to 4000 pounds at the age of 4 weeks to 4000 to 5000 pounds at 52 weeks while with 2 per cent it varies from 6000 to 7000 pounds at 4 weeks.

2. COMPRESSION TESTS

While a large number of cylinders and cubes (333 of each) were tested and it was necessary to draw stress deformation curves for each cylinder in order to obtain the moduli and yield point which are reported in Tables 33 to 36, it was not deemed essential to reproduce them in this paper and only one log sheet is reproduced for each aggregate and age.

For the stone and gravel concrete there is little difference between the proportions by weight and by volume. This is due to the fact that the weight per cubic foot of the sand and of the stone differs but little from 100 pounds. The proportions by weight for the cinder concrete differs considerably from the proportions by volume, due to the low weight per cubic foot of the cinders.

The percentage of water given is obtained in the same way as already described (p. 18) and brings the concrete to medium consistency as there defined. The percentage of water required for the granite is about 8.3; limestone 10; gravel 9.5; and about 18.9 for the cinders.

The weight per cubic foot of the concrete as given in column 5, Tables 33-36, varies from about 148 to 149 pounds for granite, about 146 to 147 pounds for limestone, 143 to 144 pounds for gravel and 118 to 119 pounds for cinders. The weight per cubic foot of the 6-inch cubes as given in column 11 is much more erratic than that obtained for the cylinders although the average is not so very different. The stone and gravel concrete is seen to differ but little from 150 pounds per cubic foot, the weight usually assumed.

Column 5 contains the ultimate strength of the cylinders, while column 10 contains the ultimate strength of the cubes.

Two hundred thousand pounds was the capacity of the largest machine available at the time the 4, 13 and 26 week tests were made. The sectional area of an 8-inch cylinder is approximately

50 square inches, while a 6-inch cube is 36 square inches. Consequently all cylinders which would go above 4000 pounds per square inch, and all cubes stronger than about 5500 pounds per square inch could not be broken. This was the case with the 13 and 26 week granite cylinders and a few of the cubes, several of the 13 and 26 week limestone cylinders and all but one of the 13 and 26 week gravel cylinders. The quantity followed by an asterisk, in the columns for ultimate strengths, are not to be understood as being the ultimate compressive strength of the concrete but are obtained by dividing 200 000 pounds the capacity of the machine, by the actual sectional area of the test piece. It is thought, however, that the ultimate strength of the granite and gravel cylinders at 13 weeks differs but little from the values given in this table, as will be indicated later.

The average line of the last column of these tables contains the ratio of the ultimate strength of the cylinders to that of the cubes. Where both the cylinders and cubes broke, this ratio could be obtained directly from the data and is correct. For those cases in which the ultimate strength of all the cylinders in a given group exceeded the capacity of the machine, this ratio could not be obtained directly and the following method was used and is believed to give results which approximate the true values. These approximate values are shown diagrammatically in Figs. 31 and 32.

This method assumes that the quality of the concrete is the same in both cylinders and cubes and that therefore their ultimate strength for a given age is a function of their shape alone. If this is true, the ratio of the ultimate strength of the cylinders of two different aggregates should be the same as the ratio of the ultimate strengths of the cubes of the same aggregate.

This would mean that if we started with the known ratio of the ultimate strengths of the cubes, and multiplied by the ultimate strength of the cylinders that did break, the resulting product should be the ultimate strength of the cylinders that did not break. This is, of course, only an approximation and the result is necessarily in error, but the degree of accuracy may be judged by the uniformity with which the points thus obtained line up with those at 4 and 52 weeks, at which ages all the test pieces were broken,

Fig. 31.—Effect of Age on Compressive Strength of Six-Inch Cubes. (Age in Weeks)

Fig. 32.—Effect of Age on Compressive Strength of Eight-Inch Cylinders. (Age in Weeks)

and also by the fact that the ultimate strength could not be below 4000 pounds per square inch.

Column 7 contains the initial modulus of elasticity. These values were obtained by drawing a line, as already indicated, on the individual compression-stress gross-deformation curves obtained by plotting the data as given on page 140. The average of these values gives the average modulus of elasticity obtained by drawing a line on the compressive-stress gross-deformation curve constructed with the average unit gross deformation and the average unit compressive stresses for each age and aggregate.

Column 8 contains the yield point and was obtained from the individual curves as indicated.

The data summarized in these tables will enable a comparison to be made between individual values and will serve as a check on the uniformity of the tests. For the comparison of the different materials and the influence of age on the strength and elastic behavior of the concrete, average values can be used to greater advantage and lead to conclusions of more general application. Any investigation of concrete in compression should furnish data showing the influence of age on the strength and elasticity of concrete and the relative strengths of concrete of different aggregates. The following comparisons are made on the tests herein reported:

- (a) Influence of age on the ultimate strength of cubes and cylinders.
- (b) Effect of age on the initial modulus of elasticity.
- (c) Effect of age on yield point.
- (d) Ratio of ultimate strength of cylinders to that of cubes.
- (e) Ratio of the yield point to the ultimate strength.

(a) INFLUENCE OF AGE ON THE ULTIMATE STRENGTH OF CUBES AND CYLINDERS

Fig. 31, page 100, shows the influence of age on the ultimate strength of the cubes while Fig. 32 gives the same information for the cylinders.

Examining Figs. 31 and 32 the growth in strength of cinder concrete from 4 to 13 weeks is seen to be 19.4 per cent for the cubes, 34.7 per cent for the cylinders; from 4 to 26 weeks the increase is about 25.5 per cent for the cubes to 53.4 per cent for

the cylinders, while the cylinders increase 9.4 per cent from 26 to 52 weeks, and the cubes 15 per cent.

Similarly, limestone shows an increase from 4 to 13 weeks of 30 per cent for the cubes, and for the cylinders 44.5 per cent, while from 4 to 26 weeks the increase is 32.8 and 52 per cent, respectively. From 26 to 52 weeks the gain for the cylinders is 16 and for the cubes 9.8 per cent.

The granite cubes show an increase of 32.5 per cent from 4 to 13 weeks and 37.6 per cent from 4 to 26 weeks. The increase in the strength of the cylinders can not be determined exactly. Their ultimate strength at the age of 4 weeks was 3054 pounds, while at 13 and 26 weeks it exceeded 4000 pounds per square inch, the capacity of the testing machines. At 52 weeks the increase in the strength of the cylinders over that at 4 weeks was 73.4 per cent.

The gravel cubes showed an increase of 18.3 per cent from 4 to 13 weeks and 2.1 per cent from 13 to 26 weeks. The gravel cylinders at 4 weeks had an ultimate strength of 3175 pounds, and, as was the case for the granite, exceeded 4000 pounds at succeeding ages. The increase in strength at 52 weeks over that at 4 weeks was 65 per cent. What seems particularly noticeable in the above tests is the substantial and uniform increase in strength up to an age of 1 year, at which time it is still gaining strength. In general, it may be roughly stated that the concrete used in these tests increased 65 per cent in strength from an age of 4 weeks to that at the end of a year and that at that time was still increasing in strength.

(b) EFFECT OF AGE ON THE INITIAL MODULUS OF ELASTICITY

The influence of age on the initial modulus of elasticity is shown graphically in Fig. 33, page 105. The points plotted are the averages of the values in Tables 33 to 36.

An examination of this figure will show that the modulus of elasticity does vary with age as does the ultimate strength. Granite shows the smallest increase, the modulus at 26 weeks being but 5 per cent greater than that at 4 weeks, while cinders with the least ultimate strength show an increase of 32 per cent for the same ages and just about half as much at 13 weeks. Gravel

shows scarcely any increase from 4 to 13 weeks, but a substantial increase of 14 per cent from 4 to 26 weeks, while for limestone there is an increase of 6 per cent from 4 to 13 weeks and a 20 per cent increase at 26 weeks over the results at 4 weeks.

The actual values are in all cases, except the cinder concrete, fairly high and while it should be remembered that the concrete did not rest for any length of time under load before the micrometers were read (about one minute per 100 pounds per square inch), yet the moduli are not as high as would be the case if based on elastic rather than gross deformations.

(c) EFFECT OF AGE ON YIELD POINT

It has already been indicated that for stresses below the yield point the gross deformation curve for concrete in compression is sensibly a straight line. Even beyond this point many curves follow this line for a considerable distance, so that a constant modulus of elasticity can be assumed for these concretes up to a unit stress considerably in excess of the yield point. The following table shows the percentage variation of the average curves, Figs. 37, 38, 39 and 40, pages 111 to 114, from the straight line for an assumed unit stress 1.5 times the yield point.

Table 37.—Variation of the Average Deformation Curve for a Load 1.5 Times Yield Point

Age, in Weeks	Cinders		Granite		Gravel		Limestone	
	Load, lbs. per sq. in.	Variation, per cent.	Load, lbs. per sq. in.	Variation, per cent.	Load, lbs. per sq. in.	Variation, per cent.	Load, lbs. per sq. in.	Variation, per cent.
4	750	4.5	1350	5.3	1500	5.2	1050	5.3
13	750	4.5	1950	3.1	2250	3.1	2100	5.0
26	1350	5.2	1650	2.1	1800	3.0	1500	4.2
52	1350	3.7	2700	4.4	2250	3.2	2400	6.5
Average	....	4.0	....	3.7	....	3.6	....	5.4

An examination of the above percentages shows that, even for such high unit stresses, the percentage variation from a straight line is relatively small.

The variation with age, of the average yield point, as given in Tables 33 to 36, pages 129 to 136, is shown in Fig. 34, page 106. In

Fig. 33.—Effect of Age on the Initial Modulus of Elasticity of Concrete in Compression. (Age in Weeks)

Fig. 34.—Effect of Age on the Yield Point of Concrete in Compression. (Age in Weeks)

every case the yield point increases from 4 to 13 weeks and for the granite and cinder continues to increase up to 52 weeks. Although the modulus of elasticity of the gravel and limestone increases from 13 to 26 weeks, the yield point seems to decrease, indicating that while the initial part of the curve at 26 weeks is steeper than at 13 weeks yet it turns from the straight line at a lower unit stress. While no explanation of this behavior is suggested, the peculiarity is similarly illustrated in Figs. 37 to 40, pages 111 to 114. At the age of 52 weeks the yield point for these aggregates again show an increase.

As may be seen from Fig. 36 in only one instance, namely, the four-week tests on cinder concrete, does the range fall below 500 pounds per square inch. It would seem, therefore, that the assumption of a straight-line stress gross-deformation diagram for concrete in compression is permissible for all average concretes of the proportions and ages given and is certainly warranted for all the stone and gravel concretes herein reported. As will be shown in discussing the results of the tests on the reinforced beams, the fact that the concrete in many of the beams is stressed considerably above this point seems to exert little influence on the position of the neutral axis and consequently upon the resisting moment of all beams failing by the tension of the reinforcement, although it does determine the stress in the extreme fiber of the concrete.

(d) RATIO OF THE ULTIMATE STRENGTH OF THE CYLINDERS TO THE ULTIMATE STRENGTH OF THE CUBES

The ratio of the ultimate strength of the cylinders to that of the cubes is shown graphically in Fig. 35, page 108. The number of tests which were averaged for the point plotted is indicated by a number at each point. Where a different number of tests were averaged for both the cylinders and cubes, the numbers are written as a fraction—i. e., $\frac{21}{14}$. This would indicate that the ratio as plotted was obtained by dividing the average ultimate strength of 21 cylinders by that of 14 cubes.

It was explained on pages 99 and 100 that in a number of cases the ultimate load of the cylinders exceeded the capacity of the testing machine and that an attempt was made to approximate their ultimate strengths. These approximate ultimate strengths were used

Fig. 35.—Effect of Age on the Ratio of the Ultimate Strength of Cylinders and Cubes. (Age in Weeks.)

in obtaining the ratios for the points that are connected by dash lines on the diagram.

In every case the ratio increases considerably with age, the ultimate strength of the cylinder approaching that of the cubes at the age of 52 weeks.

(e) RATIO OF THE YIELD POINT TO THE ULTIMATE STRENGTH

Fig. 36, page 110, shows the ratio of the yield point to the ultimate strength for different ages, computed on approximate ultimate strengths as described on page 107. The erratic value for gravel concrete at the age of 13 weeks is due to the high value of the yield point as given in Fig. 36. The ultimate strength, Fig. 32, of the gravel at the age of 13 weeks compares favorably with that at 4 and 26 weeks, and with the strength of the other concretes, and there is no apparent reason why at this age such a high value should be obtained for the yield point.

Fig. 36 shows that the ratio of the yield point to the ultimate strength increases approximately between 4 and 52 weeks, from 0.30 to 0.40.

(f) AVERAGE STRESS-GROSS DEFORMATION CURVES

Since general relations can be brought out much more clearly by the comparison of average curves than by the inspection of a large number of individual curves, Figs. 37, 38, 39, and 40 were prepared. In each case the average unit stress of the cylinders is plotted against the corresponding average unit gross deformation.

The values plotted, which are the averages for 21 cylinders for each age and aggregate, were obtained from the log sheets for the individual cylinders. Since there is considerable difference in the ultimate strength of supposedly identical test pieces, the compressometer for measuring the compression was necessarily removed from some test pieces earlier than others. Since the upper limit of the curve is determined by the lowest unit stress at which the compressometer is removed in a given set of 21 cylinders, the last point in several cases is considerably below the average ultimate strength. In several cases points, which are the averages of less than 21 tests, have been plotted, but in many cases after several test pieces have dropped out, the curve beyond this point does not line up with that below. In every case the curve

Fig. 36.—Effect of Age on the Ratio of the Yield Point in Pounds per Square Inch to the Ultimate Strength. (Age in Weeks)

Fig. 37.—Average Compressive Stress Gross Deformation Curve for Granite Concrete

Fig. 38.—Average Compressive Stress Gross Deformation Curves for Limestone Concrete

Fig. 39.—Average Compressive Stress Gross Deformation Curves for Gravel Concrete

Fig. 40.—Average Compressive Stress-Deformation Curves for Cinder Concrete

itself has been drawn up to the last point only for which 21 tests have been averaged. The values from the log sheet of one representative cylinder for each age and aggregate are given in Appendix I.

The increase in slope of the line of initial coefficient of elasticity with age is very clearly brought out by these figures, and it is believed that they show very representative curves for the aggregates used.

VII. CONCLUSIONS

1. REINFORCED CONCRETE IN FLEXURE

From a study of the behavior of the reinforced concrete beams herein reported the following conclusions may be stated:

(a) CONDITIONS AT FIRST CRACK

(1) The unit elongation of the extreme lower fiber at the time of the occurrence of the first crack is 0.00012, for stone and gravel concrete, 0.00018 for cinder concrete, and equals the unit elongation of the lower fiber at rupture of a beam of the same concrete without reinforcement.

(2) The unit elongation of the extreme lower fiber at time of the occurrence of the first visible crack increases with the percentage of reinforcement.

(3) The distance between cracks due to tension varies with the percentage of the reinforcement, slightly with the kind of aggregate, and is independent of the age of the concrete.

(b) STRESS IN REINFORCEMENT AT MAXIMUM LOAD

(1) The ratio of the unit stress in the reinforcement at maximum load to the yield point varies with the percentage of the reinforcement, is independent of the age of the concrete, and shows no regular variation with the initial modulus of elasticity of the concrete.

(c) BOND STRESS IN REINFORCEMENT

(1) The unit bond stress at a load just below maximum, for a unit stress in the reinforcement somewhat less than the yield point, is almost constant and equal to about 120 pounds per square inch.

It increases slightly as the percentage of the reinforcement increases, increases somewhat with age, and with the strength of the concrete.

(d) RESISTING AND BENDING MOMENT

(1) Basing the resisting moment of a reinforced concrete beam on the tensile stress in the reinforcement, and neglecting the tensile resistance of the concrete, the ratio of the resisting moment to the bending moment is always less than 1 between 0.5 per cent and 1.7 per cent "effective" reinforcement. This ratio is independent of the kind of aggregate used, decreases with age, and increases with the percentage of reinforcement.

(e) EFFECTIVE PERCENTAGE OF REINFORCEMENT

(1) The behavior of a reinforced concrete beam, having the reinforcement in two horizontal planes is identical with a beam having all the reinforcement concentrated in one plane, and equal in amount to the reinforcement in the lower plane plus that in the upper plane multiplied by the ratio of the distances of the upper and lower planes from the neutral axis.

(f) VARIATION OF THE POSITION OF THE NEUTRAL AXIS

(1) **With effective percentage of reinforcement.**—The percentage depth of the neutral axis below the top of the beam increases with the percentage of reinforcement and increases or decreases with different amounts of reinforcement as the intensity of loading increases, depending upon the ultimate strength of the concrete as influencing a compression failure, and the relative stiffness of the concrete for varying degrees of stress as determined by the character of the stress deformation diagram of the cylinders (fixed by the proportions, consistency, kind, and age of concrete).

(2) **With age of concrete.**—For all practical purposes the percentage depth to the neutral axis for a given unit stress in the reinforcement may be taken as independent of the age of the concrete.

(3) **With modulus of elasticity of concrete.**—The character of the concrete as measured by its modulus of elasticity exerts an influence on the position of the neutral axis.

(g) VARIATION OF $\frac{M}{bd^2}$

(1) **With effective percentage of reinforcement.**—For any given percentage of effective reinforcement the moment of resistance varies as the ordinates of a straight line, and based on the moment

of resistance of a plain concrete beam the moment of resistance for a reinforced concrete beam is proportional to the effective percentage of reinforcement.

(2) **With character of concrete.**—The moment of resistance is appreciably affected by the character of the aggregate used and the age of the concrete.

(h) **VARIATION OF THE DEFLECTION AT CENTER OF SPAN**

(1) **With effective percentage of reinforcement and character of concrete.**—For a given unit stress in the reinforcement the deflection increases with the percentage of “effective” reinforcement and increases as the modulus of elasticity and ultimate strength of the concrete decreases.

(2) **With unit stress in the reinforcement.**—The deflection of a reinforced concrete beam increases in direct proportion to the increase in the unit stress in the reinforcement.

(i) **VARIATION OF THE UNIT COMPRESSIVE STRESS IN THE EXTREME UPPER FIBER**

(1) **With the effective percentage of reinforcement.**—The unit compressive stress in the extreme upper fiber varies with the percentage of effective reinforcement as the ordinates to a straight line.

(2) **With a given unit stress in the reinforcement.**—Excepting cinder concrete for the earlier ages and low percentages of effective reinforcement, the unit stress of 16 000 pounds per square inch in the reinforcement corresponds to a unit compressive stress in the extreme upper fiber of at least 1000 pounds per square inch.

2. CONCRETE IN COMPRESSION

The conclusions as to the general effect of age on the various elements (ultimate strength, initial modulus of elasticity, and yield point) that determine the value of a given concrete are probably of fairly general application.

(a) **COMPARISON OF AGGREGATES**

It should be recognized that the results obtained for each class of material—i. e., granites, limestones, gravels, etc.—used in these tests may not be applicable to other materials of the same class obtained from a different source. There are too many elements affecting the strength of concrete to warrant the assertion

that because an individual of a class—i. e., granite—gives excellent results, that therefore all granites will give equally good results. The gravel used in these tests had smooth round surfaces but developed a compressive strength but little inferior to that of the granite, and appreciably greater than that of the limestone. Yet it can not be stated that the use of any given gravel for concrete is permissible, because this particular sample, which originated from a hard flinty rock and is well graded, gives excellent results. A gravel deposit will necessarily partake of the physical properties of the rock from which it is derived and no good results can be hoped for by the use of a gravel which originated from a soft chalky limestone or from some weak cleavable shale or sandstone. The compressive strength of the stone affects the compressive strength of the concrete in which it is used in too great a degree to warrant the neglect of the consideration of this influence, while even for the same stone, the strength of the concrete will be greatly influenced by the uniformity or nonuniformity of the grading.

Again for equally good grading, the material which grades down from the larger particles will nearly always show the greater strength. The effect of a large amount of dust in decreasing the strength of the concrete should not be overlooked. It must be recognized that the quality of the sand used in making the concrete—i. e., its hardness, size, and grading, the presence of a large amount of very fine material—are all elements which will modify conclusions as to the excellence of a given stone or gravel.

From a consideration of the above facts it is always advisable to make careful investigation of the materials available, even though the costs of tests seem excessive.

(b) WEIGHT PER CUBIC FOOT OF CONCRETE

The weight per cubic foot for a 1:2:4 stone and gravel concrete may be taken as 150 pounds and a cinder concrete 120 pounds.

(c) ULTIMATE STRENGTH OF CONCRETES AT 4 WEEKS

The ultimate strength of 2000 pounds per square inch for a 1:2:4 concrete at the age of 4 weeks, frequently the basis for unit stresses, was exceeded by almost 50 per cent for the granite and gravel and by 25 per cent for the limestone concrete, but the

value found was 20 per cent less than 2000 pounds per square inch for the cinder concrete.

(d) EFFECT OF AGE ON ULTIMATE STRENGTH

The ultimate compressive strength of concrete shows a substantial increase from an age of 4 to one of 52 weeks, the strength at 4 weeks being about 65 per cent of that at 52 weeks.

(e) POSITION OF THE YIELD POINT

The yield point at the age of 4 weeks averages about 0.30 the ultimate strength and for stone and gravel concretes is well above 500 pounds per square inch, but for cinders is somewhat less. The yield point shows a substantial increase with age.

(f) COMPRESSIVE STRESS GROSS DEFORMATION DIAGRAM

The compressive stress, gross deformation diagram of concrete may be represented by a straight line up to a unit stress 1.5 times the yield point with a maximum error of about 6.5 per cent. A working formula for reinforced concrete in flexure, based on a constant stress deformation diagram for concrete in compression, will therefore give correct results up to an extreme unit fiber stress of 0.30, the ultimate strength. This would correspond to a factor of safety of about 3 and for a unit fiber stress 50 per cent greater the error will not exceed 7 per cent.

(g) INITIAL MODULUS OF ELASTICITY

The initial modulus of elasticity at the age of 4 weeks exceeds 2 500 000, the amount usually specified, by about 85 per cent for gravel, 70 per cent for granite, and 45 per cent for limestone concrete but is 35 per cent less for cinder concrete. The increase in stiffness with age as measured by the modulus of elasticity while marked is not nearly so great as the increase in strength.

(h) ULTIMATE STRENGTH OF CONCRETE

The ultimate strength of concrete in compression as given by the cylinder test is always less than that given by the cube test, the ratio being about 75 per cent at the age of 4 weeks, and showing a substantial increase with age due to the greater percentage increase of strength for the cylinders.

3. REINFORCEMENT

A study of the 1260 tests of the steel (Table 4) used as reinforcement for the beams herein recorded shows that—

(a) For even practically identical ultimate strengths there is considerable variation in the percentage of elongation and reduction of area.

(b) The yield point bears no relation to the ultimate strength.

WASHINGTON, JUNE 27, 1911.

Table 4.—Average Results of Tests on Reinforcement. One-half Inch Round Bars.

CINDER AGGREGATE

AGE OF BEAM, 4 WEEKS

Reinforcement used in Beam No.	No. of Bars	Elastic Limit (by Dividers)	Yield Point (Drop of Beam)	Maximum Unit Stress	Breaking Strength	Percentage Elongation in 8 Inches	Percentage Reduction in Area
417	2	36 960	36 960	54 630	37 520	30.3	70.4
418	2	37 070	37 720	57 920	35 730	28.5	68.0
419	2	37 070	37 390	53 080	37 520	29.5	70.8
429	3	39 710	39 090	57 950	39 970	29.3	68.2
430	3	39 030	40 490	58 010	38 690	28.1	67.8
431	3	39 530	41 300	57 420	37 340	30.5	67.2
441	4	39 200	40 520	57 400	37 970	29.1	67.2
442	4	39 610	41 840	57 840	38 750	27.8	68.1
443	4	39 750	41 150	59 350	39 460	28.0	64.5
453	5	37 330	40 330	56 000	38 040	28.9	69.8
454	5	36 910	38 210	56 130	37 880	28.4	66.1
455	5	37 520	39 750	55 000	35 660	29.5	69.1
465	6	35 620	36 980	53 430	36 800	29.8	69.4
466	6	35 500	37 870	54 300	37 780	29.0	68.6
467	6	35 470	37 350	56 440	38 400	30.0	69.4
477	7	33 880	36 730	57 050	38.970	28.0	67.8
478	7	33 180	35 790	53 690	35 810	29.5	69.1
479	7	33 690	37 620	53 560	37 860	30.4	69.8
489	8	36 030	38 020	54 810	37 050	29.2	69.5
490	8	35 910	37 690	54 580	36 970	28.8	71.0
491	8	35 680	37 950	55 420	38 550	30.2	69.4

AGE OF BEAM, 13 WEEKS

420	2	37 750	38 400	55 850	37 670	28.8	69.8
421	2	37 440	39 200	61 130	44 090	27.5	59.7
422	2	37 020	40 010	57 810	37 650	28.5	66.3
432	3	39 020	39 860	55 460	36 380	29.8	68.2
433	3	38 620	39 550	57 810	36 990	29.3	69.1
434	3	39 300	40 520	58 140	36 650	29.0	65.2
444	4	39 220	39 900	56 550	38 340	32.3	67.8
445	4	38 220	39 780	56 640	36 420	29.9	67.8
446	4	39 490	41 670	57 810	37 180	28.9	68.5
456	5	37 320	38 780	52 840	36 420	30.7	70.0
457	5	37 180	38 000	54 150	35 750	29.3	70.4
458	5	37 650	40 810	56 770	39 490	29.3	67.4
468	6	35 660	38 010	55 280	39 590	30.1	67.8
469	6	35 380	37 970	52 710	36 270	31.9	69.9
470	6	35 380	37 630	54 630	37 390	30.6	69.8
480	7	34 180	36 110	53 260	35 700	30.7	66.1
481	7	34 240	36 260	54 610	37 640	31.3	69.1
482	7	33 810	36 980	56 450	40 120	29.6	69.1
492	8	36 060	37 210	54 260	37 330	30.9	70.3
493	8	35 580	38 190	56 740	37 450	29.5	67.2
494	8	35 710	36 440	53 120	36 680	29.9	71.1

Table 4.—Average Results of Tests on Reinforcement. One-half Inch Round Bars—Continued

CINDER AGGREGATE—Continued

AGE OF BEAM, 26 WEEKS

Reinforce- ment used in Beam No.	No. of Bars	Elastic Limit (by Dividers)	Yield Point (Drop of Beam)	Maximum Unit Stress	Breaking Strength	Percentage Elongation in 8 Inches	Percentage Reduction in Area
423	2	37 440	38 220	55 900	37 040	30.0	69.8
424	2	37 220	38 770	53 560	34 600	30.3	70.2
425	2	37 920	39 680	56 100	36 660	28.5	69.6
435	3	39 740	40 230	55 510	35 650	29.0	68.6
436	3	38 990	40 450	57 260	37 480	29.5	66.8
437	3	39 630	40 480	59 580	40 000	29.0	65.3
447	4	39 270	41 350	57 340	38 260	28.7	67.4
448	4	39 240	40 850	56 970	44 630	28.5	67.2
449	4	38 970	39 740	56 860	38 550	29.1	67.7
459	5	36 960	38 950	54 280	36 830	28.7	70.2
460	5	37 590	39 050	57 100	47 430	29.4	68.7
461	5	35 970	36 880	53 890	36 730	30.7	69.0
471	6	34 980	38 100	54 630	38 010	30.1	70.2
472	6	35 160	36 800	54 340	36 420	30.5	70.4
473	6	35 650	37 940	54 770	38 380	29.0	68.7
483	7	33 800	35 920	54 080	35 910	30.2	70.3
484	7	34 160	36 460	54 030	37 330	28.8	70.3
485	7	33 930	36 880	52 340	36 370	30.7	69.0
495	8	35 530	37 140	54 660	38 470	30.4	70.5
496	8	35 520	36 790	53 500	35 510	31.4	71.7
497	8	36 600	37 820	54 730	39 250	30.3	70.2

AGE OF BEAM, 52 WEEKS

426	2	37 160	38 890	56 200	37 090	31.5	69.9
427	2	36 720	38 480	54 030	35 930	30.8	69.7
428	2	38 290	37 760	55 730	36 220	31.5	71.4
438	3	39 230	40 290	58 190	36 740	28.3	66.0
439	3	39 860	40 850	56 300	37 870	31.2	70.7
440	3	39 410	41 040	56 690	36 140	29.2	68.8
450	4	40 520	41 630	58 350	38 040	29.6	66.8
451	4	39 690	41 050	59 750	40 030	29.9	67.5
452	4	39 590	40 610	58 600	38 190	28.4	65.7
462	5	35 930	37 420	54 720	36 240	29.2	70.7
463	5	35 570	37 460	55 200	36 810	30.0	70.0
464	5	35 760	38 800	55 390	36 590	28.4	70.0
474	6	33 120	36 710	60 390	40 120	28.4	64.5
475	6	34 300	38 770	56 800	37 830	30.6	67.7
476	6	34 620	37 400	56 100	38 860	31.0	69.2
486	7	34 080	37 620	53 660	37 020	30.3	68.9
487	7	34 150	37 230	53 160	37 120	30.9	70.2
488	7	34 220	37 230	53 010	34 670	31.3	71.1
498	8	35 940	37 760	54 980	36 880	30.1	69.4
499	8	36 530	38 620	54 880	38 070	29.0	70.0
500	8	35 750	37 760	55 100	36 770	29.1	68.4

Table 4.—Average Results of Tests on Reinforcement. One-Half Inch Round Bars—Continued

GRANITE AGGREGATE

AGE OF BEAM, 4 WEEKS

Reinforcement used in Beam No.	No. of Bars	Elastic Limit (by Dividers)	Yield Point (Drop of Beam)	Maximum Unit Stress	Breaking Strength	Percentage Elongation in 8 Inches	Percentage Reduction in Area
162	2	40 230	42 610	60 010	40 340	27.9	61.1
163	2	39 180	42 560	56 930	39 590	28.8	67.6
164	2	39 760	42 300	57 370	37 270	28.5	69.5
174	3	38 870	42 150	56 530	37 740	28.4	67.9
175	3	39 490	42 130	55 670	34 410	29.6	67.7
176	3	39 530	42 780	56 870	35 960	28.6	69.4
186	4	39 360	42 840	58 160	39 970	28.0	64.9
187	4	39 960	42 540	57 760	36 890	28.8	69.2
188	4	39 850	43 750	57 980	38 390	28.7	66.0
198	5	39 460	42 180	56 550	35 910	29.3	66.2
199	5	39 650	42 210	58 070	40 500	28.1	67.5
200	5	39 190	43 020	58 780	40 930	28.4	65.3
210	6	39 640	42 220	59 130	41 460	29.7	66.0
211	6	(1)					
212	6	(1)					
222	7	39 660	42 100	58 640	41 140	28.7	63.3
223	7	39 330	42 020	57 430	38 660	29.8	68.3
224	7	39 450	42 300	59 220	40 580	29.5	66.1
237	8	37 240	41 650	54 870	33 900	29.9	68.5
238	8	37 260	41 720	55 480	36 780	29.4	68.9
239	8	37 560	42 200	56 790	37 330	29.3	66.9

AGE OF BEAM, 13 WEEKS

165	2	39 460	42 230	56 020	37 400	28.2	70.8
166	2	39 180	42 200	57 740	41 420	29.4	67.3
167	2	39 350	41 910	56 330	37 160	29.4	69.6
177	3	39 520	41 940	58 430	37 900	29.9	65.6
178	3	38 900	43 390	55 860	41 110	29.8	69.9
179	3	39 580	43 470	58 150	37 860	28.1	66.8
189	4	38 920	41 960	56 040	35 940	30.0	70.7
190	4	39 680	42 480	58 910	39 010	28.9	66.8
191	4	39 440	40 670	58 780	43 150	27.6	63.5
201	5	39 680	40 920	60 530	42 320	28.8	63.4
202	5	39 820	41 460	60 140	44 730	28.5	61.6
203	5	39 820	40 410	59 760	42 390	29.5	64.0
213	6	39 840	41 460	59 010	40 860	29.5	65.3
214	6	39 970	41 230	58 780	44 260	30.4	64.2
215	6	39 310	41 080	56 630	37 620	29.9	65.4
225	7	38 920	41 180	61 650	45 820	28.2	61.1
226	7	39 290	42 110	60 200	46 050	28.1	64.5
227	7	39 120	40 750	60 520	42 200	29.8	63.5
243	8	37 580	41 790	57 740	38 400	29.2	67.7
244	8	37 480	41 780	56 860	37 240	28.9	67.9
245	8	37 300	41 400	55 470	36 040	29.8	67.4

¹ Tags of steel numbers mixed. The average elastic limit in these two beams was 39 000 to 40 000.

Table 4.—Average Results of Tests on Reinforcement. One-Half Inch Round Bars—Continued

GRANITE AGGREGATE—Continued

AGE OF BEAM, 26 WEEKS

Reinforce- ment used in Beam No.	No. of Bars	Elastic Limit (by Dividers)	Yield Point (Drop of Beam)	Maximum Unit Stress	Breaking Strength	Percentage Elongation in 8 Inches	Percentage Reduction in Area
168	2	39 290	43 160	59 560	43 730	26.9	56.9
169	2	39 700	42 810	57 620	39 330	29.4	69.8
170	2	39 460	42 520	60 080	40 650	26.6	65.1
180	3	39 750	42 700	56 920	38 390	29.2	68.3
181	3	39 300	41 320	56 860	43 320	28.4	68.9
182	3	39 480	43 730	58 650	43 750	27.0	65.7
192	4	40 320	42 570	59 440	41 440	28.5	66.4
193	4	38 670	41 350	56 720	35 810	30.2	69.1
194	4	39 420	42 800	59 460	38 680	29.1	66.7
204	5	39 840	41 380	61 510	46 450	27.8	63.2
205	5	39 720	42 700	64 040	49 830	26.7	60.4
206	5	39 630	41 340	61 420	49 420	28.5	61.2
216	6	40 000	41 680	59 020	44 340	28.8	65.3
217	6	39 450	41 930	59 690	40 500	29.0	66.1
218	6	39 190	41 420	58 350	42 380	28.7	66.6
231	7	37 040	40 960	55 740	36 620	28.5	69.0
232	7	37 990	40 450	55 330	38 110	29.0	67.3
233	7	37 230	40 610	55 370	40 850	29.7	67.9
240	8	37 880	42 170	56 190	37 620	28.9	68.9
241	8	37 070	40 760	55 270	36 700	29.5	69.3
242	8	37 430	42 400	55 950	37 420	29.6	69.1

AGE OF BEAM, 52 WEEKS

171	2	38 640	42 480	57 360	38 290	28.1	67.2
172	2	39 430	42 480	57 690	36 820	28.1	68.1
173	2	38 900	42 760	56 800	39 190	30.3	68.0
183	3	39 420	43 000	57 670	37 150	28.4	66.8
184	3	39 850	42 190	58 040	38 440	29.5	68.9
185	3	39 760	40 910	54 300	36 920	30.0	68.9
195	4	39 350	42 560	57 790	39 660	29.0	67.5
196	4	38 530	42 170	57 590	40 370	29.0	68.2
197	4	38 890	42 230	56 230	36 800	29.2	69.0
207	5	39 460	41 040	59 710	39 720	28.5	65.4
208	5	39 210	41 910	56 890	40 320	28.6	67.7
209	5	39 290	42 090	58 500	39 980	29.0	67.2
219	6	39 470	41 800	59 540	40 480	30.0	65.3
220	6	39 380	41 360	59 130	41 520	29.3	64.4
221	6	39 440	42 900	58 030	36 920	28.5	68.4
228	7	37 040	40 950	56 800	39 020	29.5	68.1
229	7	37 310	40 610	54 370	36 890	29.5	69.6
230	7	37 260	40 430	55 100	38 390	29.0	67.1
234	8	37 370	41 460	56 480	38 300	29.2	67.5
235	8	37 790	42 440	56 340	36 400	29.1	68.4
236	8	37 670	41 730	55 210	35 850	29.9	68.8

Table 4.—Average Results of Tests on Reinforcement One-half Inch Round Bars—Continued

GRAVEL AGGREGATE

AGE OF BEAM, 4 WEEKS

Reinforcement used in Beam No.	No. of Bars	Elastic Limit (by Dividers)	Yield Point (Drop of Beam)	Maximum Unit Stress	Breaking Strength	Percentage Elongation in 8 Inches	Percentage Reduction in Area
333	2	40 990	43 500	60 380	40 020	29.1	64.2
334	2	41 090	41 910	59 460	41 970	27.5	64.0
335	2	41 730	44 930	71 330	61 850	25.1	57.9
345	3	41 440	41 440	61 150	41 990	28.8	65.7
346	3	41 160	43 640	59 770	40 940	26.7	63.8
347	3	41 200	43 760	58 660	36 640	29.6	68.5
357	4	41 000	43 460	63 880	49 020	26.3	65.0
358	4	41 380	42 410	57 150	38 310	29.6	65.8
359	4	40 910	41 930	75 150	61 820	24.6	55.1
369	5	39 040	40 270	59 520	41 910	27.4	66.6
370	5	39 320	39 930	56 640	39 010	28.0	65.3
371	5	39 540	39 540	56 630	39 300	28.6	65.5
381	6	37 300	38 010	55 510	40 310	29.9	69.9
382	6	37 410	38 570	56 060	39 160	29.1	68.7
383	6	37 600	39 170	54 900	38 410	29.6	69.3
393	7	38 170	39 680	56 570	38 240	29.8	66.6
394	7	37 800	39 120	55 630	40 140	30.0	68.5
395	7	37 790	40 030	54 210	36 120	29.4	69.4
405	8	37 370	38 360	55 560	38 590	29.2	69.0
406	8	37 530	38 680	57 060	37 940	28.9	68.9
407	8	37 530	38 590	55 590	38 390	29.1	68.5

AGE OF BEAM, 13 WEEKS

336	2	40 860	42 590	59 390	39 030	28.9	64.3
337	2	40 570	41 530	61 150	46 120	26.9	65.5
338	2	41 170	42 370	60 300	44 140	28.8	63.6
348	3	40 650	42 010	57 510	39 660	28.0	68.1
349	3	40 120	41 330	56 870	37 920	29.2	67.9
350	3	41 250	43 390	59 760	40 500	26.6	64.2
360	4	41 080	43 310	60 350	46 490	28.7	65.4
361	4	39 520	39 830	57 540	37 230	29.3	68.0
362	4	39 050	40 040	57 930	38 840	29.3	66.2
372	5	39 090	39 510	56 680	38 280	28.9	68.6
373	5	39 460	39 900	57 640	43 030	28.4	67.5
374	5	38 920	39 830	57 710	38 620	29.4	67.7
384	6	37 270	37 950	56 160	37 650	29.0	67.4
385	6	37 280*	37 470	55 230	39 160	30.6	69.9
386	6	37 330	38 050	56 190	38 710	29.8	69.0
396	7	37 420	38 080	55 450	37 590	29.9	69.7
397	7	37 820	41 020	57 420	42 160	28.8	68.8
398	7	37 820	38 920	57 910	40 590	29.4	67.7
408	8	37 400	38 940	55 960	37 610	29.1	66.8
409	8	37 590	38 630	55 660	37 490	29.0	66.4
410	8	37 240	38 110	55 780	37 420	29.8	67.6

Table 4.—Average Results of Tests on Reinforcement. One-half Inch Round Bars—Continued

GRAVEL AGGREGATE—Continued

AGE OF BEAM, 26 WEEKS

Reinforcement used in Beam No.	No. of Bars	Elastic Limit (by Dividers)	Yield Point (Drop of Beam)	Maximum Unit Stress	Breaking Strength	Percentage Elongation in 8 Inches	Percentage Reduction in Area
339	2	42 160	42 160	62 510	48 650	26.9	57.8
340	2	41 530	45 220	71 680	63 720	21.9	45.9
341	2	40 700	40 700	58 350	40 560	31.6	66.3
351	3	41 120	42 110	60 100	41 810	29.0	63.4
352	3	41 360	43 960	64 690	55 330	24.5	60.5
353	3	40 990	43 140	58 880	45 470	30.0	67.5
363	4	39 280	39 400	56 830	39 140	28.3	68.3
364	4	39 400	40 310	58 440	43 720	28.3	66.0
365	4	39 230	39 680	57 790	41 560	28.6	68.7
375	5	39 090	39 850	57 840	39 030	28.0	68.3
376	5	39 000	39 660	57 840	40 590	28.9	67.9
377	5	38 960	39 680	57 430	41 050	28.0	68.4
387	6	37 100	38 400	56 010	38 030	29.1	69.2
388	6	37 340	38 120	57 670	38 830	28.2	68.0
389	6	37 390	38 540	55 820	38 930	29.4	67.9
399	7	37 460	39 050	55 790	39 180	28.8	67.9
400	7	37 120	38 250	57 750	38 700	30.0	68.7
401	7	37 740	38 740	55 990	41 190	29.4	67.7
411	8	37 630	38 120	55 620	36 550	30.1	68.4
412	8	37 290	38 240	55 580	36 740	29.2	69.1
413	8	37 420	38 620	56 080	36 890	28.7	68.1

AGE OF BEAM, 52 WEEKS

342	2	41 380	43 870	61 610	47 400	26.9	59.4
343	2	41 130	42 520	62 180	52 480	26.9	61.0
344	2	42 840	46 030	69 800	54 780	25.0	56.5
354	3	42 030	44 280	67 050	55 600	25.9	59.3
355	3	41 180	42 980	59 810	39 700	29.2	65.2
356	3	41 080	42 880	59 260	57 600	28.1	66.1
366	4	39 320	40 480	58 850	40 130	28.4	66.7
367	4	39 170	40 030	59 200	40 440	29.1	67.5
368	4	39 220	39 810	56 790	38 200	29.1	67.5
378	5	37 610	38 090	56 280	39 240	30.4	68.6
379	5	37 220	37 850	56 260	39 550	28.4	67.9
380	5	37 300	38 180	55 810	40 710	28.6	68.9
390	6	37 560	39 330	55 670	40 720	29.2	67.9
391	6	37 310	38 050	55 360	41 490	29.2	68.9
392	6	37 240	38 510	56 350	40 040	29.1	68.8
402	7	37 890	38 580	54 560	38 640	28.8	68.9
403	7	38 300	38 910	56 100	53 800	29.7	69.2
404	7	37 620	38 970	57 120	38 300	28.5	68.0
414	8	37 460	38 670	55 810	37 090	29.4	69.9
415	8	37 080	38 320	55 350	36 680	29.6	69.9
416	8	37 560	38 940	53 570	37 010	30.6	68.5

Table 4.—Average Results of Tests on Reinforcement. One-Half Inch Round Bars—Continued

LIMESTONE AGGREGATE

AGE OF BEAM, 4 WEEKS

Reinforce- ment used in Beam No.	No. of Bars	Elastic Limit (by Dividers)	Yield Point (Drop of Beam)	Maximum Unit Stress	Breaking Strength	Percentage Elongation in 8 Inches	Percentage Reduction in Area
255	2	37 770	42 350	55 920	35 030	30.3	68.1
256	2	38 120	41 200	59 300	40 490	29.7	65.7
257	2	37 320	41 410	53 590	31 470	30.0	70.6
261	3	37 530	40 720	55 260	33 940	28.7	70.5
262	3	37 780	41 080	56 190	34 140	29.0	70.9
263	3	36 810	41 330	56 750	35 770	30.2	67.0
273	4	37 570	40 720	61 020	45 640	28.2	63.3
274	4	37 720	40 280	57 970	41 570	29.4	62.8
275	4	37 550	41 370	59 360	39 790	28.9	62.9
285	5	38 200	42 550	58 900	41 520	29.3	66.0
286	5	37 790	41 850	55 540	35 570	30.5	68.8
287	5	37 350	41 030	59 360	42 210	28.6	65.4
297	6	35 450	40 330	54 490	38 060	27.2	68.5
298	6	35 870	40 790	55 620	37 390	30.0	68.7
299	6	35 850	40 660	54 780	36 030	30.9	69.3
318	7	35 690	42 620	62 560	48 830	27.7	63.9
319	7	35 570	39 740	55 560	39 530	30.1	64.9
320	7	35 760	40 900	55 460	38 030	29.7	68.2
321	8	35 900	39 210	55 270	39 150	29.5	68.2
322	8	35 920	37 140	53 680	38 550	30.1	68.8
323	8	35 790	37 760	55 370	38 770	28.8	68.7

AGE OF BEAM, 13 WEEKS

249	2	36 970	41 800	57 140	39 480	27.6	70.9
250	2	37 620	41 350	56 260	37 890	27.9	69.9
251	2	37 800	40 740	60 690	43 240	30.0	63.9
264	3	37 760	42 980	57 870	36 000	29.8	67.7
265	3	37 590	42 160	60 200	43 280	28.9	64.6
266	3	37 350	40 040	59 080	41 840	27.5	64.2
276	4	37 310	41 500	57 240	40 930	28.9	66.9
277	4	37 240	42 020	58 670	44 440	29.1	67.2
278	4	37 520	40 540	58 930	40 340	29.3	66.1
288	5	35 710	40 000	54 920	37 000	30.3	69.3
289	5	35 970	40 150	58 200	42 180	28.9	66.7
290	5	35 330	40 280	53 660	37 610	30.5	67.5
300	6	35 840	40 050	53 940	37 030	29.1	68.1
301	6	35 580	40 740	54 640	36 460	29.2	70.3
302	6	35 510	40 570	56 160	38 250	30.3	68.7
312	7	35 230	41 120	56 670	37 790	29.8	68.6
313	7	35 970	40 070	58 430	42 510	29.3	68.1
314	7	36 440	40 440	56 420	38 070	30.6	67.9
324	8	35 900	37 250	54 170	37 600	30.6	68.7
325	8	35 760	37 730	55 950	38 520	28.8	70.2
326	8	35 710	36 830	54 310	37 940	30.4	69.5

Table 4.—Average Results of Tests on Reinforcement. One-Half Inch Round Bars—Continued

LIMESTONE AGGREGATE—Continued

AGE OF BEAM, 26 WEEKS

Reinforcement used in Beam No.	No. of Bars	Elastic Limit (by Dividers)	Yield Point (Drop of Beam)	Maximum Unit Stress	Breaking Strength	Percentage Elongation in 8 Inches	Percentage Reduction in Area
252	2	37 560	40 750	53 140	34 680	29.4	73.4
253	2	37 450	41 650	56 020	36 140	31.3	70.1
254	2	37 830	40 290	57 620	41 020	30.7	68.2
267	3	37 270	40 680	56 480	37 750	26.9	66.6
268	3	37 580	40 750	58 940	42 460	28.3	63.6
269	3	37 310	40 710	53 090	36 350	29.2	71.4
279	4	37 250	41 040	58 230	41 320	29.7	65.1
280	4	38 130	40 990	58 140	37 360	31.6	67.4
281	4	37 530	41 090	58 890	42 650	30.3	65.6
291	5	35 840	39 800	53 780	37 110	29.5	66.9
292	5	35 820	39 990	54 090	38 090	30.5	68.7
293	5	35 980	40 300	55 150	37 410	30.2	69.2
303	6	34 940	41 890	58 350	39 730	30.0	66.3
304	6	36 080	41 350	53 810	37 590	30.0	68.0
305	6	35 920	41 060	54 590	36 140	30.0	69.7
315	7	35 460	39 600	54 550	37 510	30.3	68.6
316	7	35 530	37 530	54 410	40 300	29.1	67.4
317	7	35 900	39 870	54 940	39 600	30.0	65.8
327	8	35 740	36 730	54 990	38 000	30.0	69.8
328	8	35 960	37 140	54 440	37 460	30.5	69.3
329	8	35 910	36 900	55 220	33 240	29.7	69.7

AGE OF BEAM, 52 WEEKS

246	2	36 870	41 100	54 900	37 670	29.1	70.0
247	2	37 670	41 230	53 990	37 220	30.0	70.6
248	2	36 840	40 680	56 940	38 580	28.5	67.5
270	3	37 260	41 900	60 600	41 770	29.0	63.2
271	3	38 670	41 890	58 650	42 530	29.2	67.0
272	3	37 440	41 660	62 110	44 710	28.8	63.2
282	4	37 730	41 040	59 100	40 800	28.3	66.8
283	4	37 240	40 990	57 690	38 420	30.4	67.6
284	4	37 930	42 210	57 340	40 740	29.1	65.1
294	5	35 870	39 720	53 930	38 140	30.4	67.3
295	5	36 350	40 270	55 490	40 250	30.3	69.4
296	5	36 070	40 840	55 450	39 280	31.0	69.2
306	6	35 300	39 650	53 890	37 930	30.9	68.7
307	6	36 210	40 770	56 390	39 210	28.7	66.9
308	6	35 760	40 440	54 240	35 850	30.1	68.2
309	7	35 690	40 590	55 580	35 670	30.7	70.1
310	7	35 940	39 750	56 000	40 740	29.2	68.2
311	7	35 730	40 820	55 460	37 180	31.2	70.6
330	8	36 210	36 790	59 550	38 290	29.8	70.4
331	8	36 020	37 510	55 930	38 020	29.6	70.7
332	8	35 000	38 720	56 790	37 790	28.4	67.8

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement			Greater than that at Yield Point					
			Number of $\frac{3}{8}$ " round rods	Nominal Per cent	Effective Per cent	Minimum Compressive Stress Upper Fiber, lbs. per sq. in.			C_2 C_1	C_3 C_1	Unit Bond Stress, lbs. per sq. in.
						C_1 from cylinder Curve	C_2 from Resisting Moment	C_3 from Bending Moment			
1	2	3	4	5	6	25	26	27	28	29	30
162	1170	145.4	2	0.49	0.4						
163	1200	143.5	2	.49	.4	1780	845	1205	0.47	0.68	120
164	1230	151.9	2	.49	.4	1900	1405	1695	.74	.89	140
Average						1600	1255	1675	.78	1.05	131
									.66	.87	130
174	1200	150.1	3	.74	.7						
175	1190	148.7	3	.74	.7	2230	1105	1600	.50	.72	125
176	1200	150.3	3	.74	.7	2250	1365	1670	.62	.74	121
Average						2320	1515	1685	.65	.73	120
									.59	.73	122
186	1210	146.6	4	.98	.9						
187	1190	146.2	4	.98	.9	2410	1895	2340	.79	.97	130
188	1210	145.2	4	.98	.9	2260	1735	2020	.77	.89	111
Average						2340	1985	2230	.85	.95	120
									.80	.94	120
198	1230	149.8	5	1.23	1.1						
199	1230	150.4	5	1.23	1.1	2510	2095	2495	.83	.99	128
200	1230	147.9	5	1.23	1.1	2520	2190	2490	.87	.99	127
Average						2500	2215	2515	.89	1.01	127
									.86	1.00	127
210	1220	147.6	6	1.47	1.3						
211	1210	144.0	6	1.47	1.3	2560	2195	2645	.86	1.03	124
212	1200	146.9	6	1.47	1.3	2480	2290	2575	.92	1.04	115
Average						2590	2230	2480	.86	.96	117
									.88	1.01	119
222	1240	150.4	7	1.72	1.5						
223	1230	148.2	7	1.72	1.5	2810	2525	2775	.90	.99	123
224	1220	146.8	7	1.72	1.5	2770	2600	2980	1.01	1.08	124
Average						2720	2685	2828	.99	1.04	117
									.97	1.04	121
237	1220	146.8	8	1.96	1.7						
238	1240	150.1	8	1.96	1.7	2860	2485	2855	.87	1.00	123
239	1240	147.2	8	1.96	1.7	2720	2815	2965	1.03	1.09	113
Average						2800	2930	3085	1.05	1.10	119
Grand Ave									.98	1.06	118
										.95	122

1 Beam was dropped when tentally loaded to 3900 lbs. before test.
 Remarks.—Average bond stress developed
 Note.—Values in parentheses are estimated.

165	1209	149.1	2	0.49	0.4	1890	880	1445	0.47	0.76	138
166	1190	147.7	2	.49	.4	1780	1190	1655	.67	.93	135
167	1210	150.3	2	.49	.4	1930	1070	1550	.55	.80	137
Average									.56	.83	137
177	1200	148.2	3	.74	.7						
178	1200	146.6	3	.74	.7	2180	1470	1910	.67	.83	122
179	1200	146.8	3	.74	.7	2300	1600	2135	.70	.93	133
Average						2080	1100	1775	.53	.85	123
									.63	.89	126
189	1240	152.7	4	.98	.9						
190	1190	146.2	4	.98	.9	2600	1630	2175	.63	.84	121
191	1200	147.8	4	.98	.9	2690	2115	2430	.79	.90	124
Average						2390	1475	1995	.62	.83	112
									.68	.86	119
201	1210	146.2	5	1.23	1.1						
202	1210	147.2	5	1.23	1.1	2610	1935	2515	.74	.96	121
203	1210	148.1	5	1.23	1.1	2650	2060	2545	.78	.86	121
Average						2550	1985	2580	.78	1.01	121
									.77	.98	121
213	1230	149.1	6	1.47	1.3						
214	1210	147.3	6	1.47	1.3	2980	2360	2985	.79	1.00	130
215	1240	152.1	6	1.47	1.3	3040	2440	3010	.80	.99	129
Average						3030	2595	3055	.86	1.01	129
									.82	1.00	129
225	1220	147.7	7	1.72	1.5						
226	1230	147.3	7	1.72	1.5	3330	2780	3125	.83	.94	122
227	1240	150.4	7	1.72	1.5	3100	2850	3275	.92	1.06	121
Average						3170	2750	3200	.87	1.01	121
									.87	1.00	121
243	1240	147.6	8	1.96	1.7						
244	1260	149.8	8	1.96	1.7	3330	2605	3175	.78	.95	118
245	1250	149.2	8	1.96	1.7	3200	2855	3480	.89	1.09	122
Average						3060	2755	3360	.90	1.10	116
Grand Ave		148.5							.85	1.05	119
									.94		125

Remarks.—Average bond stress developed

SUMMARY OF TESTS ON REINFORCED CONCRETE BEAMS

Table 6.—Granite Concrete Proportions, 1:2:4. Age, 4 Weeks

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement				First Crack		Maximum Load						Analysis of beam at Unit Elongation in Reinforcement Less than that at Yield Point																	Unit Bond Stress, lbs. per sq. in.
			Number of round rods	Nominal per cent	Effective per cent	Area, in sq. in.	Applied Load, in lbs.	Unit Elongation in Lower Fiber, inches per inch	Applied Load, in lbs.	Deflection, inches	Unit Elongation in Steel, inches per inch	Unit Stress of Steel, lbs. per sq. in. S ₁	Yield Point of Steel, lbs. per sq. in. S ₂	S ₁ S ₂	Applied Load, in lbs.	Unit Elongation in Steel, inches per inch	Unit Stress in Steel, lbs. per sq. in.	KD, in inches	D-35KD in inches	Resisting Moment, inch lbs., Mr	Bending Moment, inch lbs., Mb	Mr Mb	Unit Deformation Upper Fiber, inches per inch	Unit Compressive Stress Upper Fiber, lbs. per sq. in.								
																								C ₁ from Cylinder Curve	C ₂ from Resisting Moment	C ₃ from Pending Moment	C ₂ C ₁	C ₃ C ₁				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30			
162	1170	145.4	2	0.49	0.49	0.393	3000	0.000137	5900	(0.356)	(0.001100)	(33 000)	42 610	0.77	5500	0.001014	30 400	3.18	8.89	106 100	151 900	0.70	0.000472	1780	845	1205	0.47	0.68	120			
163	1200	145.5	2	.49	.49	.393	2500	.000124	7000	.395	(.001492)	(44 800)	42 560	1.05	6750	.001415	42 500	2.67	9.07	151 400	182 400	.83	.000516	1900	1405	1695	.74	.89	140			
164	1230	151.9	2	.49	.49	.393	3000	.000124	6500	(.340)	(.001420)	(37 200)	42 300	.88	6250	.001200	36 000	2.53	9.11	128 800	170 900	.75	.000406	1600	1255	1675	.78	1.05	130			
Average									6470	.364	(.001277)	(38 300)		.90								.76				.66	.87	131				
174	1200	150.1	3	.74	.74	.589	3000	1.000269	9300	.415	(.001135)	(34 100)	42 150	.81	9000	.001068	32 000	3.83	8.66	163 300	236 400	.69	.000665	2230	1105	1600	.50	.72	125			
175	1190	148.7	3	.74	.74	.589	2500	.000131	8900	.445	(.001246)	(37 400)	42 130	.89		.001234	37 000	3.54	8.76	190 900	230 200	.83	.000677	2250	1365	1670	.62	.74	121			
176	1200	150.3	3	.74	.74	.589	2500	.000124	9000	(.430)	(.001431)	(42 900)	42 760	1.00	8750	.001332	40 000	3.50	8.78	206 900	230 400	.90	.000717	2320	1515	1685	.65	.73	122			
Average									9070	.430	(.001271)	38 500		.90								.81				.59	.73	122				
186	1210	146.6	4	.98	.98	.785	2400	.000995	13 280	.460	(.001340)	(40 200)	42 840	.94	13 000	.001320	39 600	3.69	8.71	270 900	332 500	.81	.000772	2410	1895	2340	.79	.97	130			
187	1190	146.2	4	.98	.98	.785	2000	.000086	11 650	.450	(.001369)	(41 100)	42 540	.97	11 000	.001191	35 700	3.64	8.73	244 800	284 200	.86	.000682	2260	1735	2020	.77	.89	111			
188	1210	145.2	4	.98	.98	.785	4000	.000223	12 460	.465	(.001409)	(42 300)	43 750	.97	12 000	.001328	39 800	3.54	8.76	273 800	308 500	.89	.000727	2340	1985	2230	.85	.95	120			
Average									12 460	.458	(.001373)	(41 200)		.96								.85				.80	.94	120				
198	1230	149.8	5	1.23	1.11	.982	3000	.000128	14 090	(.487)	(.001429)	(42 900)	42 180	1.02	13 500	.001344	40 300	3.84	8.66	291 400	344 900	.84	.000839	2510	2095	2495	.83	.99	128			
199	1200	150.4	5	1.23	1.11	.982	2500	.000130	13 750	(.475)	(.001497)	(44 900)	42 210	1.06	13 500	.001350	41 700	3.80	8.67	301 900	344 900	.88	.000850	2520	2190	2490	.87	.99	127			
200	1230	147.9	5	1.23	1.11	.982	3500	.000155	13 920	(.483)	(.001446)	(43 400)	43 020	.99	13 500	.001386	41 600	3.75	8.69	302 200	344 900	.88	.000831	2500	2215	2515	.89	1.01	127			
Average									13 920					1.02								.87				.86	1.00	127				
210	1220	147.6	6	1.47	1.30	1.178	2500	.000103	16 000	.555	(.001559)	(46 800)	42 220	1.11	15 000	.001282	38 500	4.06	8.58	314 500	387 000	.83	.000877	2560	2195	2645	.86	1.03	124			
211	1210	144.0	6	1.47	1.30	1.178	2500	.000110	15 500	.535	(.001538)	(46 100)	(4)	-----	14 000	.001277	38 300	3.89	8.64	316 500	350 500	.89	.000814	2480	2290	2575	.92	1.04	115			
212	1200	146.9	6	1.47	1.30	1.178	2500	.000117	15 100	.635	(.001687)	(50 600)	(4)	-----	14 000	.001311	39 300	4.08	8.57	320 600	356 400	.90	.000901	2590	2230	2480	.86	.96	117			
Average									15 530	.575	(.001595)	(47 800)		1.11								.87				.88	1.01	119				
222	1240	150.4	7	1.72	1.54	1.375	3500	.000157	18 000	.600	(.001679)	(50 400)	42 100	1.20	17 500	.001398	41 900	4.53	8.41	400 600	441 000	.91	.001159	2810	2525	2775	.90	.99	123			
223	1230	148.2	7	1.72	1.54	1.375	3000	.000153	19 200	.630	(.001809)	(54 300)	42 020	1.29	18 000	.001465	44 000	4.31	8.49	426 800	452 900	.94	.001108	2770	2600	2980	1.01	1.08	124			
224	1220	146.8	7	1.72	1.54	1.375	3000	.000146	18 450	.650	(.001933)	(58 000)	42 300	1.37	17 000	.001398	41 900	4.28	8.50	407 200	428 700	.95	.001045	2720	2685	2828	.99	1.04	117			
Average									18 530	.627	(.001807)	(54 200)		1.29								.93				.97	1.04	121				
237	1220	146.8	8	1.96	1.72	1.571	3500	.000117	19 650	.640	(.001474)	(44 200)	41 650	1.06	19 000	.001335	40 100	4.87	8.30	413 000	476 700	.87	.001268	2860	2485	2855	.87	1.00	123			
238	1240	150.1	8	1.96	1.72	1.571	3000	.000152	19 150	.560	(.001679)	(50 400)	41 720	1.21	18 000	.001344	40 300	4.38	8.47	429 800	453 000	.95	.001045	2720	2815	2965	1.03	1.09	113			
239	1240	147.2	8	1.96	1.72	1.571	4000	.000176	19 920	.625	(.001774)	(52 200)	42 200	1.26	19 000	.001426	42 800	4.46	8.44	453 800	477 000	.95	.001148	2800	2930	3085	1.05	1.10	119			
Average									19 570	.608	(.001642)	(49 300)		1.18								.92				.98	1.06	118				
Grand Ave		147.9					2900	.000130																			.95		122			

* Beam was dropped when being placed in machine.

* Accidentally loaded to 4000 lbs. before test.

* Value taken from curve produced.

* Steel was mixed.

* Accidentally loaded to 3900 lbs. before test.

Remarks.—Average bond stress developed in beam=122 lbs. per square inch.

Average ultimate bond stress from bond test pieces=489 lbs. per square inch. Ratio=4.0.

Note.—Values in parentheses are estimated.

Table 7.—Granite Concrete Proportions, 1:2:4. Age, 13 Weeks

165	1200	149.1	2	0.49	0.49	0.393	2000	0.000072	6800	0.350	0.001138	34 100	42 230	0.81	6500	0.001015	30 500	3.06	8.93	107 000	176 400	0.61	0.000447	1890	880	1445	0.47	0.76	138
166	1190	147.7	2	.49	.49	.393	3000	.000105	6500	.325	.001176	35 300	42 200	.84	6500	.001176	35 300	2.62	9.08	125 900	176 200	.72	.000418	1780	1190	1655	.67	.93	135
167	1210	150.3	2	.49	.49	.393	2500	.000096	6600	.345	.001164	34 900	41 910	.83	6500	.001147	34 400	2.84	9.01	121 700	176 500	.69	.000454	1930	1070	1550	.55	.80	137
Average									6630	.340	.001159	34 800		.83								.67				.56	.83	137	
177	1200	148.2	3	.74	.74	.589	3000	.000121	9210	.410	.001215	36 500	41 940	.87	9000	.001157	34 700	3.13	8.90	181 900	236 400	.77	.000527	2180	1470	1910	.67	.83	122
178	1200	146.6	3	.74	.74	.589	3000	.000109	10 000	.410	.001248	37 400	43 990	.86	10 000	.001248	37 400	3.10	8.92	196 500	260 400	.75	.000560	2300	1600	2135	.70	.93	133
179	1200	146.8	3	.74	.74	.589	4000	.000149	9840	.390	.001070	32 100	43 470	.74	9000	.000949	28 500	3.44	8.80	147 700	236 400	.62	.000498	2080	1100	1775	.53	.85	123
Average									9680	.403	.001178	35 300		.82								.71				.63	.89	126	
189	1240	152.7	4	.98	.98	.785	4000	.000399	12 700	.455	.001226	36 800	41 950	.88	12 000	.001125	33 800	3.66	8.72	231 500	309 000	.75	.000650	2600	1630	2175	.63	.84	121
190	1190	146.2	4	.98	.98	.785	3000	.000094	12 560	.475	.001374	41 200	42 460	.97	12 500	.001344	40 300	3.37	8.82	279 200	320 200	.87	.000682	2690	2115	2430	.79	.90	124
191	1200	147.8	4	.98	.98	.785	4000	.000142	11 780	.400	.001176	35 300	40 670	.87	11 000	.001021	30 600	3.66	8.72	209 600	284 400	.74	.000588	2390	1475	1995	.62	.83	112
Average									12 350	.443	.001259	37 800		.91								.79				.68	.86	119	
201	1210	146.2	5	1.23	1.11	.982	4000	.000125	13 000	.430	.001443	43 300	40 920	1.06	13 000	.001164	34 900	3.61	8.74	255 600	332 500	.77	.000657	2610	1935	2515	.74	.96	121
202	1210	147.1	5	1.23	1.11	.982	3000	.000112	13 650	.435	.001323	39 700	40 460	.96	13 000	.001215	36 500	3.55	8.76	268 200	332 500	.81	.000670	2650	2060	2545	.78	.86	121
203	1210	148.1	5	1.23	1.11	.982	4000	.000143	14 180	.465	.001379	44 400	40 410	1.10	13 000	.001166	35 000	3.53	8.76	257 300	332 500	.77	.000637	2550	1985	2580	.78	.101	121
Average									13 810	.443	.001415	42 500		1.04								.78				.77	.98	121	
213	1230	149.1	6	1.47	1.30	1.178	3000	.000106	16 550	.490	.001321	39 600	41 460	.96	16 000	.001279	38 400	3.79	8.67	319 200	404 900	.79	.000782	2980	2360	2985	.79	1.00	130
214	1210	147.3	6	1.47	1.30	1.178	3000	.000103	16 800	.525	.001404	44 800	41 230	1.09	16 000	.001321	39 600	3.78	8.68	329 600	404 500	.81	.000803	3040	2440	3010	.80	.99	129
215	1240	152.1	6	1.47	1.30	1.178	4000	.000147	16 500	.495	.001422	42 700	41 080	1.04	16 000	.001368	41 000	3.69	8.71	343 100	405 000	.85	.000799	3030	2595	3055	.86	1.01	129
Average									16 620	.497	.001412	42 400		1.03								.82				.82	1.00	129	
225	1230	147.7	7	1.72	1.54	1.375	3000	.000096	18 250	.510	.001593	45 100	41 180	1.10	18 000	.001354	40 600	4.03	8.59	400 900	452 700	.89	.000913	3330	2780	3125	.83	.94	122
226	1230	147.3	7	1.72	1.54	1.375	4000	.000104	18 650	.505	.001594	50 800	42 110	1.21	18 000	.001321	39 600	3.85	8.65	396 200	452 900	.87	.000827	3100	2850	3275	.82	1.06	121
227	1240	150.4	7	1.72	1.54	1.375	4000	.000133	18 780	.495	.001443	43 300	40 750	1.06	18 000	.001308	39 200	3.94	8.62	389 200	453 000	.86	.000850	3170	2750	3200	.87	1.01	121
Average									18 550	.503	.001547	46 400		1.12								.87				.87	1.00	121	
243	1240	147.6	8	1.96	1.72	1.571	3000	.000095	21 300	.615	.001706	51 200	41 790	1.23	19 000	.001215	36 500	4.30	8.50	391 500	477 000	.82	.000917	3330	2605	3175	.78	.95	118
244	1230	149.8	8	1.96	1.72	1.571	4000	.000119	21 280	.530	.001405	42 200	41 780	1.01	20 000	.001252	37 600	4.07	8.58	409 600	501 400	.82	.000860	3200	2855	3480	.89	1.09	122
245	1250	149.2	8	1.96	1.72	1.571	4000	.000131	22 120	.595	.001631	54 900	41 400	1.33	19 000	.001198	35 900	4.03	8.59	391 900	477 200	.82	.000809	3060	2755	3360	.90	1.10	116
Average									21 570	.580	.001647	49 400		1.19								.82				.86	1.05	119	
Grand Ave	148.5						3400	.000117																				.94	125

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement				Less than that at Yield Point					
			Number of 3/4" round rods	Nominal Per cent	Effective Per cent	Area in sq. in.	Unit Oppressive Stress Upper Fiber, lbs. per sq. in.			C ₂ C ₁	C ₃ C ₁	Unit Bond Stress, lbs. per sq. in.
							C ₁ from Cylinder Curve	C ₂ from Resisting Moment	C ₃ from Bending Moment			
1	2	3	4	5	6	7	25	26	27	28	29	30
169	1210	148.8	2	.49	.49	.4						
170	1210	147.4	2	.49	.49	.4	1740	1100	1663	0.63	0.96	135
Average.							1550	840	1465	.54	.95	128
180	1220	149.0	3	.74	.74	.4						
181	1220	148.9	3	.74	.74	.4	2020	1375	1960	.68	.97	122
182	1230	150.3	3	.74	.74	.4	2190	1555	2180	.71	1.00	133
Average.							2290	1640	2180	.72	.95	133
192	1190	146.5	4	.98	.98	.7				.70	.97	129
193	1210	149.5	4	.98	.98	.7	2620	1805	2275	.69	.87	120
194	1210	145.6	4	.98	.98	.7	2730	1535	2125	.56	.78	121
Average.							2350	1945	2445	.83	1.04	119
204	1210	145.2	5	1.23	1.11	.9						
205	1240	150.3	5	1.23	1.11	.9	2570	1960	2595	.76	1.01	121
206	1210	146.2	5	1.23	1.11	.9	2470	2020	2660	.82	1.08	120
Average.							2730	2215	2835	.81	1.04	129
216	1220	147.6	6	1.47	1.30	1.1				.80	1.04	123
217	1230	146.8	6	1.47	1.30	1.1	2920	1890	2710	.65	.93	124
218	1240	150.3	6	1.47	1.30	1.1	2900	2185	3020	.75	1.04	129
Average.							2930	2415	3105	.82	1.06	128
231	1240	148.7	7	1.72	1.54	1.3				.74	1.01	127
232	1240	147.6	7	1.72	1.54	1.3	3050	2695	3310	.88	1.09	120
233	1240	150.3	7	1.72	1.54	1.3	3220	2890	3490	.90	1.08	126
Average.							3100	2455	3200	.79	1.03	121
240	1240	147.9	8	1.96	1.72	1.5				.86	1.07	122
242	1240	148.3	8	1.96	1.72	1.5	3370	2730	3450	.81	1.02	123
Average.							3540	2850	3595	.81	1.02	129
Grand Ave.										.81	1.02	126
											1.00	125

Remarks.—Average bond stress developed in beam

171	1190	144.3	2	0.49	0.49	.3	1850	1210	1855	0.63	1.00	143
172	1190	145.8	2	.49	.49	.3	1970	990	1660	.50	.84	145
173	1210	147.3	2	.49	.49	.3	2010	995	1660	.50	.83	145
Average.										.55	.89	144
183	1210	146.6	3	.74	.74	.5	2430	1825	2275	.75	.94	132
184	1210	147.5	3	.74	.74	.5	2310	1340	1890	.58	.82	122
185	1220	146.1	3	.74	.74	.5	2190	1285	2105	.59	.96	134
Average.										.64	.91	129
195	1180	142.1	4	.98	.98	.7	2800	1715	2425	.61	.87	129
196	1220	145.9	4	.98	.98	.7	2800	1920	2530	.69	.90	128
197	1220	148.3	4	.98	.98	.7	2760	1840	2505	.67	.91	129
Average.										.66	.89	129
207	1220	147.3	5	1.23	1.11	.9	3060	2140	2760	.70	.90	129
208	1230	149.0	5	1.23	1.11	.9	3300	2115	2850	.64	.86	139
209	1240	148.6	5	1.23	1.11	.9	3090	2320	3025	.75	.98	137
Average.										.70	.91	135
219	1240	147.1	6	1.47	1.30	1.1	3230	2670	3185	.83	.99	127
220	1230	145.8	6	1.47	1.30	1.1	3190	2405	3100	.75	.97	128
221	1240	147.3	6	1.47	1.30	1.1	3300	2665	3350	.81	1.02	135
Average.										.80	.99	130
228	1240	148.9	7	1.72	1.54	1.3	3650	2800	3390	.77	.93	127
229	1240	147.6	7	1.72	1.54	1.3	3810	2880	3510	.76	.92	134
230	1240	148.2	7	1.72	1.54	1.3	3430	3005	3570	.88	1.04	126
Average.										.80	.96	129
234	1240	149.3	8	1.96	1.72	1.5						
235	1240	148.2	8	1.96	1.72	1.5	3920	3340	3575	.85	.91	121
236	1240	148.2	8	1.96	1.72	1.5	4060	3105	3010	.77	.89	128
Average.							3830	2905	3465	.76	.90	122
Grand Av										.79	.90	124
											.93	131

Remarks.—Average bond stress developed in beam in parentheses are estimated.

SUMMARY OF TESTS ON REINFORCED CONCRETE BEAMS—Continued

Table 8.—Granite Concrete Proportions, 1:2:4. Age, 26 Weeks

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Number of round rods	Reinforcement			First Crack		Maximum Load					Analysis of beam at Unit Elongation in Reinforcement Less than that at Yield Point															
				Nominal Per cent	Effective Per cent	Area, in sq. in.	Applied Load, in lbs.	Unit Elongation in Lower Fiber, inches per inch	Applied Load, in lbs.	Deflection, inches	Unit Elongation in Steel, inches per inch	Unit Stress of Steel, lbs. per sq. in. S_t	Yield Point of Steel, lbs. per sq. in. S_y	S_t/S_y	Applied Load, in lbs.	Unit Elongation in Steel, inches per inch	Unit Stress in Steel, lbs. per sq. in.	KD, in inches	D-35KD in inches	Resisting Moment, inch lbs., Mr	Bending Moment, inch lbs., Mb	Mr/Mb	Unit Deformation Upper Fiber, inches per inch	Unit Oppressive Stress Upper Fiber, lbs. per sq. in.			C_2/C_1	C_3/C_1	Unit Bond Stress, lbs. per sq. in.
																								C_1 from Cylinder Curve	C_2 from Resisting Moment	C_3 from Bending Moment			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
169	1210	148.8	2	.49	.49	.393	2500	0.000082	6810	0.340	0.001178	35 300	42 810	.82	6500	0.001089	32 700	2.63	9.08	116 600	176 540	0.661	0.000389	1740	1100	1663	0.63	0.96	135
170	1210	147.4	2	.49	.49	.393	2500	0.000083	6350	.325	0.001044	31 300	42 520	.74	6000	0.000887	26 600	2.80	9.02	94 200	164 540	.573	0.000346	1550	840	1465	.54	.95	128
Average.									6580	.333	0.001111	33 300		.78								.617					.59	.96	132
189	1220	149.0	3	.74	.74	.589	3000	0.001115	9820	.380	0.001226	36 800	42 700	.86	9000	0.001053	31 600	3.05	8.93	166 200	236 705	.702	0.000462	2020	1375	1960	.68	.97	122
181	1220	148.9	3	.74	.74	.589	2000	0.000963	10 780	.425	0.001303	39 100	41 320	.95	10 000	0.001178	35 300	3.01	8.95	186 100	260 705	.714	0.000508	2190	1555	2180	.71	1.00	133
182	1230	150.3	3	.74	.74	.589	3000	0.001118	10 000	.405	0.001241	37 200	43 730	.85	10 000	0.001241	37 200	3.01	8.95	196 100	260 870	.752	0.000533	2290	1640	2180	.72	.95	133
Average.									10 200	.403	0.001257	37 700		.89								.723					.70	.97	129
192	1190	146.5	4	.98	.98	.785	3500	0.00126	12 360	.425	0.001280	38 400	42 570	.90	12 000	0.001181	35 400	3.47	8.79	244 400	308 210	.793	0.000527	2620	1805	2275	.69	.87	120
193	1210	149.5	4	.98	.98	.785	3000	0.00112	12 500	.425	0.001210	36 300	41 350	.88	12 000	0.001089	32 700	3.76	8.68	222 900	308 540	.723	0.000656	2730	1535	2125	.56	.78	121
194	1210	145.6	4	.98	.98	.785	4000	0.00126	12 530	.415	0.001313	39 400	42 800	.92	12 000	0.001173	35 200	3.20	8.88	215 500	308 540	.796	0.000551	2350	1945	2445	.83	1.04	119
Average.									12 460	.422	0.001268	38 000		.90								.771					.69	.90	120
204	1210	145.2	5	1.23	1.11	.982	3000	0.00099	13 550	.445	0.001267	38 000	41 380	.92	13 000	0.001138	34 100	3.49	8.78	251 500	332 540	.756	0.000610	2570	1960	2595	.76	1.01	121
205	1240	150.3	5	1.23	1.11	.982	3000	0.00116	14 730	.540	0.001684	50 500	42 700	1.18	13 000	0.001137	34 100	3.39	8.81	252 600	333 035	.759	0.000583	2470	2020	2630	.82	1.08	120
206	1210	146.2	5	1.23	1.11	.982	4000	0.00135	14 440	.480	0.001393	41 800	41 340	1.01	14 000	0.001258	37 700	3.42	8.80	278 900	356 540	.782	0.000655	2730	2215	2835	.81	1.04	129
Average.									14 270	.488	0.001448	43 400		1.04								.766					.80	1.04	123
216	1220	147.6	6	1.47	1.30	1.178	3000	0.00086	16 000	.480	0.001292	38 800	41 680	.93	15 000	0.001077	32 300	3.97	8.61	265 400	380 705	.697	0.000708	2920	1890	2710	.65	.93	124
217	1230	146.8	6	1.47	1.30	1.178	4000	0.00124	16 350	.470	0.001224	36 700	41 930	.88	16 000	0.001171	35 100	3.75	8.69	292 700	404 870	.723	0.000703	2900	2185	3020	.75	1.04	129
218	1240	150.3	6	1.47	1.30	1.178	3000	0.00098	16 300	.480	0.001337	40 100	41 420	.97	16 000	0.001251	37 500	3.63	8.73	315 000	405 035	.778	0.000712	2930	2415	3105	.82	1.06	128
Average.									16 220	.477	0.001284	38 500		.93								.733					.74	1.01	127
231	1240	148.7	7	1.72	1.54	1.375	4000	0.00113	18 980	.475	0.001309	39 300	40 960	.96	18 000	0.001226	36 800	3.79	8.67	368 600	453 035	.814	0.000746	3050	2695	3310	.88	1.09	120
232	1240	147.6	7	1.72	1.54	1.375	4000	0.00119	19 370	.511	0.001436	43 100	40 450	1.07	19 000	0.001313	39 400	3.78	8.68	395 100	477 035	.828	0.000798	3220	2890	3490	.90	1.08	126
233	1240	150.3	7	1.72	1.54	1.375	4000	0.00112	19 450	.520	0.001474	44 200	40 610	1.09	18 000	0.001168	35 000	3.94	8.62	347 500	453 035	.767	0.000759	3100	2455	3200	.79	1.03	121
Average.									19 340	.502	0.001406	42 200		1.04								.803					.86	1.07	122
240	1240	147.9	8	1.96	1.72	1.571	4000	0.00107	21 620	.550	0.001438	43 100	42 170	1.02	20 000	0.001219	36 600	4.13	8.55	396 500	501 035	.791	0.000856	3370	2730	3450	.81	1.02	123
242	1240	148.3	8	1.96	1.72	1.571	4000	0.00105	22 480	.580	0.001619	48 600	42 400	1.15	21 000	0.001284	38 500	4.16	8.54	416 400	525 035	.793	0.000913	3540	2850	3595	.81	1.02	126
Average.									22 050	.565	0.001529	45 900		1.09								.792					.81	1.02	125
Grand Ave.		148.2					3300	0.00107																				1.00	125

Remarks.—Average bond stress developed in beam—125 pounds per square inch. Average ultimate bond stress from bond test pieces—791 pounds per square inch. Ratio—6.3.

Table 9.—Granite Concrete Proportions, 1:2:4. Age, 52 Weeks

171	1190	144.3	2	0.49	0.49	.393	3000	0.00092	7300	0.345	0.001347	40 400	42 480	0.95	7000	0.001144	34 300	2.50	9.12	122 900	188 200	0.653	0.000383	1850	1210	1855	0.65	1.00	143
172	1190	145.8	2	.49	.49	.393	3000	0.00095	7000	.305	0.001055	31 700	42 480	.75	7000	0.001055	31 700	2.83	9.01	112 200	188 200	.596	0.000415	1970	990	1660	.50	.81	145
173	1210	147.3	2	.49	.49	.393	3000	0.00116	7200	.345	0.001104	33 100	42 760	.77	7000	0.001067	32 000	2.84	9.01	113 200	188 550	.600	0.000424	2010	995	1660	.50	.83	145
Average.									7170	.332	0.001169	35 100		.82								.616					.55	.89	144
183	1210	146.6	3	.74	.74	.589	2000	0.00075	10 750	.430	0.001573	47 200	43 000	1.10	10 000	0.001313	39 400	2.86	9.00	208 900	260 550	.802	0.000526	2430	1825	2275	.75	.94	132
184	1210	147.5	3	.74	.74	.589	2000	0.00076	10 900	.375	0.001080	38 400	42 190	.91	9 000	0.001065	32 000	3.16	8.89	167 600	236 550	.709	0.000403	2310	1340	1890	.58	.82	124
185	1220	146.1	3	.74	.74	.589	2000	0.00063	10 670	.335	0.001115	33 500	40 910	.82	10 000	0.001014	30 400	3.14	8.90	159 400	260 700	.611	0.000464	2190	1285	2105	.59	.96	132
Average.									10 470	.397	0.001323	39 700		.94								.707					.64	.91	129
195	1180	142.1	4	.98	.98	.785	3000	0.00089	13 670	.445	0.001217	36 500	42 500	.86	13 000	0.001135	34 100	3.51	8.77	234 700	332 050	.707	0.000613	2600	1715	2425	.61	.87	129
196	1220	146.9	4	.98	.98	.785	4000	0.00127	13 000	.390	0.001214	36 400	42 170	.86	13 000	0.001214	36 400	3.35	8.83	252 400	332 700	.759	0.000612	2800	1920	2530	.69	.90	128
197	1220	146.3	4	.98	.98	.785	3000	0.00095	13 100	.415	0.001200	(36 000)	42 230	.85	13 000	0.001178	35 300	3.39	8.81	244 300	332 700	.734	0.000605	2760	1840	2505	.67	.91	129
Average.									13 260	.417	0.001210	36 300		.86								.733					.66	.89	128
207	1220	147.3	5	1.23	1.11	.982	4000	0.00140	14 500	.430	0.001472	44 200	41 040	1.08	14 000	0.001253	37 600	3.52	8.77	276 900	356 700	.776	0.000680	3060	2140	2760	.70	.90	139
208	1230	149.6	5	1.23	1.11	.982	3000	0.00095	15 770	.500	0.001518	45 500	41 910	1.09	15 000	0.001291	38 700	3.66	8.72	282 500	380 850	.742	0.000745	3200	2115	2850	.64	.86	137
209	1240	148.0	5	1.23	1.11	.982	3000	0.00100	15 380	.465	0.001379	41 400	42 090	.98	15 000	0.001318	39 500	3.42	8.80	292 200	381 050	.767	0.000685	3090	2320	3015	.75	.98	137
Average.									15 220	.465	0.001456	43 700		1.05								.762					.70	.91	135
219	1240	147.1	6	1.47	1.30	1.178	3000	0.00092	15 700	.530	0.001639	49 200	41 800	1.18	16 000	0.001338	40 100	3.52	8.77	339 300	405 050	.838	0.000727	3230	2670	3185	.83	.99	127
220	1230	145.8	6	1.47	1.30	1.178	3000	0.00097	16 600	.535	0.001749	52 500	41 360	1.27	16 000	0.001248	37 400	3.64	8.73	314 100	404 900	.776	0.000715	3190	2405	3100	.75	.97	128
221	1240	147.3	6	1.47	1.30	1.178	3000	0.00103	17 650	.470	0.001438	43 100	42 900	1.00	17 000	0.001350	40 500	3.56	8.75	341 500	429 100	.796	0.000746	3300	2665	3350	.81	1.02	130
Average.									17 320	.512	0.001609	48 300		1.15								.803					.80	.99	135
228	1240	148.9	7	1.72	1.54	1.375	4000	0.00146	20 650	.560	0.001644	49 300	40 950	1.20	19 000	0.001320	39 600	3.91	8.63	393 800	477 050	.826	0.000846	3650	2800	3390	.77	.93	124
229	1240	147.6	7	1.72	1.54	1.375	3000	0.00092	20 750	.545	0.001585	47 600	40 610	1.17	20 000	0.001388	41 900	3.99	8.60	411 500	501 100	.821	0.000893	3810	2880	3405	.76	.92	127
230	1240	148.2	7	1.72	1.54	1.375	4000	0.00136	21 000	.535	0.001521	45 600	40 430	1.13	19 000	0.001331	39 600	3.69	8.71	402 100	477 600	.842	0.000781	3430	3025	3570	.88	1.04	126
Average.									20 800	.547	0.001683	47 500		1.17								.830					.88	.96	129
234	1240	149.3	8	1.96	1.72	1.571	3000	0.00116	21 000	.550	0.001507	48 200	41 460	1.16	20 000	0.001424	42 700	3.96	8.61	468 100	501 050	.934	0.000932	3920	3340	3575	.85	.91	121
235	1240	148.2	8	1.96	1.72	1.571	3000	0.00096	22 100	.550	0.001698	49 400	42 440	1.16	21 000	0.001390	41 700	4.14	8.55	451 800	525 050	.860	0.000980	4060	3105	3610	.77	.89	128
236	1240	148.2	8	1.96	1.72	1.571	3000	0.00100	22 000	.605	0.001790	53 700	41 730	1.29	20 000	0.001291	38 700	4.11	8.56	420 100	501 050	.838	0.000901	3830	2905	3465	.79	.90	122
Average.									21 700	.592	0.001682	50 400		1.20								.877					.76	.90	124
Gmnd Av		147.2					3100	0.00102																			.79	.93	131

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement			than that at Yield Point					
			Number of $\frac{1}{2}$ " round rods	Nominal Per cent	Effective Per cent	Compressive Stress Upper Fiber, lbs. per sq. in.			$\frac{C_2}{C_1}$	$\frac{C_3}{C_1}$	Unit Bond Stress, lbs. per sq. in.
						from under curve	C_2 from Resisting Moment	C_3 from Bending Moment			
1	2	3	4	5	6	25	26	27	28	29	30
255	1200	146.5	2	0.49	0.49	1480	860	1210	0.52	0.82	120
256	1200	149.3	2	.49	.49	1590	1090	1365	.69	.86	128
257	1200	148.3	2	.49	.49	1470	785	1170	.53	.80	120
Average									.60	.83	123
261	1230	147.1	3	.74	.74	1660	1395	1810	.84	1.09	123
262	1220	147.5	3	.74	.74	1690	1795	1950	1.06	1.15	121
263	1230	145.4	3	.74	.74	1540	1515	1760	.98	1.14	110
Average									.96	1.13	118
273	1230	146.9	4	.98	.98	1810	1855	2040	1.02	1.13	111
274	1230	144.7	4	.98	.98	1680	1630	1895	.97	1.13	102
275	1240	148.3	4	.98	.98	1800	1785	2030	.99	1.13	111
Average									.99	1.13	108
285	1220	147.0	5	1.23	1.11	1890	2300	2500	1.22	1.32	122
286	1230	147.6	5	1.23	1.11	1860	1990	2425	1.07	1.30	123
287	1240	144.4	5	1.23	1.11	1890	2145	2440	1.13	1.29	123
Average									1.14	1.30	123
297	1220	144.4	6	1.47	1.30	2040	2410	2535	1.18	1.24	116
298	1240	151.2	6	1.47	1.30	2070	2165	2435	1.05	1.18	117
299	1220	144.5	6	1.47	1.30	2020	1905	2240	.94	1.11	110
Average									1.06	1.18	114
318	1240	146.8	7	1.72	1.54	2200	2305	2535	1.05	1.15	113
319	1240	149.5	7	1.72	1.54	2100	2100	2385	1.00	1.14	106
320	1230	147.1	7	1.72	1.54	2150	2330	2425	1.08	1.13	106
Average									1.04	1.14	108
321	1240	147.8	8	1.96	1.72	2210	2545	2680	1.15	1.21	109
322	1230	148.0	8	1.96	1.72	2200	2500	2690	1.14	1.22	109
323	1230	145.9	8	1.96	1.72	2260	2600	2825	1.15	1.25	115
Average									1.15	1.23	111
Grand Ave									1.13	1.13	115

Remarks.—Average bond stress developed in , in parentheses are estimated.

249	1180	143.7	2	0.49	0.49	1620	865	1350	0.53	0.83	128
250	1190	145.0	2	.49	.49	1500	890	1415	.59	.94	128
251	1210	148.8	2	.49	.49	1360	945	1500	.69	1.10	127
Average ..									.60	.96	128
264	1220	149.0	3	.74	.74	1820	1580	1905	.87	1.05	115
265	1210	147.9	3	.74	.74	1700	1225	1620	.72	.99	110
266	1210	148.7	3	.74	.74	1770	1300	1690	.73	.95	110
Average ..									.77	1.00	112
276	1200	147.5	4	.98	.98	2080	1540	2025	.74	.97	111
277	1210	145.3	4	.98	.98	2180	2100	2385	.96	1.09	119
278	1210	147.3	4	.98	.98	2110	1730	2085	.82	.99	111
Average ..									.84	1.02	114
288	1210	146.2	5	1.23	1.11	2490	2020	2435	.81	.98	122
289	1230	149.6	5	1.23	1.11	2300	2055	2360	.89	1.03	113
290	1240	149.3	5	1.23	1.11	2450	2210	2540	.90	1.04	122
Average ..									.87	1.02	119
300	1210	146.0	6	1.47	1.30	2510	2130	2565	.85	1.02	115
301	1220	146.0	6	1.47	1.30	2630	2300	2675	.87	1.02	119
302	1210	147.3	6	1.47	1.50	2590	1935	2480	.75	.96	117
Average ..									.82	1.00	117
312	1240	148.2	7	1.72	1.54	2780	2555	2935	.92	1.06	116
313	1260	151.0	7	1.72	1.54	2850	2515	3065	.88	1.08	123
314	1220	146.0	7	1.72	1.54	2900	2640	3030	.87	1.04	121
Average ..									.89	1.06	120
324	1220	146.3	8	1.96	1.72	3200	2990	3435	.93	1.07	130
325	1250	146.3	8	1.96	1.72	3000	2855	3360	.95	1.12	124
326	1230	147.3	8	1.96	1.72	2900	2560	2975	.88	1.03	113
Average ..									.92	1.07	122
Grand Ave									1.01	1.01	119

Remarks.—Average bond stress developed in eses are estimated.

SUMMARY OF TESTS ON REINFORCED CONCRETE BEAMS—Continued

Table 10.—Limestone Concrete. Proportions, 1:2:4. Age, 4 Weeks

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement				First Crack		Maximum Load						Analysis of beam at Unit Elongation in Reinforcement Less than that at Yield Point															
			Number of ½" round rods	Nominal Per cent	Effective Per cent	Area, in sq. in.	Applied Load, in lbs.	Unit Elongation in Lower Fiber, inches per inch	Applied Load, in lbs.	Deflection, inches	Unit Elongation in Steel, inches per inch	Unit Stress of Steel, lbs. per sq. in. S ₁	Yield Point of Steel, lbs. per sq. in. S ₂	S ₁	S ₂	Applied Load, in lbs.	Unit Elongation in Steel, inches per inch	Unit Stress in Steel, lbs. per sq. in.	KD, in inches	D-.35KD in inches	Resting Moment, inch lbs., Mr	Bending Moment, inch lbs., Mb	Mr Mb	Unit Deformation Upper Fiber, inches per inch	Unit Compressive Stress Upper Fiber, lbs. per sq. in.			C ₂ C ₁	C ₃ C ₁	Unit Bond Stress, lbs. per sq. in.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
255	1200	146.5	2	0.49	0.49	0.393	2000	0.000103	5850	0.355	(0.001107)	(33 200)	42 350	0.78	5500	0.001030	30 900	3.17	8.89	108 000	152 500	0.71	0.000478	1480	860	1210	0.58	0.82	120	
256	1200	149.3	2	.49	.49	.393	2000	.000114	6350	.405	(.001321)	(39 600)	42 350	.96	6000	.001239	37 200	3.01	8.95	131 000	164 500	.80	.000535	1450	860	1365	.69	.86	128	
257	1200	148.3	2	.49	.49	.393	2000	.000082	5900	.350	(.001111)	(33 300)	41 410	.85	5500	.000973	29 200	3.28	8.85	101 500	152 500	.67	.000475	1470	785	1170	.53	.80	120	
Average									6030	.370	(.001180)	(35 400)		.85								.73				.60	.83	123		
261	1230	147.1	3	.74	.74	.589	2000	.000093	9420	.425	(.001233)	(37 000)	40 720	.91	9000	.001169	35 100	3.34	8.83	182 500	237 000	.77	.000586	1660	1395	1810	.84	1.09	123	
262	1230	147.5	3	.74	.74	.589	3000	.000145	9320	.420	(.001451)	(43 500)	41 080	1.06	9000	.001376	41 300	3.05	8.93	217 500	237 000	.92	.000605	1690	1795	1950	1.06	1.15	121	
263	1230	145.4	3	.74	.74	.589	3500	.000163	8470	.385	(.001314)	(39 400)	41 330	.95	8000	.001162	34 900	3.05	8.93	183 500	213 000	.86	.000511	1540	1515	1760	.98	1.14	110	
Average									9070	.410	(.001333)	(40 000)		.97								.85				.96	1.13	118		
273	1230	146.9	4	.98	.98	.785	3000	.000141	11 300	.435	(.001381)	(41 400)	40 740	1.02	11 000	.001251	37 500	3.57	8.75	258 000	285 000	.91	.000693	1810	1855	2040	1.02	1.13	111	
274	1230	144.7	4	.98	.98	.785	3000	.000133	10 800	.350	(.001269)	(38 100)	40 280	.95	10 000	.001087	32 600	3.53	8.76	224 500	261 000	.86	.000593	1680	1630	1895	.97	1.13	102	
275	1240	148.3	4	.98	.98	.785	3000	.000124	11 500	.400	(.001306)	(39 200)	41 370	.95	11 000	.001214	36 400	3.60	8.74	250 000	285 000	.88	.000682	1800	1785	2030	.99	1.13	108	
Average									11 200	.395	(.001319)	(39 600)		.97								.88				.99	1.13	108		
285	1220	147.0	5	1.23	1.11	.982	3000	.000117	13 000	.445	(.001400)	(42 000)	42 550	.99	13 000	.001400	42 000	3.65	8.72	306 500	332 500	.92	.000803	1890	2300	2500	1.22	1.32	122	
286	1230	147.6	5	1.23	1.11	.982	3500	.000123	13 670	.510	(.001375)	(41 300)	41 850	.99	13 000	.001256	37 700	3.78	8.73	333 000	332 500	.82	.000764	1860	1990	2165	1.07	1.30	123	
287	1240	144.4	5	1.23	1.11	.982	3000	.000123	13 100	.500	(.001504)	(45 100)	41 030	1.10	13 000	.001348	40 400	3.76	8.68	293 000	333 000	.88	.000812	1890	2145	2440	1.13	1.29	123	
Average									13 260	.485	(.001426)	(42 800)		1.03								.87				1.14	1.30	123		
297	1220	144.4	6	1.47	1.30	1.178	3000	.000145	14 860	.525	(.001527)	(45 800)	40 330	1.14	14 000	.001373	41 200	3.97	8.61	338 500	356 500	.95	.000903	2040	2410	2535	1.18	1.24	116	
298	1240	151.2	6	1.47	1.30	1.178	3000	.000119	15 520	.560	(.001560)	(46 800)	40 790	1.15	14 000	.001307	39 200	4.18	8.54	318 000	357 000	.89	.000937	2100	2165	2405	1.05	1.18	117	
299	1220	144.5	6	1.47	1.30	1.178	3000	.000133	15 100	.585	(.001615)	(48 500)	40 660	1.16	13 000	.001176	35 300	4.27	8.51	284 500	332 500	.90	.000878	2020	2105	2240	.94	1.11	110	
Average									15 160	.557	(.001567)	(47 000)		1.16								.90				1.06	1.18	114		
318	1240	146.8	7	1.72	1.54	1.375	3000	.000125	17 650	.595	(.001566)	(47 000)	42 620	1.10	16 000	.001294	38 800	4.59	8.39	369 500	405 000	.91	.001099	2220	2305	2535	1.05	1.15	113	
319	1240	149.5	7	1.72	1.54	1.375	3000	.000121	17 000	.560	(.001570)	(47 100)	39 740	1.19	15 000	.001168	35 000	4.55	8.41	334 500	381 000	.88	.000976	2100	2165	2385	1.00	1.14	106	
320	1230	147.1	7	1.72	1.54	1.375	3000	.000143	16 600	.590	(.001713)	(51 400)	40 900	1.26	15 000	.001270	38 100	4.47	8.44	366 000	381 000	.96	.001026	2150	2390	2425	1.08	1.13	106	
Average									17 080	.582	(.001616)	(48 500)		1.18								.92				1.04	1.14	108		
321	1240	147.8	8	1.96	1.72	1.571	3000	.000128	18 870	.620	(.001808)	(54 200)	39 210	1.38	17 000	.001291	38 700	4.63	8.38	405 500	429 000	.95	.001114	2210	2545	2680	1.15	1.21	109	
322	1230	148.0	8	1.96	1.72	1.571	3000	.000130	18 320	.625	(.001549)	(46 500)	37 140	1.25	17 000	.001272	38 200	4.68	8.38	400 000	429 000	.93	.001103	2200	2500	2690	1.14	1.22	109	
323	1230	145.9	8	1.96	1.72	1.571	3000	.000130	18 960	.595	(.001635)	(49 100)	37 760	1.30	18 000	.001337	40 100	4.64	8.36	418 500	453 000	.92	.001177	2260	2600	2825	1.15	1.25	115	
Average									18 720	.613	(.001664)	(49 900)		1.31								.93				1.15	1.23	111		
Grand Ave		147.1					2900	.000126														.93					1.13		111	

1 Value taken from curve produced

Remarks.—Average bond stress developed in beams=115 pounds per square inch. Average ultimate bond stress from bond test pieces=388 pounds per square inch. Ratio=3.4

Note.—Values in parentheses are estimated.

Table 11.—Limestone Concrete. Proportions, 1:2:4. Age, 13 Weeks

249	1180	143.7	2	0.49	0.49	0.393	3000	0.000128	6000	0.305	0.000997	29 900	41 800	0.72	6000	0.000997	29 900	3.06	8.93	104 900	164 000	0.64	0.000440	1620	865	1350	0.53	0.83	128
250	1190	145.0	2	.49	.49	.393	3000	.000113	6450	.350	.001091	32 700	41 750	.79	6000	.000979	29 400	2.92	8.98	103 700	164 200	.63	.000440	1500	890	1415	.59	.94	128
251	1210	148.8	2	.49	.49	.393	3000	.000111	6000	.290	.000973	29 200	40 740	.72	6000	.000973	29 200	2.73	9.04	103 700	164 500	.63	.000366	1360	945	1500	.69	1.10	127
Average									6150	.315	.001021	30 600		.74								.63				.60	.96	128	
264	1220	149.0	3	.74	.74	.589	3000	.000118	8780	.385	.001403	42 100	42 980	.98	8500	.001183	35 500	2.98	8.96	187 400	224 700	.83	.000503	1820	1580	1905	.87	1.05	115
265	1210	147.9	3	.74	.74	.589	3000	.000122	8500	.335	.001101	33 000	42 160	.78	8000	.000988	29 600	3.20	8.88	154 800	212 500	.73	.000466	1700	1225	1680	.72	.99	110
266	1210	148.7	3	.74	.74	.589	3500	.000135	8520	.390	.001246	37 400	40 040	.93	8000	.001043	31 300	3.19	8.88	163 700	212 500	.77	.000489	1770	1300	1690	.73	.95	110
Average									8640	.370	.001250	37 500		.90								.78				.77	1.00	112	
276	1200	147.5	4	.98	.98	.785	3000	.000096	11 930	(.427)	.001168	35 000	41 500	.84	11 000	.001050	31 500	3.61	8.74	216 200	284 400	.76	.000593	2080	1540	2025	.74	.97	111
277	1210	145.3	4	.98	.98	.785	3000	.000113	12 000	.410	.001297	38 900	42 020	.93	12 000	.001297	38 900	3.27	8.86	270 700	308 500	.88	.000629	2180	2100	2385	.96	1.09	119
278	1210	147.3	4	.98	.98	.785	4000	.000150	11 170	.415	.001202	36 100	40 540	.89	11 000	.001138	34 100	3.48	8.78	235 500	284 500	.83	.000607	2110	1730	2085	.82	.99	111
Average									11 700	.417	.001222	36 700		.89								.82				.84	1.02	114	
288	1210	146.2	5	1.23	1.11	.982	4000	.000132	13 850	.460	.001397	41 900	40 000	1.05	13 000	.001262	37 900	3.75	8.69	275 300	332 500	.83	.000756	2490	2020	2435	.81	.98	122
289	1230	149.6	5	1.23	1.11	.982	4000	.000146	12 800	.470	.001542	46 300	40 150	1.15	12 000	.001221	36 600	3.57	8.75	268 600	308 900	.87	.000678	2300	2050	2360	.89	1.03	119
290	1240	149.5	5	1.23	1.11	.982	4000	.000141	13 140	.445	.001352	40 600	40 260	1.01	13 000	.001320	39 600	3.59	8.74	290 200	333 000	.87	.000739	2450	2210	2540	.92	1.04	122
Average									13 260	.458	.001430	42 900		1.07								.86				.91	1.02	113	
300	1210	146.0	6	1.47	1.30	1.178	4000	.000148	15 700	.545	.001644	49 300	40 050	1.23	14 000	.001193	35 800	3.91	8.63	295 300	356 500	.83	.000766	2510	2130	2565	.85	1.02	115
301	1220	146.0	6	1.47	1.30	1.178	4000	.000143	14 900	.490	.001557	46 700	40 740	1.15	14 500	.001282	38 500	3.89	8.64	318 200	368 700	.86	.000816	2630	2300	2675	.87	1.02	115
302	1210	147.0	6	1.47	1.30	1.178	4000	.000143	14 800	.480	.001426	42 800	40 570	1.05	14 000	.001142	34 300	4.10	8.57	279 700	356 500	.78	.000794	2480	2190	2610	.75	.96	117
Average									15 130	.505	.001542	46 300		1.14								.82				.82	1.00	117	
312	1240	148.2	7	1.72	1.54	1.375	4000	.000141	18 000	.500	.001487	44 600	41 120	1.08	17 000	.001268	38 000	4.10	8.57	373 800	429 000	.87	.000880	2780	2555	2935	.92	1.06	116
313	1260	151.0	7	1.72	1.54	1.375	4000	.000150	18 420	.500	.001345	40 400	40 070	1.01	18 000	.001272	38 200	4.18	8.54	373 700	453 400	.82	.000914	2850	2590	3065	.88	1.08	108
314	1220	146.0	7	1.72	1.54	1.375	4000	.000131	17 770	.500	.001325	39 800	40 440	.98	17 770	.001325	39 800	4.15	8.55	390 200	447 200	.85	.000940	2800	2640	3030	.87	1.04	121
Average									18 060	.500	.001386	41 600		1.02								.85				.89	1.06	120	
324	1220	146.3	8	1.96	1.72	1.571	4000	.000135	21 360	.600	.001603	48 100	37 250	1.29	21 000	.001419	42 600	4.37	8.47	454 500	524 700	.87	.001102	3200	2990	3435	.93	1.07	130
325	1250	146.8	8	1.96	1.72	1.571	4000	.000134	20 730	.590	.001528	45 800	37 730	1.21	20 000	.001325	39 800	4.28	8.50	427 200	501 200	.85	.000990	3000	2855	3360	.95	1.12	124
326	1230	147.3	8	1.96	1.72	1.571	4000	.000132	19 920	.550	.001564	46 900	36 830	1.27	18 000	.001212	36 400	4.36	8.47	388 400	452 800	.86	.000939	2900	2560	2975	.88	1.03	113
Average									20 670	.580	.001565	46 900		1.26								.86				.92	1.01	119	
Grand Ave		146.9					3600	.000132																					

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement			that at Yield Point				
			Number of $\frac{1}{2}$ " round rods	Nominal Per cent	Effective Per cent	Compressive Stress Upper Fiber, lbs. per sq. in.		C ₂ C ₁	C ₃ C ₁	Unit Bond Stress, lbs. per sq. in.
						C ₂ from Resisting Moment.	C ₃ from Bending Moment.			
1	2	3	4	5	6	26	27	28	29	30
252	1190	146.9	2	0.49	0.49	780	1370	0.48	0.85	128
253	1200	146.4	2	.49	.49	830	1405	.52	.87	128
254	1200	142.6	2	.49	.49	1005	1545	.66	1.02	127
Average								.55	.91	128
267	1220	147.9	3	.74	.74	1740	2070	.87	1.03	121
268	1210	146.1	3	.74	.74	1410	1960	.75	1.04	121
269	1210	146.5	3	.74	.74	1650	2170	.76	1.00	133
Average								.79	1.02	125
279	1200	146.9	4	.98	.98	2035	2425	.87	1.04	119
280	1220	147.0	4	.98	.98	1845	2250	.83	1.07	110
281	1200	145.6	4	.98	.98	1555	2100	.71	.96	111
Average								.82	1.02	113
291	1220	146.5	5	1.23	1.11	2355	2740	.98	1.14	119
292	1230	147.5	5	1.23	1.11	1790	2385	.79	1.05	113
293	1240	148.7	5	1.23	1.11	1910	2515	.77	1.01	122
Average								.85	1.07	118
303	1200	143.5	6	1.47	1.34	2600	3060	1.02	1.20	119
304	1200	143.4	6	1.47	1.34	2565	2985	.98	1.13	120
305	1230	145.9	6	1.47	1.34	2505	3095	.92	1.14	129
Average								.97	1.16	122
315	1230	146.2	7	1.72	1.54	2655	2985	.91	1.02	121
316	1240	144.9	7	1.72	1.54	2635	2960	.90	1.01	121
317	1250	147.7	7	1.72	1.54	2850	3275	.98	1.13	120
Average								.93	1.05	121
327	1220	144.1	8	1.96	1.72	2870	3190	.98	1.07	110
328	1220	144.0	8	1.96	1.72	2770	3220	.88	1.02	117
(1) Average								.92	1.05	114
Grand Ave									1.04	120

Remarks.—Average bond stress developed

246	1200	146.1	2	0.49	0.49	550	1245	0.34	0.76	130
247	1200	144.1	2	.49	.49	980	1500	.57	.88	127
248	1210	148.3	2	.49	.49	715	1395	.46	.91	128
Average								.46	.85	128
270	1230	147.6	3	.74	.74	1785	2275	.98	1.25	119
271	1220	145.7	3	.74	.74	1050	1930	.63	1.15	122
272	1230	146.8	3	.74	.74	1440	2190	.88	1.34	120
Average								.83	1.25	120
282	1230	147.1	4	.98	.98	2130	2585	.96	1.16	118
283	1230	145.9	4	.98	.98	1915	2435	.81	1.03	119
284	1220	147.7	4	.98	.98	2020	2485	.87	1.07	118
Average								.88	1.09	118
294	1220	145.3	5	1.23	1.11	2565	2985	.95	1.11	127
295	1240	146.4	5	1.23	1.11	2395	2955	.92	1.14	128
296	1240	147.1	5	1.23	1.11	2275	2830	.83	1.03	129
Average								.90	1.09	128
306	1230	149.6	6	1.47	1.30	2365	2830	.78	.93	122
307	1250	145.6	6	1.47	1.30	2750	3145	1.02	1.17	119
308	1230	147.2	6	1.47	1.30	1885	3480	1.05	1.94	125
Average								.95	1.05	122
309	1220	145.1	7	1.72	1.54	2595	3170	.80	.98	122
310	1220	146.5	7	1.72	1.54	2855	3170	.84	.93	121
311	1240	146.9	7	1.72	1.54	2760	3315	.81	.97	128
Average								.82	.96	124
330	1230	144.6	8	1.96	1.72	3395	3660	1.01	1.09	120
331	1250	149.5	8	1.96	1.72	3050	3595	.85	1.00	129
332	1210	145.7	8	1.96	1.72	3180	3170	.87	.87	128
Average								.91	.99	126
Grand Ave									1.04	124

Remarks.—Average bond stress developed

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SUMMARY OF TESTS ON REINFORCED CONCRETE BEAMS—Continued

Table 12.—Limestone Concrete. Proportions, 1:2:4. Age, 26 Weeks

Beam Number	Reinforcement						First Crack		Maximum Load						Analysis of Beam at Unit Elongation in Reinforcement Less than that at Yield Point																
	Total Weight of Beam, in lbs.	Weight of cu. ft. in lbs.	Number of # round rods	Non-linear Per cent	Effective Per cent	Area, in sq. in.	Applied Load, in lbs.	Unit Elongation in Lower Fiber, inches per inch	Applied Load, in lbs.	Deflection, inches	Unit Elongation in Steel, inches per inch	Unit Stress of Steel, lbs. per sq. in. S ₁	Yield Point of Steel, lbs. per sq. in. S ₂	S ₁ S ₂	Applied Load, in lbs.	Unit Elongation in Steel, inches per inch	Unit Steel Stress in lbs. per sq. in.	K.D. in inches	D-35 K.D. in inches	Resisting Moment, in lb.-ft.	Bending Moment, in lb.-ft.	Mr Mb	Unit Deformation Upper Fiber, inches per inch	Unit Compressive Stress Upper Fiber, lbs. per sq. in.							
																								C ₁ from Cylinder Curve.	C ₂ from Resisting Moment.	C ₃ from Bending Moment.	C ₄ from C ₁	C ₅ from C ₁	Unit Bond Stress, lbs. per sq. in.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
252	1190	146.9	2	0.49	0.49	0.393	3000	0.000106	6310	0.335	0.001065	32 000	40 750	0.79	6000	0.000889	26 700	3.03	8.94	93 700	164 400	0.57	0.000387	1610	780	1370	0.48	0.85	128		
253	1200	146.4	2	.49	.49	.393	3000	.000099	6000	.290	.000923	27 700	41 650	.67	6000	.000923	27 700	2.95	8.97	97 600	164 400	.59	.000385	1610	830	1405	.52	.87	128		
254	1200	142.6	2	.49	.49	.393	2000	.000076	6000	.285	.001001	30 000	40 290	.74	6000	.001001	30 000	2.64	9.08	107 000	164 400	.65	.000359	1520	1005	1545	.66	1.02	127		
Average									6100	.303	.000996	29 900		.73								.60					.55	.91	128		
267	1220	147.9	3	.74	.74	.589	3500	.000117	9110	.380	.001356	40 700	40 690	1.00	9000	.001251	37 500	2.86	9.00	198 800	236 700	.84	.000502	2010	1740	2070	.87	1.03	121		
268	1210	146.1	3	.74	.74	.589	4000	.000134	9000	.350	.001072	32 200	40 750	.79	9000	.001072	32 200	3.03	8.94	169 600	236 500	.72	.000467	1890	1410	1960	.75	1.04	121		
269	1210	146.5	3	.74	.74	.589	3000	.000084	10 270	.420	.001284	38 500	41 000	.95	10 000	.001255	37 700	3.03	8.94	198 500	260 500	.76	.000545	2160	1650	2170	.76	1.00	133		
Average									9460	.383	.001237	37 100		.91								.77					.79	1.02	125		
279	1200	146.9	4	.98	.98	.785	3000	.000094	12 380	.435	.001325	39 800	41 040	.97	12 000	.001248	37 400	3.25	8.86	260 300	308 460	.84	.000602	2340	2035	2425	.87	1.04	119		
280	1220	147.0	4	.98	.98	.785	4000	.000120	11 430	.415	.001268	38 000	40 990	.93	11 000	.001115	33 500	3.21	8.88	233 600	284 700	.82	.000526	2100	1845	2250	.89	1.07	110		
281	1200	145.6	4	.98	.98	.785	3500	.000094	11 740	.425	.001215	36 500	41 090	.89	11 000	.001042	30 700	3.49	8.78	211 700	284 400	.74	.000549	2180	1555	2100	.71	.96	111		
Average									11 850	.425	.001269	38 100		.93								.80					.82	1.02	113		
291	1220	146.5	5	1.23	1.11	.982	4000	.000116	13 220	.460	.001504	45 100	39 800	1.13	13 000	.001277	38 300	3.27	8.86	285 900	332 700	.86	.000621	2400	2355	2740	.98	1.14	119		
292	1230	147.5	5	1.23	1.11	.982	4000	.000132	13 000	.415	.001296	38 900	39 990	.97	12 000	.001058	31 700	3.55	8.76	326 900	308 900	.75	.000583	2280	2565	2885	.79	1.05	113		
293	1240	146.7	5	1.23	1.11	.982	4000	.000144	13 600	.475	.001315	39 500	40 300	.98	13 000	.001147	34 400	3.61	8.74	251 900	333 000	.79	.000649	2480	1910	2515	.77	1.01	122		
Average									13 270	.450	.001372	41 200		1.03								.79					.85	1.07	118		
303	1200	143.5	6	1.47	1.30	1.178	4000	.000115	15 820	.490	.001549	46 500	41 890	1.11	15 000	.001274	38 200	3.45	8.79	324 300	380 400	.85	.000671	2540	2600	3060	1.02	1.20	119		
304	1260	143.4	6	1.47	1.30	1.178	4000	.000133	15 710	.490	.001564	46 900	41 550	1.10	15 000	.001285	38 600	3.53	8.76	326 000	380 400	.86	.000702	2630	2565	2985	.98	1.13	120		
305	1230	145.9	6	1.47	1.30	1.178	4000	.000123	16 930	.510	.001503	45 100	41 060	1.10	16 000	.001294	38 800	3.62	8.73	326 000	404 900	.81	.000736	2710	2505	3095	.92	1.14	129		
Average									16 150	.497	.001539	46 200		1.11								.84					.97	1.16	122		
315	1230	146.2	7	1.72	1.54	1.375	4000	.000121	18 940	.505	.001470	44 100	39 600	1.11	18 000	.001260	37 800	3.94	8.62	375 300	452 900	.89	.000820	2920	2655	2985	.91	1.02	121		
316	1240	144.9	7	1.72	1.54	1.375	4000	.000106	18 880	.535	.001561	46 800	37 530	1.25	18 000	.001264	37 500	3.97	8.61	375 500	453 000	.89	.000831	2940	2635	2960	.90	1.01	121		
317	1280	147.7	7	1.72	1.54	1.375	5000	.000159	18 800	.465	.001309	39 600	39 870	.99	18 000	.001309	39 300	3.82	8.66	392 800	453 200	.87	.000889	2920	2850	3275	.98	1.13	120		
Average									18 610	.502	.001447	43 400		1.12								.88					.93	1.05	121		
327	1220	144.1	8	1.96	1.72	1.571	4000	.000132	20 000	.520	.001597	47 500	36 730	1.30	18 000	.001250	37 500	4.04	8.59	409 200	452 700	.90	.000847	2980	2870	3190	.98	1.07	110		
328	1220	144.0	8	1.96	1.72	1.571	4000	.000127	20 420	.585	.001656	49 700	37 140	1.34	19 000	.001267	38 600	4.22	8.52	409 300	476 700	.80	.000923	3150	2770	3220	.98	1.02	117		
(1) Average									20 210	.553	.001627	48 800		1.32								.88					.92	1.05	114		
Grand Ave							3500	.000115																				1.04	120		

¹ Sent to Jamestown.

Remarks.—Average bond stress developed in beam—120 pounds per square inch. Average ultimate bond stress from bond test pieces—604 pounds per square inch. Ratio—5.0.

Table 13.—Limestone Concrete. Proportions, 1:2:4. Age, 52 Weeks

246	1200	146.1	2	0.49	0.49	0.393	3000	0.000107	7000	0.350	0.001253	37 600	41 100	0.91	6000	0.000596	20 900	3.37	8.82	72 400	164 350	0.441	0.000353	1630	550	1245	0.34	0.76	130
247	1200	144.1	2	.49	.49	.393	2000	.000070	6800	.355	.001256	37 700	41 230	.91	6000	.001005	30 200	2.72	9.05	107 300	164 350	.653	.000375	1710	980	1500	.57	.88	127
248	1210	148.3	2	.49	.49	.393	3000	.000077	6380	.320	.000868	26 000	40 680	.64	6000	.000800	24 000	2.96	8.96	84 400	164 500	.513	.000336	1540	715	1395	.46	.85	128
Average									6730	.342	.001255	33 800		.82								.536					.46	.85	128
270	1230	147.6	3	.74	.74	.589	3000	.000091	9360	.375	.001258	37 700	41 900	.90	9000	.001156	34 700	2.58	9.10	186 000	236 860	.785	.000403	1820	1785	2275	.98	1.25	119
271	1220	145.7	3	.74	.74	.589	3000	.000082	9000	.340	.000815	24 500	41 890	.58	9000	.000815	24 500	3.09	8.92	128 800	236 700	.544	.000365	1680	1050	1930	.63	1.15	120
272	1230	146.8	3	.74	.74	.589	3000	.000112	9700	.380	.001115	33 500	41 660	.80	9000	.000974	29 200	2.69	9.06	155 900	236 850	.658	.000357	1640	1440	2190	.68	1.34	122
Average									9350	.365	.001187	31 900		.76								.662					.63	1.25	120
282	1230	147.1	4	.98	.98	.785	3000	.000097	12 000	.380	.001205	36 200	41 040	.88	12 000	.001205	36 200	3.00	8.95	254 500	308 850	.824	.000517	2230	2130	2585	.96	1.16	118
283	1230	145.9	4	.98	.98	.785	3000	.000088	12 620	.440	.001303	39 100	40 950	.95	12 000	.001162	34 900	3.22	8.87	243 200	308 850	.787	.000553	2360	1915	2435	.81	1.03	118
284	1220	147.7	4	.98	.98	.785	3000	.000107	12 200	.435	.001308	39 200	42 210	.93	12 000	.001198	35 900	3.14	8.90	250 900	308 700	.813	.000547	2330	2020	2485	.87	1.07	118
Average									12 270	.418	.001272	38 200		.92								.808					.88	1.09	118
294	1220	145.3	5	1.23	1.11	.982	3000	.000092	14 670	.470	.001487	44 600	39 720	1.12	14 000	.001368	41 000	3.22	8.87	306 700	356 700	.860	.000651	2690	2565	2985	.95	1.11	127
295	1240	146.4	5	1.23	1.11	.982	3000	.000095	14 380	.460	.001410	42 300	40 270	1.05	14 000	.001289	38 700	3.25	8.86	289 000	357 000	.810	.000620	2590	2395	2955	.92	1.14	128
296	1240	147.1	5	1.23	1.11	.982	3000	.000097	14 100	.460	.001453	43 600	40 840	1.07	14 000	.001294	38 800	3.42	8.80	287 000	357 000	.804	.000671	2750	2275	2930	.88	1.09	128
Average									14 380	.463	.001450	43 500		1.08								.825					.90	1.09	128
306	1230	149.6	6	1.47	1.30	1.178	3000	.000104	16 450	.550	.001692	50 800	39 650	1.28	15 000	.001272	38 200	3.77	8.68	318 000	380 900	.835	.000770	3050	2365	2830	.78	.93	122
307	1250	145.6	6	1.47	1.30	1.178	3000	.000097	16 070	.458	.001728	51 800	40 770	1.27	15 000	.001299	39 000	3.34	8.83	333 400	381 150	.875	.000652	2690	2750	3145	1.02	1.17	129
308	1230	147.2	6	1.47	1.30	1.178	4000	.000065	16 000	.460	.000846	12 500	40 440	1.63	16 000	.000846	25 400	3.18	8.89	219 300	404 900	.542	.0010395	1790	1885	2160	.85	1.04	125
Average									16 170	.489	.001710	51 300		1.28								.751					.95	1.05	122
309	1220	145.1	7	1.72	1.54	1.375	3000	.000147	18 800	.500	.001328	39 800	40 590	.98	18 000	.001254	37 600	4.00	8.60	371 900	453 850	.819	.000835	3230	2595	3170	.80	.98	122
310	1220	145.7	7	1.72	1.54	1.375	4000	.000131	19 465	.535	.001581	47 400	39 750	1.19	18 000	.001369	41 100	3.98	8.61	407 200	452 700	.900	.000904	3410	2850	3170	.84	.93	121
311	1240	146.9	7	1.72	1.54	1.375	4000	.000124	19 320	.575	.001422	42 700	40 820	1.05	19 000	.001344	40 300	4.03	8.59	398 000	478 200	.832	.000907	3420	2760	3140	.81	.97	128
Average									19 040	.537	.001444	43 300		1.07								.850					.82	.96	124
330	1220	144.6	8	1.96	1.72	1.571	4000	.000130	21 000	.555	.001574	47 200	36 790	1.28	20 000	.001403	42 100	3.85	8.65	464 800	500 850	.928	.000878	3350	3395	3660	1.01	1.09	120
331	1250	149.5	8	1.96	1.72	1.571	4000	.000114	21 580	.530	.001432	43 600	37 510	1.15	21 000	.001374	41 200	4.16	8.54	445 700	525 200	.849	.000980	3690	3640	3910	.87	.87	126
332	1210	145.7	8	1.96	1.72	1.571	4000	.000128	21 150	.548	.001588	43 400	38 720	1.23	21 000	.001422	42 700	4.14	8.55	462 700	524 500	.882	.001003	3640	3180	3170	.81	.99	126
Average									21 240	.544	.001531	45 900		1.22								.886					.87	1.04	124
Grand Ave		146.6					3200	.000101																					

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement			Less than that at Yield Point						
			Number of 3/4" round rods	Nominal Per cent	Effective Per cent	Area, sq. in.	Unit Compressive Stress Upper Fiber, lbs. per sq. in.			C ₂ C ₁	C ₃ C ₁	Unit Bond Stress, lbs. per sq. in.
							C ₁ , from Cylinder Curve	C ₂ , from Resisting Moment	C ₃ , from Bending Moment			
1	2	3	4	5	6		25	26	27	28	29	30
333	1150	143.6	2	0.49	0.49	0	1780	1060	1360	0.60	0.76	117
334	1140	140.0	2	.49	.49		1750	830	1260	.47	.72	118
335	1170	141.8	2	.49	.49		1790	1130	1615	.63	.90	135
Average..										.57	.79	123
345	1180	145.8	3	.74	.74		2300	1970	2010	.86	.87	120
346	1170	144.6	3	.74	.74		2180	1410	1740	.65	.80	116
347	1170	144.4	3	.74	.74		2270	1410	1810	.62	.80	122
Average..										.71	.82	119
357	1170	143.7	4	.98	.98		2610	2170	2385	.83	.91	128
358	1180	146.0	4	.98	.98		2420	1900	2290	.79	.95	119
359	1190	144.6	4	.98	.98		2410	2200	2420	.91	1.00	119
Average..										.84	.95	122
369	1170	141.8	5	1.23	1.11		2730	2060	2395	.75	.88	122
370	1160	141.6	5	1.23	1.11		2490	2020	2320	.81	.93	112
371	1160	145.3	5	1.23	1.11		2710	2200	2470	.81	.91	121
Average..										.79	.91	118
381	1180	145.7	6	1.47	1.30	1	2840	2080	2445	.73	.86	117
382	1190	143.6	6	1.47	1.30	1	2850	2530	2780	.89	.98	122
383	1200	145.2	6	1.47	1.30	1	2690	2620	2910	.97	1.08	121
Average..										.86	.97	120
393	1210	147.4	7	1.72	1.54	1	2940	2670	2935	.91	1.00	116
394	1190	145.5	7	1.72	1.54	1	2980	2860	2950	.96	.99	115
395	1200	143.4	7	1.72	1.54	1	2850	2840	3055	1.00	1.07	115
Average..										.96	1.02	115
405	1200	146.3	8	1.96	1.72	1	3000	2500	2940	.83	.98	113
406	1220	147.8	8	1.96	1.72	1	3000	3140	3305	1.05	1.10	116
407	1210	147.3	8	1.96	1.72	1	3000	3020	3245	1.01	1.08	117
Average..										.96	1.05	115
Grand Ave			144.5								.93	119

¹ Not used.

Remarks.—Average bond stress developed in beam.—Values in parentheses are estimated.

336	1170	143.7	2	0.49	0.49	0	1980	1290	1790	0.65	0.90	143
337	1170	141.7	2	.49	.49		1800	1210	1705	.67	.95	134
338	1160	142.4	2	.49	.49		1540	710	1290	.46	.84	118
Average..										.59	.90	132
348	1190	147.0	3	.74	.74		2160	1380	1915	.64	.89	121
349	1200	145.7	3	.74	.74		2440	2140	2610	.88	1.07	143
350	1180	145.9	3	.74	.74		1880	1220	1745	.65	.93	109
Average..										.72	.96	124
360	1190	145.7	4	.98	.98		2460	2010	2450	.82	1.00	118
361	1200	143.0	4	.98	.98		2320	2060	2595	.89	1.10	118
362	1180	145.0	4	.98	.98		2610	2140	2460	.82	.94	118
Average..										.84	1.01	118
372	1210	147.1	5	1.23	1.11		2860	2160	2805	.76	.98	130
373	1200	144.9	5	1.23	1.11		3040	2350	2975	.77	.98	137
374	1210	147.4	5	1.23	1.11		2940	2500	2905	.85	.99	128
Average..										.79	.98	132
384	1190	143.1	6	1.47	1.30	1	3000	2750	3235	.92	1.08	127
385	1210	146.4	6	1.47	1.30	1	2890	2570	3025	.89	1.05	120
386	1200	145.9	6	1.47	1.30	1	3000	2390	2915	.80	.97	121
Average..										.87	1.03	123
396	1200	149.6	7	1.72	1.54	1	3280	3040	3455	.95	1.05	123
397	1200	143.3	7	1.72	1.54	1	3000	2800	3255	.93	1.08	113
398	1230	148.7	7	1.72	1.54	1	3270	2810	3270	.86	1.00	120
Average..										.91	1.04	119
408	1230	147.4	8	1.96	1.72	1	3540	3230	3715	.91	1.05	127
409	1240	147.6	8	1.96	1.72	1	3540	3280	3725	.93	1.05	127
410	1200	142.8	8	1.96	1.72	1	3500	3130	3515	.89	1.00	121
Average..										.91	1.03	125
Grand Ave											.99	125

Remarks.—Average bond stress developed in beam.—Values in parentheses are estimated.

SUMMARY OF TESTS ON REINFORCED CONCRETE BEAMS—Continued

Table 14.—Gravel Concrete. Proportions, 1:2:4. Age, 4 Weeks

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement				First Crack		Maximum Load						Analysis of beam at Unit Elongation in Reinforcement Less than that at Yield Point																
			Number of # round rods	Nominal Per cent	Effective Per cent	Area, in sq. in.	Applied Load, in lbs.	Unit Elongation in Lower Fiber, inches per inch	Applied Load, in lbs.	Deflection, inches	Unit Elongation in Steel, inches per inch	Unit Stress of Steel, lbs. per sq. in. S ₁	Yield Point of Steel, lbs. per sq. in. S ₂	S ₁ S ₂	Applied Load, in lbs.	Unit Elongation in Steel, inches per inch	Unit Stress in Steel, lbs. per sq. in.	K.D. in inches	D-.35KD. in inches	Resisting Moment, inch lbs., Mr	Bending Moment, inch lbs., Mb	Mr Mb	Unit Deformation Upper Fiber, inches per inch	Unit Compressive Stress Upper Fiber, lbs. per sq. in.			C ₀ C ₁	C ₂ C ₃	Unit Bond Stress, lbs. per sq. in.		
																								C ₀ from Cylinder Curve	C ₀ from Resisting Moment	C ₀ from Bending Moment					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
333	1150	143.6	2	0.49	0.49	0.393	2000	0.000999	5800	0.325	(.001289)	(38 700)	43 500	0.89	5500	0.001104	33 100	2.77	9.03	117 500	151 600	0.78	0.000422	1780	1060	1360	0.60	0.76	117		
334	1140	140.0	2	.49	.49	.393	2000	.000994	6000	.350	(.001253)	(37 600)	41 910	.90	5500	.000949	28 500	3.02	8.94	100 000	151 400	.66	.000411	1750	830	1260	.47	.72	118		
335	1170	141.8	2	.49	.49	.393	2000	.000985	6160	.370	(.001194)	(35 800)	44 930	.80	6300	.001150	34 500	2.69	9.06	122 800	175 900	.70	.000424	1790	1130	1615	.63	.90	135		
Average									6140	.348	(.001245)	(37 400)		.86								.71				.57	.79		123		
345	1180	145.8	3	.74	.74	.589	2000	.000995	9420	.435	(.001699)	(51 000)	41 440	1.23	9000	.001460	43 800	2.95	8.97	231 500	236 000	.98	.000609	2300	1970	2010	.86	.87	120		
346	1170	144.6	3	.74	.74	.589	2500	.000116	9000	.415	(.001328)	(39 600)	43 640	.91	8500	.001156	34 700	3.26	8.86	181 000	223 900	.81	.000560	2180	1410	1740	.65	.80	116		
347	1170	144.4	3	.74	.74	.589	2500	.000109	9250	.425	(.001263)	(37 900)	43 760	.87	9000	.001183	35 550	3.34	8.83	184 900	235 900	.78	.000593	2270	1410	1810	.62	.80	122		
Average									9220	.425	(.001430)	(38 900)		1.00								.86				.71	.82		119		
357	1170	143.7	4	.98	.98	.785	3000	.000118	13 000	.470	.001557	46 700	43 460	1.07	12 500	.001408	42 200	3.45	8.79	291 600	319 900	.91	.000741	2610	2170	2385	.83	.91	128		
358	1160	146.0	4	.98	.98	.785	3000	.000119	12 260	.465	(.001296)	(38 900)	42 410	.92	12 000	.001241	37 200	3.46	8.79	257 000	308 000	.83	.000656	2420	1900	2290	.79	.95	119		
359	1150	144.6	4	.98	.98	.785	3000	.000119	12 050	.455	(.001379)	(41 400)	41 930	.99	12 000	.001350	40 500	3.26	8.86	281 800	308 200	.91	.000652	2410	2200	2420	.91	1.00	119		
Average									12 450	.463	(.001411)	42 300		.99								.88				.74	.95		122		
369	1170	141.8	5	1.23	1.11	.982	2000	.000306	14 000	.500	.001497	44 900	40 270	1.11	13 000	.001308	39 200	3.81	8.67	283 900	331 900	.86	.000805	* 2730	2060	2395	.75	.88	117		
370	1160	143.6	5	1.23	1.11	.982	2000	.000378	13 400	.515	(.001704)	(51 100)	39 920	1.18	12 000	.001212	35 400	3.71	8.74	266 600	307 700	.87	.000685	* 2790	2020	2320	.81	.93	112		
371	1160	145.3	5	1.23	1.11	.982	2000	.000395	13 870	.540	.001527	45 800	39 540	1.16	12 000	.001356	40 700	3.69	8.71	296 700	331 700	.89	.000791	* 2710	2200	2470	.81	.91	121		
Average									13 750	.518	(.001576)	47 300		1.18								.87				.79	.91		118		
381	1180	145.7	6	1.47	1.30	1.178	3000	.000110	15 240	.565	(.001631)	(48 900)	38 010	1.29	14 000	.001234	37 000	4.11	8.56	301 300	355 000	.85	.000862	* 2840	2080	2445	.73	.86	117		
382	1190	143.6	6	1.47	1.30	1.178	3000	.000118	15 300	.555	(.001621)	(48 600)	38 570	1.26	15 000	.001392	41 800	3.85	8.65	346 100	380 200	.91	.000870	* 2850	2530	2780	.89	.98	122		
383	1200	145.2	6	1.47	1.30	1.178	3000	.000123	15 920	.520	(.001539)	(46 200)	39 170	1.18	15 000	.001362	40 900	3.65	8.72	343 000	380 400	.89	.000782	2650	2320	2910	.97	1.08	121		
Average									15 490	.547	(.001597)	(47 900)		1.24								.89				.86	.97		120		
393	1210	147.4	7	1.72	1.54	1.375	3000	.000105	17 510	.535	.001391	41 700	39 680	1.05	17 000	.001326	39 800	4.11	8.56	390 900	428 500	.91	.000927	* 2940	2670	2935	.91	1.00	116		
394	1190	145.5	7	1.72	1.54	1.375	3000	.000117	18 240	.585	(.001626)	(48 800)	42 120	1.25	17 000	.001402	42 100	4.06	8.58	414 900	428 200	.97	.000959	* 2980	2860	2950	.96	.99	115		
395	1200	143.4	7	1.72	1.54	1.375	3000	.000107	17 920	.530	(.001706)	(51 200)	40 030	1.28	17 000	.001344	40 300	3.93	8.62	400 200	428 400	.93	.000872	* 2850	2840	3055	1.00	1.07	115		
Average									17 890	.550	(.001574)	47 200		1.19								.94				.96	1.02		116		
405	1200	146.3	8	1.96	1.72	1.571	3000	.000093	19 950	.580	.001617	48 500	38 630	1.26	18 000	.001214	36 400	4.45	8.44	386 100	452 400	.85	.000975	* 3000	2500	2940	.83	.98	113		
406	1220	147.8	8	1.96	1.72	1.571	3000	.000105	19 800	.585	.001783	53 500	38 680	1.38	19 000	.001393	41 800	4.11	8.56	453 700	476 800	.95	.000974	* 3000	3140	3305	1.05	1.10	116		
407	1210	147.3	8	1.96	1.72	1.571	3000	.000071	20 450	.630	(.001788)	53 600	38 590	1.39	19 000	.001366	41 000	4.18	8.53	443 300	476 500	.93	.000979	* 3000	3020	3245	1.01	1.08	117		
Average									20 070	.598	.001729	51 900		1.34								.91				.96	1.05		115		
Grand Ave		144.5					2500	.000103														.91				.96	.93		111		

¹ Not used in average.

² Average of only 3 rods.

³ Value taken from average curve produced.

Remarks.—Average bond stress developed in beam=119 pounds per square inch. Average ultimate bond stress from bond test pieces=586 pounds per square inch. Ratio=4.9.

Note.—Values in parentheses are estimated.

Table 15.—Gravel Concrete. Proportions, 1:2:4. Age, 13 Weeks

336	1170	143.7	2	0.49	0.49	0.393	2500	0.000098	7350	0.365	0.001357	40 700	42 590	0.96	7000	0.001256	37 700	2.59	9.09	134 600	187 900	0.72	0.000439	1980	1290	1790	0.65	0.90	143
337	1170	141.7	2	.49	.49	.393	2000	.000076	6740	.340	.001241	37 200	41 530	.90	6500	.001162	34 900	2.55	9.11	124 900	175 900	.71	.000398	1800	1210	1705	.67	.95	134
338	1160	142.4	2	.49	.49	.393	2000	.000077				37 200	42 370		5500	.000797	23 900	2.97	8.96	84 100	151 700	.55	.000337	1540	710	1290	.46	.84	118
Average									7050	.353	.001299	39 000		.93								.66				.59	.90		132
348	1190	147.0	3	.74	.74	.589	3000	.000105	9620	.390	.001338	40 100	42 010	.95	9000	.001072	32 200	3.10	8.92	169 000	236 200	.72	.000481	2160	1380	1915	.64	.89	121
349	1200	145.7	3	.74	.74	.589	3000	.000102	11 050	.465	.001516	45 500	41 330	1.10	11 000	.001467	44 000	2.73	9.04	234 300	284 400	.82	.000551	2440	1880	2140	.68	1.07	143
350	1180	145.9	3	.74	.74	.589	3000	.000116	8800	.345	.001250	37 500	43 390	.86	8000	.000945	28 400	3.07	8.93	149 100	212 000	.70	.000418	1880	1220	1745	.65	.93	109
Average									9820	.400	.001368	41 000		.97								.75				.72	.96		124
360	1190	145.7	4	.98	.98	.785	4000	.000136	12 850	.400	.001362	40 900	43 310	.94	12 000	.001200	36 000	3.17	8.89	251 300	308 200	.82	.000556	2460	2010	2450	.82	1.00	118
361	1200	143.0	4	.98	.98	.785	3000	.000094	12 450	.390	.001309	39 300	39 830	.99	12 000	.001188	35 500	3.05	8.93	249 700	308 400	.81	.000521	2370	2060	2395	.89	1.10	118
362	1180	145.0	4	.98	.98	.785	3000	.000104	12 960	.430	.001468	44 000	40 040	1.10	12 000	.001282	38 500	3.08	8.93	268 800	308 000	.87	.000597	2610	2140	2460	.82	.94	118
Average									12 750	.407	.001380	41 400		1.01								.83				.84	1.01		130
372	1210	147.1	5	1.23	1.11	.982	3000	.000109	14 870	.470	.001385	41 600	39 510	1.05	14 000	.001248	37 400	3.48	8.78	275 800	356 500	.77	.000667	2860	2160	2805	.76	.98	130
373	1200	144.5	5	1.23	1.11	.982	3000	.000098	15 150	.505	.001376	41 300	39 900	1.04	15 000	.001361	40 800	3.48	8.78	300 900	380 400	.79	.000725	3040	2350	2975	.77	.98	130
374	1210	147.4	5	1.23	1.11	.982	3000	.000112	14 550	(.482)	.001458	43 700	39 800	1.10	14 000	.001380	41 400	3.33	8.83	307 700	356 500	.86	.000690	2940	2500	2905	.75	.98	125
Average									14 860	.486	.001406	42 200		1.06								.81				.79	.98		132
384	1190	146.1	6	1.47	1.30	1.178	3000	.000103	16 840	.520	.001553	49 600	37 950	1.31	16 000	.001345	40 400	3.45	8.79	342 500	404 200	.85	.000710	3000	2750	3235	.92	1.08	127
385	1210	143.4	6	1.47	1.30	1.178	3000	.000098	16 720	.485	.001539	46 800	37 470	1.25	15 000	.001270	38 100	3.48	8.78	322 900	380 500	.85	.000678	2890	2590	3025	.89	1.05	127
386	1200	145.9	6	1.47	1.30	1.178	3000	.000103	16 000	.465	.001391	41 700	38 050	1.10	15 000	.001241	37 200	3.64	8.73	312 400	390 400	.82	.000709	3000	2750	2915	.87	1.03	121
Average									16 520	.490	.001534	46 000		1.22								.84				.87	1.03		123
396	1200	149.6	7	1.72	1.54	1.375	4000	.000127	19 650	.535	.001602	48 100	38 080	1.26	18 630	.001359	40 800	3.73	8.69	410 000	467 500	.88	.000807	3260	3040	3455	.95	1.05	123
397	1220	143.3	7	1.72	1.54	1.375	4000	.000113	19 960	.550	.001718	51 500	41 020	1.26	17 100	.001231	36 900	3.63	8.72	372 500	430 800	.86	.000712	3000	2800	3255	.93	1.08	123
398	1230	148.7	7	1.72	1.54	1.375	4000	.000122	19 100	.500	.001655	49 700	38 720	1.28	18 000	.001294	38 800	3.86	8.66	387 800	452 900	.86	.000803	3270	3060	3270	.86	1.00	120
Average									19 570	.547	.001658	49 800		1.27								.87				.91	1.04		119
408	1230	147.6	8	1.96	1.72	1.571	4000	.000117	22 500	.540	.001504	45 100	38 940	1.16	21 000	.001385	41 600	3.98	8.61	455 100	524 900	.87	.000915	3540	3230	3715	.91	1.05	127
409	1210	147.6	8	1.96	1.72	1.571	4000	.000118	22 350	.595	.001826	54 800	38 630	1.42	21 000	.001397	41 900	3.95	8.62	459 900	525 000	.88	.000914	3540	3280	3725	.93	1.05	127
410	1200	142.8	8	1.96	1.72	1.571	4000	.000122	21 600	.575	.001610	48 300	38 110	1.27	20 000	.001349	40 500	4.00	8.60	442 900	500 400	.88	.000898	3500	3130	3515	.89	1.03	121
Average									22 010	.570	.001647	49 400		1.28								.88				.91	1.03		125
Grand Ave		145.2					3200	.000107																			.99		

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement			Stress less than that at Yield Point						
			Number of $\frac{3}{8}$ " round rods	Nominal Per cent	Effective Per cent	Area, sq. in.	Unit Compressive Stress Upper Fiber, lbs. per sq. in.			C_2 C_1	C_3 C_1	Unit Bond Stress, lbs. per sq. in.
							C_1 , from Cylinder Curve	C_2 , from Resisting Moment	C_3 , from Bending Moment			
1	2	3	4	5	6	7	25	26	27	28	29	30
333	1150	143.6	2	0.49	0.49	0.00	1780	1060	1360	0.60	0.76	117
334	1140	140.0	2	.49	.49	0.00	1750	830	1260	.47	.72	118
335	1170	141.8	2	.49	.49	0.00	1790	1130	1615	.63	.90	135
Average...										.57	.79	123
345	1180	145.8	3	.74	.74	0.00	2300	1970	2010	.86	.87	120
346	1170	144.6	3	.74	.74	0.00	2180	1410	1740	.65	.80	116
347	1170	144.4	3	.74	.74	0.00	2270	1410	1810	.62	.80	122
Average...										.71	.82	119
357	1170	143.7	4	.98	.98	0.00	2610	2170	2385	.83	.91	128
358	1180	146.0	4	.98	.98	0.00	2420	1900	2290	.79	.95	119
359	1190	144.6	4	.98	.98	0.00	2410	2200	2420	.91	1.00	119
Average...										.84	.95	122
369	1170	141.8	5	1.23	1.11	0.00	2730	2060	2395	.75	.88	122
370	1160	141.6	5	1.23	1.11	0.00	2490	2020	2320	.81	.93	112
371	1160	145.3	5	1.23	1.11	0.00	2710	2200	2470	.81	.91	121
Average...										.79	.91	118
381	1180	145.7	6	1.47	1.30	0.00	2840	2080	2445	.73	.86	117
382	1190	143.6	6	1.47	1.30	0.00	2850	2530	2780	.89	.98	122
383	1200	145.2	6	1.47	1.30	0.00	2690	2620	2910	.97	1.08	121
Average...										.86	.97	120
393	1210	147.4	7	1.72	1.54	0.00	2940	2670	2935	.91	1.00	116
394	1190	145.5	7	1.72	1.54	0.00	2980	2860	2950	.96	.99	115
395	1200	143.4	7	1.72	1.54	0.00	2850	2840	3055	1.00	1.07	115
Average...										.96	1.02	115
405	1200	146.3	8	1.96	1.72	0.00	3000	2500	2940	.83	.98	113
406	1220	147.8	8	1.96	1.72	0.00	3000	3140	3305	1.05	1.10	116
407	1210	147.3	8	1.96	1.72	0.00	3000	3020	3245	1.01	1.08	117
Average...										.96	1.05	115
Grand Ave		144.5									.93	119

¹ Not reproduced.

Remarks.—Average bond stress developed in beam.—Values in parentheses are estimated.

336	1170	143.7	2	0.49	0.49	1980	1290	1790	0.65	0.90	143
337	1170	141.7	2	.49	.49	1800	1210	1705	.67	.95	134
338	1160	142.4	2	.49	.49	1540	710	1290	.46	.84	118
Average									.59	.90	132
348	1190	147.0	3	.74	.74	2160	1380	1915	.64	.89	121
349	1200	145.7	3	.74	.74	2440	2140	2610	.88	1.07	143
350	1180	145.9	3	.74	.74	1880	1220	1745	.65	.93	109
Average									.72	.96	124
360	1190	145.7	4	.98	.98	2460	2010	2450	.82	1.00	118
361	1200	143.0	4	.98	.98	2320	2060	2595	.89	1.10	118
362	1180	145.0	4	.98	.98	2610	2140	2460	.82	.94	118
Average									.84	1.01	118
372	1210	147.1	5	1.23	1.11	2860	2160	2805	.76	.98	130
373	1200	144.9	5	1.23	1.11	3040	2350	2975	.77	.98	137
374	1210	147.4	5	1.23	1.11	2940	2500	2905	.85	.99	128
Average									.79	.98	132
384	1190	143.1	6	1.47	1.30	3000	2750	3235	.92	1.08	127
385	1210	146.4	6	1.47	1.30	2890	2570	3025	.89	1.05	120
386	1200	145.9	6	1.47	1.30	3000	2390	2915	.80	.97	121
Average									.87	1.03	123
396	1200	149.6	7	1.72	1.54	3280	3040	3455	.95	1.05	123
397	1200	143.3	7	1.72	1.54	3000	2800	3255	.93	1.08	113
398	1230	148.7	7	1.72	1.54	3270	2810	3270	.86	1.00	120
Average									.91	1.04	119
408	1230	147.4	8	1.96	1.72	3540	3230	3715	.91	1.05	127
409	1240	147.6	8	1.96	1.72	3540	3280	3725	.93	1.05	127
410	1260	142.8	8	1.96	1.72	3500	3130	3515	.89	1.00	121
Average									.91	1.03	125
Grand Ave		145.2								.99	125

Remarks.—Average bond stress developed in beam.—Values in parentheses are estimated.

SUMMARY OF TESTS OF REINFORCED CONCRETE BEAMS—Continued

Table 16.—Gravel Concrete. Proportions, 1:2:4. Age, 26 Weeks

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement			First Crack		Maximum Load							Analysis of beam at Unit Elongation in Reinforcement Less than that at Yield Point										Unit Compressive Stress Upper Fiber, lbs. per sq. in.					Ult Bond Stress, lbs. per sq. in.
			Number of round rods	Nominal Per cent	Effective Per cent	Area, in sq. in.	Applied Load, in lbs.	Unit Elongation in Lower Fiber, inches per inch	Applied Load, in lbs.	Deflection, in inches	Unit Elongation in Steel, inches per inch	Unit Stress of Steel, lbs. per sq. in. S ₁	Yield Point of Steel, lbs. per sq. in. S ₂	S ₁ S ₂	Applied Load, in lbs.	Unit Elongation in Steel, inches per inch	Unit Stress in Steel, lbs. per sq. in.	K _D , in inches	D, 35 K _D , in inches	Resisting Moment, inch lbs., Mr	Bending Moment, inch lbs., Mb	Mr Mb	Unit Deformation Upper Fiber, inches per inch	Unit Compressive Stress Upper Fiber, lbs. per sq. in.						
																								C ₁ From Cylinder Curve,	C ₂ from Resisting Moment	C ₃ from Bending Moment	C ₁ C ₁	C ₂ C ₁	C ₃ C ₁	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27 _a	28	29	30	
339	1170	143.4	2	0.49	0.49	0.393	2500	0.000087	6500	0.280	0.001127	33 800	42 160	0.80	6500	0.001127	33 800	2.60	9.09	120 700	175 900	0.69	0.000396	2030	1150	1665	0.57	0.82	134	
340	1170	141.7	2	.49	.49	.393	3000	.000111	6500	.290	.001029	30 900	45 220	.68	6500	.001029	30 900	2.59	9.09	110 300	175 900	.63	.000361	1870	1060	1685	.57	.90	134	
341	1170	144.3	2	.49	.49	.393	2500	.000091	6680	.320	.001212	36 400	40 700	.89	6500	.001144	34 300	2.52	9.12	122 900	175 900	.70	.000384	1960	1200	1715	.61	.87	134	
Average									6560	.297	.001123	33 700		.79								.67						.58	.86	134
351	1150	143.1	3	.74	.74	.589	3500	.000110	10 000	.370	.001241	37 200	42 110	.88	10 000	.001241	37 200	2.95	8.97	196 600	260 000	.76	.000519	2570	1670	2195	.65	.85	132	
352	1200	143.7	3	.74	.74	.589	3000	.000110	10 300	.380	.001200	36 600	43 960	.83	10 000	.001164	34 900	2.99	8.95	184 000	260 000	.71	.000497	2470	1550	2185	.63	.88	133	
353	1150	143.9	3	.74	.74	.589	3000	.000098	9830	.360	.001078	32 300	43 140	.75	9000	.000950	23 500	3.16	8.87	149 200	236 000	.63	.000438	2220	1200	1905	.54	.86	121	
Average									10 040	.370	.001180	35 400		.82								.70						.61	.86	129
363	1200	144.6	4	.98	.98	.785	3000	.000094	13 530	.445	.001429	42 900	39 400	1.09	13 000	.001299	39 000	3.10	8.91	273 200	332 400	.82	.000583	2830	2220	2705	.78	.96	127	
364	1150	140.4	4	.98	.98	.785	3000	.000097	13 100	.430	.001543	46 300	40 310	1.15	12 000	.001229	36 900	2.95	8.97	260 000	308 000	.84	.000513	2550	2210	2630	.87	1.03	117	
365	1190	144.5	4	.98	.98	.785	3000	.000094	13 000	.400	.001239	37 200	39 680	.94	13 000	.001239	37 200	3.22	8.87	259 200	332 200	.78	.000588	2840	2040	2615	.72	.92	127	
Average									13 210	.425	.001404	42 100		1.06								.81						.79	.97	124
375	1150	141.9	5	1.23	1.11	.982	3000	.000094	15 780	.500	.001579	47 400	39 850	1.19	15 000	.001415	42 450	3.26	8.87	317 000	380 000	.83	.000683	3210	2620	3155	.82	.98	136	
376	1170	139.3	5	1.23	1.11	.982	3000	.000096	14 990	.470	.001328	39 800	39 660	1.00	14 000	.001205	36 150	3.32	8.84	269 100	355 900	.76	.000599	2900	2190	2925	.76	.99	127	
377	1170	140.9	5	1.23	1.11	.982	4000	.000140	15 360	.490	.001543	46 300	39 680	1.17	14 000	.001267	36 000	3.31	8.84	282 900	355 900	.79	.000627	3000	2310	2925	.79	.98	127	
Average									15 380	.487	.001483	44 500		1.12								.79						.79	.98	130
387	1200	145.0	6	1.47	1.30	1.178	4000	.000122	16 880	.525	.001607	48 200	38 400	1.26	16 000	.001249	37 500	3.87	8.65	310 400	404 400	.77	.000788	3580	2260	2935	.63	.82	130	
388	1190	141.4	6	1.47	1.30	1.178	4000	.000121	17 000	.485	.001516	45 500	38 120	1.19	16 000	.001340	40 200	3.37	8.82	313 000	404 200	.85	.000680	3200	2810	3305	.88	1.03	126	
389	1200	144.8	6	1.47	1.30	1.178	4000	.000130	16 980	.485	.001463	43 900	38 540	1.14	16 000	.001272	38 200	3.65	8.72	320 400	404 400	.79	.000731	3380	2450	3100	.73	.92	128	
Average									16 950	.498	.001529	43 900		1.20								.80						.79	.92	128
399	1200	144.0	7	1.72	1.54	1.375	4000	.000119	19 650	.495	.001496	44 900	39 050	1.15	19 000	.001338	40 100	3.82	8.66	400 800	476 400	.84	.000828	3700	2910	3465	.75	.94	126	
400	1210	142.5	7	1.72	1.54	1.375	4000	.000113	20 000	.495	.001415	42 500	38 250	1.11	19 000	.001313	39 400	3.61	8.74	399 100	476 500	.84	.000741	3420	3040	3620	.89	1.06	125	
401	1200	144.5	7	1.72	1.54	1.375	4000	.000124	19 880	.505	.001578	47 900	38 740	1.22	18 000	.001290	38 700	3.64	8.73	391 300	452 400	.87	.000740	3410	2960	3400	.87	.99	119	
Average									19 680	.498	.001496	44 900		1.16								.85						.85	1.00	123
(b)	1200	141.9	8	1.96	1.72	1.571	4000	.000118	22 900	.530	.001492	44 800	38 240	1.17	21 000	.001383	41 500	3.75	8.69	461 400	524 400	.88	.000828	3700	3140	3710	.83	1.06	125	
412	1220	144.7	8	1.96	1.72	1.571	4000	.000117	22 000	.555	.001559	46 500	38 620	1.20	21 000	.001316	39 500	3.81	8.67	437 500	524 700	.83	.000810	3640	3420	3880	.88	1.07	125	
Average									22 000	.543	.001521	45 700		1.19								.86						.91	1.07	125
Grand Ave	143.0						3400	.000109																					.95	

^a Sent to Jamestown.

Remarks.—Average bond stress developed in beam=128 pounds per square inch. Average ultimate bond stress from bond test pieces=738 pounds per square inch. Ratio=5.8.

Table 17.—Gravel Concrete. Proportions, 1:2:4. Age, 52 Weeks

342	1150	142.0	2	0.49	0.49	0.393	3000	0.000107	6280	0.250	0.001091	32 700	43 870	0.75	6000	0.000872	26 200	2.71	9.05	93 100	163 550	0.569	0.000325	1760	855	1500	0.49	0.25	126
343	1150	142.5	2	.49	.49	.393	3000	.000119	5800	.265	.000773	23 200	42 520	.55	5500	.000603	18 100	3.19	8.88	63 100	151 550	.416	.000282	1560	500	1200	.32	.77	120
344	1160	144.5	2	.49	.49	.393	3000	.000123	6800	.365	.001169	35 100	46 030	.76	6500	.001111	33 300	2.75	9.04	118 200	175 700	.673	.000420	2220	1070	1590	.48	.72	130
Average									6290	.293	.001011	30 300		.69								.553					.43	.78	127
354	1160	143.3	3	.74	.74	.589	3000	.000104	9600	.370	.001456	43 700	44 280	.99	9000	.001142	34 300	3.00	8.95	180 900	235 700	.768	.000488	2560	1515	1975	.59	.77	121
355	1160	142.3	3	.74	.74	.589	3000	.000097	10 450	.420	.001444	43 200	42 980	1.01	10 000	.001306	39 200	2.82	9.01	208 100	259 700	.801	.000513	2690	1845	2305	.69	.86	122
356	1150	141.0	3	.74	.74	.589	3500	.000118	9950	.380	.001431	42 900	42 880	1.00	9000	.001123	33 700	2.98	8.96	177 900	235 550	.755	.000477	2500	1500	1995	.60	.79	120
Average									10 000	.390	.001444	43 300		1.00								.775					.63	.81	124
366	1170	143.0	4	.98	.98	.785	3000	.000100	13 950	.470	.001562	46 900	40 480	1.16	13 000	.001374	41 200	3.02	8.94	289 300	331 900	.872	.000596	3070	2410	2765	.79	.90	126
367	1190	144.2	4	.98	.98	.785	3000	.000098	13 870	.435	.001439	43 200	40 030	1.08	13 000	.001279	38 400	3.17	8.89	268 100	332 200	.807	.000595	3070	2140	2650	.70	.86	127
368	1160	144.6	4	.98	.98	.785	3500	.000092	13 870	.435	.001390	41 700	39 810	1.05	13 000	.001232	37 000	3.40	8.81	256 000	332 050	.771	.000635	3240	1925	2495	.59	.77	128
Average									13 900	.452	.001464	43 900		1.10								.817					.69	.84	127
378	1170	144.5	5	1.23	1.11	.982	3000	.000112	14 230	.450	.001240	(37 200)	38 090	.98	14 000	.001210	36 300	3.49	8.78	267 700	357 050	.750	.000648	3300	2085	2780	.63	.84	129
379	1180	143.8	5	1.23	1.11	.982	3000	.000106	14 850	.480	.001364	40 900	37 850	1.08	14 000	.001234	37 000	3.47	8.79	273 200	356 050	.767	.000657	3340	2470	2790	.64	.84	119
380	1160	141.9	5	1.23	1.11	.982	3000	.000106	14 000	.460	.001568	47 000	38 180	1.23	13 000	.001224	36 700	3.32	8.84	273 100	331 700	.823	.000608	3120	2220	2700	.71	.87	126
Average									14 360	.463	.001391	41 700		1.10								.780					.66	.85	127
390	1190	143.5	6	1.47	1.30	1.178	4000	.000106	16 980	.470	.001190	(35 700)	39 330	.91	16 000	.001105	33 200	3.99	8.60	272 400	405 400	.672	.000733	3650	1930	2870	.53	.79	131
391	1200	143.1	6	1.47	1.30	1.178	4000	.000114	17 440	.490	.001487	44 600	38 050	1.17	17 000	.001391	41 700	3.54	8.76	352 200	428 400	.822	.000760	3750	2760	3360	.74	.90	135
392	1190	144.3	6	1.47	1.30	1.178	4000	.000143	17 250	.525	.001668	50 000	38 510	1.30	16 000	.001309	39 300	3.57	8.75	331 400	404 250	.820	.000728	3620	2580	3145	.71	.87	128
Average									17 220	.495	.001446	43 400		1.13								.771					.66	.85	131
402	1200	144.1	7	1.72	1.54	1.375	4000	.000105	19 920	.507	.001400	(42 000)	38 580	1.09	19 000	.001295	38 900	3.89	8.64	387 500	477 500	.812	.000823	3970	2770	3410	.70	.86	117
403	1220	146.5	7	1.72	1.54	1.375	4000	.000119	19 860	.555	.001675	50 300	38 910	1.20	18 000	.001345	40 400	3.70	8.71	407 100	452 700	.899	.000791	3960	3030	3375	.79	.87	129
404	1200	144.3	7	1.72	1.54	1.375	4000	.000123	20 200	.539	.001771	53 100	38 970	1.25	19 000	.001374	41 200	3.75	8.69	413 800	476 400	.869	.000826	3990	3085	3510	.76	.88	126
Average									19 900	.534	.001615	48 500		1.25								.860					.75	.87	124
414	1190	143.7	8	1.96	1.72	1.571	4000	.000119	21 410	.585	.001916	57 500	38 670	1.49	20 000	.001315	39 500	3.96	8.61	433 000	500 250	.866	.000861	4110	3085	3560	.75	.87	121
415	1190	143.8	8	1.96	1.72	1.571	4000	.000112	21 440	.516	.001589	(47 700)	38 320	1.24	20 000	.001222	36 700	3.99	8.60	401 400	501 250	.891	.000810	3930	2845	3550	.75	.84	121
416	1190	143.5	8	1.96	1.72	1.571	4000	.000127	21 000	.560	.001651	49 500	38 940	1.33	20 000	.001365	41 000	3.98	8.61	449 200	500 250	.898	.000904	4240	3190	3550	.74	.87	126
Average									21 280	.554	.001719	51 600		1.33								.855					.74	.84	126
Grand Ave		143.5					3900	.000112																					

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement			A s	less than that at Yield Point					
			Number of $\frac{3}{4}$ " round rods	Nominal Per cent	Effective Per cent		Unit Compressive Stress Upper Fiber, lbs. per sq. in.			C ₂ C ₁	C ₃ C ₁	Unit Bond Stress, lbs. per sq. in.
							C ₁ From Cylinder Curve.	C ₂ from Resisting Moment	C ₃ from Bending Moment			
1	2	3	4	5	6	25	26	27 _a	28	29	30	
339	1170	143.4	2	0.49	0.49							
340	1170	141.7	2	.49	.49	2030	1150	1665	0.57	0.82	134	
341	1170	144.3	2	.49	.49	1870	1060	1685	.57	.90	134	
Average						1980	1200	1715	.61	.87	134	
									.58	.86	134	
351	1180	143.1	3	.74	.74							
352	1200	143.7	3	.74	.74	2570	1670	2195	.65	.85	132	
353	1180	143.9	3	.74	.74	2470	1550	2185	.63	.88	133	
Average						2220	1200	1905	.54	.86	121	
									.61	.85	129	
363	1200	144.6	4	.98	.98							
364	1180	140.4	4	.98	.98	2830	2220	2705	.78	.96	127	
365	1190	144.5	4	.98	.98	2550	2210	2630	.87	1.03	117	
Average						2840	2040	2615	.72	.92	127	
									.79	.97	124	
375	1180	141.9	5	1.23	1.11							
376	1170	139.3	5	1.23	1.11	3210	2620	3155	.82	.98	136	
377	1170	140.9	5	1.23	1.11	2900	2190	2880	.76	.99	127	
Average						3000	2310	2925	.79	.98	127	
									.79	.98	130	
387	1200	145.0	6	1.47	1.30							
388	1190	141.4	6	1.47	1.30	3580	2260	2935	.63	.82	130	
389	1200	144.8	6	1.47	1.30	3200	2810	3305	.88	1.03	126	
Average						3380	2450	3100	.73	.92	128	
									.75	.92	128	
399	1200	144.0	7	1.72	1.54							
400	1210	142.5	7	1.72	1.54	3700	2910	3465	.79	.94	126	
401	1200	144.5	7	1.72	1.54	3420	3040	3620	.89	1.06	125	
Average						3420	2960	3400	.87	.99	119	
									.85	1.00	123	
(1)												
412	1200	141.9	8	1.96	1.72							
413	1220	144.7	8	1.96	1.72	3700	3440	3710	.93	1.06	125	
Average						3640	3220	3880	.88	1.07	125	
Grand Ave		143.0							.91	1.07	125	
										.95	128	

Remarks.—Average bond stress developed in b

342	1150	142.0	2	0.49	0.49	1760	855	1500	0.49	0.85	126
343	1150	142.5	2	.49	.49	1560	500	1200	.32	.77	120
344	1160	144.5	2	.49	.49	2220	1070	1590	.48	.72	135
Average									.43	.78	127
354	1160	143.3	3	.74	.74						
355	1160	142.2	3	.74	.74	2560	1515	1975	.59	.77	121
356	1150	141.0	3	.74	.74	2690	1845	2305	.69	.86	132
Average						2500	1500	1985	.60	.79	120
									.63	.81	124
366	1170	143.0	4	.98	.98						
367	1190	144.2	4	.98	.98	3070	2410	2765	.79	.90	126
368	1180	144.6	4	.98	.98	3070	2140	2650	.70	.86	127
Average						3240	1925	2495	.59	.77	128
									.69	.84	127
378	1170	144.5	5	1.23	1.11						
379	1180	143.8	5	1.23	1.11	3300	2085	2780	.63	.84	129
380	1160	141.9	5	1.23	1.11	3340	2140	2790	.64	.84	129
Average						3120	2220	2700	.71	.87	119
									.66	.85	126
390	1190	143.5	6	1.47	1.30						
391	1200	143.1	6	1.47	1.30	3650	1930	2870	.53	.79	131
392	1190	144.3	6	1.47	1.30	3750	2760	3360	.74	.90	135
Average						3620	2580	3145	.71	.87	128
									.66	.85	131
402	1200	144.1	7	1.72	1.54						
403	1220	146.5	7	1.72	1.54	3970	2770	3410	.70	.86	127
404	1200	144.3	7	1.72	1.54	3860	3035	3375	.79	.87	119
Average						3990	3050	3510	.76	.88	126
									.75	.87	124
414	1190	143.7	8	1.96	1.72						
415	1190	143.0	8	1.96	1.72	4110	3085	3560	.75	.87	121
416	1190	143.5	8	1.96	1.72	3930	2845	3550	.72	.90	121
Average						4240	3190	3550	.75	.84	121
Grand Ave		143.5							.74	.87	121
										.84	126

Remarks.—Average bond stress developed in be

Values in parentheses are estimated.

SUMMARY OF TESTS ON REINFORCED CONCRETE BEAMS—Continued

Table 18.—Cinder Concrete. Proportions 1:2:4. Age, 4 Weeks

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement				First Crack		Maximum Load						Analysis of beam at Unit Elongation in Reinforcement Less than that at Yield Point																Unit Bond Stress, lbs. per sq. in.
			Number of round rods	Nominal Per cent	Effective Per cent	Area, in sq. in.	Applied Load, in lbs.	Unit Elongation in Lower Fiber, Inches per inch	Applied Load, in lbs.	Deflection, inches	Unit Elongation in Steel, inches per inch	Unit Stress of Steel, lbs. per sq. in. S ₁	Yield Point of Steel, lbs. per sq. in. S ₂	S ₁ S ₂	Applied Load, in lbs.	Unit Elongation in Steel, inches per inch	Unit Stress in Steel, lbs. per sq. in.	KD, in inches	D-35 KD, in inches	Resisting Moment, inch lbs., M _r	Bending Moment, inch lbs., M _b	M _r M _b	Unit Deformation Upper Fiber, inches per inch	Unit Compressive Stress Upper Fiber, lbs. per sq. in.			C ₂ C ₁	C ₃ C ₁			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
417	970	120.8	2	0.49	0.49	0.393	2000	0.000195	5900	0.440	0.001169	35 100	36 960	0.95	5500	0.001009	30 300	4.06	8.58	102 100	148 600	0.69	0.000688	940	660	925	0.70	1.02	120		
418	980	121.4	2	.49	.49	.393	1500	.000132	5900	.385	.001132	34 000	37 720	.90	5500	.000976	29 300	4.08	8.57	98 600	148 700	.66	.000674	930	635	960	.68	1.03	121		
419	980	117.6	2	.49	.49	.393	2000	.000201	6390	.445	.001294	38 800	37 330	1.04	6000	.001205	36 200	4.11	8.56	121 700	160 300	.74	.000840	1080	780	1025	.72	.95	130		
Average									6050	.423	.001198	36 000		.96																	
423	990	121.8	3	.74	.74	.589	2000	.000157	8700	.520	.001405	42 200	39 030	1.08	8500	.001311	39 300	4.50	8.43	195 200	220 900	.78	.001073	1240	1160	1320	.84	1.06	120		
430	990	122.5	3	.74	.74	.589	2000	.000171	8760	.520	.001362	40 900	40 490	1.01	8500	.001236	37 100	4.65	8.37	182 900	220 900	.83	.001072	1240	1060	1275	.85	1.03	121		
431	980	121.9	3	.74	.74	.589	2500	.000199	8940	.505	.001234	37 000	41 300	1.09	8500	.001113	33 400	4.81	8.32	163 700	220 700	.74	.001032	1210	920	1245	.76	1.03	121		
Average									8800	.515	.001334	40 000		1.00																	
441	960	119.2	4	.98	.98	.785	2000	.000166	10 500	.585	.001414	42 400	40 520	1.05	10 000	.001215	36 500	5.50	8.08	231 600	256 400	.90	.001487	1410	1175	1305	.83	.93	108		
442	970	119.1	4	.98	.98	.785	2000	.000153	10 900	.595	.001335	(40 100)	41 840	.96	10 500	.001186	35 600	5.54	8.06	225 300	256 600	.84	.001431	1400	1135	1350	.81	.96	113		
443	970	118.3	4	.98	.98	.785	3000	.000249	11 470	.625	.001458	(43 700)	41 150	1.06	10 000	.001060	31 800	5.43	8.10	202 300	256 600	.79	.001258	1330	1035	1310	.78	.99	108		
Average									10 960	.602	.001402	(42 500)		1.02																	
453	960	118.6	5	1.23	1.11	.982	2000	.000173	11 700	.740	.001684	50 500	40 330	1.25	11 000	.001246	37 400	5.70	8.01	238 700	280 400	.85	.001654	1460	1245	1465	.85	1.00	117		
454	980	118.5	5	1.23	1.11	.982	2000	.000176	11 130	.765	.001655	49 700	38 210	1.30	10 000	.001126	33 800	5.59	8.04	217 400	256 700	.85	.001654	1460	1155	1360	.83	.98	107		
455	940	118.5	5	1.23	1.11	.982	2000	.000170	11 450	.665	.001508	45 200	39 750	1.14	10 000	.001097	32 900	5.36	8.12	215 300	256 700	.84	.001258	1330	1180	1405	.88	1.05	110		
Average									11 430	.723	.001616	48 500		1.23																	
465	970	118.1	6	1.47	1.30	1.178	2000	.000164	13 100	(.760)	.001660	(49 800)	36 980	1.35	12 000	.001231	36 900	5.93	7.92	260 200	304 600	.85	.001790	1500	1345	1580	.90	1.05	115		
466	980	117.4	6	1.47	1.30	1.178	2000	.000157	13 460	.810	.001906	(57 200)	37 870	1.51	12 000	.001176	35 300	5.71	8.00	254 200	304 700	.83	.001566	1440	1330	1625	.94	1.13	113		
467	980	119.6	6	1.47	1.30	1.178	2000	.000153	14 100	.845	.001762	(52 900)	37 350	1.42	13 500	.001318	39 500	5.67	8.02	285 800	340 700	.84	.001726	1480	1380	1620	1.03	1.23	125		
Average									13 550	.805	.001776	(53 300)		1.43																	
477	990	119.2	7	1.72	1.54	1.375	3000	.000219	14 870	.885	.001925	57 800	36 730	1.57	13 000	.001179	35 400	5.86	7.95	306 900	328 900	.93	.001668	1460	1580	1700	1.08	1.16	101		
478	980	116.4	7	1.72	1.54	1.375	3000	.000213	14 590	.870	.001701	51 000	35 790	1.42	13 000	.001198	35 900	5.82	7.96	312 600	328 700	.93	.001668	1460	1515	1700	1.11	1.16	101		
479	980	117.7	7	1.72	1.54	1.375	2000	.000146	15 170	.875	.001949	(58 500)	37 620	1.56	13 000	.001097	32 900	5.93	7.92	283 100	328 700	.86	.001598	1440	1445	1650	1.00	1.17	102		
Average									14 880	.877	.001858	(55 800)		1.52																	
489	990	118.9	8	1.96	1.72	1.571	2000	.000148	15 750	.990	.002045	(61 400)	38 020	1.61	13 000	.001094	32 800	6.28	7.80	297 800	328 900	.91	.001844	1510	1475	1620	.98	1.07	96		
490	1000	117.5	8	1.96	1.72	1.571	3000	.000219	16 000	1.005	.001974	59 200	37 690	1.57	13 000	.001055	31 700	6.09	7.87	293 700	329 100	.89	.001641	1460	1485	1670	1.02	1.14	95		
491	1000	150.0	8	1.96	1.72	1.571	3000	.000208	16 410	1.000	.001993	(59 800)	37 950	1.58	14 000	.001145	34 400	6.06	7.88	319 600	353 100	.90	.001765	1490	1625	1805	1.09	1.21	101		
Average									16 050	.995	.002004	(60 100)		1.59																	
Grand Ave		119.0					2200	.000180																							

Note.—Values in parentheses are estimated.

1 Values taken from average curve produced.

Table 19.—Cinder Concrete. Proportions 1:2:4. Age, 13 Weeks

420	960	119.2	2	0.49	0.49	0.393	1000	0.000094	6120	0.395	0.001265	38 000	38 400	0.99	6000	0.001085	32 600	3.83	8.66	110 900	160 400	0.69	0.000674	1160	750	1085	0.65	0.94	128
421	1050	122.4	2	.49	.49	.393	2000	.000163	5860	.340	.001044	31 300	39 220	.80	6500	.000875	26 300	3.83	8.66	89 400	149 100	.60	.000543	970	605	1010	.62	1.04	120
422	980	120.7	2	.49	.49	.393	2000	.000174	5860	.360	.001197	35 900	40 010	.90	5500	.000959	28 800	3.83	8.66	97 900	148 700	.66	.000596	1040	665	1010	.64	.97	119
Average									5950	.365	.001169	35 100		.90															
432	1010	123.5	3	.74	.74	.589	3000	.000219	8810	.420	.001219	36 600	39 860	.92	8730	.001162	34 900	4.12	8.56	176 000	226 800	.78	.000815	1340	1125	1440	.84	1.07	121
433	1020	123.4	3	.74	.74	.589	2000	.000144	9400	.440	.001214	36 400	39 550	.92	9000	.001101	33 000	4.14	8.55	166 200	233 400	.71	.000778	1380	1055	1485	.81	1.14	125
434	990	119.5	3	.74	.74	.589	3000	.000211	9270	.435	.001200	36 000	40 520	.89	9000	.001065	32 000	4.42	8.45	159 300	232 900	.68	.000842	1380	960	1410	.70	1.02	126
Average									9160	.432	.001211	36 300		.91															
444	1000	120.5	4	.98	.98	.785	2000	.000138	12 000	.515	.001285	38 600	39 900	.97	12 000	.001285	38 600	4.64	8.38	254 100	305 100	.83	.001111	1640	1470	1770	.90	1.08	124
445	1000	118.1	4	.98	.98	.785	3000	.000205	11 750	.525	.001381	41 400	39 780	1.04	11 000	.001164	34 900	4.44	8.45	231 600	281 100	.82	.000931	1480	1390	1695	.94	1.15	113
446	1000	120.9	4	.98	.98	.785	2000	.000146	12 000	.535	.001482	44 500	41 670	1.07	11 000	.001209	36 300	4.56	8.40	239 500	281 100	.85	.001014	1560	1405	1655	.90	1.06	114
Average									11 920	.525	.001383	41 500		1.03															
456	990	119.5	5	1.23	1.11	.982	2000	.000144	12 500	.550	.001482	44 500	38 780	1.15	12 000	.001244	37 300	4.88	8.29	252 500	304 900	.83	.001184	1700	1490	1795	.88	1.06	120
457	1020	122.5	5	1.23	1.11	.982	3000	.000193	14 000	.615	.001296	38 900	39 124	1.24	13 000	.001320	39 600	4.72	8.35	271 100	329 400	.82	.001181	1700	1645	2005	.97	1.18	128
458	1010	121.6	5	1.23	1.11	.982	2000	.000144	13 230	.620	.001510	48 300	40 810	1.18	12 000	.001221	36 600	4.92	8.28	247 200	305 200	.81	.001183	1700	1450	1790	.85	1.05	121
Average									13 230	.595	.001554	46 600		1.19															
468	1000	120.5	6	1.47	1.30	1.178	2000	.000122	14 560	.585	.001188	35 600	38 010	.94	14 000	.001128	33 800	5.39	8.11	250 300	353 100	.71	.001317	1800	1395	1965	.78	1.09	127
469	1000	118.6	6	1.47	1.30	1.178	2000	.000135	14 550	(.595)	.001296	38 000	37 970	1.02	14 000	.001209	30 300	5.29	8.15	271 200	353 100	.77	.001360	1820	1535	1985	.84	1.09	126
470	920	118.6	6	1.47	1.30	1.178	2000	.000144	15 000	.599	.001297	52 400	37 530	1.39	14 000	.001344	40 300	5.10	8.22	305 800	352 900	.87	.001399	1840	1770	2040	.96	1.11	124
Average									14 700	.593	.001410	42 300		1.12															
480	1010	120.4	7	1.72	1.54	1.375	3000	.000194	16 650	.645	.001547	46 400	36 110	1.28	15 000	.001125	33 800	5.36	8.12	304 800	377 200	.81	.001297	1780	1680	2075	.94	1.17	111
481	1020	119.4	7	1.72	1.54	1.375	2000	.000122	17 150	1.965	1.003130	193 900	36 260	2.59	15 000	.001137	34 100	5.48	8.00	304 700	377 400	.81	.001317	1830	1650	2035	.97	1.17	112
482	990	115.7	7	1.72	1.54	1.375	2000	.000119	17 500	(.735)	.001781	53 600	36 960	1.45	16 000	.001183	35 500	5.61	8.04	314 100	400 700	.78	.001377	1910	1670	2140	.87	1.12	120
Average									17 100	.690	.001666	50 000		1.37															
492	1010	117.9	8	1.96	1.72	1.571	3000	.000186	18 050	.760	.001726	51 800	37 210	1.39	16 000	.001164	34 900	5.61	8.04	338 300	401 200	.84	.001487	1900	1820	2165	.96	1.14	110
493	1030	118.4	8	1.96	1.72	1.571	4000	.000232	18 860	.783	.001600	48 100	37 190	1.26	17 000	.001234	34 700	5.66	8.02	334 100	425 600	.83	.001596	1950	1890	2285	.97	1.17	117
494	1020	121.3	8	1.96	1.72	1.571	3000	.000187	18 140	.805	.001807	54 200	36 440	1.49	16 000	.001149	34 500	5.66	8.02	332 900	401 400	.83	.001501	1900	1785	2145	.94	1.13	110
Average									18 020	.783	.001711	51 300		1.38															
Grand Ave									2400	.002163	16 000																		

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement			
			Number of $\frac{1}{2}$ " round rods	Nominal Per cent	Effective Per cent	Area, in sq. in.
1	2	3	4	5	6	7
417	970	120.8	2	0.49	0.49	0.393
418	980	121.4	2	.49	.49	.393
419	950	117.6	2	.49	.49	.393
Average						
429	990	121.8	3	.74	.74	.589
430	990	122.5	3	.74	.74	.589
431	980	121.9	3	.74	.74	.589
Average						
441	960	119.2	4	.98	.98	.785
442	970	119.1	4	.98	.98	.785
443	970	118.3	4	.98	.98	.785
Average						
453	960	118.6	5	1.23	1.11	.982
454	980	118.8	5	1.23	1.11	.982
455	980	119.5	5	1.23	1.11	.982
Average						
465	970	118.1	6	1.47	1.30	1.178
466	980	117.4	6	1.47	1.30	1.178
467	980	119.6	6	1.47	1.30	1.178
Average						
477	990	119.2	7	1.72	1.54	1.375
478	980	116.4	7	1.72	1.54	1.375
479	980	117.1	7	1.72	1.54	1.375
Average						
489	990	118.9	8	1.96	1.72	1.571
490	1000	117.5	8	1.96	1.72	1.571
491	1000	150.0	8	1.96	1.72	1.571
Average						
Grand Ave		119.0				

Note.—Values in parentheses are estimated.

420	960	119.2	2	0.49	0.49	0.393
421	1000	122.4	2	.49	.49	.393
422	980	120.7	2	.49	.49	.393
Average						
432	1010	123.5	3	.74	.74	.589
433	1020	123.4	3	.74	.74	.589
434	990	119.5	3	.74	.74	.589
Average						
444	1000	120.5	4	.98	.98	.785
445	1000	118.1	4	.98	.98	.785
446	1000	120.9	4	.98	.98	.785
Average						
456	990	119.5	5	1.23	1.11	.982
457	1020	122.5	5	1.23	1.11	.982
458	1010	121.6	5	1.23	1.11	.982
Average						
468	1000	120.5	6	1.47	1.30	1.178
469	1000	118.3	6	1.47	1.30	1.178
470	990	118.6	6	1.47	1.30	1.178
Average						
480	1010	120.4	7	1.72	1.54	1.375
481	1020	119.0	7	1.72	1.54	1.375
482	980	115.7	7	1.72	1.54	1.375
Average						
492	1010	117.9	8	1.96	1.72	1.571
493	1030	118.4	8	1.96	1.72	1.571
494	1020	121.3	8	1.96	1.72	1.571
Average						
Grand Ave		120.1				

Remarks.—Average bond stress developed in beam—
4672°—12 (To face page 128.) No.

less than that at Yield Point

Unit Compressive Stress Upper Fiber, lbs. per sq. in.			C ₂ C ₁	C ₃ C ₁	Unit Bond Stress, lbs. per sq. in.
C ₁ from Cylinder Curve	C ₂ from Resisting Moment	C ₃ from Bending Moment			
25	26	27	28	29	30
940	660	925	0.70	1.02	120
930	635	960	.68	1.03	121
1080	780	1025	.72	.95	130
			.74	1.00	124
1240	1160	1320	.94	1.06	120
1240	1060	1275	.85	1.03	121
1210	920	1245	.76	1.03	121
			.85	1.04	121
1410	1175	1305	.83	.93	108
1400	1135	1350	.81	.96	113
1330	1035	1310	.78	.99	108
			.81	.96	110
1460	1245	1465	.85	1.00	117
1390	1155	1360	.83	.98	107
1340	1180	1405	.88	1.05	105
			.85	1.01	110
1500	1345	1580	.90	1.05	115
1440	1350	1625	.94	1.13	113
1480	1530	1820	1.03	1.23	125
			.96	1.14	118
1460	1580	1700	1.08	1.16	101
1460	1615	1700	1.11	1.16	101
1440	1445	1680	1.00	1.17	102
			1.06	1.16	101
1510	1475	1620	.98	1.07	96
1460	1485	1670	1.02	1.14	95
1490	1625	1805	1.09	1.21	101
			1.03	1.14	97
			1.08		111

Note.—Values in parentheses are estimated.

SUMMARY OF TESTS ON REINFORCED CONCRETE BEAMS—Continued

Table 20.—Cinder Concrete. Proportions, 1:2:4. Age, 26 Weeks

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement				First Crack		Maximum Load					Analysis of beam at Unit Elongation in Reinforcement Less than that at Yield Point															
			Number of 1/2 round rods	Nominal Per Cent	Effective Per Cent	Area, in sq. in.	Applied Load, in lbs.	Unit Elongation in Lower Fiber, inches per inch	Applied Load, in lbs.	Deflection, inches	Unit Elongation in Steel, inches per inch	Unit Stress at Steel, lbs. per sq. in. S ₁	Yield Point of Steel, lbs. per sq. in. S ₂	S ₁ S ₂	Applied Load, in lbs.	Unit Elongation in Steel, inches per inch	Unit Stress in Steel, lbs. per sq. in.	K.D. in inches	D-.35KD in inches	Restat-ing Moment, inch lbs., Mr	Bending Moment, inch lbs., Mb	Mr Mb	Unit Deformation Upper Fiber, inches per inch	Unit Compressive Stress Upper Fiber, lbs. per sq. in.			C ₂ C ₁	C ₃ C ₁	Unit Bond Stress, lbs. per sq. in.
																								C ₁ from Cylinder Curve	C ₂ from Resisting Moment	C ₃ from Bending Moment			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
423	1000	122.4	2	0.49	0.49	0.393	2000	0.000134	6610	0.360	0.001101	33 000	38 220	0.86	6500	0.000933	28 000	3.88	8.64	95 000	173 100	0.55	0.000591	1210	640	1165	0.53	0.96	130
424	990	121.0	2	.49	.49	.393	2500	.000156	6460	.335	.000945	28 400	38 770	.73	6000	.000848	35 400	8.32	8.66	88 400	160 900	.54	.000525	1090	585	1085	.54	1.00	139
425	990	121.0	2	.49	.49	.393	2500	.000191	6320	.330	.001029	30 900	39 680	.78	6000	.000904	27 100	3.71	8.70	92 600	160 900	.58	.000534	1110	585	1100	.58	1.00	132
Average									6460	.342	.001025	30 800	39 800	.79								.56					.55	.99	128
435	980	120.4	3	.74	.74	.589	2500	.000173	9500	.420	.001210	36 300	40 230	.90	9000	.001019	30 600	4.36	8.47	152 700	232 700	.66	.000786	1510	930	1410	.62	.93	125
436	1000	119.3	3	.74	.74	.589	3000	.000195	9300	.410	.001202	36 100	40 450	.89	9000	.001072	32 200	4.03	8.59	162 900	233 100	.70	.000724	1420	1060	1515	.75	1.07	124
437	980	119.3	3	.74	.74	.589	2500	.000169	9550	.435	.001253	37 600	40 480	.93	9000	.001056	31 700	4.11	8.56	159 600	232 700	.69	.000738	1440	1020	1480	.71	1.03	124
Average									9450	.422	.001222	36 700	40 400	.91								.68					.69	1.01	124
447	970	115.5	4	.98	.98	.785	3000	.000179	12 600	.500	.001354	40 600	41 350	.98	12 000	.001096	32 900	4.71	8.34	215 500	304 600	.71	.000986	1780	1225	1725	.69	.97	124
448	990	117.4	4	.98	.98	.785	3000	.000169	12 830	.515	.001311	39 300	40 850	.96	12 000	.001120	33 600	4.50	8.43	222 500	304 900	.72	.000916	1690	1320	1810	.78	1.07	123
449	990	118.5	4	.98	.98	.785	4000	.000241	13 000	.510	.001376	41 300	39 740	1.04	12 000	.001109	33 300	4.60	8.39	219 400	304 900	.72	.000944	1730	1280	1780	.74	1.03	123
Average									12 810	.508	.001347	40 400	40 400	.99								.72					.74	1.02	123
459	990	117.9	5	1.23	1.11	.982	3000	.000179	13 730	.525	.001315	39 500	38 950	1.01	13 000	.001195	35 900	4.74	8.34	245 300	328 900	.75	.001075	1880	1485	1980	.79	1.05	128
460	990	116.9	5	1.23	1.11	.982	3000	.000174	13 980	.530	.001385	41 600	39 050	1.07	13 000	.001234	37 000	4.49	8.43	257 000	328 900	.78	.001006	1800	1620	2075	.90	1.15	126
461	980	118.9	5	1.23	1.11	.982	3000	.000182	13 100	.570	.001272	38 200	36 800	1.04	13 000	.001221	36 000	4.78	8.33	249 600	328 700	.76	.001117	1830	1495	1965	.77	1.02	128
Average									13 600	.542	.001324	39 800	38 800	1.02								.76					.82	1.07	127
471	990	118.0	6	1.47	1.30	1.178	3000	.000172	15 400	.585	.001545	46 400	38 100	1.22	14 000	.001109	33 300	5.16	8.19	251 200	352 900	.71	.001182	2090	1445	2035	.72	1.02	124
472	990	117.1	6	1.47	1.30	1.178	3000	.000176	15 570	.640	.001561	46 800	36 800	1.27	14 000	.001156	34 700	4.92	8.28	267 000	352 900	.78	.001119	1950	1595	2100	.83	1.09	122
473	990	118.5	6	1.47	1.30	1.178	3000	.000174	15 000	.590	.001566	47 000	36 900	1.24	14 000	.001195	35 900	4.90	8.29	276 700	352 900	.71	.001146	1960	1655	2120	.84	1.08	122
Average									15 320	.605	.001557	46 700	36 700	1.24								.75					.80	1.06	123
483	1000	117.5	7	1.72	1.54	1.375	3000	.000172	17 000	.655	.001638	49 100	35 920	1.37	16 000	.001232	37 000	5.27	8.16	366 300	401 100	.84	.001371	2190	1875	2230	.86	1.02	117
484	1020	119.4	7	1.72	1.54	1.375	3000	.000166	17 550	(.640)	.001540	46 200	36 460	1.27	17 000	.001308	39 200	5.23	8.17	357 200	425 400	.85	.001433	2240	2005	2390	.92	1.14	120
485	1010	119.3	7	1.72	1.54	1.375	3000	.000167	17 000	.615	.001482	44 500	36 880	1.21	15 000	.001067	32 000	5.39	8.11	287 900	377 200	.76	.001249	2060	1580	2080	.77	1.01	111
Average									17 180	.637	.001553	46 600	36 800	1.28								.82					.84	1.03	117
495	1000	117.2	8	1.96	1.72	1.571	3000	.000154	19 730	.680	.001602	48 100	37 140	1.30	18 100	.001174	35 200	5.64	8.03	340 400	451 500	.75	.001521	2330	1825	2435	.79	1.05	114
496	1030	120.4	8	1.96	1.72	1.571	4000	.000212	20 700	.690	.001579	47 400	36 790	1.29	18 000	.001217	36 500	5.31	8.13	361 900	449 600	.81	.001392	2200	2025	2500	.92	1.14	120
497	1010	118.5	8	1.96	1.72	1.571	5000	.000249	20 000	.690	.001385	41 600	37 820	1.19	19 000	.001191	35 700	5.57	8.05	347 100	473 200	.73	.001499	2300	1880	2575	.82	1.12	120
Average									19 810	.687	.001522	45 700	37 800	1.23								.76					.84	1.10	124
Grand Ave		118.9					3000	.000180																				1.04	124

¹ Values taken from average curve produced

Remarks.—Average bond stress developed in beam=124 pounds per square inch. Average ultimate bond stress from bond test pieces=397 pounds per square inch. Ratio=32.

Note.—Values in parentheses are estimated.

Table 21.—Cinder Concrete. Proportions, 1:2:4. Age, 52 Weeks

426	970	120.8	2	0.49	0.49	0.393	2500	0.000186	6460	(0.343)	0.001161	34 800	38 890	0.89	6000	0.000889	26 700	3.95	8.62	90 400	160 050	.565	0.000579	1220	595	1055	0.49	0.86	129
427	960	120.2	2	.49	.49	.393	2000	.000151	6500	.385	.000926	27 800	38 490	.72	6500	.000926	27 800	4.24	8.52	93 000	172 400	.539	.000680	1400	580	1075	.41	.77	140
428	980	122.5	2	.49	.49	.393	2000	.000145	6400	(.340)	.000949	28 500	37 660	.76	6000	.000809	24 300	4.20	8.53	81 400	160 950	.506	.000586	1238	570	1010	.41	.82	131
Average									6450	.356	.001161	30 370		.79								.537					.44	.82	133
438	930	115.2	3	.74	.74	.589	2000	.000143	9500	(.459)	.001325	39 800	40 290	.99	9000	.001125	33 800	4.45	8.44	168 100	231 950	.725	.000901	1750	1005	1385	.57	.79	125
439	960	119.2	3	.74	.74	.589	2500	.000171	9930	(.444)	.001174	35 200	40 850	.86	9000	.001009	30 300	4.47	8.44	150 700	232 400	.648	.000816	1630	900	1390	.55	.85	125
440	960	118.3	3	.74	.74	.589	3000	.000202	9850	(.462)	(.001183)	35 500	41 400	.87	9000	.001034	31 000	4.40	8.46	154 500	232 400	.665	.000813	1620	935	1405	.58	.87	125
Average									9760	(.455)	.001227	36 830		.91								.679					.57	.84	125
450	960	118.3	4	.98	.98	.785	3000	.000181	12 000	.500	.001272	38 200	41 650	.92	12 000	.001272	38 200	4.69	8.37	251 100	304 450	.825	.001122	2050	1440	1745	.70	.85	123
451	960	115.0	4	.98	.98	.785	2000	.000126	12 000	(.482)	.001297	38 900	41 050	.95	11 000	.001210	33 600	4.69	8.37	230 900	280 450	.788	.000987	1880	1265	1605	.67	.85	114
452	950	116.6	4	.98	.98	.785	3000	.000190	12 000	.505	.001227	36 800	40 150	.91	12 000	.001227	36 800	4.68	8.37	241 900	304 450	.795	.001079	2010	1390	1750	.69	.87	123
Average									12 000	.496	.001265	37 970		.93								.803					.70	.86	110
462	960	115.6	5	1.23	1.11	.982	3000	.000243	13 900	(.558)	(.000314)	39 400	37 420	1.05	13 000	.001186	35 600	4.13	8.35	243 600	329 550	.739	.001065	1990	1475	1995	.74	1.00	128
463	970	117.4	5	1.23	1.11	.982	3000	.000209	13 350	(.534)	.001303	39 100	37 460	1.04	13 000	.001226	36 800	4.72	8.35	251 900	328 600	.767	.001095	2030	1525	1990	.75	.98	128
464	960	117.4	5	1.23	1.11	.982	2000	.000133	13 250	(.554)	.001379	41 400	38 800	1.07	13 000	.001238	37 100	4.90	8.29	251 100	328 450	.765	.001187	2130	1475	1990	.73	.91	128
Average									13 500	(.549)	.001332	39 970		1.05								.757					.73	.96	128
474	970	117.9	6	1.47	1.30	1.178	3000	.000257	14 480	(.628)	(.001480)	44 400	36 710	1.21	13 000	.001150	34 500	5.06	8.23	262 500	329 750	.796	.001179	2130	1535	1930	.72	.91	115
475	990	117.8	6	1.47	1.30	1.178	4000	.000330	15 250	(.580)	.001285	38 600	38 770	1.02	15 000	.001246	37 400	5.04	8.28	287 600	376 950	.763	.001217	2180	1710	2240	.73	1.03	130
476	970	118.8	6	1.47	1.30	1.178	3000	.000188	14 240	(.607)	.001658	50 000	37 400	1.34	13 000	.001215	36 400	5.02	8.25	278 900	328 600	.819	.001223	2180	1635	1925	.75	.88	114
Average									14 660	(.605)	.001478	44 330		1.18								.803					.75	.94	120
486	960	116.5	7	1.72	1.54	1.375	3000	.000255	17 000	.675	.001572	47 200	37 620	1.25	15 000	.001026	30 800	5.68	8.01	270 900	377 600	.717	.001347	2390	1820	1995	.62	.87	114
487	990	116.3	7	1.72	1.54	1.375	4000	.000314	18 000	.620	.001350	40 500	37 230	1.09	17 000	.001027	36 200	5.30	8.15	328 300	424 900	.773	.001360	2390	1835	2360	.79	1.02	124
488	990	117.8	7	1.72	1.54	1.375	3000	.000166	17 850	(.660)	.001603	48 100	37 230	1.29	16 000	.001174	35 200	5.25	8.17	320 500	400 900	.729	.001340	2250	1795	2245	.79	1.09	117
Average									17 620	.652	.001508	45 270		1.21								.763					.73	.96	118
498	1000	119.4	8	1.96	1.72	1.571	4100	.000214	19 250	(.696)	.001665	50 000	37 760	1.32	18 000	.001256	37 700	5.59	8.04	365 900	449 100	.815	.001590	2520	1980	2430	.79	.96	122
499	1020	120.3	8	1.96	1.72	1.571	5100	.000225	19 800	(.700)	(.001708)	51 200	38 620	1.33	18 000	.001210	36 300	5.41	8.11	358 100	450 600	.795	.001426	2370	1985	2495	.84	1.05	121
500	1000	118.9	8	1.96	1.72	1.571	4000	.000209	19 760	(.704)	.001658	49 700	37 760	1.32	18 000	.001198	35 900	5.44	8.10	353 200	449 100	.786	.001428	2380	1950	2480	.82	1.04	121
Average									19 600	(.700)	.001677	50 300		1.32								.799					.82	1.02	121
Grand Ave		118.1					2900	.000192																				.91	124

¹ Not used in average.

Note.—Values in parentheses estimated.

Remarks.—Average bond stress developed in beam=124 pounds per square inch. Average ultimate bond stress from bond test pieces=462 pounds per square inch. Ratio=3.7.

Beam Number	Total Weight of Beam, in lbs.	Weight per cu. ft., in lbs.	Reinforcement			that at Yield Point					Unit Bond Stress, lbs. per sq. in.
			Number of $\frac{1}{2}$ " round rods	Nominal Per cent	Effective Per cent	Compressive Stress Upper Fiber, lbs. per sq. in.			C ₂ C ₁	C ₃ C ₁	
						Stress	C ₂ from Resisting Moment	C ₃ from Bending Moment			
1	2	3	4	5	6	7	26	27	28	29	30
423	1000	122.4	2	0.49	0.49	10	640	1165	0.53	0.95	139
424	990	121.0	2	.49	.49	90	585	1085	.54	1.00	129
425	990	121.0	2	.49	.49	10	645	1110	.58	1.00	128
Average...									.55	.99	132
435	980	120.4	3	.74	.74	10	930	1410	.62	.93	125
436	1000	119.9	3	.74	.74	20	1060	1515	.75	1.07	124
437	980	119.3	3	.74	.74	40	1020	1480	.71	1.03	124
Average...									.69	1.01	124
447	970	116.5	4	.98	.98	80	1225	1725	.69	.97	124
448	990	117.4	4	.98	.98	90	1320	1810	.78	1.07	123
449	990	118.5	4	.98	.98	30	1280	1780	.74	1.03	123
Average...									.74	1.02	123
459	990	117.9	5	1.23	1.11	80	1485	1980	.79	1.05	128
460	990	116.9	5	1.23	1.11	00	1620	2075	.90	1.15	126
461	980	118.9	5	1.23	1.11	30	1495	1965	.77	1.02	128
Average...									.82	1.07	127
471	990	118.0	6	1.47	1.30	00	1445	2035	.72	1.02	124
472	990	117.1	6	1.47	1.30	30	1595	2100	.83	1.09	122
473	990	118.5	6	1.47	1.30	60	1655	2120	.84	1.08	122
Average...									.80	1.06	123
483	1000	117.5	7	1.72	1.54	90	1875	2230	.86	1.02	117
484	1020	119.4	7	1.72	1.54	40	2005	2360	.90	1.05	124
485	1010	119.3	7	1.72	1.54	60	1580	2080	.77	1.01	111
Average...									.84	1.03	117
495	1000	117.2	8	1.96	1.72	20	1825	2435	.79	1.05	124
496	1030	120.4	8	1.96	1.72	00	2025	2500	.92	1.14	120
497	1010	118.5	8	1.96	1.72	00	1880	2575	.82	1.12	129
Average...									.84	1.10	124
Grand Ave		118.9								1.04	124

Remarks.—Average bond stress developed in Note.—Values in parentheses are estimated.

426	970	120.8	2	0.49	0.49	20	595	1055	0.49	0.86	129
427	960	120.2	2	.49	.49	00	580	1075	.41	.77	140
428	980	122.5	2	.49	.49	38	570	1010	.41	.82	131
Average...									.44	.82	133
438	930	115.2	3	.74	.74	60	1005	1385	.57	.79	125
439	960	119.2	3	.74	.74	30	900	1390	.55	.85	125
440	960	118.3	3	.74	.74	20	935	1405	.58	.87	125
Average...									.57	.84	125
450	960	118.3	4	.98	.98	60	1440	1745	.70	.85	123
451	960	115.0	4	.98	.98	80	1265	1605	.67	.85	114
452	950	116.6	4	.98	.98	10	1390	1750	.69	.87	123
Average...									.69	.86	120
462	960	115.6	5	1.23	1.11	90	1475	1995	.74	1.00	128
463	970	117.4	5	1.23	1.11	30	1525	1990	.75	.98	128
464	960	117.4	5	1.23	1.11	30	1475	1930	.69	.91	129
Average...									.73	.96	128
474	970	117.9	6	1.47	1.30	30	1535	1930	.72	.91	115
475	990	117.8	6	1.47	1.30	70	1710	2240	.79	1.03	130
476	970	118.8	6	1.47	1.30	80	1635	1925	.75	.88	114
Average...									.75	.94	120
486	960	116.5	7	1.72	1.54	00	1430	1995	.62	.87	114
487	990	116.3	7	1.72	1.54	20	1825	2360	.79	1.02	124
488	990	117.8	7	1.72	1.54	60	1795	2245	.79	1.99	117
Average...									.73	.96	118
498	1000	119.4	8	1.96	1.72	20	1980	2430	.79	.96	122
499	1020	120.3	8	1.96	1.72	70	1985	2495	.84	1.05	121
500	1000	118.9	8	1.96	1.72	80	1950	2480	.82	1.04	121
Average...									.82	1.02	121
Grand Ave		118.1								.91	124

Remarks.—Average bond stress developed in Note.—Values in parentheses estimated.

Table 33.—Compression Tests on Granite Concrete of Medium Consistency Similar to that Used in Beams

[Proportions 1 : 2 : 4 by volume, or 1 : 2.01 : 3.81 by weight]

AGE, 4 WEEKS

Register number	Percentage of water	Cylinders						Cubes				Stress ratio of cylinders to cubes
		Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	Initial modulus of elasticity	Yield point	Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	
		Diameter, inches	Length, inches					Base, inches	Height, inches			
162	8.3	8.02	16.16	148.7	3083	4 200 000	900	6.04 x 5.99	6.02	148.8	3803	.....
163	8.3	8.04	16.08	148.2	3521	4 100 000	900	6.03 x 6.03	6.07	144.9	4268	.....
164	8.3	8.03	16.08	149.3	3120	3 900 000	1000	6.02 x 6.04	5.98	150.0	3880	.....
174	8.3	7.98	16.02	148.8	3117	4 320 000	1000	6.01 x 6.01	6.09	147.3	4138	.....
75	8.3	8.02	16.04	149.3	3045	4 080 000	.....	6.03 x 6.02	6.03	146.0	3914	.....
176	8.3	8.03	15.99	146.7	2772	4 240 000	1000	6.02 x 6.01	5.98	149.8	4076	.....
186	8.3	7.99	15.75	149.3	3081	3 940 000	1000	6.03 x 6.03	5.98	145.1	3914	.....
187	8.3	8.02	16.00	148.6	2784	4 000 000	1000	5.99 x 5.98	6.00	148.7	3349	.....
188	8.3	8.00	16.25	147.5	2556	3 860 000	800	6.02 x 5.99	6.04	147.8	4060	.....
198	8.3	7.98	15.75	151.4	3234	4 200 000	1000	6.04 x 5.94	6.09	148.3	2190	.....
199	8.3	7.99	15.75	151.5	3311	3 920 000	1000	6.01 x 6.04	6.07	145.1	3657	.....
200	8.3	7.94	16.00	151.3	2989	3 980 000	1000	6.01 x 6.01	5.98	150.0	4101	.....
210	8.1	7.98	16.13	150.0	2879	4 200 000	800	6.00 x 6.00	6.14	148.5	3898	.....
211	8.0	8.01	15.75	151.3	2480	3 930 000	1000	6.02 x 6.02	6.09	147.8	4063	.....
212	8.0	8.02	16.00	148.0	2940	4 060 000	700	6.03 x 6.02	6.12	147.7	3581	.....
222	8.1	8.02	15.88	152.2	3393	4 980 000	1000	6.02 x 6.02	6.14	145.6	3907	.....
223	8.1	7.99	16.25	147.9	3312	4 380 000	1000	6.00 x 6.01	6.12	144.9	3674	.....
224	8.1	8.00	16.13	149.2	3036	5 660 000	800	6.03 x 5.98	6.16	147.9	3981	.....
237	8.1	7.99	15.75	152.6	3336	5 320 000	1000	6.03 x 6.03	6.07	146.8	4018	.....
238	8.1	8.02	15.75	150.4	3041	4 520 000	800	5.99 x 6.00	6.04	143.3	3930	.....
239	8.1	7.98	16.13	147.3	3097	4 230 000	.....	5.98 x 6.09	6.03	145.6	3439	.....
Average.	.....	.....	.....	149.4	3054	4 290 000	950	.....	.....	.....	3802	0.803

AGE, 13 WEEKS

165	8.3	8.02	16.15	147.4	1 3959	4 640 000	900	6.03 x 6.03	6.09	146.4	5274	.....
166	8.3	8.00	16.04	149.5	1 3979	4 760 000	1100	6.08 x 5.95	6.08	147.4	5130	.....
167	8.3	8.06	16.07	147.0	1 3920	4 280 000	1000	6.04 x 6.03	6.12	145.4	5200	.....
177	8.3	8.01	16.03	148.1	1 3969	4 540 000	1100	6.04 x 6.03	6.03	146.5	5349	.....
178	8.3	8.00	16.00	148.0	1 3979	4 480 000	1300	6.04 x 6.03	6.06	146.8	5036	.....
179	8.3	8.02	16.02	147.1	1 3957	4 540 000	1300	6.10 x 6.02	6.03	146.4	5178	.....
189	8.3	8.01	16.01	149.1	1 3969	4 580 000	1000	6.00 x 6.05	6.08	146.8	4599	.....
190	8.3	8.05	16.07	147.9	1 3930	3 930 000	1800	6.01 x 6.00	6.03	148.1	5026	.....
191	8.3	8.00	16.08	148.0	1 3979	4 440 000	1000	6.04 x 6.02	6.07	144.9	4753	.....
201	8.3	7.99	16.03	147.8	1 3989	4 540 000	800	6.03 x 6.00	6.11	145.6	5017	.....
202	8.3	8.00	16.00	148.5	1 3680	4 460 000	1200	6.05 x 6.09	6.12	143.8	4525	.....
203	8.3	8.00	16.07	148.4	1 3979	4 440 000	2000	6.03 x 6.18	6.13	143.7	5137	.....
213	8.1	8.02	16.07	146.9	1 3959	4 600 000	1000	6.02 x 6.02	1.15	145.8	5251	.....
214	8.1	8.02	16.25	148.2	1 3959	4 080 000	1900	6.00 x 6.19	6.06	145.9	5201	.....
215	8.1	8.04	16.15	147.0	1 3939	4 780 000	1900	6.02 x 6.00	6.15	147.4	5188	.....
225	8.1	8.00	16.19	147.6	1 3978	4 050 000	2700	6.04 x 6.04	6.00	148.0	5017	.....
226	8.1	8.03	16.02	149.1	1 3949	4 270 000	1100	6.02 x 6.00	6.07	147.9	5180	.....
227	8.1	8.00	16.24	147.1	1 3978	4 250 000	1800	6.08 x 6.03	6.02	146.8	4973	.....
243	8.1	8.03	16.07	146.5	1 3949	4 540 000	1000	6.02 x 6.06	6.01	147.8	4936	.....
244	8.1	8.02	16.06	145.9	1 3959	4 480 000	1300	6.04 x 6.09	5.98	147.4	4948	.....
245	8.1	8.00	16.03	147.4	1 3978	4 360 000	1200	6.00 x 6.02	6.10	145.1	4919	.....
Average.	.....	.....	.....	.....	.....	4 430 000	1350	.....	.....	.....	5040	1 0.823

¹ Exceeded capacity of testing machine of 200 000 lbs., equivalent to given stress.

Table 33.—Compression Tests on Granite Concrete of Medium Consistency Similar to that Used in Beams—Continued

AGE, 26 WEEKS

Register number	Percentage of water	Cylinders						Cubes				Stress of cylinders to Cubes
		Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	Initial modulus of elasticity	Yield point	Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	
		Diameter, inches	Length, inches					Base, inches	Height, inches			
168	8.3	8.01	16.05	149.0	¹ 3969	4 210 000	2400	6.00 x 6.02	6.08	146.5	5537	.....
169	8.3	8.01	16.15	147.3	¹ 3969	4 360 000	1700	6.02 x 6.02	5.98	151.5	5519	.....
170	8.3	8.00	16.00	148.3	¹ 3979	4 520 000	1700	6.02 x 6.02	5.96	149.0	5519	.....
180	8.3	8.00	16.01	149.3	¹ 3979	4 000 000	1900	6.02 x 6.02	6.01	148.8	¹ 5519	.....
181	8.3	8.05	16.02	148.4	¹ 3930	4 640 000	1300	5.98 x 6.04	6.08	146.5	¹ 5538	.....
182	8.3	8.03	16.00	148.8	¹ 3949	3 940 000	2400	6.01 x 6.05	6.10	144.1	5501	.....
192	8.3	8.00	16.03	140.5	¹ 3979	4 120 000	1200	6.00 x 6.00	6.00	147.0	4017	.....
193	8.3	8.02	15.95	146.6	¹ 3959	4 260 000	1000	6.00 x 6.00	6.00	148.0	4890	.....
194	8.3	8.05	16.00	145.3	¹ 3930	3 990 000	1800	6.00 x 6.00	6.00	148.0	5094	.....
204	8.3	7.99	16.03	149.4	¹ 4007	4 720 000	1200	6.08 x 6.00	6.00	148.0	5483	.....
205	8.1	8.00	16.00	148.7	¹ 3979	5 000 000	2000	6.03 x 5.99	6.00	148.0	5100	.....
206	8.1	8.03	15.97	149.8	¹ 3949	4 540 000	1700	5.97 x 6.12	6.00	149.4	5255	.....
216	8.1	7.99	16.02	149.3	¹ 3989	4 800 000	1800	6.13 x 5.98	6.00	147.8	4747	.....
217	8.1	7.99	15.96	149.1	¹ 3989	4 300 000	2300	6.09 x 5.98	6.00	148.3	5055	.....
218	8.1	8.00	16.07	149.2	¹ 3979	4 320 000	1700	6.04 x 6.03	6.00	148.3	5519	.....
231	8.1	8.01	16.06	149.2	¹ 3969	4 600 000	2000	5.98 x 6.03	6.06	.....	5497	.....
232	8.1	8.03	16.00	148.7	¹ 3949	5 000 000	1100	6.00 x 6.00	6.02	146.5	5538	.....
233	8.1	8.02	16.02	149.1	¹ 3959	4 300 000	2200	6.03 x 5.98	6.08	150.3	¹ 5546	.....
240	8.1	8.00	16.02	149.7	¹ 3979	4 900 000	1300	6.01 x 6.00	6.07	147.5	5091	.....
241	8.1	8.01	16.00	147.5	¹ 3969	4 920 000	1200	6.01 x 5.99	6.15	146.8	5507	.....
242	8.1	8.00	16.02	148.3	¹ 3979	4 540 000	1600	6.03 x 6.04	6.06	146.4	5439	.....
Average.	.....	.....	.....	.....	.....	4 480 000	1700	.....	.....	.....	(5239)	10.849

AGE, 52 WEEKS

171	8.3	8.04	16.01	148.8	5539	4 400 000	2300	6.01 x 6.09	6.02	147.5	6154	.....
172	8.3	8.02	16.03	148.4	5838	4 760 000	1900	6.00 x 6.09	6.02	147.8	5176	.....
173	8.3	7.99	15.98	149.1	5390	4 720 000	1900	6.00 x 6.00	6.00	149.0	5607	.....
183	8.3	7.98	15.92	149.5	4716	4 740 000	1500	6.01 x 6.02	6.01	148.6	6362	.....
184	8.3	8.00	16.04	148.9	5418	4 820 000	1200	6.03 x 6.00	6.00	149.3	6144	.....
185	8.3	8.00	16.05	147.2	5271	5 080 000	2000	6.03 x 6.00	6.01	148.1	6142	.....
195	8.3	8.02	16.00	149.9	5071	4 560 000	1700	6.02 x 5.99	6.00	147.8	4988	.....
196	8.3	8.00	16.02	148.3	5197	4 320 000	1800	6.01 x 6.02	6.01	149.5	5076	.....
197	8.3	7.98	16.00	148.9	4999	4 640 000	1600	6.04 x 6.02	6.01	147.3	5158	.....
207	8.1	8.02	16.00	150.3	5305	4 880 000	1900	5.98 x 6.15	6.03	146.1	6580	.....
208	8.1	8.00	15.98	149.5	5950	4 880 000	2300	6.02 x 6.08	6.01	148.3	6748	.....
209	8.1	7.98	16.02	150.4	5299	4 880 000	1900	6.01 x 6.06	6.03	150.5	6168	.....
219	8.1	8.00	16.12	148.7	5424	4 640 000	2100	6.00 x 6.07	6.01	149.0	6278	.....
220	8.1	8.01	16.12	149.2	4961	5 160 000	1500	5.98 x 6.07	6.00	148.8	6572	.....
221	8.1	7.98	16.08	149.8	5299	5 000 000	1800	6.01 x 6.09	6.01	148.3	6391	.....
228	8.1	8.00	16.07	147.6	5968	5 200 000	1700	6.02 x 6.12	5.99	147.3	6432	.....
229	8.1	8.01	16.13	148.8	5573	4 900 000	3100	6.04 x 6.17	6.01	146.6	5612	.....
230	8.1	8.02	16.12	148.1	5055	4 700 000	2700	5.94 x 6.16	6.06	148.1	5426	.....
234	8.1	7.99	16.05	148.8	4939	4 520 000	2300	5.99 x 6.09	6.01	147.8	6409	.....
235	8.1	8.01	15.96	148.2	5058	4 640 000	2300	6.01 x 6.13	6.02	147.2	5774	.....
236	8.1	8.00	15.98	147.7	4874	4 720 000	1700	6.02 x 6.09	6.03	146.6	6058	.....
Average.	.....	.....	.....	.....	5086	4 770 000	1962	.....	.....	.....	5964	18.52

¹ Exceeded capacity of testing machine of 200 000 lbs., equivalent to given stress.

Table 34.—Compression Tests on Limestone Concrete of Medium Consistency Similar to that Used in Beams

[Proportions 1:2:4 by volume, 1:2.01:3.91 by weight]

AGE, 4 WEEKS

Register number	Percentage of water	Cylinders						Cubes				Stress ratio of cylinders to cubes
		Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	Initial modulus of elasticity	Yield point	Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	
		Diameter, inches	Length, inches					Base, inches	Height, inches			
255	10.0	8.00	16.21	145.5	2250	3 480 000	600	6.00 x 6.01	6.21	143.7	2896	.....
256	10.0	8.01	16.20	145.2	2121	3 360 000	600	6.03 x 6.21	6.00	143.3	2935	.....
257	10.0	8.00	16.20	146.1	1890	4 400 000	700	6.00 x 6.00	6.30	142.9	3518	.....
261	10.0	7.99	16.01	146.4	2447	3 660 000	700	6.01 x 6.01	6.08	.....	3216	.....
262	10.0	8.01	16.00	146.5	2273	3 290 000	700	6.07 x 6.01	6.08	.....	3015	.....
263	10.0	8.02	16.00	145.4	1979	2 600 000	600	6.06 x 6.00	6.11	.....	3086	.....
273	10.0	8.01	16.12	146.5	2745	3 760 000	800	6.01 x 6.00	6.02	148.3	4116	.....
274	10.0	8.01	16.00	145.7	2542	3 790 000	700	6.08 x 6.08	6.07	144.5	3420	.....
275	10.0	7.99	16.13	146.1	2513	4 170 000	600	6.03 x 6.04	6.06	145.9	3664	.....
285	10.0	8.05	16.15	146.1	3078	3 640 000	900	6.04 x 6.01	6.12	154.6	3554	.....
286	10.0	8.08	16.10	146.0	2588	4 820 000	1300	6.06 x 6.04	6.01	145.3	4003	.....
287	10.0	8.02	16.09	145.6	2679	3 800 000	1000	6.03 x 6.04	6.14	144.9	3655	.....
297	10.0	8.03	16.06	145.2	2844	3 990 000	900	6.03 x 6.02	6.05	146.6	3446	.....
298	10.0	8.01	16.11	145.3	2997	3 340 000	700	6.03 x 6.06	6.03	146.1	3293	.....
299	10.0	8.02	16.12	144.9	2178	3 750 000	700	6.01 x 6.02	6.03	145.5	3015	.....
318	10.0	8.01	16.01	147.2	2653	3 510 000	900	6.00 x 6.05	6.16	143.0	3581	.....
319	10.0	8.04	16.14	145.8	2535	3 325 000	900	6.01 x 6.04	6.11	144.1	3323	.....
320	10.0	8.08	16.04	143.9	1853	2 940 000	700	6.03 x 6.02	6.17	142.7	3085	.....
321	10.0	7.98	16.11	146.6	2859	3 660 000	900	6.05 x 6.02	6.04	143.4	3405	.....
322	10.0	8.01	16.11	147.1	2897	3 590 000	1000	6.05 x 6.25	6.00	139.0	3485	.....
323	10.0	8.03	16.03	145.3	2419	3 230 000	800	6.01 x 6.05	5.99	143.9	3511	.....
Average	.....	.....	.....	.....	2492	3 590 000	800	.....	.....	.....	3392	0.735

AGE, 13 WEEKS

249	10.0	8.01	16.04	146.4	3417	3 440 000	1700	6.01 x 6.00	6.13	144.6	4332	.....
250	10.0	8.03	16.07	146.0	3483	4 160 000	800	6.02 x 6.03	6.12	145.9	4118	.....
251	10.0	8.00	16.20	146.4	3481	3 900 000	1300	6.04 x 5.98	6.16	145.7	4489	.....
264	10.0	8.02	16.10	144.5	3609	3 790 000	1100	6.02 x 6.04	6.03	143.9	4410	.....
265	10.0	8.02	16.00	147.0	3569	3 930 000	2000	6.02 x 6.04	6.04	145.6	4368	.....
266	10.0	8.02	16.25	144.2	3768	4 150 000	900	6.02 x 6.05	6.10	144.0	4397	.....
276	10.0	8.01	16.02	146.6	3878	4 110 000	1500	6.02 x 6.09	6.03	142.7	5111	.....
277	10.0	8.01	16.04	147.5	3969	4 460 000	1100	6.01 x 6.11	6.02	144.6	4303	.....
278	10.0	8.02	16.01	145.3	3959	3 900 000	1500	5.90 x 6.02	6.08	145.9	4541	.....
288	10.0	8.00	16.08	147.0	3777	3 980 000	1200	6.01 x 6.05	6.15	142.9	5123	.....
289	10.0	.....	.....	.....	.....	.....	.....	6.03 x 6.02	6.12	142.0	4905	.....
290	10.0	8.01	16.11	146.3	3969	4 260 000	900	6.05 x 6.00	6.14	143.5	4802	.....
300	10.4	8.01	16.20	145.5	3494	2 400 000	2700	6.03 x 6.07	6.00	137.7	4025	.....
301	10.0	8.03	16.03	144.7	3306	3 660 000	1400	6.04 x 6.17	6.03	134.6	3713	.....
302	10.0	8.04	16.14	143.9	2826	3 990 000	1500	5.98 x 6.02	6.12	135.4	3815	.....
312	10.2	7.99	16.09	146.7	3968	3 400 000	2000	6.03 x 6.13	6.03	135.7	4645	.....
313	10.0	8.00	16.20	145.4	3562	3 885 000	1500	6.02 x 6.03	6.04	140.0	4083	.....
314	10.0	8.00	16.08	145.4	3362	2 980 000	1500	6.01 x 6.03	6.01	140.8	4331	.....
324	10.0	7.98	16.06	147.6	3826	4 180 000	1700	6.03 x 6.03	6.05	147.4	4300	.....
325	10.0	7.99	16.08	147.1	3809	3 860 000	1200	6.02 x 6.02	6.06	145.6	4643	.....
326	10.0	8.00	16.05	146.7	3700	3 790 000	1400	6.06 x 6.15	6.02	142.5	4387	.....
Average	.....	.....	.....	.....	3600	3 810 000	1450	.....	.....	.....	4421	0.814

¹ Exceeded capacity of testing machine of 200 000 lbs., equivalent to given stress.

Table 34.—Compression Tests on Limestone Concrete of Medium Consistency Similar to that Used in Beams—Continued

AGE, 26 WEEKS												
Register number	Percentage of water	Cylinders						Cubes				Stress of cylinders to Cubes
		Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	Initial modulus of elasticity	Yield point	Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	
		Diameter, inches	Length, inches					Base, inches	Height, inches			
252	10.0	7.99	16.09	147.4	3636	4 400 000	1500	6.04 x 6.00	6.11	146.4	4228	.....
253	10.0	8.00	16.09	147.6	3327	4 280 000	1600	6.06 x 6.01	6.11	144.6	4106	.....
254	10.0	7.99	16.03	147.0	3577	4 120 000	1300	5.99 x 6.01	6.08	147.0	4115	.....
267	10.0	7.99	16.10	148.1	3901	3 940 000	1400	5.98 x 6.02	6.12	145.6	4838	.....
268	10.0	7.99	16.04	147.3	3761	4 040 000	1800	6.04 x 6.02	6.04	147.5	4903	.....
269	9.8	8.00	16.04	147.6	3948	4 240 000	1800	6.03 x 6.02	6.05	148.7	5408	.....
279	10.0	7.99	16.08	147.7	3690	4 000 000	1400	6.03 x 6.00	6.06	146.9	4875	.....
280	10.0	8.02	16.06	146.5	3667	3 860 000	1500	6.0 x 6.00	6.08	147.6	4876	.....
281	10.0	8.00	16.06	148.1	3956	4 360 000	1200	6.03 x 6.00	6.03	148.0	3606	.....
291	10.0	8.00	16.06	148.5	¹ 3979	4 500 000	1400	6.01 x 6.01	6.06	147.5	5056	.....
292	10.0	7.99	16.13	148.0	¹ 3989	4 780 000	1300	6.02 x 6.00	6.00	148.0	4927	.....
293	10.0	7.99	.....	.....	¹ 3989	4 160 000	1600	6.0 x 6.01	6.08	147.9	4113	.....
303	10.0	7.99	16.01	148.0	3904	4 400 000	1300	5.99 x 6.02	6.08	147.9	4250	.....
304	10.0	7.99	16.14	147.3	3690	4 500 000	1000	6.0 x 6.01	6.08	147.4	4331	.....
305	10.2	7.99	16.10	147.8	3789	4 340 000	1400	6.04 x 6.00	6.12	146.0	4344	.....
315	10.0	8.02	16.00	147.5	3781	4 500 000	1400	6.0 x 6.03	6.08	146.8	4000	.....
316	10.0	8.00	16.00	147.5	3912	3 780 000	1500	5.97 x 5.96	6.07	149.5	4727	.....
317	10.0	8.00	16.00	146.2	3803	4 400 000	1300	6.0 x 6.00	6.06	147.0	4503	.....
327	10.0	7.99	16.03	147.8	3890	4 580 000	900	6.03 x 6.05	6.00	148.0	4839	.....
328	10.0	8.00	16.14	147.5	3879	4 640 000	1300	6.02 x 6.05	6.00	148.3	4248	.....
329	10.0	7.98	15.95	148.4	3899	4 780 000	1400	6.02 x 6.00	6.00	148.5	4271	.....
Average	.....	.....	.....	.....	3778	4 310 000	1400	.....	.....	.....	4503	0.839

AGE, 52 WEEKS												
246	10.0	8.00	16.18	147.6	4101	4 280 000	1800	6.03 x 6.06	6.02	146.3	4659	.....
247	10.0	8.01	16.15	146.7	4136	4 460 000	1700	6.03 x 6.15	5.99	147.3	4560	.....
248	10.0	8.01	16.08	146.3	3969	4 040 000	1700	6.09 x 6.01	6.01	148.3	4652	.....
270	9.8	8.00	16.10	147.4	4575	4 400 000	1600	6.03 x 6.00	6.00	147.3	5228	.....
271	10.0	8.00	16.20	148.0	4600	4 760 000	1500	6.03 x 6.07	5.98	149.0	5111	.....
272	10.0	8.01	16.04	148.8	4657	4 880 000	1700	6.09 x 6.00	5.99	147.5	5122	.....
282	10.0	7.99	15.98	147.7	4265	4 680 000	1700	6.00 x 6.02	6.00	147.0	5498	.....
283	10.0	7.99	16.03	147.8	4353	4 720 000	1700	6.08 x 6.03	5.97	147.0	4849	.....
284	10.0	8.01	16.18	146.2	4463	4 540 000	1600	6.02 x 6.02	6.01	147.9	4560	.....
294	10.0	7.99	16.10	149.0	4089	4 600 000	1800	6.00 x 6.08	6.00	147.5	4959	.....
295	10.0	8.00	15.98	148.8	4641	4 720 000	1500	5.98 x 6.01	5.99	150.5	4786	.....
296	10.0	7.98	16.06	149.5	5122	4 620 000	1600	5.96 x 6.10	6.00	150.0	5090	.....
306	10.2	8.00	16.14	147.6	4151	4 240 000	1500	5.98 x 5.99	6.00	148.2	5179	.....
307	10.0	8.01	16.12	148.0	4326	4 860 000	1500	6.00 x 6.03	6.00	150.3	5019	.....
308	10.0	8.01	16.08	147.5	4526	4 580 000	1600	6.02 x 6.07	6.00	148.2	5282	.....
309	10.0	8.03	16.06	145.3	4328	4 640 000	1500	5.99 x 6.09	6.00	146.5	4896	.....
310	10.0	8.01	16.16	145.6	4366	4 160 000	2100	6.02 x 6.07	6.03	147.0	4779	.....
311	10.2	8.02	16.10	145.3	4584	4 500 000	1700	5.92 x 6.02	6.03	148.7	4277	.....
330	10.0	8.00	16.04	148.3	4626	4 840 000	1700	6.00 x 6.10	6.00	146.6	5682	.....
331	10.0	8.01	16.20	146.5	3811	4 560 000	1700	6.05 x 6.01	6.02	147.5	5008	.....
332	10.0	7.98	16.10	147.9	4252	4 560 000	1500	5.97 x 6.12	6.05	147.6	4592	.....
Average	.....	.....	.....	.....	4378	4 550 000	1652	.....	.....	.....	4942	0.886

¹ Exceeded capacity of testing machine of 200 000 lbs., equivalent to given stress.

Table 35.—Compression Tests on Gravel Concrete of Medium Consistency Similar to that Used in Beams

[Proportions 1:2:4 by volume 1:2.01:4.10 by weight]

AGE, 4 WEEKS

Register number	Percentage of water	Cylinders						Cubes				Stress ratio of cylinders to cubes
		Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	Initial modulus of elasticity	Yield point	Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	
		Diameter, inches	Length, inches					Base, inches	Height, inches			
333	8.6	8.03	16.17	143.8	3626	5 040 000	.....	6.07 x 6.04	6.11	141.8	3692	.....
334	8.6	8.07	16.16	141.9	3646	4 940 000	1300	6.01 x 6.00	6.08	142.8	4243	.....
335	9.0	7.99	16.07	144.5	3051	4 380 000	1200	6.04 x 6.05	6.12	140.1	4105	.....
345	9.0	8.10	16.18	140.1	2939	4 620 000	800	6.01 x 6.01	6.15	142.9	4098	.....
346	9.0	8.02	16.15	143.5	2573	4 360 000	900	6.18 x 5.97	6.15	139.9	3740	.....
347	9.0	8.01	16.20	143.1	2719	4 440 000	900	6.03 x 6.11	6.13	141.5	4228	.....
357	9.4	8.03	16.28	143.9	3735	4 720 000	1100	6.05 x 6.04	6.10	143.4	4576	.....
358	9.4	8.00	16.24	145.0	3386	4 620 000	1100	6.06 x 6.11	6.17	139.9	4144	.....
359	9.3	8.03	16.28	143.8	3199	4 740 000	1000	5.98 x 6.08	6.13	143.4	4106	.....
369	9.3	8.03	16.06	143.4	3268	5 020 000	1000	6.05 x 6.02	6.11	141.7	3763	.....
370	9.3	8.03	16.17	143.5	3092	4 620 000	1100	6.00 x 6.04	6.11	142.5	3804	.....
371	9.4	8.03	16.11	143.2	3389	4 800 000	1000	6.01 x 6.01	6.11	143.9	3465	.....
381	9.4	8.02	16.11	143.3	2652	3 880 000	900	.....	.....	.....	.....	.....
382	9.4	7.98	16.12	146.3	3079	4 400 000	1000	.....	.....	.....	.....	.....
383	9.4	8.02	16.05	144.6	3317	4 160 000	1100	.....	.....	.....	.....	.....
¹ 393	9.6	8.00	16.27	145.8	3232	4 000 000	600	.....	.....	.....	.....	.....
¹ 394	9.6	8.03	16.25	143.8	2861	4 410 000	1000	.....	.....	.....	.....	.....
¹ 395	9.8	8.01	16.10	144.1	2778	4 290 000	900	.....	.....	.....	.....	.....
¹ 405	9.8	8.00	16.13	147.1	3561	5 040 000	1200	.....	.....	.....	.....	.....
¹ 406	9.8	8.04	16.05	145.0	3211	5 720 000	1400	.....	.....	.....	.....	.....
¹ 407	9.8	8.03	16.11	145.1	3357	4 380 000	1200	.....	.....	.....	.....	.....
Average	.....	.....	.....	.....	3175	4 600 000	1050	.....	.....	.....	3997	0.794

AGE, 13 WEEKS

336	9.0	8.02	16.15	143.8	² 3959	4 015 000	2900	6.04 x 6.04	6.10	147.7	4975	.....
337	9.0	8.00	16.18	143.7	² 3979	4 780 000	2700	6.16 x 6.00	6.03	140.5	4690	.....
338	9.0	8.01	16.24	142.0	² 3969	4 640 000	1500	6.07 x 6.03	5.98	144.1	4795	.....
348	9.0	8.00	16.14	144.0	² 3979	4 860 000	1600	6.00 x 6.02	6.18	142.3	4606	.....
349	9.6	8.02	16.09	143.8	² 3959	3 980 000	2700	6.00 x 6.00	6.08	145.1	4596	.....
350	9.6	8.00	16.15	143.9	² 3979	4 760 000	1600	6.00 x 6.04	6.04	143.1	4527	.....
360	9.3	8.01	16.10	145.1	² 3969	4 920 000	2000	6.02 x 6.01	6.08	143.4	4552	.....
361	9.3	8.00	16.10	144.7	² 3979	4 100 000	1800	6.05 x 6.09	6.15	139.2	4180	.....
362	9.3	8.01	16.15	144.7	² 3969	5 360 000	1200	6.01 x 6.01	6.00	145.5	4283	.....
372	9.4	8.02	16.25	143.7	² 3959	4 560 000	2300	6.05 x 6.03	6.14	141.8	5003	.....
373	9.4	8.00	16.15	144.5	² 3979	4 680 000	2200	6.06 x 6.00	6.10	149.0	5052	.....
374	9.4	8.02	16.18	144.3	² 3959	4 900 000	2100	6.02 x 6.07	6.03	144.2	4909	.....
384	9.4	8.02	16.12	144.3	² 3959	4 680 000	2400	6.02 x 6.03	6.07	144.2	5018	.....
385	9.4	8.01	16.15	144.9	² 3969	4 800 000	2200	6.04 x 5.98	6.13	143.5	5382	.....
386	9.4	8.04	16.15	142.8	² 3939	4 720 000	2000	6.03 x 5.98	6.09	143.6	4906	.....
¹ 396	9.8	8.02	16.00	144.6	² 3959	4 740 000	1400	6.00 x 6.15	6.00	142.5	4308	.....
¹ 397	9.8	8.03	16.11	144.5	3929	4 680 000	2500	6.05 x 6.03	6.10	141.7	4863	.....
¹ 398	9.8	8.00	16.15	145.3	3780	4 540 000	2100	6.07 x 6.04	6.05	143.2	4655	.....
¹ 408	9.8	8.00	16.10	145.5	² 3979	4 470 000	2900	6.10 x 6.03	6.04	144.0	4872	.....
¹ 409	9.8	8.00	16.14	143.0	3596	4 310 000	2400	6.13 x 6.03	6.00	143.2	4171	.....
¹ 410	9.8	8.00	16.12	145.3	3978	4 450 000	2100	6.11 x 6.07	6.05	141.6	4460	.....
Average	.....	.....	.....	.....	(3821)	4 620 000	2100	.....	.....	.....	4729	0.846

¹ Proportions 1:2:4 by volume. 1:2.01:3.99 by weight.² Exceeded capacity of testing machine of 200 000 lbs., equivalent to given stress.

Table 35.—Compression Tests on Gravel Concrete of Medium Consistency Similar to that Used in Beams—Continued

AGE, 26 WEEKS

Register number	Percentage of water	Cylinders						Cubes				Stress of cylinders to Cubes
		Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	Initial modulus of elasticity	Yield point	Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	
		Diameter, inches	Length, inches					Base, inches	Height, inches			
339	9.0	8.00	16.60	140.3	² 3979	5 440 000	1600	6.00 x 6.03	6.01	143.6	5063	.....
340	9.0	8.01	16.10	145.0	² 3969	5 060 000	1300	6.01 x 6.08	6.02	143.4	5405	.....
341	9.0	8.02	16.03	145.0	² 3959	5 420 000	1600	6.03 x 6.00	6.00	145.8	5153	.....
351	9.4	8.01	16.16	144.4	² 3969	5 260 000	1600	6.03 x 6.05	6.03	144.9	5091	.....
352	9.4	7.99	16.40	142.1	² 3989	5 040 000	1600	6.07 x 6.02	6.03	145.1	5044	.....
353	9.4	8.00	16.12	145.7	² 3979	5 420 000	1500	6.02 x 6.04	5.99	146.3	5406	.....
363	9.3	8.00	16.08	145.5	² 3979	4 940 000	1600	6.01 x 6.05	6.00	144.5	4959	.....
364	9.3	8.01	16.16	145.7	² 3969	4 940 000	2500	6.06 x 6.09	5.97	144.6	5196	.....
365	9.3	7.99	16.16	145.1	² 3989	4 900 000	1800	6.02 x 6.06	6.04	145.1	4939	.....
375	9.4	8.01	16.08	145.0	² 3969	5 200 000	1500	6.01 x 6.11	6.02	144.2	5163	.....
376	9.4	8.00	16.16	144.2	² 3979	5 200 000	1500	6.00 x 6.06	6.00	145.1	5388	.....
377	9.4	7.99	16.08	146.0	² 3989	4 940 000	1500	6.07 x 6.01	6.04	146.1	² 5483	.....
387	9.4	8.02	16.14	145.0	² 3959	5 080 000	1400	6.06 x 5.94	6.06	144.5	4648	.....
388	9.4	7.99	16.10	145.3	² 3989	5 500 000	1600	6.00 x 6.09	6.01	144.6	4803	.....
¹ 389	9.4	8.00	16.13	145.2	² 3979	6 080 000	1200	6.03 x 6.05	6.01	146.3	5154	.....
¹ 399	9.8	8.00	16.13	145.6	² 3979	4 940 000	1900	6.02 x 6.09	6.03	144.5	4148	.....
¹ 400	9.8	8.00	16.10	145.9	² 3979	5 320 000	1200	6.03 x 6.10	6.03	145.1	4111	.....
¹ 401	9.8	7.99	16.17	146.1	² 3989	4 960 000	1600	6.00 x 6.04	6.01	.....	4813	.....
¹ 411	9.9	7.99	16.02	146.0	² 3989	5 400 000	1400	6.00 x 6.05	6.04	143.8	3339	.....
¹ 412	9.9	8.00	16.13	145.8	² 3979	5 480 000	1400	6.00 x 6.04	6.01	144.8	3994	.....
¹ 413	9.9	8.00	16.15	144.9	² 3979	5 600 000	1400	6.02 x 6.01	6.03	144.5	3788	.....
Average.	.....	.....	.....	.....	² 3979	5 240 000	1550	.....	.....	.....	4830	0.88

AGE, 52 WEEKS

342	9.0	8.00	16.12	145.5	5028	5 220 000	2100	6.11 x 5.97	6.03	144.4	5914	.....
343	9.0	8.00	16.16	145.2	5073	5 600 000	2000	6.03 x 6.02	6.01	144.5	5762	.....
344	9.0	8.00	16.06	145.0	5458	5 720 000	2200	6.01 x 6.13	6.01	143.5	5800	.....
354	9.4	7.99	16.04	146.6	5086	5 600 000	2200	6.00 x 6.08	5.99	144.3	5857	.....
355	9.4	8.00	16.24	145.3	4471	5 280 000	1800	6.00 x 6.12	6.00	144.2	5502	.....
356	9.4	7.98	16.06	145.7	5341	5 600 000	1500	6.00 x 6.08	6.01	144.8	4709	.....
366	9.3	7.99	16.12	145.7	5477	5 380 000	2100	6.13 x 6.02	6.01	143.7	5381	.....
367	9.3	7.98	16.16	146.2	4999	4 800 000	2800	6.08 x 6.00	5.99	145.8	5433	.....
368	9.3	7.99	16.18	146.0	5251	5 120 000	2400	6.01 x 6.09	6.04	145.7	5651	.....
378	9.4	8.00	16.05	146.7	5667	5 500 000	1800	6.03 x 6.01	6.00	155.0	6512	.....
379	9.4	8.01	16.13	145.1	5646	5 700 000	2300	6.00 x 6.05	6.00	156.7	6072	.....
380	9.4	8.00	16.02	145.7	5636	5 120 000	2200	6.00 x 6.09	5.99	146.0	6240	.....
390	9.4	8.00	16.07	145.9	5761	5 360 000	2200	5.99 x 6.10	6.03	144.2	5496	.....
391	9.4	7.98	16.06	146.1	4933	4 860 000	2600	6.00 x 6.10	6.00	144.6	5290	.....
¹ 392	9.4	8.02	16.10	145.3	4949	5 860 000	1900	6.01 x 6.07	6.03	144.4	5456	.....
¹ 402	9.8	7.99	16.13	146.4	4886	5 740 000	2400	6.03 x 6.12	5.99	144.6	5759	.....
403	9.8	7.98	16.07	147.3	5400	5 600 000	2200	6.00 x 6.12	6.02	145.7	5490	.....
404	9.8	7.99	16.17	146.9	4687	5 260 000	1900	6.00 x 6.13	5.99	147.1	5822	.....
414	9.9	8.00	16.10	145.6	5288	5 140 000	2400	6.02 x 6.04	6.00	144.5	4932	.....
415	9.9	8.00	16.08	146.4	5552	5 560 000	2000	6.01 x 6.12	6.00	144.9	5672	.....
416	9.9	8.00	16.10	146.0	5561	5 280 000	1700	6.00 x 6.04	6.01	145.9	5906	.....
Average.	.....	.....	.....	.....	5245	5 395 000	2129	.....	.....	.....	5650	.928

¹ Proportions 1:2:4 by volume. 1:2.01:3.99 by weight.² Exceeded capacity of testing machine of 200 000 lbs., equivalent to given stress.

Table 36.—Compression Tests on Cinder Concrete of Medium Consistency
Similar to that Used in Beams

[Proportions 1:2:4 by volume. 1:2.01:1.97 by weight.]

AGE, 4 WEEKS

Register number	Percentage of water	Cylinders						Cubes				Stress ratio of cylinders to cubes
		Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	Initial modulus of elasticity	Yield point	Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	
		Diameter, inches	Length, inches					Base, inches	Height, inches			
417	19.2	7.99	16.08	121.6	1499	2 320 000	500					
418	19.2	8.06	16.21	118.3	1835	1 690 000	500					
419	19.3	8.01	16.14	119.5	1554	1 180 000	600					
429	18.9	8.04	16.11	120.4	1891	1 760 000	500					
430	18.9	8.07	16.11	120.1	1918	1 820 000	500	6.06 x 6.13	5.98	117.7	2417	
431	18.9	8.08	16.10	119.6	1964	1 690 000	400	6.02 x 6.00	6.04	119.8	2486	
441	18.9	8.10	16.00	115.8	1514	1 190 000	500	6.02 x 6.16	6.04	118.7	2523	
442	18.9	8.03	16.10	117.9	1575	1 620 000	500	6.05 x 6.05	6.10	117.1	2161	
443	18.8	8.00	15.95	119.6	1577	1 600 000	600	6.05 x 6.05	6.13	115.6	2195	
453	18.8	8.03	16.16	118.5	1593	1 615 000	500	5.98 x 6.08	6.04	117.2	2258	
454	18.8	8.04	16.30	117.5	1576	1 645 000	300					
455	18.9	8.01	16.18	117.9	1620	1 640 000	500					
465	18.9	8.01	16.25	116.1	1572	1 535 000	400					
466	18.9	8.00	16.31	116.7	1534	1 435 000	400	6.01 x 6.02	6.11	117.3	2170	
467	18.9	8.01	16.16	119.1	1532	1 660 000	400	6.07 x 6.04	6.09	116.1	2046	
477	18.9	8.01	16.16	119.1	1532	1 660 000	400	6.03 x 6.05	6.07	117.1	2121	
478	18.9	8.04	16.05	118.5	1614	1 660 000	400	6.05 x 5.97	6.15	116.7	2139	
478	18.9	8.02	16.07	119.2	1682	1 450 000	500	6.07 x 6.09	6.15	112.2		
479	18.9	8.05	16.23	115.8	1603	1 540 000	400	6.05 x 6.03	6.08	114.0	1990	
489	18.9	8.03	16.05	116.9	1629	1 530 000	500	6.02 x 6.02	6.09	117.5	1956	
490	18.9	8.03	16.04	118.1	1710	1 680 000	300	6.04 x 6.03	6.12	116.3	1850	
491	18.9	8.02	16.05	118.3	1589	1 620 000	500	6.01 x 6.07	6.10	115.5	1849	
Average.					1647	1 610 000	450				2154	0.763

AGE, 13 WEEKS

420	19.3	8.01	16.05	118.8	2260	1 700 000	900	6.00 x 6.01	6.02	117.4	2773	
421	19.5	8.00	16.05	120.2	2399	1 930 000	700	6.07 x 6.02	6.10	119.2	2442	
422	19.5	8.00	16.13	119.4	2322	1 930 000	600	6.04 x 6.03	6.11	117.5	2843	
432	18.9	8.00	16.16	121.5	2445	1 880 000	1100	6.05 x 6.02	6.18	118.0	2965	
433	18.9	8.02	16.01	120.5	2426	1 800 000	1000	6.04 x 6.04	6.18	118.9	2784	
434	18.9	8.00	16.09	119.4	2259	1 790 000	700	6.02 x 6.05	6.07	119.1	2858	
444	18.8	8.01	16.09	119.2	2147	1 730 000	900	6.03 x 6.03	6.10	115.9	2676	
445	18.8	8.00	16.05	120.2	2110	1 720 000	900	6.05 x 6.00	6.07	116.7	2590	
446	18.8	8.02	16.11	118.6	1981	1 870 000	900	6.01 x 6.03	6.02	120.7	2667	
456	18.9	8.00	16.10	119.1	2306	1 810 000	800	6.13 x 6.03	6.04	114.2	2166	
457	18.9	7.99	16.23	121.6	2266	1 910 000	900	5.99 x 6.00	6.01	120.0	1842	
458	18.9	8.00	16.11	119.6	2185	1 820 000	900	6.04 x 6.04	6.01	121.2	2423	
468	18.9	8.02	16.06	117.9	2203	1 740 000	1000	6.02 x 6.00	6.04	117.8	2556	
469	18.9	8.01	16.23	118.6	2180	1 730 000	900	6.02 x 6.01	6.09	116.7	2419	
470	18.9	8.01	16.15	119.2	2201	1 920 000	500	6.01 x 6.03	6.02	119.8	2541	
480	18.9	8.01	16.03	118.2	2150	1 850 000	600	6.04 x 6.08	6.04	115.9	2568	
481	18.9	8.00	16.13	118.3	2108	1 800 000	700	6.05 x 5.99	5.98	118.7	2644	
482	18.9	8.01	16.18	118.2	2121	1 840 000	600	6.06 x 6.02	5.97	119.0	2452	
492	18.9	8.01	16.01	119.9	2107	1 760 000	600	6.01 x 6.00	6.10	116.9	2516	
493	18.9	8.00	16.10	120.1	2169	1 740 000	700	6.01 x 6.02	6.10	115.5	2731	
494	18.9	8.00	16.02	118.6	2217	1 820 000	800	5.98 x 6.01	6.05	117.3	2579	
Average.					2217	1 820 000	800				2571	0.862

Table 36.—Compression Tests on Cinder Concrete of Medium Consistency Similar to that Used in Beams—Continued.

AGE, 26 WEEKS

Register number	Percentage of water	Cylinders						Cubes				Stress of cylinders to Cubes
		Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	Initial modulus of elasticity	Yield point	Dimensions		Weight, lbs. per cu. ft.	Ultimate strength, lbs. per sq. in.	
		Diameter, inches	Length, inches					Base, inches	Height, inches			
423	19.5	8.00	16.15	122.0	2792	2 240 000	800	6.01 x 6.08	6.00	120.2	2831	.....
424	19.5	8.02	16.26	121.6	2746	2 300 000	900	6.00 x 6.05	6.00	124.1	3486	.....
425	19.5	8.00	16.04	123.0	2586	2 200 000	1000	6.00 x 6.11	6.01	121.1	3021	.....
435	18.9	8.01	16.16	120.0	2778	2 320 000	900	6.04 x 6.07	6.00	120.8	2609	.....
436	18.9	8.00	16.14	121.0	2714	2 080 000	1000	6.05 x 5.93	6.09	121.0	2403	.....
437	18.9	7.99	16.12	120.8	2546	2 080 000	800	6.02 x 6.06	6.03	119.8	2084	.....
447	18.8	8.00	16.20	119.5	2359	2 060 000	1000	6.03 x 6.25	6.04	116.3	2778	.....
448	18.8	8.01	16.32	119.5	2371	2 250 000	800	6.00 x 6.28	6.00	118.5	2857	.....
449	18.8	8.02	16.12	120.0	2344	2 000 000	900	6.03 x 6.26	5.98	118.6	2443	.....
459	18.9	8.00	16.42	115.8	2591	2 130 000	900	6.03 x 6.03	6.02	117.4	3210	.....
460	18.9	8.01	16.38	117.1	2546	2 250 000	1100	6.03 x 6.11	6.01	119.5	2902	.....
461	18.9	8.02	16.47	116.8	2486	2 380 000	1200	6.06 x 6.00	5.99	118.1	2866	.....
471	18.9	7.99	16.02	119.0	2706	2 040 000	1000	6.08 x 6.02	6.03	117.5	2485	.....
472	18.9	8.00	16.02	119.9	2615	1 880 000	900	6.03 x 6.05	6.02	118.5	2166	.....
473	18.9	7.99	16.02	119.4	2595	1 830 000	900	6.00 x 6.00	6.01	114.3	1750	.....
483	18.9	8.00	16.14	119.3	2284	2 120 000	900	6.02 x 5.98	6.04	117.3	2880	.....
484	18.9	8.02	16.04	117.8	2344	2 080 000	900	6.02 x 6.04	6.02	118.4	2862	.....
485	18.9	8.01	16.01	120.5	2187	2 040 000	700	6.06 x 6.04	6.08	117.5	2903	.....
495	18.9	8.00	16.04	118.7	2563	1 990 000	900	6.00 x 6.08	6.00	118.4	2557	.....
496	18.9	8.00	16.08	118.9	2388	1 960 000	1000	6.00 x 6.04	6.20	115.4	2775	.....
497	18.9	8.02	16.04	118.5	2482	2 180 000	900	5.99 x 6.04	5.98	120.9	2879	.....
Average.	.....	.....	.....	.....	2525	2 120 000	900	.....	.....	.....	2702	0.935

AGE, 52 WEEKS

426	19.5	8.00	16.04	122.7	2941	2 350 000	1000	6.01 x 6.02	6.03	119.8	3457	.....
427	18.9	8.00	16.10	121.4	2945	2 020 000	1000	6.00 x 6.09	6.02	120.8	3040	.....
428	18.9	8.00	16.12	120.2	2947	2 290 000	900	6.00 x 6.05	6.02	121.0	3054	.....
438	18.9	8.00	16.16	119.1	2886	2 090 000	800	5.99 x 6.00	6.00	119.2	3454	.....
439	18.9	8.00	16.16	118.6	2958	2 170 000	1100	5.99 x 6.10	6.00	118.7	3236	.....
440	18.9	7.99	16.15	120.6	2838	2 000 000	1200	6.01 x 6.04	6.02	120.1	3269	.....
450	18.8	8.00	16.11	119.8	2685	2 240 000	1200	6.25 x 6.03	5.97	118.1	2793	.....
451	18.9	7.99	16.14	121.5	2493	2 080 000	1200	6.28 x 5.99	6.00	118.7	2637	.....
452	18.9	8.00	16.10	119.6	2680	2 340 000	900	5.99 x 6.26	5.99	119.7	2669	.....
462	18.9	8.02	16.08	118.7	2767	2 030 000	1100	6.01 x 6.01	5.96	117.9	3108	.....
463	18.9	8.01	16.18	117.9	2610	1 980 000	1100	6.04 x 6.00	6.00	119.7	3158	.....
464	18.9	7.98	16.11	118.6	2678	1 990 000	.....	6.02 x 6.01	6.01	119.7	2948	.....
474	18.9	8.00	16.12	119.7	2685	1 910 000	1400	5.99 x 6.07	6.03	115.3	3578	.....
475	18.9	8.00	16.10	120.0	2783	2 170 000	1000	6.03 x 6.02	6.00	120.1	3269	.....
476	18.9	8.01	16.14	119.0	2778	2 090 000	1000	5.97 x 6.10	5.99	118.9	2999	.....
486	18.9	7.98	16.09	120.5	2766	2 060 000	1300	6.00 x 6.02	6.02	118.3	3214	.....
487	18.9	7.98	16.11	120.4	2600	2 070 000	1200	6.00 x 6.05	6.01	116.8	2908	.....
488	18.9	8.02	16.08	118.3	2655	2 080 000	800	6.00 x 6.02	5.98	119.0	2896	.....
498	18.9	8.01	16.22	118.7	2877	2 150 000	1100	5.99 x 6.03	6.03	119.0	2912	.....
499	18.9	8.02	16.17	120.6	2771	1 950 000	1200	5.98 x 6.05	6.00	120.5	3448	.....
500	18.9	8.01	16.12	119.1	2640	2 180 000	1000	6.00 x 6.08	6.02	122.0	3407	.....
Average.	.....	.....	.....	.....	2761	2 114 000	1075	.....	.....	.....	3117	.886

Appendix I—Log Sheets for one Representa-

1:2:4 GRANITE CONCRETE

Total Load, lbs.	Cylinder No. 162 Granite 4 weeks		Cylinder No. 244 Granite 13 weeks		Cylinder No. 170 Granite 26 weeks		Cylinder No. 173 Granite 52 weeks	
	Unit Stress, lb. per sq. in.	Deformation, millionths of in. per in.	Unit Stress, lb. per sq. in.	Deformation, millionths of in. per in.	Unit Stress, lb. per sq. in.	Deformation, millionths of in. per in.	Unit Stress, lb. per sq. in.	Deformation, millionths of in. per in.
250							5	
5000	99	20	99	25	100	21	100	21
10 000	198	30	198	50	199	42	199	42
15 000	297	30	297	71	298	67	299	63
20 000	396	50	396	92	398	83	399	83
25 000	495	70	495	115	497	100	499	104
30 000	594	100	594	138	597	125	598	125
35 000	693	130	693	158	696	146	698	145
40 000	792	150	792	182	796	163	798	167
45 000	891	180	891	204	895	188	897	188
50 000	990	220	990	228	995	217	997	208
55 000	1089	240	1089	250	1094	238	1097	229
60 000	1188	270	1188	271	1194	258	1197	250
65 000	1287	300	1287	294	1293	283	1296	271
70 000	1386	330	1386	315	1392	304	1396	292
75 000	1485	370	1485	346	1492	333	1496	313
80 000	1584	400	1584	371	1591	354	1595	338
85 000	1683	430	1683	396	1691	375	1695	358
90 000	1782	480	1782	413	1790	400	1795	379
95 000	1881	530	1881	433	1890	425	1894	404
100 000	1980	580	1980	457	1989	450	1994	429
105 000	2079	650	2079	483	2089	483	2094	454
110 000	2178	710	2178	513	2188	508	2194	479
115 000	2276	760	2276	538	2288	538	2293	504
120 000	2375	830	2375	563	2387	563	2393	529
125 000	2474	920	2474	588	2487	592	2493	554
130 000			2573	611	2586	621	2592	579
135 000			2672	646	2686	654	2692	604
140 000			2771	675	2785	675	2792	629
145 000			2870	700	2885	713	2892	658
150 000			2969	738	2984	750	2991	688
155 000			3068	783	3084	779	3091	717
160 000			3167	817	3183	817	3191	742
165 000			3266	867	3283	854	3290	771
170 000			3365	896	3382	896	3390	804
175 000			3464	933	3482	933	3490	838
180 000			3563	988	3581	988	3590	871
185 000			(1)		(1)		3689	904
190 000							3789	938
195 000							3889	971
200 000							3988	1004
205 000							4088	1046
210 000							4188	1092
215 000							4288	1138
220 000							4387	1183
225 000							4487	1233
230 000							4587	1288
235 000							4686	1342
240 000							4786	1413
245 000							4886	1488

¹ Ultimate load exceeded the capacity of the testing machine (200 000 lb.—3969 lb. per sq. in.).

tive Cylinder for each Age and Aggregate

1:2:4 GRAVEL CONCRETE

Cylinder No. 359 Gravel 4 weeks		Cylinder No. 338 Gravel 13 weeks		Cylinder No. 351 Gravel 26 weeks		Cylinder No. 366 Gravel 52 weeks		Total load, lbs.
Unit Stress, lb. per sq. in.	Deforma- tion, millionths of in. per in.	Unit Stress, lb. per sq. in.	Deforma- tion, millionths of in. per in.	Unit Stress, lb. per sq. in.	Deforma- tion, millionths of in. per in.	Unit Stress, lb. per sq. in.	Deforma- tion, millionths of in. per in.	
				5		5		250
99	20	99	50	99	25	100	21	5000
197	30	198	79	198	42	199	38	10 000
296	50	298	108	298	63	299	50	15 000
395	80	397	138	397	83	399	67	20 000
494	100	496	154	496	100	499	88	25 000
592	130	595	171	595	121	598	104	30 000
691	140	695	196	695	142	698	125	35 000
790	160	794	208	794	154	798	146	40 000
889	180	893	233	893	171	897	163	45 000
987	210	992	254	992	192	997	179	50 000
1086	230	1092	267	1092	208	1097	192	55 000
1185	250	1191	296	1191	233	1197	213	60 000
1284	280	1290	317	1290	250	1296	235	65 000
1382	310	1389	338	1389	271	1396	254	70 000
1481	330	1488	358	1488	288	1496	275	75 000
1580	350	1588	379	1588	308	1595	288	80 000
1678	380	1687	404	1687	325	1695	304	85 000
1777	400	1786	425	1786	354	1795	321	90 000
1876	440	1885	450	1885	375	1894	346	95 000
1975	470	1984	475	1984	392	1994	367	100 000
2074	500	2084	500	2084	413	2094	388	105 000
2172	550	2183	525	2183	433	2194	408	110 000
2271	580	2282	550	2282	454	2293	429	115 000
2370	620	2381	575	2381	479	2393	450	120 000
2468	650	2481	600	2481	500	2493	467	125 000
2567	700	2580	633	2580	521	2592	488	130 000
		2679	667	2679	546	2692	508	135 000
		2778	700	2778	575	2792	533	140 000
		2877	733	2877	600	2892	550	145 000
		2977	767	2977	621	2991	571	150 000
		3076	800	3076	650	3091	600	155 000
		3175	833	3175	679	3191	625	160 000
		3274	863	3274	708	3290	642	165 000
		3374	896	3374	738	3390	671	170 000
		3473	933	3473	771	3490	688	175 000
		3572	983	3572	804	3590	708	180 000
		3671	1038	3671	838	3689	733	185 000
		3770	1104	3770	871	3789	754	190 000
		3870	1225	3870	913	3889	775	195 000
		3969	1375	3969	971	3988	804	200 000
		(¹)		(¹)		4088	833	205 000
						4188	863	210 000
						4288	896	215 000
						4387	925	220 000
						4487	954	225 000
						4587	983	230 000
						4686	1021	235 000
						4786	1058	240 000
						4886	1092	245 000
						4986	1142	250 000
						5085	1192	255 000
						5185	1267	260 000

¹ Ultimate load exceeded the capacity of the testing machine (200 000 lb.=3969 lb. per sq. in.).

1:2:4 LIMESTONE CONCRETE—Continued

	Cylinder No. 274 Limestone 4 weeks	Cylinder No. 264 Limestone 13 weeks	Cylinder No. 305 Limestone 26 weeks	Cylinder No. 283 Limestone 52 weeks
Total Load, lbs.	Unit Stress, lb. per sq. in.	Deformation, millionths of in. per in.	Unit Stress, lb. per sq. in.	Deformation, millionths of in. per in.
250			5	5
5000	99	99	17	21
10 000	198	198	38	42
15 000	298	297	58	58
20 000	397	396	83	83
25 000	496	495	108	104
30 000	595	594	125	125
35 000	695	693	150	146
40 000	794	792	175	171
45 000	893	891	196	192
50 000	992	990	225	213
55 000	1092	1089	246	233
60 000	1191	1188	275	254
65 000	1290	1287	292	275
70 000	1389	1386	317	296
75 000	1488	1485	350	317
80 000	1587	1584	379	338
85 000	1687	1683	408	358
90 000	1786	1782	433	383
95 000	1885	1881	463	408
100 000	1985	1980	492	458
105 000		2079	529	463
110 000		2178	554	492
115 000		2276	592	521
120 000		2375	621	550
125 000		2474	658	575
130 000		2573	696	604
135 000		2672	729	633
140 000		2771	767	657
145 000		2870	808	700
150 000		2969	854	733
155 000		3068	896	771
160 000		3167	950	804
165 000		3266	1004	842
170 000		3365	1063	879
175 000			1121	921
180 000			1179	963
185 000			1258	1004
190 000			1358	1050
195 000				1096
200 000				1146
205 000				1217

Cylinder for each Age and Aggregate—Continued

1:2:4 CINDER CONCRETE—Continued

Cylinder No. 455 Cinder 4 weeks		Cylinder No. 456 Cinder 13 weeks		Cylinder No. 459 Cinder 26 weeks		Cylinder No. 475 Cinder 52 weeks		Total load, lbs.
Unit Stress, lb. per sq. in.	Deforma- tion, millionths of in. per in.	Unit Stress, lb. per sq. in.	Deforma- tion, millionths of in. per in.	Unit Stress, lb. per sq. in.	Deforma- tion, millionths of in. per in.	Unit Stress, lb. per sq. in.	Deforma- tion, millionths of in. per in.	
99	50	100	42	100	46	99	46	250
198	110	199	83	199	88	199	88	5000
298	170	298	133	298	133	298	133	10 000
397	240	398	188	398	175	398	183	15 000
496	300	497	246	497	217	497	225	20 000
595	380	597	308	597	267	597	271	25 000
695	460	696	354	696	313	696	313	30 000
794	570	796	429	796	363	796	363	35 000
893	700	895	483	895	413	895	408	40 000
992	770	995	538	995	463	995	458	45 000
1092	900	1094	592	1094	513	1094	504	50 000
1191	1050	1194	663	1194	567	1194	558	55 000
1290	1230	1293	738	1293	625	1293	617	60 000
1389	1600	1392	804	1392	683	1392	671	65 000
		1492	892	1492	746	1492	725	70 000
		1591	971	1591	808	1591	779	75 000
		1691	1071	1691	879	1691	833	80 000
		1790	1188	1790	950	1790	900	85 000
		1890	1317	1890	1021	1890	963	90 000
		1989	1463	1989	1108	1989	1029	95 000
		2089	1650	2089	1196	2089	1104	100 000
		2188	1908	2188	1288	2188	1188	105 000
				2288	1396	2288	1275	110 000
				2387	1529	2387	1367	115 000
				2487	1671	2487	1483	120 000
				2586	1904	2586	1613	125 000
						2685	1775	130 000
								135 000

Appendix II—Log Sheets of Concrete Beams

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 162						BEAM 174					
0	24.85	30	24	55.3	0.005	0	25.47	61	50	54.8	0.015
500	39.85	48	39	55.4	.015	500	40.47	77	72	51.8	.025
1000	54.85	66	53	55.4	.025	1000	55.47	105	109	49.0	.035
1500	69.85	82	65	55.9	.030	1500	70.47	129	137	48.6	.045
2000	84.85	103	82	55.7	.035	2000	85.47	160	164	49.4	.055
2500	99.85	127	94	57.5	.050	2500	100.47	193	193	50.0	.065
2750	107.35	139	103	57.5	.055	3000	115.47	222	224	49.8	.080
3000	114.85	150	111	57.5	.060	3500	130.47	249	260	49.0	.095
3250	122.35	159	130	55.1	.070	4000	145.47	279	301	48.1	.105
3500	129.85	178	166	51.8	.075	4500	160.47	314	359	46.6	.115
3750	137.35	274	441	38.3	.135	5000	175.47	352	458	43.4	.155
4000	144.85	307	528	36.7	.165	5500	190.47	388	540	41.8	.175
4250	152.35	334	612	35.3	.205	6000	205.47	431	619	41.0	.215
4500	159.85	369	704	34.4	.235	6500	220.47	467	691	40.3	.245
5000	174.85	424	868	32.8	.285	7000	235.47	505	769	39.6	.265
5500	189.85	472	1014	31.8	.325	7500	250.47	544	845	39.1	.295
5900	201.85					8000	265.47	587	930	38.7	.330
5100	177.85		1561		.425	8500	280.47	626	997	38.6	.360
						9000	295.47	665	1068	38.4	.385
						9300	304.47		(1135)		.415
						7500	250.47	797	1979	28.7	.465
BEAM 163						BEAM 175					
0	25.47	29	31	48.3	0.015	0	25.26	37	27	58.0	0.010
500	40.47	47	41	53.6	.025	800	49.26	62	53	53.8	.015
1000	55.47	61	53	53.4	.035	1600	73.26	92	75	55.2	.025
1500	70.47	75	70	51.8	.045	2000	85.26	109	87	55.6	.035
2000	85.47	94	87	51.9	.055	2500	100.26	127	108	54.0	.045
2500	100.47	110	103	51.6	.065	3000	115.26	147	130	53.0	.065
3000	115.47	129	125	50.7	.065	3500	130.26	184	183	50.2	.070
3250	122.97	144	140	50.7	.075	3750	137.76	245	321	43.3	.095
3500	130.47	166	173	49.0	.085	4000	145.26	256	349	42.3	.110
3750	137.97	225	369	37.8	.125	4250	152.76	285	402	41.5	.125
4000	145.47	258	489	34.6	.155	4500	160.26	311	468	39.9	.145
4250	152.97	281	583	32.5	.165	4750	167.76	333	504	39.8	.165
4500	160.47	309	674	31.4	.185	5000	175.26	357	556	39.1	.180
4750	167.97	330	769	30.0	.215	5250	182.76	375	602	38.4	.195
5000	175.47	366	885	29.2	.245	5500	190.26	392	639	38.0	.205
5250	182.97	392	956	29.1	.255	6000	205.26	437	750	36.8	.240
5500	190.47	409	1019	28.7	.265	6500	220.26	476	841	36.1	.275
5750	197.97	433	1085	28.5	.285	7000	235.26	521	930	35.9	.295
6000	205.47	451	1156	28.1	.325	7500	250.26	564	1026	35.5	.335
6250	212.97	471	1238	27.6	.345	8000	265.26	609	1109	35.4	.365
6500	220.47	495	1313	27.4	.355	8500	280.26	652	1198	35.2	.405
6750	227.97	516	1415	26.7	.385	8750	287.76	677	1234	35.4	.425
7000	235.47		1492		.395	8900	292.26				.445
BEAM 164						BEAM 176					
0	26.09	23	21	52.5	0.005	0	25.47	37	24	60.7	0.010
500	41.09	36	41	46.6	.015	500	40.47	50	39	56.4	.020
1000	56.09	49	55	47.2	.020	1000	55.47	69	53	56.6	.030
1500	71.09	62	70	46.8	.025	1500	70.47	88	65	57.4	.030
2000	86.09	82	84	49.5	.035	2000	85.47	105	82	56.2	.040
2500	101.09	95	99	48.9	.040	2500	100.47	126	101	55.6	.045
3000	116.09	111	121	47.8	.050	3000	115.47	146	121	54.7	.055
3250	123.59	122	137	47.1	.055	3500	130.47	178	154	53.6	.070
3500	131.09	131	185	41.4	.065	3750	137.97	193	191	50.3	.080
3750	138.59	163	256	38.9	.085	4000	145.47	221	234	48.5	.090
4000	146.09	191	344	35.7	.110	4250	152.97	254	309	45.1	.100
4250	153.59	243	550	30.6	.145	4500	160.47	291	403	41.9	.120
4500	161.09	264	641	29.2	.170	4750	167.97	331	453	42.2	.140
4750	168.59	285	737	27.9	.195	5000	175.47	362	509	41.5	.160
5000	176.09	306	815	27.3	.220	5500	190.47	407	602	40.4	.190
5250	183.59	326	896	26.7	.245	6000	205.47	443	694	39.0	.220
5500	191.09	346	974	26.2	.260	6500	220.47	500	786	38.9	.260
5750	198.59	368	1062	25.7	.275	7000	235.47	538	875	38.1	.240
6000	206.09	389	1140	25.5	.305	7500	250.47	581	962	37.7	.300
6250	213.59	406	1200	25.3	.325	8000	265.47	619	1065	36.8	.330
6500	221.09					8500	280.47	685	1212	36.1	
						8750	287.97	717	1332	35.0	
						9000	295.47		1431		

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ³ per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ³ per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 186						BEAM 198					
0	25.68	26	21	55.7	0.010	0	26.09	39	24	62.0	0.010
800	49.68	50	38	57.0	.020	1000	56.09	66	53	55.4	.020
1600	73.68	75	56	57.1	.030	2000	86.09	100	75	57.1	.030
2400	97.68	100	77	56.5	.040	3000	116.09	135	104	56.5	.050
3200	121.68	130	101	56.2	.050	3500	131.09	159	126	55.8	.060
3600	133.68	148	118	55.7	.060	4000	146.09	181	162	52.8	.070
4000	145.68	173	150	53.6	.070	4500	161.09	206	200	50.8	.080
4400	157.68	195	179	52.1	.080	5000	176.09	234	255	47.9	.100
4800	169.68	232	234	49.8	.090	5500	191.09	277	335	45.2	.120
5200	181.68	276	287	49.0	.100	6000	206.09	314	419	42.8	.140
5600	193.68	303	349	46.4	.130	6500	221.09	350	491	41.6	.160
6000	205.68	334	410	44.9	.150	7000	236.09	390	566	40.8	.190
6500	220.68	371	479	43.6	.160	8000	266.09	450	689	39.5	.230
7000	235.68	400	557	41.8	.190	9000	296.09	514	809	38.9	.270
8000	265.68	466	670	41.0	.230	10 000	326.09	576	916	38.6	.320
9000	295.68	530	805	39.7	.260	11 000	356.09	651	1043	38.4	.360
10 000	325.68	591	930	38.9	.300	12 000	386.09	720	1154	38.4	.410
11 000	355.68	648	1065	37.8	.350	13 000	416.09	798	1280	38.4	.450
11 500	370.68	681	1128	37.7	.380	13 500	431.09	839	1344	38.4	.470
12 000	385.68	712	1190	37.4	.395	14 000	446.09	889	1429	31.9	.510
12 500	400.68	744	1262	37.1	.420	11 900	383.09	889	1897	26.6	.630
13 000	415.68	772	1320	36.9	.440	12 500	401.09	1038	2860		
13 280	424.08		1340		.460						
BEAM 187						BEAM 199					
0	25.26	19	17	52.5	0.010	0	26.09	30	29	50.8	0.010
1000	55.26	53	43	55.1	.020	1000	56.09	62	56	52.5	.020
2000	85.26	88	70	55.7	.030	2000	86.09	93	84	52.5	.030
3000	115.26	128	108	54.2	.050	3000	116.09	127	115	52.5	.050
3500	130.26	154	133	53.7	.060	3500	131.09	152	140	52.0	.060
4000	145.26	181	164	52.5	.070	4000	146.09	169	169	50.0	.070
4500	160.26	217	222	49.4	.080	4500	161.09	202	224	47.5	.080
5000	175.26	260	311	45.5	.110	5000	176.09	230	263	46.6	.095
5500	190.26	297	386	43.5	.130	5500	191.09	264	328	44.6	.110
6000	205.26	332	462	41.8	.165	6000	206.09	300	405	42.6	.140
7000	235.26	400	621	39.2	.210	6500	221.09	342	482	41.5	.160
8000	265.26	467	768	37.8	.260	7000	236.09	376	545	40.8	.180
9000	295.26	533	930	36.4	.310	8000	266.09	447	674	39.9	.220
10 000	325.26	607	1038	36.9	.350	9000	296.09	508	798	38.9	.260
11 000	355.26	682	1191	36.4	.400	10 000	326.09	581	920	38.7	.300
11 650	374.76		1369		.450	11 000	356.09	651	1051	38.3	.350
10 000	325.26	781	1701	30.5	.470	12 000	386.09	724	1178	38.1	.400
						13 000	416.09	799	1311	37.9	.440
						13 500	431.09	850	1390	37.9	
						14 000	446.09		1497		
						12 300	395.09	932	2041	31.3	
BEAM 188						BEAM 200					
0	25.68	34	31	52.5	0.005	0	26.09	37	27	58.0	0.015
1000	55.68	75	85	46.9	.025	1000	56.09	82	62	57.0	.030
2000	85.68	105	109	49.0	.035	2000	86.09	116	84	58.0	.045
3000	115.68	147	144	50.4	.050	3000	116.09	146	111	56.8	.055
3500	130.68	165	159	51.0	.060	3500	131.09	163	126	56.5	.065
4000	145.68	190	185	50.6	.075	4000	146.09	185	150	55.2	.075
4500	160.68	215	224	49.0	.085	4500	161.09	211	188	52.9	.085
5000	175.68	251	292	46.2	.105	5000	176.09	243	236	50.7	.100
5500	190.68	284	378	42.9	.125	6000	206.09	317	379	45.5	.135
6000	205.68	321	455	41.3	.155	7000	236.09	388	530	42.3	.175
7000	235.68	389	597	39.5	.205	8000	266.09	463	653	41.5	.205
8000	265.68	451	750	37.6	.245	9000	296.09	525	778	40.3	.255
9000	295.68	515	903	36.3	.295	10 000	326.09	595	903	39.7	.295
10 000	325.68	581	1022	36.3	.335	11 000	356.09	657	1022	39.1	.345
11 000	355.68	644	1157	35.8	.395	12 000	386.09	723	1159	38.4	.390
11 500	370.68	681	1232	35.6	.425	13 000	416.09	794	1308	37.8	.445
12 000	385.68	727	1328	35.4	.445	13 500	431.09	831	1386	37.5	.465
12 460	399.48		1409		.465	13 750	438.59		1412		
10 800	349.68	781	1821	30.0	.495	13 300	425.09	854	1474	36.7	
						12 100	389.09	900	1921	31.9	.525

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber			
BEAM 210						BEAM 222						
0	25.88	26	21	55.7	0.005	0	26.29	37	32	53.9	0.010	
1500	70.88	74	58	55.9	.025	1000	56.29	66	55	54.6	.020	
2500	100.88	105	84	55.7	.035	2000	86.29	101	87	53.8	.030	
3500	130.88	143	120	54.4	.045	3000	116.29	138	115	54.5	.040	
4000	145.88	168	149	53.0	.060	3500	131.29	158	128	55.3	.050	
4500	160.88	195	179	52.1	.075	4000	146.29	188	154	55.0	.060	
5000	175.88	225	212	51.5	.085	4500	161.29	211	183	53.5	.070	
5500	190.88	257	255	50.2	.095	5000	176.29	240	217	52.5	.080	
6000	205.88	293	311	48.5	.115	5500	191.29	270	253	51.6	.090	
7000	235.88	359	419	46.1	.155	6000	206.29	299	285	51.2	.110	
8000	265.88	421	521	44.7	.195	7000	236.29	361	393	47.9	.140	
9000	295.88	487	626	43.7	.235	8000	266.29	421	485	46.5	.180	
10 000	325.88	552	744	42.6	.275	9000	296.29	488	585	45.5	.210	
11 000	355.88	616	858	41.8	.305	10 000	326.29	552	670	45.2	.250	
12 000	385.88	679	971	41.2	.345	11 000	356.29	627	769	44.9	.280	
13 000	415.88	744	1080	40.8	.375	12 000	386.29	688	853	44.6	.320	
14 000	445.88	798	1178	40.4	.425	13 000	416.29	772	930	45.4	.350	
15 000	475.88	877	1282	40.6	.465	14 000	446.29	837	1014	45.2	.390	
15 500	490.88	927	1366	40.4	.485	15 000	476.29	919	1115	45.2	.420	
15 860	501.68	-----	1477	-----	-----	16 000	506.29	1003	1214	45.2	.460	
16 000	505.88	-----	1559	-----	.555	17 000	536.29	1100	1332	45.2	.515	
14 300	454.88	1050	2010	34.3	.555	17 500	551.29	1159	1398	45.3	.540	
						17 820	560.89	-----	1443	-----	.560	
						17 100	539.29	1217	1547	44.0	.570	
						18 000	566.29	-----	1679	-----	.600	
						16 250	513.79	1338	2009	40.0	.620	
BEAM 211						BEAM 223						
0	25.68	27	31	46.5	0.005	0	26.09	45	44	50.8	0.005	
1500	70.68	75	65	53.6	.015	2000	86.09	109	94	53.7	.030	
2500	100.68	102	91	52.8	.030	3000	116.09	139	126	52.5	.060	
3500	130.68	138	123	52.9	.045	4000	146.09	182	169	51.8	.050	
4000	145.68	166	156	51.6	.055	5000	176.09	237	231	50.7	.090	
4500	160.68	188	191	49.6	.065	6000	206.09	295	313	48.6	.110	
5000	175.68	213	229	48.2	.080	7000	236.09	354	419	45.8	.150	
5500	190.68	254	284	47.2	.095	8000	266.09	423	521	44.8	.180	
6000	205.68	282	340	45.3	.115	9000	296.09	478	605	44.1	.210	
7000	235.68	337	458	42.4	.155	10 000	326.09	542	703	43.5	.250	
8000	265.68	405	576	41.3	.195	11 000	356.09	608	790	43.5	.290	
9000	295.68	465	687	40.3	.235	12 000	386.09	671	884	43.1	.320	
10 000	325.68	530	807	39.6	.275	13 000	416.09	745	997	42.8	.360	
11 000	355.68	602	923	39.5	.315	14 000	446.09	805	1080	42.7	.390	
12 000	385.68	661	1039	38.9	.355	15 000	476.09	877	1179	42.7	.430	
13 000	415.68	731	1161	38.6	.405	16 000	506.09	938	1246	43.0	.460	
14 000	445.68	814	1277	38.9	.445	17 000	536.09	1030	1352	43.2	.500	
15 000	475.68	904	1462	38.2	.495	17 500	551.09	1071	1409	43.2	.520	
15 500	490.58	-----	1538	-----	.535	18 000	566.09	1108	1465	43.1	.540	
15 000	475.68	963	1617	37.3	-----	18 500	581.09	-----	1521	-----	.570	
15 400	487.68	-----	-----	-----	.555	18 000	566.09	1177	1600	42.4	.575	
14 900	472.68	1006	1773	36.2	.565	-----						.600
						19 000	596.09	1250	1716	42.1	.610	
						19 200	602.09	-----	1809	-----	.630	
						16 800	530.09	1336	2248	37.3	.660	
BEAM 212						BEAM 224						
0	25.47	34	27	55.8	0.015	0	25.88	37	31	54.7	0.010	
1500	70.47	83	68	54.8	.035	2000	85.88	94	91	50.9	.040	
2500	100.47	119	96	55.3	.050	3000	115.88	128	121	51.5	.050	
3500	130.47	158	128	55.3	.065	4000	145.88	174	171	50.5	.070	
4000	145.47	188	156	54.7	.075	5000	175.88	230	239	49.1	.090	
4500	160.47	217	191	53.2	.095	6000	205.88	287	328	46.6	.120	
5000	175.47	252	239	51.3	.105	7000	235.88	353	415	46.0	.150	
5500	190.47	289	285	50.3	.125	8000	265.88	414	508	44.9	.190	
6000	205.47	329	335	49.6	.145	9000	295.88	475	605	44.0	.220	
6500	220.47	369	409	47.4	.175	10 000	325.88	544	692	44.0	.250	
7000	235.47	405	470	46.3	.205	11 000	355.88	607	802	43.1	.290	
8000	265.47	468	588	44.3	.245	12 000	385.88	677	903	42.8	.330	
9000	295.47	534	709	43.0	.285	13 000	415.88	743	1005	42.5	.370	
10 000	325.47	612	824	42.6	.335	14 000	445.88	807	1106	42.2	.410	
11 000	355.47	671	944	41.5	.365	15 000	475.88	885	1197	42.5	.440	
12 000	385.47	740	1056	41.2	.405	16 000	505.88	955	1292	42.5	.480	
13 000	415.47	817	1171	41.1	.455	17 000	535.88	1045	1398	42.8	.530	
14 000	445.47	901	1311	40.8	.505	18 000	565.88	1143	1579	42.0	.580	
15 000	475.47	1056	1614	39.6	.595	18 200	571.88	-----	1733	-----	.610	
15 100	478.47	-----	1687	-----	.635	18 450	579.38	-----	1933	-----	.650	
13 600	433.47	1140	1964	36.7	.655	16 600	523.88	1310	2229	37.0	.670	

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M $\frac{lb\ddot{s}.}{sq. in.}$	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M $\frac{lb\ddot{s}.}{sq. in.}$	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 237						BEAM 165					
0	25.88	33	15	69.0	0.010	0	25.47	26	14	65.0	0.005
2000	85.88	106	65	61.9	.040	1000	55.47	72	36	66.8	.020
3000	115.88	144	85	63.0	.050	2000	85.47	104	56	65.0	.030
3500	130.88	180	91	66.4	.050	3000	115.47	134	87	60.6	.040
4000	145.88	209	109	65.7	.050	3500	130.47	155	106	59.4	.050
4500	160.88	241	133	64.4	.050	4000	145.47	183	156	54.0	.060
5000	175.88	275	164	62.6	.075	4500	160.47	258	325	44.3	.110
6000	205.88	338	241	58.4	.100	5000	175.47	307	485	38.7	.155
7000	235.88	402	318	55.8	.130	5500	190.47	351	643	35.3	.200
8000	265.88	470	398	54.2	.170	6000	205.47	400	843	32.2	.255
9000	295.88	518	499	50.9	.210	6500	220.47	447	1015	30.6	.305
10 000	325.88	574	605	48.7	.240	6800	229.47	-----	1138	-----	.350
11 000	355.88	646	656	49.6	.270	4900	172.47	384	1003	27.7	.355
12 000	385.88	710	737	49.1	.310						
13 000	415.88	781	814	49.0	.340						
14 000	445.88	852	901	48.6	.370						
15 000	475.88	925	988	48.3	.410						
16 000	505.88	1003	1072	48.3	.440						
17 000	535.88	1079	1185	47.7	.480						
18 000	565.88	1159	1263	47.9	.510						
19 000	595.88	1268	1335	48.7	.550						
19 300	604.88	-----	1361	-----	-----						
19 400	607.88	-----	1393	-----	-----						
19 500	610.88	1383	1456	48.7	.620						
19 650	615.38	-----	1474	-----	.640						
17 600	553.88	1355	1400	49.2	.650						
BEAM 238						BEAM 166					
0	26.29	42	44	49.0	0.010	0	25.26	23	17	57.5	0.010
2000	86.29	107	94	53.2	.030	1000	55.26	52	34	60.6	.020
3000	116.29	143	125	53.4	.040	2000	85.26	82	60	57.8	.030
4000	146.29	184	169	52.1	.055	3000	115.26	114	85	57.3	.040
5000	176.29	228	232	49.6	.080	3500	130.26	135	104	56.5	.050
6000	206.29	279	303	47.9	.100	4000	145.26	162	138	54.0	.060
7000	236.29	332	383	46.4	.130	4500	160.26	257	448	36.5	.130
8000	266.29	408	474	46.3	.170	5000	175.26	311	672	31.6	.185
9000	296.29	461	557	45.3	.195	5500	190.26	346	839	29.2	.240
10 000	326.29	546	634	46.3	.230	6000	205.26	383	1027	27.2	.285
11 000	356.29	612	725	45.8	.260	6500	220.26	418	1176	26.2	.325
12 000	386.29	672	807	45.4	.290	5000	175.26	423	1634	20.6	.350
13 000	416.29	734	882	45.4	.310						
14 000	446.29	785	968	44.0	.340						
15 000	476.29	842	1051	44.5	.380						
16 000	506.29	899	1132	44.3	.410						
17 000	536.29	972	1231	44.1	.440						
18 000	566.29	1045	1344	43.8	.480						
19 000	596.29	1187	1629	42.1	.550						
19 150	600.79	-----	1679	-----	.560						
17 500	551.29	1224	1947	38.6	-----						
BEAM 239						BEAM 167					
0	26.29	38	34	52.5	0.005	0	25.68	26	17	60.6	0.010
2000	86.29	103	85	54.9	.030	1000	55.68	63	36	63.6	.020
3000	116.29	135	113	54.5	.040	2000	85.68	92	62	59.7	.030
4000	146.29	173	144	54.6	.055	2500	100.68	108	77	58.4	.035
5000	176.29	217	191	53.2	.070	3000	115.68	127	92	58.0	.045
6000	206.29	270	255	51.5	.100	3500	130.68	148	116	56.1	.050
7000	236.29	337	340	49.8	.120	4000	145.68	193	238	44.7	.075
8000	266.29	399	434	47.9	.150	4500	160.68	253	432	37.0	.105
9000	296.29	451	521	46.4	.180	5000	175.68	336	740	31.2	.190
10 000	326.29	518	609	46.0	.210	5500	190.68	384	882	30.3	.235
11 000	356.29	589	691	46.0	.245	6000	205.68	416	1015	29.0	.275
12 000	386.29	642	778	45.2	.280	6500	220.68	454	1147	28.4	.320
13 000	416.29	702	860	44.9	.320	6600	223.68	-----	1164	-----	.345
14 000	446.29	765	944	44.7	.350	5200	181.68	408	1063	27.8	.345
15 000	476.29	833	1031	44.7	.380						
16 000	506.29	899	1120	44.5	.420						
17 000	536.29	990	1227	44.6	.460						
18 000	566.29	1065	1326	44.5	.495						
19 000	596.29	1148	1426	44.6	.540						
19 500	611.29	-----	1485	-----	.590						
19 630	615.19	-----	1578	-----	.590						
19 920	623.89	-----	1774	-----	.625						
18 000	566.29	-----	-----	-----	.640						

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 177						BEAM 189					
0	25.47	24	19	56.0	0.010	0	26.29	28	17	62.4	0.010
1000	55.47	55	46	54.5	.020	1000	55.29	58	36	61.6	.020
2000	85.47	85	74	53.4	.030	2000	86.29	87	58	60.1	.035
3000	115.47	117	99	54.1	.040	3000	116.29	118	82	59.0	.045
3500	130.47	134	121	52.5	.050	4000	146.29	150	113	57.1	.055
4000	145.47	157	145	52.0	.060	4500	161.29	171	137	55.6	.070
4500	160.47	192	226	45.9	.080	5000	176.29	189	166	53.2	.080
5000	175.47	239	337	41.5	.100	5500	191.29	217	214	50.3	.100
6000	205.47	331	617	34.9	.180	6000	206.29	248	282	46.7	.120
7000	235.47	392	810	32.6	.240	7000	236.29	328	460	41.7	.165
8000	265.47	457	976	31.9	.310	8000	266.29	411	597	40.8	.210
8500	280.47	490	1063	31.5	.340	9000	296.29	462	726	38.9	.260
9000	295.47	527	1157	31.3	.370	10 000	326.29	522	858	37.8	.305
9210	301.77	-----	1215	-----	.410	11 000	356.29	592	988	37.5	.350
7600	253.47	500	1116	30.9	.410	12 000	386.29	650	1125	36.6	.400
						12 700	407.29	-----	1226	-----	.455
						10 100	329.29	706	1853	27.6	.475
BEAM 178						BEAM 190					
0	25.47	19	22	46.4	0.010	0	25.26	26	10	72.1	0.005
1000	55.47	56	38	59.4	.020	1000	55.26	62	21	74.7	.025
2000	85.47	81	62	56.7	.035	2000	85.26	94	43	68.6	.035
3000	115.47	113	89	56.0	.050	3000	115.26	126	74	63.0	.045
3500	130.47	132	106	55.4	.055	4000	145.26	160	106	60.2	.060
4000	145.47	149	128	53.8	.060	4500	160.26	181	128	58.6	.070
4500	160.47	174	171	50.5	.075	5000	175.26	207	164	55.7	.080
5000	175.47	213	229	48.2	.090	5500	190.26	234	209	52.8	.085
6000	205.47	315	497	38.8	.160	6000	205.26	279	292	48.8	.110
7000	235.47	375	694	35.0	.220	7000	235.26	357	477	42.8	.165
8000	265.47	434	867	33.4	.280	8000	265.26	420	656	39.0	.230
9000	295.47	496	1046	32.2	.345	9000	295.26	489	814	37.5	.275
10 000	325.47	560	1248	31.0	.410	10 000	325.26	531	979	35.2	.320
7700	256.47	507	817	38.3	.410	11 000	355.26	590	1132	34.3	.370
						12 000	385.26	651	1277	33.7	.415
						12 500	400.26	682	1344	33.7	.445
						12 560	402.06	-----	1374	-----	.475
						9800	319.26	603	1150	34.4	.475
BEAM 179						BEAM 191					
0	25.47	28	21	57.6	0.010	0	25.47	21	21	50.1	0.010
1000	55.47	53	43	55.1	.010	1000	55.47	43	44	49.6	.025
2000	85.47	79	67	54.2	.020	2000	85.47	72	68	51.4	.035
3000	115.47	107	96	52.7	.030	3000	115.47	107	92	53.8	.045
4000	145.47	138	123	52.9	.040	4000	145.47	145	116	55.6	.055
4500	160.47	157	144	52.2	.050	4500	160.47	165	135	55.0	.065
5000	175.47	184	178	50.8	.060	5000	175.47	190	159	54.5	.075
5500	190.47	227	253	47.3	.090	5500	190.47	218	191	53.4	.085
6000	205.47	276	369	42.8	.130	6000	205.47	261	244	51.7	.100
7000	235.47	356	588	37.7	.200	7000	235.47	346	421	45.1	.150
8000	265.47	413	776	34.8	.260	8000	265.47	411	588	41.1	.205
9000	295.47	498	949	34.4	.325	9000	295.47	469	735	39.0	.250
9840	320.67	-----	1070	-----	.390	10 000	325.47	533	892	37.4	.300
8200	271.47	501	974	34.0	.400	11 000	355.47	588	1021	36.6	.345
						11 780	378.87	-----	1176	-----	.400
						10 100	328.47	673	1561	30.1	.420

Appendix II—Log Sheets for Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 201						BEAM 213					
0	25.68	23	15	60.4	0.005	0	26.09	23	15	60.4	0.005
1000	55.68	50	32	61.0	.015	1000	56.09	53	39	57.4	.015
2000	85.68	79	55	58.9	.025	2000	86.09	75	62	54.7	.020
3000	115.68	112	77	59.4	.035	3000	116.09	106	87	54.8	.030
4000	145.68	142	101	58.5	.045	4000	146.09	141	123	53.4	.045
5000	175.68	186	152	55.0	.060	5000	176.09	184	171	51.8	.060
6000	205.68	236	250	48.6	.085	6000	206.09	228	241	48.7	.090
7000	235.68	311	405	43.4	.135	7000	236.09	299	333	47.3	.115
8000	265.68	372	542	40.7	.175	8000	266.09	360	441	44.9	.150
9000	295.68	429	682	38.6	.215	9000	296.09	416	550	43.1	.185
10 000	325.68	485	802	37.7	.255	10 000	326.09	471	665	41.4	.220
11 000	355.68	548	916	37.4	.290	11 000	356.09	519	749	40.9	.255
12 000	385.68	600	1045	36.5	.325	12 000	386.09	572	856	40.1	.290
13 000	415.68	657	1164	36.1	.370	13 000	416.09	626	961	39.5	.325
13 550	432.18	-----	1301	-----	.410	14 000	446.09	670	1060	38.7	.365
13 600	433.68	-----	1443	-----	.430	15 000	476.09	723	1157	38.5	.400
12 300	394.68	740	1680	30.6	.440	16 000	506.09	782	1279	37.9	.435
						16 550	522.59	-----	1321	-----	.470
						14 800	470.09	777	1262	37.6	.480
BEAM 202						BEAM 214					
0	25.68	21	19	52.5	0.010	0	25.68	23	17	57.5	0.010
1000	55.68	48	39	55.4	.020	1000	55.68	53	38	58.0	.020
2000	85.68	79	65	54.9	.030	2000	85.68	79	60	56.8	.030
3000	115.68	109	92	54.2	.040	3000	115.68	107	84	55.9	.040
4000	145.68	144	130	52.5	.055	4000	145.68	141	115	55.0	.055
5000	175.68	190	190	50.0	.075	5000	175.68	185	161	53.5	.075
6000	205.68	249	291	46.1	.105	6000	205.68	238	217	52.3	.100
7000	235.68	316	429	42.4	.140	7000	235.68	298	313	48.7	.130
8000	265.68	379	566	40.1	.190	8000	265.68	363	434	45.5	.165
9000	295.68	437	687	38.9	.230	9000	295.68	420	556	43.0	.210
10 000	325.68	477	815	36.9	.270	10 000	325.68	469	665	41.3	.240
11 000	355.68	549	957	36.5	.310	11 000	355.68	523	781	40.1	.275
12 000	385.68	604	1084	35.8	.350	12 000	385.68	570	885	39.2	.315
13 000	415.68	670	1215	35.6	.395	13 000	415.68	621	991	38.5	.355
13 650	435.18	-----	1323	-----	.435	14 000	445.68	682	1094	38.4	.390
12 450	399.18	740	1634	31.2	.460	15 000	475.68	748	1202	38.3	.430
						16 000	505.68	803	1321	37.8	.465
						16 800	529.68	-----	1494	-----	.525
						14 600	463.68	877	1930	31.3	.530
BEAM 203						BEAM 215					
0	25.68	23	17	57.5	0.010	0	26.29	21	15	58.1	0.010
1000	55.68	55	44	55.5	.025	1000	56.29	51	43	54.1	.020
2000	85.68	77	67	53.5	.035	2000	86.29	82	62	57.0	.030
3000	115.68	106	91	53.8	.045	3000	116.29	111	87	56.0	.040
4000	145.68	136	118	53.5	.055	4000	146.29	146	120	54.9	.050
5000	175.68	174	173	50.2	.070	5000	176.29	189	174	52.1	.070
6000	205.68	233	255	47.8	.100	6000	206.29	245	277	46.9	.100
7000	235.68	296	391	43.1	.140	7000	236.29	299	379	44.1	.130
8000	265.68	363	532	40.5	.185	8000	266.29	358	494	42.0	.160
9000	295.68	418	662	38.7	.225	9000	296.29	411	597	40.8	.195
10 000	325.68	473	805	37.0	.265	10 000	326.29	461	708	39.5	.235
11 000	355.68	527	920	36.4	.310	11 000	356.29	518	821	38.7	.275
12 000	385.68	578	1043	35.7	.345	12 000	386.29	567	932	37.8	.305
13 000	415.68	637	1166	35.3	.385	13 000	416.29	618	1038	37.3	.345
14 000	445.68	713	1361	34.4	.440	14 000	446.29	670	1144	36.9	.380
14 180	451.08	-----	1479	-----	.465	15 000	476.29	726	1250	36.7	.425
12 600	403.68	772	1882	29.1	.495	16 000	506.29	799	1368	36.9	.470
						16 500	521.29	-----	1422	-----	.495
						15 500	491.29	828	1540	34.9	.510

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 225						BEAM 243					
0	25.88	23	15	60.4	0.010	0	26.29	26	17	60.6	0.010
1000	55.88	55	31	64.1	.020	1000	56.29	67	38	63.9	.025
2000	85.88	84	55	60.4	.030	2000	86.29	91	53	63.2	.035
3000	115.88	116	77	60.0	.040	3000	116.29	123	75	62.1	.045
4000	145.88	145	108	57.3	.050	4000	146.29	153	101	60.2	.060
5000	175.88	185	147	55.8	.070	5000	176.29	190	135	58.5	.080
6000	205.88	229	205	52.7	.090	6000	206.29	230	179	56.3	.100
7000	235.88	296	289	50.6	.115	7000	236.29	284	239	54.3	.120
8000	265.88	355	379	48.3	.145	8000	266.29	341	306	52.7	.140
9000	295.88	414	479	46.3	.180	9000	296.29	401	379	51.4	.170
10 000	325.88	469	579	44.8	.210	10 000	326.29	446	472	48.6	.195
11 000	355.88	522	682	43.4	.240	11 000	356.29	503	556	47.5	.225
12 000	385.88	579	773	42.8	.275	12 000	386.29	547	643	45.9	.255
13 000	415.88	625	868	41.8	.310	13 000	416.29	603	725	45.4	.285
14 000	445.88	686	966	41.5	.345	14 000	446.29	647	805	44.5	.315
15 000	475.88	732	1055	41.0	.375	15 000	476.29	696	887	44.0	.345
16 000	505.88	788	1156	40.5	.410	16 000	506.29	746	966	43.6	.370
17 000	535.88	839	1236	40.4	.440	17 000	536.29	807	1039	43.7	.400
18 000	565.88	913	1354	40.3	.485	18 000	566.29	850	1115	43.3	.430
18 250	573.38	-----	1503	-----	.510	19 000	596.29	917	1215	43.0	.470
17 250	543.38	1040	1926	35.1	.560	20 000	626.29	981	1340	42.3	.500
						20 500	641.29	1038	1456	41.6	.535
						21 000	656.29	1082	1562	40.9	.570
						21 300	665.29	-----	1706	-----	.615
						19 400	608.29	1182	2038	36.7	.630
BEAM 226						BEAM 244					
0	26.09	19	12	60.7	0.005	0	26.71	28	17	62.4	0.010
1000	56.09	45	34	56.9	.015	1000	56.71	52	32	62.0	.020
2000	86.09	73	55	57.2	.025	2000	86.71	79	53	59.7	.025
3000	116.09	101	80	55.8	.035	3000	116.71	105	72	59.3	.035
4000	146.09	130	101	56.2	.045	4000	146.71	129	91	58.6	.045
5000	176.09	167	140	54.5	.055	5000	176.71	163	115	58.6	.060
6000	206.09	205	190	51.9	.075	6000	206.71	196	156	55.6	.070
7000	236.09	257	263	49.4	.095	7000	236.71	242	209	53.6	.090
8000	266.09	313	356	46.8	.125	8000	266.71	293	275	51.6	.110
9000	296.09	368	465	44.2	.155	9000	296.71	339	354	48.9	.140
10 000	326.09	421	574	42.3	.185	10 000	326.71	381	443	46.3	.170
11 000	356.09	471	663	41.5	.215	11 000	356.71	427	532	44.5	.195
12 000	386.09	522	754	40.9	.250	12 000	386.71	474	617	43.4	.225
13 000	416.09	567	839	40.3	.285	13 000	416.71	519	697	42.7	.250
14 000	446.09	617	932	39.9	.315	14 000	446.71	566	778	42.1	.280
15 000	476.09	668	1021	39.5	.345	15 000	476.71	608	856	41.5	.310
16 000	506.09	713	1109	39.1	.375	16 000	506.71	658	937	41.2	.340
17 000	536.09	769	1205	38.9	.405	17 000	536.71	703	1014	40.9	.365
18 000	566.09	827	1321	38.5	.445	18 000	566.71	750	1089	40.8	.395
18 500	581.09	-----	1480	-----	.480	19 000	596.71	808	1173	40.8	.430
18 620	584.69	-----	1694	-----	.505	20 000	626.71	860	1252	40.7	.460
17 300	545.09	967	2075	31.8	.535	21 000	656.71	927	1379	40.2	.510
						21 280	665.11	-----	1405	-----	.530
						19 400	608.71	890	1294	40.8	.540
BEAM 227						BEAM 245					
0	26.29	19	17	52.5	0.005	0	26.50	23	19	54.9	0.010
1000	56.29	48	43	52.5	.015	1000	56.50	48	43	52.5	.020
2000	86.29	72	63	53.2	.025	2000	86.50	74	63	54.0	.030
3000	116.29	101	85	54.4	.035	3000	116.50	101	85	54.4	.040
4000	146.29	132	109	54.8	.045	4000	146.50	127	108	54.0	.050
5000	176.29	167	138	54.8	.055	5000	176.50	162	140	53.7	.060
6000	206.29	215	193	52.7	.075	6000	206.50	197	181	52.1	.075
7000	236.29	273	258	51.4	.095	7000	236.50	243	244	49.9	.095
8000	266.29	331	349	48.7	.125	8000	266.50	293	304	49.1	.120
9000	296.29	387	448	46.3	.155	9000	296.50	340	388	46.7	.145
10 000	326.29	437	550	44.3	.190	10 000	326.50	388	477	44.9	.170
11 000	356.29	488	643	43.1	.220	11 000	356.50	431	564	43.3	.200
12 000	386.29	543	732	42.6	.255	12 000	386.50	477	648	42.4	.230
13 000	416.29	589	824	41.7	.285	13 000	416.50	525	728	41.9	.260
14 000	446.29	634	911	41.0	.315	14 000	446.50	568	802	41.4	.285
15 000	476.29	690	1007	40.7	.345	15 000	476.50	615	879	41.2	.315
16 000	506.29	742	1103	40.2	.385	16 000	506.50	662	957	40.9	.345
17 000	536.29	796	1197	39.9	.415	17 000	536.50	704	1034	40.5	.370
18 000	566.29	850	1308	39.4	.455	18 000	566.50	753	1113	40.4	.400
18 780	589.69	-----	1443	-----	.495	19 000	596.50	809	1198	40.3	.430
17 400	548.29	906	1513	37.5	.530	20 000	626.50	870	1304	40.0	.470
						21 000	656.50	938	1439	39.5	.510
						22 000	686.50	1044	1720	37.8	.570
						22 120	690.10	-----	1831	-----	.595
						18 900	593.50	1108	2419	31.4	.620

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² , per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² , per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 169						BEAM 181					
0	25.68	16	10	62.0	0.005	0	25.88	16	12	57.8	0.010
1000	55.68	35	32	52.5	.020	1000	55.88	32	32	50.2	.020
2000	85.68	59	55	51.6	.030	2000	85.88	66	51	56.4	.030
2500	100.68	70	68	50.7	.035	3000	115.88	100	84	54.4	.050
3000	115.68	86	85	50.2	.050	3500	130.88	115	109	51.4	.060
3500	130.68	115	133	46.5	.060	4000	145.88	137	135	50.3	.070
4000	145.68	153	212	42.0	.085	4500	160.88	167	191	46.6	.080
4500	160.68	202	421	32.4	.140	5000	175.88	202	258	43.9	.105
5000	175.68	265	586	31.1	.185	5500	190.88	235	333	41.4	.130
5500	190.68	307	766	28.6	.230	6000	205.88	274	444	38.2	.160
6000	205.68	349	942	27.1	.265	7000	235.88	333	619	35.0	.210
6500	220.68	389	1089	26.3	.315	8000	265.88	395	815	32.7	.270
6810	229.98	-----	1178	-----	.340	9000	295.88	458	998	31.4	.325
6050	207.18	385	1135	25.3	.350	10 000	325.88	508	1178	30.1	.380
						10 780	349.28	-----	1303	-----	.425
						8100	268.88	470	1133	29.3	.440
BEAM 170						BEAM 182					
0	25.68	19	14	57.1	0.010	0	26.09	17	15	52.5	0.010
1000	55.68	45	31	59.1	.025	1000	56.09	51	51	50.1	.030
2000	85.68	66	56	54.1	.035	2000	86.09	70	70	50.0	.040
2500	100.68	87	68	56.1	.045	3000	116.09	94	99	48.6	.050
3000	115.68	100	84	54.4	.055	3500	131.09	120	123	49.4	.060
3500	130.68	122	106	53.6	.060	4000	146.09	148	168	46.8	.070
4000	145.68	175	238	42.3	.095	4500	161.09	179	222	44.6	.090
4500	160.68	232	414	35.9	.145	5000	176.09	211	289	42.2	.110
5000	175.68	278	605	31.5	.190	6000	206.09	294	528	35.8	.170
5500	190.68	313	745	29.6	.230	7000	236.09	356	708	33.5	.230
6000	205.68	346	887	28.0	.270	8000	266.09	414	891	31.7	.290
6350	216.18	-----	1044	-----	.325	9000	296.09	478	1074	30.8	.350
5230	182.58	350	979	26.4	.335	10 000	326.09	533	1241	30.0	.405
						8250	273.09	481	1132	29.8	.430
BEAM 180						BEAM 192					
0	25.88	17	15	52.5	0.010	0	25.26	19	14	57.1	0.010
1000	55.88	33	43	43.3	.020	1000	55.26	38	38	49.9	.020
2000	85.88	59	67	47.0	.030	2000	85.26	62	62	50.1	.030
3000	115.88	88	97	47.6	.040	3000	115.26	93	87	51.7	.045
3500	130.88	109	126	46.3	.050	3500	130.26	114	104	52.3	.050
4000	145.88	135	159	45.9	.065	4000	145.26	136	130	51.2	.060
4500	160.88	163	222	42.4	.080	5000	175.26	183	197	48.2	.080
5000	175.88	196	306	39.1	.100	6000	205.26	240	311	43.5	.115
6000	205.88	270	499	35.2	.150	7000	235.26	315	475	39.8	.160
7000	235.88	336	691	32.7	.210	8000	265.26	383	629	37.8	.210
8000	265.88	396	870	31.3	.265	9000	295.26	449	774	36.7	.250
9000	295.88	462	1053	30.5	.320	10 000	325.26	505	913	35.6	.300
9820	320.48	-----	1226	-----	.380	11 000	355.26	568	1051	35.1	.345
8000	265.88	575	2391	19.4	.470	12 000	385.26	627	1181	34.7	.390
						12 360	396.06	-----	1280	-----	.425
						10 900	352.26	627	1309	32.4	.430

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 193						BEAM 205					
0	25.68	19	14	57.1	0.005	0	26.29	19	19	49.9	0.010
1000	55.68	45	41	52.5	.015	1000	56.29	42	46	48.0	.020
2000	85.68	79	65	54.9	.030	2000	86.29	63	68	47.9	.030
3000	115.68	111	92	54.7	.045	3000	116.29	91	97	48.5	.045
4000	145.68	146	125	53.8	.055	4000	146.29	122	132	48.0	.060
5000	175.68	201	190	51.3	.080	5000	176.29	162	186	46.6	.080
6000	205.68	273	308	47.0	.115	6000	206.29	213	279	43.2	.110
7000	235.68	337	456	42.5	.155	7000	236.29	268	403	39.9	.140
8000	265.68	396	593	40.1	.205	8000	266.29	328	533	38.1	.180
9000	295.68	462	727	38.9	.250	9000	296.29	382	655	36.8	.220
10 000	325.68	518	841	38.1	.290	10 000	326.29	429	781	35.5	.260
11 000	355.68	585	962	37.8	.335	11 000	356.29	487	906	34.9	.300
12 000	385.68	656	1089	37.6	.395	12 000	386.29	534	1024	34.3	.340
12 500	400.68	-----	1210	-----	.425	13 000	416.29	583	1137	33.9	.380
10 500	340.68	749	1786	29.5	.470	14 000	446.29	653	1333	32.9	.440
						14 730	468.19	-----	1684	-----	.540
						13 730	438.19	722	1651	30.4	.555
BEAM 194						BEAM 206					
0	25.68	17	15	52.5	0.010	0	25.68	19	21	47.5	0.010
1000	55.68	37	31	54.7	.020	1000	55.68	38	36	51.1	.020
2000	85.68	61	50	54.8	.030	2000	85.68	68	55	55.3	.030
3000	115.68	90	77	54.0	.045	3000	115.68	100	82	55.0	.050
4000	145.68	122	103	54.3	.055	4000	145.68	133	111	54.6	.065
5000	175.68	164	178	48.0	.080	5000	175.68	173	164	51.3	.085
6000	205.68	213	250	46.0	.105	6000	205.68	229	248	48.0	.120
7000	235.68	272	412	39.8	.145	7000	235.68	284	373	43.2	.160
8000	265.68	338	605	35.9	.195	8000	265.68	346	503	40.8	.200
9000	295.68	382	754	33.6	.240	9000	295.68	403	621	39.4	.240
10 000	325.68	443	899	33.0	.285	10 000	325.68	450	744	37.7	.280
11 000	355.68	491	1034	32.2	.325	11 000	355.68	507	865	36.9	.320
12 000	385.68	551	1173	32.0	.375	12 000	385.68	551	983	35.9	.360
12 530	401.58	-----	1313	-----	.415	13 000	415.68	596	1096	35.2	.400
10 700	346.68	590	1708	25.7	.430	14 000	445.68	655	1258	34.2	.450
						14 540	461.88	-----	1393	-----	.480
						12 800	409.68	717	1756	29.0	.505
BEAM 204						BEAM 216					
0	25.68	17	15	52.5	0.01	0	25.88	17	14	54.1	0.010
1000	55.68	37	32	53.9	.02	1000	55.88	45	31	59.1	.020
2000	85.68	64	55	53.8	.03	2000	85.88	68	51	57.1	.030
3000	115.68	91	82	52.5	.04	3000	115.88	92	70	56.8	.040
4000	145.68	127	121	51.3	.06	4000	145.88	127	106	54.4	.050
5000	175.68	175	191	47.9	.085	5000	175.88	168	154	52.2	.070
6000	205.68	236	297	44.2	.12	6000	205.88	214	214	50.1	.100
7000	235.68	294	421	41.1	.16	7000	235.88	274	294	48.3	.130
8000	265.68	345	540	39.0	.20	8000	265.88	333	393	45.9	.170
9000	295.68	398	667	37.4	.24	9000	295.88	386	496	43.8	.200
10 000	325.68	455	791	36.5	.28	10 000	325.88	443	603	42.4	.240
11 000	355.68	500	887	36.1	.32	11 000	355.88	498	704	41.4	.270
12 000	385.68	558	1014	35.5	.36	12 000	385.88	547	802	40.6	.310
13 000	415.68	610	1138	34.9	.405	13 000	415.88	594	872	40.5	.345
13 550	432.18	-----	1267	-----	.445	14 000	445.88	660	978	40.3	.380
12 500	400.68	665	1485	30.9	.455	15 000	475.88	708	1077	39.7	.415
						16 000	505.88	808	1292	38.5	.480
						14 500	460.88	853	1739	32.9	.520

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 217						BEAM 232					
0	26.09	19	14	57.1	0.005	0	26.29	19	14	57.1	0.010
1000	56.09	43	29	59.5	.02	1000	56.29	42	36	53.8	.020
2000	86.09	64	50	56.0	.03	2000	86.29	61	53	53.4	.030
3000	116.09	92	74	55.5	.04	3000	116.29	93	72	56.4	.040
4000	146.09	124	101	55.2	.05	4000	146.29	119	97	55.1	.050
5000	176.09	160	147	52.2	.07	5000	176.29	149	133	52.9	.065
6000	206.09	205	203	50.3	.09	6000	206.29	197	183	51.8	.085
7000	236.09	252	274	47.9	.125	7000	236.29	238	248	49.0	.110
8000	266.09	300	342	46.7	.16	8000	266.29	282	333	45.8	.135
9000	296.09	350	439	44.4	.19	9000	296.29	330	426	43.6	.165
10 000	326.09	404	542	42.7	.23	10 000	326.29	376	503	42.8	.195
11 000	356.09	445	633	41.3	.26	11 000	356.29	425	605	41.2	.225
12 000	386.09	493	733	40.2	.295	12 000	386.29	465	689	40.3	.250
13 000	416.09	544	829	39.6	.33	13 000	416.29	506	786	39.1	.280
14 000	446.09	592	930	38.9	.365	14 000	446.29	546	872	38.5	.310
15 000	476.09	643	1041	38.2	.405	15 000	476.29	558	961	38.0	.340
16 000	506.09	703	1171	37.5	.445	16 000	506.29	631	1048	37.6	.370
16 350	516.59	-----	1224	-----	.47	17 000	536.29	681	1140	37.4	.405
15 300	485.09	777	1735	30.9	.515	18 000	566.29	725	1239	36.9	.440
						19 000	596.29	798	1313	37.8	.480
						19 570	613.39	-----	1436	-----	-----
						16 700	527.29	837	1586	34.5	.570
BEAM 218						BEAM 233					
0	26.29	16	15	50.9	0.005	0	26.29	13	14	48.8	0.005
1000	56.29	38	36	51.1	.020	1000	56.29	35	27	56.5	.015
2000	86.29	56	55	50.2	.030	2000	86.29	58	46	55.9	.030
3000	116.29	82	82	50.1	.045	3000	116.29	84	65	56.5	.040
4000	146.29	112	116	49.2	.060	4000	146.29	118	91	56.6	.050
5000	176.29	155	185	45.6	.080	5000	176.29	162	135	54.5	.070
6000	206.29	197	255	43.5	.100	6000	206.29	199	195	50.5	.085
7000	236.29	249	342	42.1	.130	7000	236.29	234	251	48.3	.110
8000	266.29	304	415	42.3	.160	8000	266.29	278	320	46.5	.135
9000	296.29	359	525	40.6	.200	9000	296.29	331	405	45.0	.160
10 000	326.29	406	629	39.2	.230	10 000	326.29	382	496	43.5	.195
11 000	356.29	456	733	38.4	.270	11 000	356.29	430	585	42.4	.220
12 000	386.29	503	836	37.6	.305	12 000	386.29	469	665	41.3	.250
13 000	416.29	555	937	37.2	.340	13 000	416.29	522	757	40.8	.285
14 000	446.29	604	1015	37.3	.375	14 000	446.29	562	834	40.2	.315
15 000	476.29	653	1130	36.6	.410	15 000	476.29	609	916	39.9	.345
16 000	506.29	712	1251	36.3	.450	16 000	506.29	659	997	39.8	.370
16 300	515.29	-----	1337	-----	.480	17 000	536.29	704	1072	39.6	.405
14 900	473.29	780	1802	30.2	.510	18 000	566.29	759	1168	39.4	.440
						19 000	596.29	827	1299	38.9	.480
						19 480	610.69	-----	1474	-----	.520
						17 760	559.09	1011	2342	30.2	.600
BEAM 231						BEAM 240					
0	26.29	21	15	58.1	0.005	0	26.29	15	12	56.2	0.010
1000	56.29	43	34	55.8	.015	1000	56.29	39	29	57.6	.020
2000	86.29	66	51	56.3	.025	2000	86.29	58	51	53.4	.030
3000	116.29	92	67	57.8	.035	3000	116.29	85	70	54.8	.040
4000	146.29	124	91	57.6	.045	4000	146.29	113	87	56.5	.050
5000	176.29	158	121	56.6	.060	5000	176.29	145	116	55.6	.060
6000	206.29	194	171	53.2	.080	6000	206.29	183	152	54.6	.085
7000	236.29	236	236	50.0	.100	7000	236.29	232	214	52.1	.100
8000	266.29	283	323	46.7	.130	8000	266.29	281	282	49.9	.125
9000	296.29	341	415	45.1	.160	9000	296.29	328	354	48.1	.150
10 000	326.29	387	504	43.4	.190	10 000	326.29	378	436	46.4	.175
11 000	356.29	434	595	42.2	.220	11 000	356.29	423	525	44.6	.210
12 000	386.29	483	696	41.0	.250	12 000	386.29	468	602	43.8	.235
13 000	416.29	529	786	40.2	.280	13 000	416.29	515	680	43.1	.260
14 000	446.29	567	862	39.7	.310	14 000	446.29	558	756	42.5	.290
15 000	476.29	603	942	39.0	.340	15 000	476.29	607	834	42.1	.320
16 000	506.29	650	1034	38.6	.370	16 000	506.29	652	913	41.7	.350
17 000	536.29	700	1120	38.5	.405	17 000	536.29	700	1007	41.0	.380
18 000	566.29	746	1226	37.9	.440	18 000	566.29	747	1065	41.2	.405
18 980	595.69	-----	1309	-----	.475	19 000	596.29	801	1132	41.4	.435
16 600	524.29	848	1896	30.9	.510	20 000	626.29	856	1219	41.2	.465
						21 000	656.29	916	1338	40.6	.500
						21 620	674.89	-----	1438	-----	.550
						18 900	593.29	923	1328	41.0	.560

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 242						BEAM 173					
0	26.29	15	12	56.2	0.010	0	25.68	23	22	51.4	0.010
1000	56.29	45	29	60.6	.020	1000	55.68	48	39	55.4	.020
2000	86.29	71	46	60.6	.030	2000	85.68	79	62	56.0	.030
3000	116.29	95	62	60.5	.035	3000	115.68	107	96	52.7	.040
4000	146.29	125	84	59.9	.075	4000	145.68	164	169	49.2	.060
5000	176.29	159	121	56.8	.090	5000	175.68	270	503	34.9	.135
6000	206.29	202	173	53.8	.110	6000	205.68	358	827	30.2	.230
7000	236.29	238	229	51.0	.130	7000	235.68	424	1067	28.4	.320
8000	266.29	282	291	49.2	.150	7200	241.68	1104	-----	-----	.345
9000	296.29	323	362	47.2	.175	5200	181.68	374	949	28.3	.350
10 000	326.29	374	439	46.0	.200						
11 000	356.29	425	518	45.1	.230						
12 000	386.29	480	590	44.8	.260						
13 000	416.29	527	644	45.0	.280						
14 000	446.29	572	738	43.6	.310						
15 000	476.29	628	815	43.5	.340						
16 000	506.29	679	891	43.2	.370						
17 000	536.29	720	959	42.9	.400						
18 000	566.29	770	1041	42.5	.425						
19 000	596.29	812	1126	41.9	.455						
20 000	626.29	855	1200	41.6	.485						
21 000	656.29	913	1284	41.6	.515						
22 000	686.29	1005	1494	40.2	.570						
22 480	700.69	-----	1619	-----	.600						
19 650	615.79	1071	2132	33.4	.610						
BEAM 171						BEAM 183					
0	25.26	21	14	59.7	.010	0	25.68	13	14	54.1	0.010
1000	55.26	47	34	58.1	.020	1000	55.68	42	36	53.8	.020
2000	85.26	73	53	58.0	.030	2000	85.68	70	62	52.9	.030
3000	115.26	96	75	56.0	.040	3000	115.68	101	92	52.2	.050
4000	145.26	124	97	56.1	.050	4000	145.68	139	144	49.1	.065
5000	175.26	166	179	48.2	.170	5000	175.68	191	250	43.3	.090
6000	205.26	320	812	28.2	.200	6000	205.68	269	468	36.5	.130
7000	235.26	383	1144	25.0	.280	7000	235.68	343	728	32.0	.200
7300	244.26	-----	1347	-----	.345	8000	265.68	411	940	30.5	.255
5350	185.76	382	1846	17.1	.350	9000	295.68	473	1118	29.7	.305
						10 000	325.68	526	1313	28.6	.360
						10 750	348.18	-----	1573	-----	.430
						8800	289.68	571	2085	21.5	.430
BEAM 172						BEAM 184					
0	25.26	21	14	59.7	0.010	0	25.68	21	17	55.1	0.010
1000	55.26	45	31	59.1	.020	1000	55.68	47	41	53.6	.020
2000	85.26	69	55	55.7	.030	2000	85.68	74	62	54.3	.030
3000	115.26	100	77	56.5	.040	3000	115.68	104	92	53.0	.045
4000	145.26	123	111	52.5	.055	4000	145.68	136	125	52.1	.060
5000	175.26	227	354	39.1	.110	5000	175.68	183	193	48.6	.075
6000	205.26	339	761	30.8	.220	6000	205.68	263	379	41.0	.115
7000	235.26	415	1055	28.3	.305	7000	235.68	353	639	35.6	.185
5100	178.26	433	2072	17.3	.405	8000	265.68	427	870	32.9	.245
						9000	295.68	493	1065	31.6	.305
						10 000	325.68	(567)	1280	(30.7)	.375
						7700	256.68	538	1885	22.2	.385

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² , lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflec- tion, inches	Applied Load, lbs.	M bd ² , lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflec- tion, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 185						BEAM 197					
0	25.88	21	15	58.1	0.010	0	25.88	23	17	57.5	0.010
1000	55.88	47	34	58.1	.020	1000	55.88	50	36	58.3	.020
2000	85.88	71	51	58.2	.030	2000	85.88	79	55	58.9	.030
3000	115.88	100	79	55.9	.045	3000	115.88	106	77	58.0	.040
4000	145.88	127	108	54.0	.055	4000	145.88	133	108	55.2	.050
5000	175.88	165	150	52.3	.075	5000	175.88	172	147	53.9	.065
6000	205.88	223	270	45.2	.100	6000	205.88	217	222	49.4	.085
7000	235.88	303	494	38.0	.170	7000	235.88	283	364	43.8	.125
8000	265.88	355	670	34.7	.225	8000	265.88	339	504	40.2	.165
9000	295.88	410	858	32.4	.285	9000	295.88	399	648	38.1	.210
10 000	325.88	464	1014	31.4	.345	10 000	325.88	452	785	36.5	.255
10 670	345.98		1115			11 000	355.88	500	918	35.3	.295
7650	355.38	405	904	31.0	.405	12 000	385.88	560	1060	34.6	.345
						13 000	415.88	605	1178	33.9	.385
						13 100	418.88				.415
						10 650	345.38	565	1135	33.2	.435
BEAM 195						BEAM 207					
0	25.06	21	19	52.5	0.010	0	25.88	21	15	58.1	0.005
1000	55.06	43	34	55.8	.020	1000	55.88	47	32	59.5	.015
2000	85.06	73	53	58.0	.030	2000	85.88	77	58	57.0	.025
3000	115.06	100	72	58.0	.040	3000	115.88	107	85	55.6	.040
4000	145.06	129	94	57.9	.050	4000	145.88	136	115	54.1	.050
5000	175.06	161	121	57.1	.065	5000	175.88	174	161	51.9	.065
6000	205.06	205	183	52.9	.085	6000	205.88	225	239	48.5	.090
7000	235.06	287	345	45.4	.130	7000	235.88	275	338	44.8	.125
8000	265.06	352	511	40.8	.180	8000	265.88	345	482	41.7	.165
9000	295.06	413	658	38.5	.220	9000	295.88	401	614	39.5	.205
10 000	325.06	457	783	36.9	.270	10 000	325.88	452	732	38.2	.245
11 000	355.06	508	901	36.1	.310	11 000	355.88	507	856	37.2	.285
12 000	385.06	563	1022	35.5	.355	12 000	385.88	568	981	36.7	.325
13 000	415.06	613	1135	35.1	.400	13 000	415.88	618	1111	35.8	.360
13 670	435.16		1217		.445	14 000	445.88	680	1253	35.2	.410
11 100	358.06	562	1106	33.7	.470	14 500	460.88		1472		.430
						12 400	397.88	746	1986	27.3	.480
BEAM 196						BEAM 208					
0	25.88	23	15	60.4	0.010	0	26.09	21	17	55.1	0.010
1000	55.88	47	39	54.8	.020	1000	56.09	50	36	58.3	.020
2000	85.88	74	58	55.9	.030	2000	86.09	73	56	56.7	.030
3000	115.88	100	82	55.0	.040	3000	116.09	106	77	58.0	.040
4000	145.88	127	104	54.9	.050	4000	146.09	137	106	56.4	.050
5000	175.88	160	138	53.7	.065	5000	176.09	172	142	54.7	.070
6000	205.88	202	214	48.5	.085	6000	206.09	214	200	51.7	.090
7000	235.88	270	347	43.7	.120	7000	236.09	273	301	47.5	.120
8000	265.88	339	515	39.7	.170	8000	266.09	337	421	44.5	.160
9000	295.88	393	668	37.0	.210	9000	296.09	405	552	42.3	.200
10 000	325.88	444	812	35.3	.260	10 000	326.09	462	680	40.5	.240
11 000	355.88	511	950	35.0	.300	11 000	356.09	519	807	39.2	.280
12 000	385.88	567	1085	34.3	.340	12 000	386.09	576	928	38.3	.320
13 000	415.88	612	1214	33.5	.390	13 000	416.09	628	1053	37.4	.360
10 500	340.88	657	2074	24.0	.440	14 000	446.09	691	1173	37.2	.400
						15 000	476.09	745	1291	36.6	.440
						15 770	499.19		1518		.500
						12 900	413.09	836	2202	27.5	.530

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M $\frac{bd^3}{4}$ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M $\frac{bd^3}{4}$ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 209						BEAM 221					
0	26.29	17	15	52.5	0.010	0	26.29	19	21	47.5	0.005
1000	56.29	45	38	54.3	.020	1000	56.29	38	41	48.1	.015
2000	86.29	69	60	53.7	.030	2000	86.29	64	60	51.7	.020
3000	116.29	100	82	55.0	.040	3000	116.29	91	85	51.6	.030
4000	146.29	133	108	55.2	.055	4000	146.29	117	111	51.4	.040
5000	176.29	165	149	52.5	.070	5000	176.29	147	137	51.8	.060
6000	206.29	204	219	48.2	.090	6000	206.29	179	185	49.2	.080
7000	236.29	263	315	45.5	.115	7000	236.29	234	270	46.5	.100
8000	266.29	324	453	41.7	.155	8000	266.29	286	368	43.7	.130
9000	296.29	374	602	38.3	.205	9000	296.29	332	475	41.2	.160
10 000	326.29	431	723	37.3	.245	10 000	326.29	387	598	39.3	.195
11 000	356.29	474	824	36.5	.280	11 000	356.29	442	708	38.5	.230
12 000	386.29	532	949	35.9	.315	12 000	386.29	489	815	37.5	.260
13 000	416.29	578	1065	35.2	.355	13 000	416.29	536	932	36.5	.300
14 000	446.29	635	1185	34.9	.400	14 000	446.29	589	1036	36.3	.335
15 000	476.29	685	1318	34.2	.435	15 000	476.29	639	1145	35.8	.370
15 380	487.69	-----	1379	-----	.465	16 000	506.29	688	1241	35.6	.405
12 500	401.29	614	1243	33.1	.485	17 000	536.29	746	1350	35.6	.440
						17 660	556.09	-----	1438	-----	.470
						15 300	485.29	805	2044	28.3	.520
BEAM 219						BEAM 228					
0	26.29	23	21	52.5	0.010	0	26.29	19	22	45.4	0.005
1000	56.29	42	38	52.5	.020	1000	56.29	43	43	50.2	.020
2000	86.29	68	58	54.1	.030	2000	86.29	70	63	52.5	.030
3000	116.29	92	75	55.2	.040	3000	116.29	99	94	51.2	.040
4000	146.29	119	97	55.1	.050	4000	146.29	128	121	51.5	.050
5000	176.29	148	121	55.1	.060	5000	176.29	160	144	52.7	.060
6000	206.29	195	190	50.7	.080	6000	206.29	195	181	51.8	.075
7000	236.29	251	292	46.2	.110	7000	236.29	246	246	50.0	.100
8000	266.29	311	402	43.6	.145	8000	266.29	298	323	48.0	.125
9000	296.29	368	526	41.1	.175	9000	296.29	351	409	46.2	.150
10 000	326.29	420	660	38.9	.215	10 000	326.29	402	492	44.9	.180
11 000	356.29	470	750	38.5	.250	11 000	356.29	442	586	43.0	.210
12 000	386.29	520	860	37.7	.285	12 000	386.29	502	685	42.3	.245
13 000	416.29	568	966	37.0	.325	13 000	416.29	546	771	41.4	.275
14 000	446.29	618	1072	36.5	.350	14 000	446.29	590	850	41.0	.305
15 000	476.29	669	1142	36.9	.390	15 000	476.29	648	947	40.6	.335
16 000	506.29	727	1338	35.2	.430	16 000	506.29	693	1024	40.4	.365
17 000	536.29	789	1496	34.5	.480	17 000	536.29	741	1121	39.8	.400
17 700	557.29	-----	1639	-----	.530	18 000	566.29	800	1214	39.7	.435
15 350	486.79	810	1713	32.1	.560	19 000	596.29	846	1320	39.1	.470
						20 000	626.29	908	1436	38.7	.505
						20 650	645.79	-----	1644	-----	.560
						17 850	561.79	1007	2178	31.6	.585
BEAM 220						BEAM 229					
0	26.09	23	15	60.4	0.010	0	26.29	17	15	52.5	0.010
1000	56.09	45	43	51.4	.020	1000	56.29	47	31	60.2	.020
2000	86.09	69	58	54.5	.030	2000	86.29	76	53	59.1	.030
3000	116.09	98	79	55.3	.040	3000	116.29	105	74	58.6	.040
4000	146.09	122	104	54.0	.055	4000	146.29	133	103	56.3	.055
5000	176.09	166	147	53.0	.065	5000	176.29	172	144	54.4	.065
6000	206.09	214	210	50.5	.085	6000	206.29	211	197	51.8	.085
7000	236.09	259	287	47.5	.115	7000	236.29	258	262	49.6	.105
8000	266.09	315	379	45.4	.145	8000	266.29	310	349	47.0	.135
9000	296.09	380	487	43.9	.180	9000	296.29	361	436	45.3	.165
10 000	326.09	425	603	41.4	.220	10 000	326.29	407	513	44.2	.190
11 000	356.09	484	709	40.6	.255	11 000	356.29	458	607	43.0	.220
12 000	386.09	523	812	39.2	.290	12 000	386.29	508	694	42.3	.250
13 000	416.09	570	913	38.4	.325	13 000	416.29	551	778	41.5	.280
14 000	446.09	620	1019	37.8	.365	14 000	446.29	593	862	40.7	.310
15 000	476.09	663	1116	37.3	.400	15 000	476.29	644	952	40.3	.345
16 000	506.09	715	1248	36.4	.435	16 000	506.29	689	1036	39.9	.375
16 600	524.09	-----	1749	-----	.535	17 000	536.29	736	1123	39.6	.405
14 900	473.09	887	2632	25.2	.600	18 000	566.29	791	1207	39.6	.435
						19 000	596.29	836	1294	39.3	.465
						20 000	626.29	893	1388	39.2	.500
						20 750	648.79	-----	1585	-----	.545
						17 400	548.29	988	2526	28.1	.595

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M $\frac{bd^2}{4}$ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M $\frac{bd^2}{4}$ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 230						BEAM 236					
0	27.01	20	15	57.2	0.005	0	26.29	19	21	47.5	0.010
1000	57.01	46	38	54.7	.015	1000	56.29	47	38	55.4	.020
2000	87.01	70	59	54.2	.025	2000	86.29	75	56	57.1	.025
3000	117.01	96	87	52.5	.035	3000	116.29	100	82	55.0	.040
4000	147.01	129	112	53.5	.045	4000	146.29	132	113	53.9	.055
5000	177.01	160	145	52.3	.055	5000	176.29	168	157	51.7	.070
6000	207.01	196	192	50.4	.080	6000	206.29	206	214	49.0	.090
7000	237.01	238	260	47.8	.100	7000	236.29	255	262	49.2	.115
8000	267.01	280	340	45.4	.120	8000	266.29	312	342	47.7	.135
9000	297.01	330	427	43.5	.160	9000	296.29	355	419	45.8	.165
10 000	327.01	375	525	41.6	.180	10 000	326.29	409	489	45.5	.185
11 000	357.01	417	611	40.5	.215	11 000	356.29	458	566	44.7	.215
12 000	387.01	465	707	39.6	.240	12 000	386.29	504	648	43.7	.245
13 000	417.01	508	795	38.9	.270	13 000	416.29	559	738	43.1	.275
14 000	447.01	556	880	38.7	.305	14 000	446.29	604	810	42.7	.305
15 000	477.01	600	975	38.1	.335	15 000	476.29	655	887	42.5	.335
16 000	507.01	640	1053	37.8	.365	16 000	506.29	704	966	42.2	.365
17 000	537.01	684	1150	37.3	.395	17 000	536.29	757	1044	42.0	.395
18 000	567.01	733	1233	37.2	.425	18 000	566.29	802	1125	41.6	.425
19 000	597.01	781	1331	36.9	.460	19 000	596.29	852	1209	41.3	.455
20 000	627.01	830	1440	36.5	.480	20 000	626.29	901	1291	41.1	.485
21 000	657.01	884	1580	35.8	.535	21 000	656.29	970	1458	40.0	.525
17 400	549.01	792	1397	36.1	.545	22 000	686.29	1790			.605
						18 400	578.29	1092	2453	30.8	.625
BEAM 234						BEAM 256					
0	26.29	21	17	55.1	0.010	0	25.47	30	29	50.8	.01
1000	56.29	42	41	50.7	.020	1000	55.47	60	63	48.8	.02
2000	86.29	67	68	49.5	.030	2000	85.47	104	94	52.5	.04
3000	116.29	94	97	49.1	.040	2500	100.47	119	113	51.2	.05
4000	146.29	124	132	48.4	.050	3000	115.47	150	147	50.5	.06
5000	176.29	162	169	48.9	.070	3250	122.97	208	301	40.9	.095
6000	206.29	207	227	47.7	.090	3500	130.47	271	463	36.9	.13
7000	236.29	253	291	46.5	.110	4000	145.47	326	653	33.3	.18
8000	266.29	308	366	45.7	.140	4500	160.47	380	832	31.3	.23
9000	296.29	352	434	44.8	.165	5000	175.47	444	990	30.9	.275
10 000	326.29	402	518	43.7	.195	5500	190.47	496	1121	30.7	.32
11 000	356.29	456	602	43.1	.225	6000	205.47	535	1239	30.1	.37
12 000	386.29	503	691	42.1	.260	6350	215.97	(1321)			.405
13 000	416.29	554	785	41.4	.285	4500	160.47	548	2007	21.4	.44
14 000	446.29	612	880	41.0	.320						
15 000	476.29	664	966	40.8	.345						
16 000	506.29	718	1058	40.4	.380						
17 000	536.29	767	1142	40.2	.410						
18 000	566.29	817	1229	39.9	.440						
19 000	596.29	885	1337	39.8	.470						
20 000	626.29	932	1424	39.6	.510						
21 000	656.29	1015	1607	38.7	.550						
18 950	594.79	1197	2562	31.8	.650						
BEAM 235						BEAM 257					
0	26.29	19	19	49.9	0.015	0	25.47	37	17	68.3	0.01
1000	56.29	42	39	51.9	.025	1000	55.47	78	36	68.3	.02
2000	86.29	79	56	58.4	.035	2000	85.47	122	63	66.0	.03
3000	116.29	116	77	60.0	.045	2500	100.47	144	82	63.8	.04
4000	146.29	148	108	57.8	.055	3000	115.47	174	108	61.7	.05
5000	176.29	187	140	57.2	.070	3250	122.97	207	167	55.3	.06
6000	206.29	230	183	55.8	.090	3500	130.47	251	272	48.0	.085
7000	236.29	281	234	54.5	.110	4000	145.47	337	532	38.8	.15
8000	266.29	328	297	52.5	.140	4500	160.47	388	673	36.6	.21
9000	296.29	380	385	49.7	.170	5000	175.47	437	853	33.8	.26
10 000	326.29	428	470	47.7	.195	5500	190.47	475	973	32.8	.305
11 000	356.29	486	559	46.5	.220	5800	199.47	(1031)			.33
12 000	386.29	532	636	45.6	.250	5900	202.47	(1111)			.35
13 000	416.29	578	720	44.5	.280	4550	161.97	534	1614	24.9	.37
14 000	446.29	634	807	44.0	.310						
15 000	476.29	679	891	43.2	.340						
16 000	506.29	724	978	42.5	.370						
17 000	536.29	771	1056	42.2	.400						
18 000	566.29	824	1144	41.9	.430						
19 000	596.29	884	1229	41.8	.465						
20 000	626.29	930	1297	41.8	.495						
21 000	656.29	980	1390	41.4	.525						
22 000	686.29	1042	1489	41.2	.570						
22 100	689.29		1648		.620						
18 850	591.79	998	1494	40.1	.625						

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 261						BEAM 273					
0	26.09	27	24	52.5	0.010	0	26.09	28	27	50.7	0.010
1000	56.09	50	48	51.0	.020	1000	56.09	60	58	50.8	.020
2000	86.09	85	77	52.5	.035	2000	86.09	92	87	51.4	.040
3000	116.09	123	109	52.9	.045	3000	115.09	129	116	52.7	.050
3500	131.09	149	137	52.2	.055	3500	131.09	148	136	52.1	.060
4000	146.09	182	185	49.6	.075	4000	146.09	175	160	52.2	.070
4500	161.09	232	306	43.1	.105	4500	161.09	205	208	49.6	.080
5000	176.09	289	439	39.7	.155	5000	176.09	254	282	47.4	.110
6000	206.09	351	646	35.2	.215	6000	206.09	335	471	41.6	.155
7000	236.09	432	824	34.4	.275	7000	236.09	407	641	38.9	.210
8000	266.09	509	1009	33.5	.335	8000	266.09	473	791	37.4	.255
9000	296.09	586	1169	33.4	.395	9000	296.09	543	953	36.3	.305
9420	308.69	-----	(1233)	-----	.425	10 000	326.09	612	1100	35.7	.350
						11 000	356.09	693	1251	35.7	.405
						11 300	365.09	-----	(1381)	-----	.435
						10 300	335.09	739	1849	28.6	.450
BEAM 262						BEAM 274					
0	25.88	25	27	47.7	0.010	0	26.09	28	25	52.5	0.010
1000	55.88	51	58	47.0	.020	1000	56.09	56	47	54.4	.015
2000	85.88	80	87	48.0	.035	2000	86.09	86	80	51.9	.030
3000	115.88	118	121	49.4	.050	3000	116.09	122	110	52.5	.040
3500	130.88	143	150	48.7	.060	3500	131.09	139	129	51.9	.050
4000	145.88	184	225	45.1	.075	4000	146.09	161	148	52.2	.060
4500	160.88	257	446	36.6	.120	4500	161.09	193	191	50.3	.075
5000	175.88	309	567	35.3	.150	5000	176.09	230	247	48.2	.080
6000	205.88	377	774	32.7	.220	6000	206.09	318	444	41.7	.130
7000	235.88	452	964	31.9	.270	7000	236.09	383	615	38.4	.185
8000	265.88	533	1150	31.7	.330	8000	266.09	447	762	37.0	.210
8500	280.88	567	1268	30.9	.365	9000	296.09	524	921	36.3	.255
9000	295.88	605	1376	30.5	.395	10 000	326.09	593	1087	35.3	.305
9320	305.48	-----	(1451)	-----	.420	10 800	350.09	-----	(1269)	-----	.350
						10 100	329.09	714	1681	29.8	.395
BEAM 263						BEAM 275					
0	26.09	25	27	47.7	0.010	0	26.29	27	22	55.5	0.010
1000	56.09	52	59	46.6	.025	1000	56.29	57	49	53.9	.020
2000	86.09	82	89	47.8	.035	2000	86.29	91	77	54.3	.040
3000	116.09	114	121	48.5	.045	3000	116.29	128	101	56.0	.050
3500	131.09	139	136	50.5	.055	3500	131.29	148	125	54.2	.060
4000	146.09	164	183	47.3	.065	4000	146.29	176	148	54.4	.070
4500	161.09	236	388	37.8	.105	4500	161.29	201	181	52.6	.080
5000	176.09	288	519	35.7	.145	5000	176.29	244	237	50.7	.100
6000	206.09	364	728	33.3	.210	6000	206.29	335	460	42.1	.155
7000	236.09	439	919	32.3	.275	7000	236.29	402	613	39.6	.205
8000	266.09	511	1162	30.5	.340	8000	266.29	454	764	37.3	.250
8470	280.19	-----	(1314)	-----	.385	9000	296.29	529	894	37.2	.290
7500	251.09	573	1870	23.5	.415	10 000	325.29	604	1063	36.2	.340
						11 000	356.29	682	1214	36.0	.370
						11 500	371.29	-----	(1306)	-----	.400
						10 400	338.29	734	1507	32.8	.410

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 285						BEAM 257					
0	25.88	27	20	57.8	0.010	0	25.88	31	28	52.5	0.010
1000	55.88	59	47	55.8	.025	1000	55.88	63	57	52.5	.020
2000	85.88	93	68	57.8	.035	2000	85.88	97	88	52.5	.035
3000	115.88	127	95	57.2	.045	3000	115.88	133	120	52.5	.050
3500	130.88	149	114	56.7	.055	4000	145.88	173	158	52.2	.060
4000	145.88	170	136	55.6	.065	5000	175.88	225	237	48.7	.090
4500	160.88	198	177	52.8	.075	6000	205.88	305	373	45.0	.120
5000	175.88	232	244	48.7	.085	7000	235.88	370	500	42.6	.165
6000	205.88	308	384	44.5	.125	8000	265.88	440	623	41.4	.205
7000	235.88	385	547	41.3	.175	9000	295.88	523	753	41.0	.250
8000	265.88	455	685	39.9	.215	10 000	325.88	597	895	40.0	.295
9000	295.88	518	815	38.8	.240	11 000	355.88	671	1014	39.8	.335
10 000	325.88	585	965	37.7	.285	12 000	385.88	743	1131	39.6	.385
11 000	355.88	657	1078	37.9	.335	13 000	415.88	823	1243	39.8	.420
12 000	385.88	739	1242	37.3	.375	14 000	445.88	903	1373	39.7	.465
13 000	415.88	803	(1394)	36.5	.430	14 600	463.88	(1460)	(1460)	39.7	.505
13 000	415.88	803	1400	36.5	.445	14 860	471.68	(1527)	(1527)	37.8	.525
12 500	400.88				.475	13 900	442.88	1045	1722		.530
BEAM 286						BEAM 298					
0	26.09	26	18	59.3	0.010	0	26.29	27	20	57.8	0.010
1000	56.09	60	40	60.0	.020	1000	56.29	56	41	57.7	.025
2000	86.09	92	68	57.5	.040	2000	86.29	89	66	57.3	.035
3000	116.09	127	90	58.5	.050	3000	116.29	125	97	56.3	.050
3500	131.09	148	103	58.9	.060	4000	146.29	168	141	54.4	.065
4000	146.09	171	122	58.3	.065	5000	176.29	236	229	50.8	.095
4500	161.09	190	146	56.5	.075	6000	206.29	318	343	48.1	.130
5000	176.09	228	192	54.3	.090	7000	236.29	394	471	45.6	.175
6000	206.09	296	315	48.4	.130	8000	266.29	469	606	43.6	.220
7000	236.09	372	474	44.0	.175	9000	296.29	541	719	42.9	.260
8000	266.09	433	623	41.0	.225	10 000	326.29	610	827	42.4	.300
9000	296.09	489	753	39.4	.265	11 000	356.29	689	940	42.3	.345
10 000	326.09	552	880	38.5	.305	12 000	386.29	762	1061	41.8	.385
11 000	356.09	613	994	38.2	.350	13 000	416.29	863	1191	42.0	.430
12 000	386.09	688	1114	38.2	.400	14 000	446.29	937	1307	41.8	.470
12 500	401.09	732	1196	38.0	.425	15 000	476.29	1054	1464	41.9	.525
13 000	416.09	764	1256	37.8	.450	15 520	491.89	(1560)	(1560)		.560
13 500	431.09	803	1334	37.6	.480	13 700	437.29				.575
13 670	436.19		(1375)		.510						
12 000	386.09				.535						
BEAM 287						BEAM 299					
0	26.29	24	22	52.5	0.010	0	25.88	38	24	61.4	0.010
1000	56.29	53	48	52.5	.020	1000	55.88	70	50	58.3	.020
2000	86.29	81	72	52.8	.030	2000	85.88	107	77	58.2	.035
3000	116.29	115	101	53.2	.050	3000	115.88	145	108	57.3	.050
3500	131.29	131	118	52.7	.060	4000	145.88	187	149	55.6	.070
4000	146.29	153	138	52.5	.065	5000	175.88	250	229	52.2	.095
4500	161.29	174	162	51.8	.070	6000	205.88	326	328	49.8	.135
5000	176.29	209	210	49.9	.090	7000	235.88	401	463	46.4	.175
6000	206.29	284	345	45.2	.130	8000	265.88	479	588	44.9	.220
7000	236.29	360	482	42.8	.170	9000	295.88	566	708	44.4	.260
8000	266.29	421	612	40.7	.215	10 000	325.88	651	827	44.0	.305
9000	296.29	497	760	39.5	.265	11 000	355.88	728	939	43.7	.345
10 000	326.29	562	887	38.8	.320	12 000	385.88	815	1058	43.5	.395
11 000	356.29	640	1022	38.5	.365	13 000	415.88	878	1176	42.7	.440
12 000	386.29	717	1172	37.9	.410	14 000	445.88	979	1328	42.4	.485
12 500	401.29	772	1266	37.9	.440	14 500	460.88	1058	1415	42.8	.520
13 000	416.29	812	1348	37.6	.465	15 000	475.88	1111	1508	42.4	.545
13 100	419.29		(1504)		.500	15 100	478.88	(1615)	(1615)		.585
12 000	386.29	872	1723	33.6	.510	12 900	412.88	1241	2162	36.5	.615

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 318						BEAM 321					
0	26.29	33	22	59.8	0.015	0	26.29	28	23	54.5	0.010
1000	56.29	68	48	58.5	.025	1000	56.29	57	50	53.4	.020
2000	86.29	102	75	57.6	.040	2000	86.29	91	76	54.6	.035
3000	116.29	141	101	58.3	.055	3000	116.29	128	105	54.9	.045
4000	146.29	184	133	58.0	.070	4000	146.29	171	141	54.7	.060
5000	176.29	242	184	56.8	.090	5000	176.29	224	204	52.4	.080
6000	206.29	313	284	52.4	.120	6000	206.29	282	285	50.0	.100
7000	236.29	389	383	50.4	.155	7000	236.29	358	375	48.8	.140
8000	266.29	463	494	48.4	.190	8000	266.29	431	464	48.1	.170
9000	296.29	536	588	47.7	.225	9000	296.29	502	556	47.4	.205
10 000	326.29	615	690	47.1	.260	10 000	326.29	566	649	46.6	.235
11 000	356.29	681	786	46.4	.300	11 000	356.29	639	743	46.2	.270
12 000	386.29	755	894	45.8	.340	12 000	386.29	702	835	45.7	.305
13 000	416.29	837	991	45.8	.375	13 000	416.29	780	920	45.9	.340
14 000	446.29	910	1085	45.6	.415	14 000	446.29	851	1013	45.7	.375
15 000	476.29	1012	1190	46.0	.460	15 000	476.29	939	1100	46.0	.415
16 000	506.29	1099	1294	45.9	.500	16 000	506.29	1016	1196	45.9	.450
17 000	536.29	1225	1413	46.4	.550	17 000	536.29	1114	1291	46.3	.490
17 500	551.29	1314	1530	46.2	.580	17 620	554.89	.....	(1387)	.....	.520
17 650	555.79	.....	(1566)	.....	.595	18 000	566.29	1254	1491	45.7	.545
16 700	527.29	1406	1737	44.7	.615	18 680	586.69	.....	(1669)	.....	.595
						18 870	592.39	.....	(1808)	.....	.620
						17 000	536.29	1557	2240	41.0	.655
BEAM 319						BEAM 322					
0	26.29	31	23	57.2	0.010	0	26.09	30	24	55.3	0.010
2000	86.29	100	73	57.7	.035	1000	56.09	64	48	57.0	.025
3000	116.29	136	98	58.1	.050	2000	86.09	98	77	55.9	.035
4000	146.29	181	134	57.4	.060	3000	116.09	130	106	55.0	.050
5000	176.29	233	189	55.2	.085	4000	146.09	167	140	54.5	.065
6000	206.29	303	276	52.3	.115	5000	176.09	219	198	52.5	.080
7000	236.29	379	375	50.2	.150	6000	206.09	279	279	50.0	.115
8000	266.29	450	473	48.8	.185	7000	236.09	354	373	48.7	.150
9000	296.29	517	577	47.2	.220	8000	266.09	431	467	48.0	.180
10 000	326.29	588	678	46.5	.255	9000	296.09	494	562	46.8	.210
11 000	356.29	658	767	46.2	.290	10 000	326.09	550	670	45.1	.250
12 000	386.29	726	862	45.7	.330	11 000	356.09	636	747	46.0	.285
13 000	416.29	823	963	46.1	.370	12 000	386.09	698	831	45.7	.320
14 000	446.29	890	1064	45.5	.405	13 000	416.09	786	920	46.1	.355
15 000	476.29	976	1168	45.5	.445	14 000	446.09	857	1002	46.1	.390
16 000	506.29	1091	1298	45.7	.495	15 000	476.09	941	1091	46.3	.425
17 000	536.29	1266	1570	44.6	.560	16 000	506.09	1015	1174	46.4	.465
16 000	506.29	1329	1811	42.3	.640	17 000	536.09	1103	1272	46.4	.500
						18 000	566.09	1241	1393	47.1	.555
						18 200	572.09	.....	(1484)	.....	.605
						18 320	575.69	.....	(1549)	.....	.625
						17 200	542.09	.....	.....	.....	.655
BEAM 320						BEAM 323					
0	26.09	40	26	60.8	0.010	0	26.09	28	23	54.5	0.010
1000	56.09	72	57	56.0	.020	1000	56.09	63	49	56.1	.020
2000	86.09	110	86	56.1	.035	2000	86.09	91	76	54.6	.030
3000	116.09	149	117	56.1	.050	3000	116.09	128	107	54.4	.040
4000	146.09	195	159	55.0	.065	4000	146.09	168	141	54.4	.045
5000	176.09	256	231	52.6	.090	5000	176.09	217	202	51.8	.075
6000	206.09	327	315	50.9	.110	6000	206.08	280	285	49.6	.100
7000	236.09	399	414	49.1	.160	7000	236.09	349	348	50.1	.125
8000	266.09	472	530	47.1	.200	8000	266.09	414	459	47.4	.155
9000	296.09	546	638	46.1	.240	9000	296.09	490	531	48.0	.185
10 000	326.09	607	734	45.3	.270	10 000	326.09	561	628	47.2	.225
11 000	356.09	677	852	44.3	.310	11 000	356.09	627	717	46.7	.245
12 000	386.09	752	959	43.9	.350	12 000	386.09	675	803	45.7	.290
13 000	416.09	841	1053	44.4	.395	13 000	416.09	755	879	46.2	.330
14 000	446.09	926	1154	44.5	.435	14 000	446.09	828	979	45.8	.360
15 000	476.09	1026	1270	44.7	.455	15 000	476.09	921	1057	46.6	.400
16 000	506.09	1137	1404	44.7	.520	16 000	506.09	1000	1146	46.6	.435
16 500	521.09	.....	(1508)	.....	.560	17 000	536.09	1092	1249	46.6	.475
16 600	524.09	.....	(1713)	.....	.590	18 000	566.09	1177	1337	46.8	.515
15 400	488.09	1358	1910	41.5	.600	18 400	578.09	.....	(1409)	.....	.540
						18 960	594.89	.....	(1635)	.....	.595
						17 000	536.09	1406	2059	40.6	.625

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 249						BEAM 264					
0	25.06	26	17	60.6	0.010	0	25.88	21	17	55.1	0.010
1000	55.06	63	41	60.7	.025	1000	55.83	51	44	53.6	.025
2000	85.06	93	68	57.8	.035	2000	85.88	85	70	54.8	.035
2500	100.06	111	84	56.9	.035	3000	115.88	117	97	54.6	.045
3000	115.06	133	104	56.1	.045	4000	145.88	152	135	53.0	.060
3500	130.06	152	120	55.8	.055	4500	160.88	183	190	49.0	.075
4000	145.06	185	186	49.8	.065	5000	175.88	227	313	42.0	.105
4500	160.06	306	578	34.6	.165	5500	190.88	281	484	36.8	.140
5000	175.06	339	696	32.7	.200	6000	205.88	326	621	34.4	.180
5500	190.06	396	862	31.5	.245	7000	235.88	386	817	32.1	.240
6000	205.06	440	997	30.6	.305	8000	265.88	460	1034	30.8	.300
4800	169.06	408	913	30.9	.320	8500	280.88	503	1183	29.8	.335
						8750	288.38	-----	1359	-----	.375
						8780	289.28	-----	1403	-----	.385
						8000	265.88	521	1362	27.7	.405
BEAM 250						BEAM 265					
0	25.26	21	19	52.5	0.005	0	25.68	16	24	40.0	0.010
1000	55.26	60	39	60.6	.015	1000	55.68	49	48	50.4	.020
2000	85.26	90	65	58.0	.025	2000	85.68	78	75	50.9	.035
3000	115.26	122	92	56.9	.040	3000	115.68	107	101	51.5	.045
3500	130.26	143	111	56.2	.050	4000	145.68	146	140	51.1	.055
4000	145.26	168	145	53.6	.060	4500	160.68	172	185	48.0	.070
4500	160.26	270	485	35.7	.140	5000	175.68	235	291	44.7	.095
5000	175.26	294	585	33.4	.180	5500	190.68	286	422	40.4	.135
5500	190.26	370	846	30.4	.250	6000	205.68	322	530	37.8	.175
6000	205.26	404	979	29.2	.290	7000	235.68	394	752	34.4	.235
6450	218.76	-----	1091	-----	.350	8000	265.68	466	988	32.0	.305
4900	172.26	431	1542	21.9	.365	8500	280.68	-----	1101	-----	.335
						7500	250.68	515	1373	27.3	.355
BEAM 251						BEAM 266					
0	25.68	24	19	56.0	0.010	0	25.68	24	19	56.0	0.010
1000	55.68	51	41	55.2	.020	1000	55.68	55	44	55.5	.025
2000	85.68	81	65	55.6	.030	2000	85.68	85	68	55.4	.040
3000	115.68	109	91	54.5	.040	3000	115.68	119	96	55.3	.050
3500	130.68	127	109	53.8	.050	3500	130.68	132	111	54.4	.060
4000	145.68	152	149	50.5	.060	4000	145.68	159	133	54.4	.070
4500	160.68	259	544	32.3	.130	4500	160.68	179	168	51.6	.080
5000	175.68	294	670	30.5	.185	5000	175.68	256	349	42.3	.110
5500	190.68	324	814	28.5	.240	5500	190.68	290	456	38.9	.145
6000	205.68	366	973	27.3	.290	6000	205.68	327	579	36.1	.180
5000	175.68	365	1344	21.4	.320	7000	235.68	406	822	33.1	.260
						8000	265.68	489	1043	31.9	.330
						8630	284.58	-----	1246	-----	.390
						7600	253.68	549	1509	26.7	.395

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 276						BEAM 288					
0	25.47	21	17	55.1	0.015	0	25.68	24	19	56.0	0.005
1000	55.47	75	27	73.6	.045	1000	55.68	61	39	61.0	.020
2000	85.47	107	53	66.9	.055	2000	85.68	95	65	59.4	.030
3000	115.47	136	75	64.4	.065	3000	115.68	125	84	59.9	.040
4000	145.47	168	104	61.7	.080	4000	145.68	157	106	59.7	.050
4500	160.47	189	130	59.2	.090	5000	175.68	212	174	55.0	.070
5000	175.47	208	159	56.7	.100	6000	205.68	296	318	48.2	.110
5500	190.47	239	198	54.7	.115	7000	235.68	368	472	43.8	.150
6000	205.47	278	274	50.3	.135	8000	265.68	431	617	41.1	.200
7000	235.47	357	487	42.3	.190	9000	295.68	484	756	39.0	.245
8000	265.47	426	627	40.4	.245	10 000	325.68	562	865	39.4	.290
9000	295.47	475	776	37.9	.295	11 000	355.68	602	983	38.0	.330
10 000	325.47	530	913	36.7	.345	12 000	385.68	682	1099	38.3	.370
11 000	355.47	593	1050	36.1	.395	13 000	415.68	756	1262	37.5	.420
11 910	382.77	-----	1157	-----	.445	13 850	441.18	-----	1397	-----	.460
11 930	383.37	-----	1168	-----	.455	12 300	394.68	797	1409	36.1	.490
10 500	340.47	601	1091	35.5	.460						
BEAM 277						BEAM 289					
0	25.68	21	21	50.1	0.005	0	26.09	28	15	65.2	0.005
1000	55.68	51	46	52.5	.015	1000	56.09	63	34	64.9	.020
2000	85.68	83	70	54.1	.025	2000	86.09	93	60	60.7	.030
3000	115.68	114	92	55.4	.035	3000	116.09	126	87	59.1	.045
4000	145.68	146	118	55.3	.050	4000	146.09	159	118	57.4	.055
4500	160.68	158	132	54.6	.055	5000	176.09	204	178	53.4	.075
5000	175.68	181	161	52.9	.065	6000	206.09	271	291	48.2	.105
5500	190.68	206	203	50.4	.075	7000	236.09	347	465	42.7	.155
6000	205.68	258	280	47.9	.095	8000	266.09	416	619	40.2	.200
7000	235.68	326	499	39.5	.155	9000	296.09	478	774	38.2	.245
8000	265.68	389	685	36.2	.205	10 000	326.09	541	915	37.1	.290
9000	295.68	445	838	34.7	.260	11 000	356.09	609	1068	36.3	.340
10 000	325.68	501	986	33.7	.310	12 000	386.09	678	1221	35.7	.390
11 000	355.68	567	1137	33.3	.355	12 800	410.09	-----	1542	-----	.470
12 000	385.68	629	1297	32.7	.410	12 000	386.09	784	1549	33.6	.480
10 200	331.68	645	1730	27.1	.435						
BEAM 278						BEAM 290					
0	25.68	24	19	56.0	0.010	0	26.29	23	17	57.5	0.010
1000	55.68	53	48	52.5	.020	1000	56.29	56	38	59.4	.020
2000	85.68	83	72	53.5	.030	2000	86.29	87	62	58.5	.030
3000	115.68	115	97	54.2	.040	3000	116.29	119	87	57.8	.045
4000	145.68	149	123	54.7	.055	4000	146.29	150	115	56.6	.055
4500	160.68	167	142	54.1	.060	5000	176.29	197	178	52.5	.075
5000	175.68	191	168	53.2	.070	6000	206.29	265	309	46.1	.105
5500	190.68	218	200	52.1	.085	7000	236.29	339	463	42.3	.155
6000	205.68	251	258	49.4	.105	8000	266.29	405	609	39.9	.200
7000	235.68	348	489	41.6	.170	9000	296.29	471	742	38.8	.240
8000	265.68	404	682	37.2	.220	10 000	326.29	528	877	37.6	.285
9000	295.68	476	838	36.2	.275	11 000	356.29	591	1005	37.0	.325
10 000	325.68	534	983	35.2	.320	12 000	386.29	659	1138	36.7	.380
11 000	355.68	607	1138	34.8	.380	13 000	416.29	739	1320	35.9	.430
11 170	360.78	-----	1202	-----	.415	13 140	420.49	-----	1352	-----	.445
10 700	346.68	617	1169	34.6	.415	11 500	371.29	709	1268	35.9	.450

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 300						BEAM 312					
0	25.68	19	17	52.5	0.010	0	26.29	21	17	55.1	0.010
1000	55.68	51	41	55.2	.015	1000	56.29	51	48	51.5	.020
2000	85.68	87	65	57.1	.030	2000	86.29	75	68	52.5	.030
3000	115.68	111	91	55.0	.040	3000	116.29	109	91	54.5	.040
4000	145.68	145	121	54.6	.050	4000	146.29	141	115	55.0	.050
5000	175.68	186	166	52.8	.070	5000	176.29	177	145	55.0	.065
6000	205.68	244	258	48.6	.095	6000	206.29	219	197	52.6	.080
7000	235.68	305	361	45.8	.130	7000	236.29	277	268	50.8	.105
8000	265.68	369	496	42.7	.170	8000	266.29	340	376	47.5	.140
9000	295.68	436	634	40.8	.215	9000	296.29	400	485	45.2	.175
10 000	325.68	502	752	40.0	.260	10 000	326.29	439	590	42.7	.205
11 000	355.68	562	863	39.4	.290	11 000	356.29	516	694	42.7	.240
12 000	385.68	611	956	39.0	.330	12 000	386.29	577	800	41.9	.270
13 000	415.68	683	1072	38.9	.370	13 000	416.29	632	885	41.7	.305
14 000	445.68	766	1193	39.1	.415	14 000	446.29	686	971	41.4	.330
14 780	469.08	-----	1292	-----	.455	15 000	476.29	745	1060	41.3	.365
15 000	475.68	874	1436	37.9	.475	16 000	506.29	814	1152	41.4	.410
15 600	493.68	-----	1574	-----	.515	17 000	536.29	880	1268	41.0	.430
15 700	496.68	-----	1644	-----	.545	18 000	566.29	-----	1487	-----	.500
13 700	436.68	997	2323	30.0	.550	16 200	512.29	1008	1853	35.2	.510
BEAM 301						BEAM 313					
0	25.88	24	21	53.6	0.010	0	26.71	24	15	61.5	0.010
1000	55.88	56	43	56.5	.020	1000	56.71	56	46	54.9	.020
2000	85.88	84	65	56.5	.030	2000	86.71	88	72	55.0	.025
3000	115.88	114	87	56.7	.040	3000	116.71	117	96	54.8	.040
4000	145.88	151	116	56.6	.055	4000	146.71	151	123	55.1	.050
5000	175.88	192	164	53.9	.070	5000	176.71	190	156	55.0	.060
6000	205.88	252	241	51.1	.100	6000	206.71	231	205	53.0	.080
7000	235.88	318	338	48.5	.130	7000	236.71	284	272	51.1	.100
8000	265.88	387	467	45.3	.170	8000	266.71	343	357	49.0	.135
9000	295.88	447	600	42.7	.210	9000	296.71	400	451	47.0	.165
10 000	325.88	507	709	41.7	.250	10 000	326.71	455	550	45.3	.200
11 000	355.88	565	817	40.9	.290	11 000	356.71	508	646	44.0	.235
12 000	385.88	628	938	40.1	.330	12 000	386.71	567	745	43.2	.270
13 000	415.88	692	1058	39.6	.370	13 000	416.71	614	827	42.6	.300
14 000	445.88	776	1198	39.3	.410	14 000	446.71	665	918	42.0	.330
14 500	460.88	816	1282	38.9	.440	15 000	476.71	718	1010	41.6	.365
14 870	471.98	-----	1371	-----	.460	16 000	506.71	787	1103	41.6	.400
14 870	471.98	-----	1462	-----	.475	17 000	536.71	844	1195	41.4	.435
14 900	472.88	-----	1557	-----	.490	18 000	566.71	914	1272	41.8	.475
13 800	439.88	956	1915	33.3	.525	18 420	579.31	-----	1345	-----	.500
						16 600	524.71	919	1277	41.8	.520
BEAM 302						BEAM 314					
0	25.68	19	15	55.5	0.010	0	25.88	21	15	58.1	0.005
1000	55.68	60	38	61.2	.020	1000	55.88	60	34	63.7	.025
2000	85.68	92	63	59.3	.035	2000	85.88	86	58	59.8	.035
3000	115.68	126	89	58.6	.045	3000	115.88	114	79	59.0	.045
4000	145.68	159	116	57.8	.055	4000	145.88	148	106	58.2	.055
5000	175.68	209	164	56.0	.075	5000	175.88	180	135	57.1	.070
6000	205.68	264	243	52.1	.100	6000	205.88	225	179	55.7	.085
7000	235.68	340	338	50.1	.135	7000	235.88	274	246	52.7	.110
8000	265.68	402	463	46.5	.175	8000	265.88	330	335	49.6	.140
9000	295.68	470	597	44.1	.215	9000	295.88	391	441	47.0	.170
10 000	325.68	531	692	43.4	.260	10 000	325.88	457	552	45.3	.200
11 000	355.68	595	805	42.5	.300	11 000	355.88	509	641	44.2	.235
12 000	385.68	654	911	41.8	.340	12 000	385.88	564	730	43.6	.270
13 000	415.68	724	1029	41.3	.375	13 000	415.88	616	819	42.9	.300
14 000	445.68	794	1142	41.0	.420	14 000	445.88	670	904	42.6	.335
14 800	469.68	-----	1426	-----	.480	15 000	475.88	735	1003	42.3	.370
14 000	445.68	920	1585	36.7	.490	16 000	505.88	805	1106	42.1	.410
						17 000	535.88	874	1222	41.7	.450
						17 770	558.98	940	1325	41.5	.500
						16 500	520.88	927	1274	42.1	.525

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M $\frac{bd^3}{4}$ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M $\frac{bd^3}{4}$ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 324						BEAM 252					
0	25.88	24	17	58.6	0.010	0	25.26	16	17	47.9	0.005
1000	55.88	58	39	59.7	.015	1000	55.26	48	43	52.5	.020
2000	85.88	86	63	57.8	.025	2000	85.26	70	62	52.9	.035
3000	115.88	118	85	58.2	.040	2500	100.26	87	75	53.7	.040
4000	145.88	148	109	57.6	.050	3000	115.26	100	87	53.6	.045
5000	175.88	178	138	56.3	.065	3500	130.26	120	109	52.5	.055
6000	205.88	231	195	54.3	.085	4000	145.26	181	262	40.9	.085
7000	235.88	287	256	52.9	.110	4500	160.26	271	506	34.9	.155
8000	265.88	341	323	51.4	.130	5000	175.26	305	631	32.6	.195
9000	295.88	402	412	49.4	.160	5500	190.26	354	786	31.1	.245
10 000	325.88	458	516	47.0	.195	6000	205.26	387	889	30.3	.285
11 000	355.88	512	602	45.9	.230	6310	214.56	-----	1065	-----	.335
12 000	385.88	563	684	45.2	.255	4300	154.26	417	1474	22.1	.355
13 000	415.88	614	766	44.5	.285						
14 000	445.88	666	841	44.2	.315						
15 000	475.88	723	923	43.9	.350						
16 000	505.88	780	998	43.9	.380						
17 000	535.88	833	1074	43.7	.410						
18 000	565.88	890	1152	43.6	.440						
19 000	595.88	966	1241	43.8	.475						
20 000	625.88	1034	1330	43.7	.510						
21 000	655.88	1102	1419	43.7	.545						
21 350	666.38	-----	1499	-----	.580						
21 360	666.68	-----	1603	-----	.600						
18 300	574.88	1191	1949	37.9	.615						
BEAM 325						BEAM 253					
0	26.50	23	17	57.5	0.010	0	25.47	19	21	47.5	0.010
1000	56.50	56	43	56.5	.025	1000	55.47	49	43	53.0	.025
2000	86.50	84	62	57.6	.035	2000	85.47	72	63	53.2	.035
3000	116.50	116	84	58.0	.050	2500	100.47	90	72	55.6	.040
4000	146.50	145	109	57.0	.060	3000	115.47	108	80	57.5	.045
5000	176.50	184	142	56.5	.075	3500	130.47	126	99	56.1	.055
6000	206.50	223	190	54.0	.090	4000	145.47	174	227	43.4	.075
7000	236.50	282	260	52.0	.120	4500	160.47	233	378	38.1	.120
8000	266.50	330	333	49.8	.145	5000	175.47	283	521	35.2	.180
9000	296.50	384	410	48.3	.175	5500	190.47	345	742	31.8	.240
10 000	326.50	440	506	46.5	.200	6000	205.47	385	923	29.5	.290
11 000	356.50	488	598	45.0	.235	5050	176.97	425	1610	20.0	.345
12 000	386.50	538	677	44.3	.260						
13 000	416.50	588	757	43.7	.295						
14 000	446.50	640	838	43.3	.325						
15 000	476.50	687	913	42.9	.355						
16 000	506.50	742	991	42.8	.385						
17 000	536.50	797	1077	42.5	.420						
18 000	566.50	850	1154	42.4	.450						
19 000	596.50	919	1231	42.8	.485						
20 000	626.50	990	1325	42.8	.525						
20 200	632.50	-----	1374	-----	.540						
20 430	639.40	-----	1458	-----	.560						
20 730	648.40	-----	1528	-----	.590						
18 000	566.50	1130	2058	35.5	.605						
BEAM 326						BEAM 254					
0	26.09	31	15	67.6	0.010	0	25.47	17	19	46.9	0.010
1000	56.09	67	38	63.9	.020	1000	55.47	42	41	50.7	.020
2000	86.09	99	62	61.5	.035	2000	85.47	70	63	52.5	.035
3000	116.09	131	84	60.9	.045	2500	100.47	85	79	51.9	.040
4000	146.09	158	106	59.9	.060	3000	115.47	102	97	51.2	.050
5000	176.09	202	140	59.1	.070	3500	130.47	118	118	50.0	.060
6000	206.09	244	188	56.4	.090	4000	145.47	165	191	46.3	.080
7000	236.09	305	258	54.2	.115	4500	160.47	235	421	35.8	.135
8000	266.09	365	335	52.1	.140	5000	175.47	282	591	32.3	.190
9000	296.09	430	441	49.3	.170	5500	190.47	317	762	29.4	.230
10 000	326.09	481	528	47.7	.200	6000	205.47	359	1001	26.4	.285
11 000	356.09	546	627	46.5	.235	4950	173.97	396	1779	18.2	.360
12 000	386.09	591	709	45.5	.260						
13 000	416.09	651	795	45.0	.295						
14 000	446.09	701	872	44.5	.325						
15 000	476.09	756	959	44.1	.355						
16 000	506.09	821	1043	44.0	.390						
17 000	536.09	880	1132	43.7	.420						
18 000	566.09	939	1212	43.6	.450						
19 000	596.09	1029	1326	43.7	.495						
19 450	609.59	-----	1397	-----	.520						
19 650	615.59	-----	1463	-----	.530						
19 920	623.69	-----	1564	-----	.550						
17 900	563.09	1224	1901	39.2	.590						

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M $\frac{bd^2}{4}$ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M $\frac{bd^2}{4}$ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 267						BEAM 279					
0	25.88	16	17	47.9	0.005	0	25.47	19	15	55.5	0.010
1000	55.88	45	38	54.3	.015	1000	55.47	47	36	56.7	.020
2000	85.88	68	60	53.3	.030	2000	85.47	69	53	56.6	.030
3000	115.88	90	79	53.4	.040	3000	115.47	96	77	55.4	.045
3500	130.88	113	96	54.2	.050	4000	145.47	130	106	55.0	.055
4000	145.88	125	109	53.4	.055	4500	160.47	154	135	53.4	.065
4500	160.88	152	147	50.8	.065	5000	175.47	178	168	51.5	.080
5000	175.88	184	221	45.5	.080	5500	190.47	208	226	47.9	.095
6000	205.88	289	573	33.5	.155	6000	205.47	246	294	45.6	.115
7000	235.88	348	783	30.7	.220	7000	235.47	316	499	38.8	.165
8000	265.88	420	974	30.1	.280	8000	265.47	379	674	36.0	.215
9000	295.88	502	1251	28.6	.350	9000	295.47	440	834	34.5	.265
9110	299.18	-----	1356	-----	.380	10 000	325.47	495	964	33.9	.310
7700	256.88	532	1718	23.6	.390	11 000	355.47	545	1094	33.3	.350
						12 000	385.47	602	1248	32.5	.395
						12 380	396.87	-----	1325	-----	.435
						10 100	328.47	574	1229	31.8	.440
BEAM 268						BEAM 280					
0	25.68	16	22	41.9	0.010	0	25.88	16	19	45.3	0.010
1000	55.68	38	46	45.4	.015	1000	55.88	30	32	48.5	.020
2000	85.68	62	67	48.3	.030	2000	85.88	53	55	49.3	.030
3000	115.68	89	91	49.4	.040	3000	115.88	82	77	51.6	.040
4000	145.68	120	111	51.9	.050	4000	145.88	109	99	52.5	.055
4500	160.68	139	132	51.2	.060	5000	175.88	152	150	50.3	.075
5000	175.68	167	181	48.1	.075	5500	190.88	183	203	47.4	.090
5500	190.68	232	368	38.7	.120	6000	205.88	217	270	44.6	.110
6000	205.68	274	480	36.3	.150	7000	235.88	295	501	37.0	.165
7000	235.68	346	699	33.1	.225	8000	265.88	361	672	34.9	.220
8000	265.68	404	882	31.4	.285	9000	295.88	413	810	33.8	.270
9000	295.68	467	1072	30.3	.350	10 000	325.88	468	949	33.0	.315
7650	255.18	429	1010	29.8	.380	11 000	355.88	526	1115	32.1	.370
						11 430	368.78	-----	1268	-----	.415
						9950	324.38	584	1609	26.7	.420
BEAM 269						BEAM 281					
0	25.68	17	14	54.1	0.010	0	25.47	17	14	54.1	0.010
1000	55.68	-----	-----	-----	-----	1000	55.47	43	31	57.9	.020
2000	85.68	66	48	57.8	.030	2000	85.47	69	44	60.9	.030
3000	115.68	92	68	57.5	.045	3000	115.47	99	65	60.4	.045
3500	130.68	107	84	55.9	.050	3500	130.47	112	75	60.0	.055
4000	145.68	122	101	54.7	.055	4000	145.47	124	94	56.9	.060
4500	160.68	136	125	52.1	.065	4500	160.47	141	116	54.8	.065
5000	175.68	167	178	48.4	.075	5000	175.47	160	135	54.2	.075
6000	205.68	268	462	36.8	.135	6000	205.47	224	263	46.0	.110
7000	235.68	358	726	33.0	.210	7000	235.47	317	485	39.5	.170
8000	265.68	423	923	31.4	.275	8000	265.47	380	627	37.8	.225
9000	295.68	484	1092	30.7	.330	9000	295.47	433	752	36.6	.265
10 000	325.68	545	1255	30.3	.390	10 000	325.47	495	891	35.7	.315
10 270	333.78	-----	1284	-----	.420	11 000	355.47	549	1022	34.9	.365
7650	255.18	476	1104	30.1	.425	11 740	377.67	-----	1215	-----	.425
						10 200	331.47	681	1801	27.4	.475

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 291						BEAM 303					
0	25.88	17	15	52.5	0.010	0	25.47	19	17	52.5	0.005
1000	55.88	42	32	56.6	.015	1000	55.47	40	32	55.3	.015
2000	85.88	68	50	57.6	.025	2000	85.47	64	53	54.6	.030
3000	115.88	93	72	56.4	.035	3000	115.47	88	70	55.7	.040
4000	145.88	129	94	57.9	.050	4000	145.47	120	94	56.0	.050
5000	175.88	160	132	54.7	.060	5000	175.47	166	147	53.0	.065
6000	205.88	225	241	48.3	.100	6000	205.47	221	234	48.5	.095
7000	235.88	301	414	42.1	.145	7000	235.47	274	326	45.7	.120
8000	265.88	353	533	39.9	.185	8000	265.47	341	467	42.2	.170
9000	295.88	411	675	37.9	.230	9000	295.47	398	583	40.6	.200
10 000	325.88	469	815	36.5	.270	10 000	325.47	451	713	38.8	.240
11 000	355.88	517	945	35.4	.310	11 000	355.47	503	831	37.7	.280
12 000	385.88	566	1082	34.4	.355	12 000	385.47	549	944	36.8	.320
13 000	415.88	621	1277	32.7	.410	13 000	415.47	587	1039	36.1	.350
13 220	422.48	-----	1504	-----	.460	14 000	445.47	635	1156	35.4	.390
11 700	376.88	697	1853	27.3	.470	15 000	475.47	671	1274	34.5	.430
						15 820	500.07	-----	1549	-----	.490
						14 500	460.47	841	2291	26.9	.575
BEAM 292						BEAM 304					
0	26.09	14	17	44.3	0.010	0	25.47	23	24	49.3	0.010
1000	56.09	35	41	45.9	.020	1000	55.47	48	41	54.2	.020
2000	86.09	57	63	47.5	.030	2000	85.47	75	62	54.7	.030
3000	116.09	87	80	52.2	.040	3000	115.47	101	82	55.2	.040
4000	146.09	117	109	51.8	.050	4000	145.47	128	109	54.0	.050
5000	176.09	153	147	51.0	.070	5000	175.47	170	154	52.5	.070
6000	206.09	200	214	48.3	.090	6000	205.47	223	243	47.9	.090
7000	236.09	282	397	41.5	.135	7000	235.47	275	337	44.9	.120
8000	266.09	354	542	39.5	.180	8000	265.47	340	484	41.3	.160
9000	296.09	410	675	37.8	.225	9000	295.47	394	593	39.9	.200
10 000	326.09	466	802	36.8	.265	10 000	325.47	444	721	38.1	.240
11 000	356.09	529	930	36.3	.310	11 000	355.47	499	834	37.4	.275
12 000	386.09	583	1058	35.5	.355	12 000	385.47	544	938	36.7	.310
13 000	416.09	666	1296	33.9	.415	13 000	415.47	593	1044	36.2	.350
11 700	377.09	744	1945	27.7	.465	14 000	445.47	644	1159	35.7	.385
						15 000	475.47	702	1285	35.3	.430
						15 710	496.77	-----	1564	-----	.490
						13 750	437.97	811	2050	28.3	.520
BEAM 293						BEAM 305					
0	26.29	17	17	49.5	0.010	0	26.09	21	14	59.7	0.005
1000	56.29	47	31	60.2	.020	1000	56.09	45	31	59.1	.015
2000	86.29	69	50	58.0	.030	2000	86.09	71	55	56.5	.025
3000	116.29	101	70	59.0	.040	3000	116.09	96	75	56.0	.040
4000	146.29	127	92	58.0	.055	4000	146.09	122	101	54.7	.050
5000	176.29	164	135	54.8	.070	5000	176.09	159	138	53.5	.060
6000	206.29	213	227	48.4	.095	6000	206.09	203	193	51.2	.080
7000	236.29	287	390	42.4	.140	7000	236.09	254	284	47.2	.110
8000	266.29	355	532	40.0	.185	8000	266.09	308	407	43.1	.140
9000	296.29	421	679	38.3	.235	9000	296.09	376	535	41.2	.185
10 000	326.29	475	791	37.5	.275	10 000	326.09	425	656	39.3	.225
11 000	356.29	530	915	36.7	.315	11 000	356.09	473	757	38.5	.260
12 000	386.29	589	1029	36.4	.365	12 000	386.09	522	862	37.7	.300
13 000	416.29	649	1147	36.1	.405	13 000	416.09	573	961	37.3	.330
13 600	434.29	-----	1315	-----	.475	14 000	446.09	627	1067	37.0	.370
11 700	377.29	752	1841	29.0	.510	15 000	476.09	675	1166	36.7	.410
						16 000	506.09	736	1294	36.2	.450
						16 930	533.99	-----	1503	-----	.510
						14 350	456.59	824	1834	31.0	.540

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 315						BEAM 327					
0	26.09	19	22	46.4	0.010	0	25.88	17	15	52.5	0.010
1000	56.09	40	39	50.6	.020	1000	55.88	45	41	52.5	.020
2000	86.09	62	56	52.5	.030	2000	85.88	74	63	54.0	.030
3000	116.09	93	80	53.7	.040	3000	115.88	103	85	54.9	.040
4000	146.09	124	99	55.6	.055	4000	145.88	133	108	55.2	.055
5000	176.09	156	132	54.2	.070	5000	175.88	171	137	55.6	.070
6000	206.09	197	176	52.8	.085	6000	205.88	213	191	52.7	.085
7000	236.09	252	250	50.2	.110	7000	235.88	260	253	50.6	.100
8000	266.09	304	337	47.4	.140	8000	265.88	311	326	48.8	.130
9000	296.09	360	435	45.2	.170	9000	295.88	368	424	46.4	.160
10 000	326.09	406	530	43.4	.200	10 000	325.88	416	520	44.4	.185
11 000	356.09	462	639	42.0	.235	11 000	355.88	474	631	42.9	.220
12 000	386.09	506	728	41.0	.265	12 000	385.88	522	715	42.2	.245
13 000	416.09	558	819	40.5	.295	13 000	415.88	584	805	42.1	.280
14 000	446.09	609	911	40.1	.330	14 000	445.88	629	880	41.7	.305
15 000	476.09	661	1002	39.8	.360	15 000	475.88	681	974	41.1	.340
16 000	506.09	716	1082	39.8	.395	16 000	505.88	730	1051	41.0	.365
17 000	536.09	771	1168	39.8	.425	17 000	535.88	780	1142	40.6	.400
18 000	566.09	820	1260	39.4	.455	18 000	565.88	847	1250	40.4	.430
18 940	594.29	-----	1470	-----	.505	19 000	595.88	926	1398	39.8	.475
16 800	530.09	955	1945	32.9	.545	20 000	625.88	1004	1597	38.6	.520
						18 000	565.88	1102	2275	32.6	.590
BEAM 316						BEAM 328					
0	26.29	19	14	57.1	0.010	0	25.88	21	17	55.1	0.010
1000	56.29	42	29	58.9	.020	1000	55.88	43	38	53.1	.020
2000	86.29	66	48	57.8	.030	2000	85.88	72	60	54.4	.030
3000	116.29	92	63	59.3	.040	3000	115.88	100	79	55.9	.045
4000	146.29	123	85	59.2	.050	4000	145.88	130	104	55.5	.060
5000	176.29	151	118	56.2	.065	5000	175.88	164	128	56.1	.070
6000	206.29	196	162	54.7	.085	6000	205.88	204	169	54.6	.090
7000	236.29	250	238	51.3	.105	7000	235.88	253	221	53.3	.110
8000	266.29	306	337	47.6	.135	8000	265.88	304	294	50.8	.155
9000	296.29	365	444	45.2	.170	9000	295.88	368	391	48.5	.165
10 000	326.29	416	538	43.6	.205	10 000	325.88	427	496	46.3	.200
11 000	356.29	467	639	42.2	.240	11 000	355.88	479	585	45.0	.230
12 000	386.29	515	733	41.3	.270	12 000	385.88	532	670	44.3	.260
13 000	416.29	563	824	40.6	.305	13 000	415.88	585	759	43.5	.290
14 000	446.29	613	915	40.1	.335	14 000	445.88	635	838	43.1	.320
15 000	476.29	664	1003	39.8	.365	15 000	475.88	689	916	42.9	.355
16 000	506.29	722	1089	39.8	.400	16 000	505.88	750	1002	42.8	.380
17 000	536.29	771	1174	39.6	.435	17 000	535.88	803	1079	42.7	.415
18 000	566.29	831	1262	39.7	.465	18 000	565.88	862	1166	42.5	.445
18 880	592.69	-----	1561	-----	.535	19 000	595.88	923	1267	42.2	.480
16 600	524.29	1017	2542	28.6	.595	20 000	625.88	1000	1397	41.7	.520
						20 420	638.48	-----	1656	-----	.585
						18 350	576.38	1054	1561	40.3	.610
BEAM 317						BEAM 246					
0	26.50	16	17	47.9	0.010	0	25.47	26	17	60.6	0.010
1000	56.50	43	41	51.3	.020	1000	55.47	58	41	58.6	.020
2000	86.50	66	58	53.3	.030	2000	85.47	84	63	57.2	.030
3000	116.50	93	80	53.7	.040	3000	115.47	114	87	56.7	.040
4000	146.50	119	104	53.4	.050	4000	145.47	148	120	55.3	.055
5000	176.50	156	130	54.6	.060	5000	175.47	234	342	40.6	.100
6000	206.50	199	198	50.1	.080	6000	205.47	353	696	33.7	.245
7000	236.50	245	272	47.4	.110	7000	235.47	-----	1253	-----	.350
8000	266.50	299	374	44.4	.140	5400	187.47	486	2265	17.7	.490
9000	296.50	344	463	42.7	.160						
10 000	326.50	398	559	41.6	.190						
11 000	356.50	443	662	40.1	.235						
12 000	386.50	488	752	39.4	.270						
13 000	416.50	537	839	39.0	.300						
14 000	446.50	589	926	38.9	.330						
15 000	476.50	639	1014	38.6	.360						
16 000	506.50	695	1106	38.6	.395						
17 000	536.50	753	1207	38.4	.430						
18 000	566.50	809	1309	38.2	.465						
16 900	533.50	962	2142	31.0	.575						

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 247						BEAM 271					
0	25.47	24	15	61.5	0.010	0	25.88	15	9	62.8	0.010
1000	55.47	55	36	60.2	.020	1000	55.88	35	27	56.5	.020
2000	85.47	82	56	59.4	.030	2000	85.88	55	44	55.5	.030
3000	115.47	113	84	57.3	.045	3000	115.88	72	68	51.4	.040
4000	145.47	143	113	55.8	.055	4000	145.88	97	96	50.2	.050
5000	175.47	266	576	31.6	.125	5000	175.88	137	145	48.6	.070
6000	205.47	375	1005	27.2	.235	6000	205.88	210	379	35.7	.130
6800	229.47	-----	1256	-----	.355	7000	235.88	265	588	31.0	.190
4700	166.47	468	2487	15.9	.440	8000	265.88	320	769	29.3	.260
						9000	295.88	365	815	30.9	.340
						8310	275.18	375	827	31.2	.480
BEAM 248						BEAM 272					
0	25.68	13	10	56.8	0.010	0	26.09	11	14	44.6	0.010
1000	55.68	35	22	61.3	.025	1000	56.09	27	31	46.5	.020
2000	85.68	58	44	56.9	.035	2000	86.09	42	72	36.7	.030
3000	115.68	88	62	58.5	.045	3000	116.09	64	96	40.0	.040
4000	145.68	119	85	58.4	.055	4000	146.09	99	109	47.7	.050
5000	175.68	249	484	33.9	.150	5000	176.09	129	137	48.6	.060
6000	205.68	336	800	29.6	.250	6000	206.09	214	338	38.7	.105
6380	217.08	-----	868	-----	.320	7000	236.09	295	544	35.2	.180
5000	175.68	321	793	28.8	.320	8000	266.09	305	781	28.1	.250
						9000	296.09	357	971	26.9	.300
						9700	317.09	-----	1115	-----	.380
						7550	252.59	435	1595	21.4	.390
BEAM 270						BEAM 282					
0	26.09	11	10	52.5	0.005	0	26.09	16	15	50.9	0.010
1000	56.09	26	22	54.6	.015	1000	56.09	30	38	44.5	.020
2000	86.09	43	46	48.6	.030	2000	86.09	48	60	44.7	.030
3000	116.09	65	68	48.7	.040	3000	116.09	73	82	47.0	.040
4000	146.09	86	96	47.3	.055	4000	146.09	94	106	47.0	.050
5000	176.09	138	214	39.1	.080	5000	176.09	122	133	47.8	.060
6000	206.09	215	424	33.6	.135	6000	206.09	165	195	45.8	.080
7000	236.09	291	716	28.9	.210	7000	236.09	236	379	38.3	.130
8000	266.09	345	911	27.5	.265	8000	266.09	304	583	34.3	.185
9000	296.09	403	1156	25.8	.320	9000	296.09	356	744	32.4	.230
9360	306.89	-----	1258	-----	.375	10 000	326.09	409	896	31.4	.280
7750	258.59	433	1578	21.6	.380	11 000	356.09	459	1022	31.0	.330
						12 000	386.09	517	1205	30.0	.380
						10 650	345.59	605	2241	21.2	.470

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² , per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² , per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 283						BEAM 295					
0	26.09	15	10	60.4	0.010	0	26.29	24	14	63.1	0.010
1000	56.09	39	29	57.6	.020	1000	56.29	47	32	59.5	.020
2000	86.09	61	50	54.8	.030	2000	86.29	71	55	56.5	.030
3000	116.09	88	72	55.0	.040	3000	116.29	101	77	56.7	.040
4000	146.09	114	97	53.9	.050	4000	146.29	126	103	55.1	.050
5000	176.09	141	123	53.4	.065	5000	176.29	152	128	54.3	.060
6000	206.09	189	179	51.4	.085	6000	206.29	192	186	50.8	.080
7000	236.09	240	359	40.1	.130	7000	236.29	265	356	42.7	.120
8000	266.09	329	550	37.4	.180	8000	266.29	321	494	39.4	.160
9000	296.09	393	706	35.8	.240	9000	296.29	373	622	37.5	.200
10 000	326.09	444	850	34.3	.280	10 000	326.29	417	773	35.0	.250
11 000	356.09	497	997	33.3	.330	11 000	356.29	458	891	34.0	.280
12 000	386.09	553	1162	32.2	.380	12 000	386.29	512	1014	33.6	.320
12 620	404.69	-----	1303	-----	.440	13 000	416.29	556	1130	33.0	.360
10 300	335.09	606	1815	25.0	.440	14 000	446.29	620	1289	32.5	.410
						14 380	457.69	-----	1410	-----	.460
						12 200	392.29	679	2140	24.1	.475
BEAM 284						BEAM 296					
0	25.88	14	22	38.5	0.010	0	26.29	24	17	58.6	0.010
1000	55.88	31	48	39.2	.020	1000	56.29	48	34	58.6	.020
2000	85.88	50	68	42.3	.035	2000	86.29	73	56	56.7	.030
3000	115.88	73	91	44.6	.045	3000	116.29	101	79	56.1	.040
4000	145.88	100	116	46.2	.055	4000	146.29	128	106	54.6	.050
5000	175.88	129	152	45.9	.065	5000	176.29	162	142	53.3	.060
6000	205.88	168	209	44.5	.085	6000	206.29	198	188	51.3	.080
7000	235.88	239	393	37.8	.135	7000	236.29	275	311	47.0	.120
8000	265.88	314	602	34.3	.195	8000	266.29	344	458	42.9	.160
9000	295.88	367	756	32.7	.255	9000	296.29	402	607	39.9	.210
10 000	325.88	429	901	32.2	.285	10 000	326.29	462	745	38.3	.250
11 000	355.88	476	1046	31.3	.330	11 000	356.29	514	877	36.9	.290
12 000	385.88	547	1198	31.4	.385	12 000	386.29	562	1005	35.9	.330
12 200	391.88	-----	1308	-----	.435	13 000	416.29	613	1126	35.2	.370
10 400	337.88	583	1708	25.4	.435	14 000	446.29	671	1294	34.2	.420
						14 100	449.29	-----	1453	-----	.460
						12 000	386.29	691	1923	26.5	.470
BEAM 294						BEAM 306					
0	25.88	19	15	55.5	0.010	0	26.09	24	17	58.6	0.010
1000	55.88	43	34	55.8	.020	1000	56.09	47	38	55.4	.020
2000	85.88	69	53	56.6	.030	2000	86.09	75	60	55.5	.030
3000	115.88	98	75	56.6	.040	3000	116.09	106	85	55.4	.040
4000	145.88	122	97	55.7	.050	4000	146.09	133	111	54.5	.050
5000	175.88	152	125	54.8	.070	5000	176.09	168	145	53.6	.070
6000	205.88	191	176	52.1	.090	6000	206.09	202	186	52.1	.085
7000	235.88	263	325	44.8	.130	7000	236.09	272	292	48.2	.110
8000	265.88	323	496	39.4	.170	8000	256.09	340	410	45.4	.150
9000	295.88	377	639	37.1	.220	9000	296.09	403	544	42.6	.190
10 000	325.88	441	821	34.9	.265	10 000	326.09	463	662	41.2	.230
11 000	355.88	491	945	34.2	.300	11 000	356.09	532	800	39.9	.270
12 000	385.88	545	1106	33.0	.350	12 000	386.09	588	906	39.3	.310
13 000	415.88	593	1197	33.1	.380	13 000	416.09	638	1005	38.8	.345
14 000	445.88	651	1368	32.2	.455	14 000	446.09	706	1126	38.5	.390
14 670	465.98	-----	1487	-----	.470	15 000	476.09	770	1272	37.7	.430
12 170	390.98	707	2072	25.4	.490	16 000	506.09	862	1538	35.9	.490
						16 450	519.59	-----	1692	-----	.550
						13 450	429.59	956	2393	28.5	.570

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 307						BEAM 310					
0	26.50	24	15	61.5	0.010	0	25.88	26	19	58.0	0.010
1000	56.50	53	39	57.4	.020	1000	55.88	55	41	57.2	.020
2000	86.50	77	58	57.0	.030	2000	85.88	84	60	58.4	.030
3000	116.50	98	79	55.3	.040	3000	115.88	114	85	57.3	.040
4000	146.50	124	103	54.7	.050	4000	145.88	145	106	57.7	.050
5000	176.50	154	128	54.6	.060	5000	175.88	174	133	56.7	.060
6000	206.50	184	171	51.8	.075	6000	205.88	212	176	54.7	.070
7000	235.50	226	243	48.2	.095	7000	235.88	263	246	51.7	.095
8000	266.50	283	340	44.7	.125	8000	265.88	319	326	49.5	.130
9000	296.50	341	489	41.0	.160	9000	295.88	385	429	47.3	.155
10 000	326.50	388	624	38.3	.200	10 000	325.88	446	566	44.0	.200
11 000	356.50	441	769	36.5	.240	11 000	355.88	505	675	42.8	.230
12 000	385.50	491	896	35.4	.275	12 000	385.88	558	779	41.7	.270
13 000	416.50	541	1014	34.8	.310	13 000	415.88	615	880	41.1	.310
14 000	446.50	593	1149	34.0	.350	14 000	445.88	670	976	40.7	.340
15 000	476.50	652	1299	33.4	.395	15 000	475.88	721	1072	40.2	.370
16 000	506.50	715	1547	31.6	.450	16 000	505.88	787	1174	40.1	.405
16 070	508.60	-----	1728	-----	-----	17 000	535.88	843	1270	39.9	.440
14 450	460.00	823	2528	24.6	.600	18 000	565.88	904	1369	39.8	.480
						19 000	595.88	997	1581	38.7	.535
						15 650	495.38	923	1484	38.4	.580
BEAM 308						BEAM 311					
0	26.09	10	09	52.5	0.005	0	27.72	33	19	63.0	0.010
1000	56.09	24	21	53.6	.015	1000	57.72	51	39	56.9	.020
2000	86.09	37	31	54.7	.025	2000	87.72	75	62	54.7	.030
3000	116.09	53	39	57.4	.035	3000	117.72	105	78	57.4	.040
4000	146.09	66	53	55.4	.045	4000	147.72	134	101	57.0	.050
5000	176.09	83	70	54.1	.060	5000	177.72	168	125	57.3	.065
6000	206.09	99	92	51.7	.075	6000	207.72	206	157	56.6	.080
7000	236.09	130	142	47.7	.100	7000	237.72	255	242	51.4	.100
8000	266.09	156	205	43.2	.130	8000	267.72	310	305	50.4	.130
9000	296.09	188	287	39.5	.175	9000	297.72	359	401	47.2	.160
10 000	326.09	215	373	36.6	.215	10 000	327.72	398	519	43.4	.190
11 000	356.09	243	443	35.5	.255	11 000	357.72	461	601	43.4	.230
12 000	386.09	266	506	34.4	.290	12 000	387.72	517	698	42.5	.260
13 000	416.09	294	574	33.9	.325	13 000	417.72	566	778	42.1	.290
14 000	446.09	328	651	33.5	.365	14 000	447.72	622	856	42.1	.330
15 000	476.09	357	723	33.1	.405	15 000	477.72	674	938	41.8	.360
16 000	506.09	395	846	31.8	.460	16 000	507.72	727	1028	41.4	.390
13 800	440.09	552	2364	19.0	.555	17 000	537.72	783	1113	41.3	.430
						18 000	567.72	833	1195	41.1	.460
						19 000	597.72	907	1344	40.3	.505
						19 320	607.32	-----	-----	-----	.575
						16 000	507.72	1059	2044	34.1	.590
BEAM 309						BEAM 330					
0	27.31	40	42	48.8	0.020	0	26.09	26	21	55.7	0.010
1000	57.31	60	58	50.8	.030	1000	56.09	51	39	56.4	.020
2000	87.31	93	89	51.1	.045	2000	86.09	81	62	56.7	.030
3000	117.31	126	122	50.9	.065	3000	116.09	110	79	58.3	.040
4000	147.31	165	163	50.2	.080	4000	146.09	135	106	56.0	.050
5000	177.31	205	211	49.3	.100	5000	176.09	164	130	55.7	.065
6000	207.31	240	251	48.9	.110	6000	206.09	197	171	53.6	.080
7000	237.31	278	299	48.2	.125	7000	236.09	249	250	49.9	.100
8000	267.31	320	352	47.6	.145	8000	266.09	294	321	47.8	.125
9000	297.31	363	425	46.0	.165	9000	296.09	338	402	45.1	.150
10 000	327.31	417	525	44.3	.200	10 000	326.09	401	503	44.4	.180
11 000	357.31	474	622	43.2	.230	11 000	356.09	453	607	42.7	.210
12 000	387.31	526	732	41.8	.270	12 000	386.09	491	691	41.5	.240
13 000	417.31	575	814	41.4	.300	13 000	416.09	537	797	40.2	.270
14 000	447.31	625	898	41.0	.330	14 000	446.09	588	875	40.2	.305
15 000	477.31	677	982	40.8	.360	15 000	476.09	628	956	39.7	.330
16 000	507.31	726	1070	40.4	.390	16 000	506.09	676	1043	39.3	.360
17 000	537.31	777	1166	40.0	.420	17 000	536.09	729	1137	39.1	.400
18 000	567.31	835	1254	40.0	.460	18 000	566.09	777	1219	38.9	.420
18 800	591.31	-----	-----	-----	.500	19 000	596.09	817	1299	38.6	.455
15 650	496.81	802	1202	40.0	.510	20 000	626.09	878	1403	38.5	.490
						20 760	648.89	-----	1513	-----	.520
						21 000	656.09	958	1574	37.9	.555
						18 350	576.59	896	1468	37.9	.590

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 331						BEAM 334					
0	26.50	19	12	60.7	0.010	0	24.23	27	22	55.5	0.010
1000	56.50	48	27	63.9	.020	2000	84.23	94	77	54.8	.035
2000	86.50	74	53	58.4	.030	2500	99.23	115	101	53.2	.050
3000	116.50	105	68	60.6	.040	2750	106.73	126	121	51.1	.055
4000	146.50	137	91	60.2	.050	3000	114.23	148	152	49.3	.065
5000	176.50	166	116	58.9	.060	3250	121.73	188	236	44.4	.090
6000	206.50	203	154	56.8	.080	3500	129.23	222	330	40.2	.110
7000	236.50	249	214	53.8	.100	4000	144.23	273	504	35.1	.155
8000	266.50	299	275	52.1	.120	4500	159.23	327	720	31.3	.200
9000	296.50	353	357	49.8	.150	5000	174.23	365	826	30.6	.250
10 000	326.50	404	439	47.9	.170	5500	189.23	411	949	30.2	.290
11 000	356.50	459	521	46.8	.200	6000	204.23	(1253)			.350
12 000	386.50	509	617	45.2	.230	5000	174.23	472	1470	24.3	.365
13 050	418.00	567	718	44.1	.270						
14 000	446.50	612	791	43.6	.295						
15 000	476.50	663	877	43.1	.320						
16 000	506.50	718	968	42.6	.360						
17 000	536.50	773	1048	42.4	.390						
18 000	566.50	818	1123	42.1	.415						
19 000	596.50	868	1205	41.9	.450						
20 000	626.50	917	1287	41.6	.480						
21 000	656.50	980	1374	41.6	.510						
21 580	673.90		1432		.530						
19 000	596.50	1087	2306	32.1	.600						
BEAM 332						BEAM 335					
0	25.68	20	9	69.5	0.010	0	24.85	22	20	52.5	0.010
1000	55.68	53	39	57.4	.025	1000	54.85	49	44	52.5	.020
2000	85.68	81	56	59.1	.035	2000	84.85	78	70	52.8	.035
3000	115.68	113	82	57.9	.045	2500	99.85	96	92	51.2	.040
4000	145.68	142	103	58.0	.055	2750	107.35	106	105	50.1	.045
5000	175.68	177	132	57.4	.065	3000	114.85	116	117	49.7	.050
6000	205.68	217	174	55.4	.085	3250	122.35	135	145	48.2	.065
7000	235.68	271	224	54.7	.105	3500	129.85	173	227	43.2	.080
8000	265.68	332	292	53.2	.135	4000	144.85	234	430	35.3	.125
9000	295.68	375	381	49.6	.160	4500	159.85	267	576	31.7	.170
10 000						5000	174.85	302	711	29.8	.210
11 000	355.68	478	564	45.9	.225	5500	189.85	341	844	28.8	.255
12 000	385.68	523	643	44.9	.255	6000	204.85	382	972	28.2	.295
13 000	415.68	573	728	44.0	.285	6500	219.85	424	1150	26.9	.355
14 000	445.68	619	812	43.2	.315	6610	223.15		(1194)		.370
15 000	475.68	669	908	42.4	.345						
16 000	505.68	727	988	42.4	.375						
17 000	535.68	766	1058	42.0	.405						
18 000	565.68	824	1149	41.8	.445						
19 000	595.68	877	1236	41.5	.475						
20 000	625.68	940	1326	41.5	.505						
21 000	655.68	1003	1422	41.4	.545						
21 150	660.18		1588								
19 000	595.68	1127	2285	33.0	.625						
BEAM 333						BEAM 345					
0	24.44	28	24	53.5	0.010	0	25.06	21	21	50.4	0.010
1000	54.44	57	51	53.0	.020	1000	55.06	56	50	53.3	.020
2000	84.44	89	82	51.9	.030	2000	85.06	85	79	52.0	.030
2500	99.44	116	118	49.5	.040	2500	100.06	104	99	51.2	.040
2750	106.94	131	145	47.4	.045	3000	115.06	128	123	50.8	.055
3000	114.44	157	231	40.5	.065	3500	130.06	157	176	47.1	.070
3500	129.44	213	404	34.5	.115	4000	145.06	203	296	40.7	.090
4000	144.44	265	569	37.2	.160	4500	160.06	248	419	37.3	.125
4500	159.44	328	768	29.9	.210	5000	175.06	289	532	35.2	.155
5000	174.44	364	935	28.0	.235	6000	205.06	356	750	32.2	.215
5500	189.44	422	1104	27.7	.285	7000	235.06	447	973	31.5	.275
5800	198.44		(1289)		.325	8000	265.06	517	1185	30.4	.340
5000	174.44	447	1382	24.4	.330	8500	280.06	566	1309	30.2	.360
						9000	295.06	609	1460	29.5	.385
						9420	307.66		(1699)		.435
						8000	265.06	663	2084	24.2	.445

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 346						BEAM 358					
0	24.85	27	27	49.3	0.010	0	25.06	21	19	52.5	0.010
1000	54.85	64	51	55.5	.020	1000	55.06	45	43	51.5	.020
2000	84.85	101	77	56.8	.035	2000	85.06	75	70	51.9	.030
2500	99.85	122	94	56.5	.040	3000	115.06	104	99	51.2	.040
3000	114.85	143	118	54.8	.055	3500	130.06	121	123	49.7	.050
3500	129.85	182	176	50.8	.070	4000	145.06	147	157	48.3	.060
4000	144.85	227	280	44.8	.100	4500	160.06	179	217	45.2	.080
4500	159.85	283	417	40.4	.135	5000	175.06	216	287	43.0	.105
5000	174.85	327	523	38.4	.165	6000	205.06	283	450	38.6	.150
6000	204.85	388	711	35.3	.220	7000	235.06	343	583	37.1	.195
7000	234.85	454	902	33.5	.285	8000	265.06	401	716	35.9	.245
8000	264.85	518	1073	32.5	.340	9000	295.06	458	846	35.1	.295
8500	279.85	560	1156	32.6	.370	10 000	325.06	518	968	34.9	.340
9000	294.85	612	1328	31.5	.415	11 000	355.06	588	1097	34.9	.390
8200	270.85	635	1596	28.4	.435	12 000	385.06	656	1241	34.6	.440
						12 260	392.86	(1296)	(1296)	28.0	.456
						10 000	325.06	712	1831	28.0	.495
BEAM 347						BEAM 359					
0	24.85	23	19	54.6	0.010	0	25.26	17	19	47.8	0.005
1000	54.85	56	46	55.0	.020	1000	55.26	44	48	47.8	.010
2000	84.85	88	72	55.2	.030	2000	85.26	74	70	51.5	.020
2500	99.85	107	89	54.7	.040	3000	115.26	102	99	50.8	.035
3000	114.85	127	113	52.9	.050	3500	130.26	123	120	50.7	.045
3500	129.85	161	156	50.9	.060	4000	145.26	150	156	49.1	.055
4000	144.85	208	260	44.5	.085	4500	160.26	180	207	46.5	.075
4500	159.85	264	379	41.1	.120	5000	175.26	222	313	41.5	.095
5000	174.85	302	485	38.4	.155	6000	205.26	287	487	37.0	.150
6000	204.85	375	672	35.9	.215	7000	235.26	306	660	31.7	.195
7000	234.85	448	846	34.6	.275	8000	265.26	375	805	31.8	.245
8000	264.85	516	1019	33.6	.330	9000	295.26	435	944	31.5	.290
8500	279.85	555	1094	33.6	.360	10 000	325.26	501	1073	31.8	.335
9000	294.85	593	1185	33.4	.395	11 000	355.26	559	1214	31.5	.385
9250	302.35	(1263)	(1263)	.425		11 500	370.26	600	1291	31.8	.410
7800	258.85	612	1643	27.1	.440	12 000	385.26	652	1350	32.6	.435
						12 080	387.66	(1379)	(1379)	32.6	.455
						10 520	340.86	612	1265	32.6	.475
BEAM 357						BEAM 369					
0	24.85	21	21	50.4	0.010	0	24.85	26	19	58.2	0.010
1000	54.85	51	44	53.4	.020	1000	54.85	58	39	59.5	.020
2000	84.85	82	70	53.6	.030	2000	84.85	90	65	58.0	.030
3000	114.85	117	97	54.5	.040	3000	114.85	127	103	55.5	.045
3500	129.85	138	130	51.5	.050	3500	129.85	155	137	53.1	.055
4000	144.85	167	173	49.2	.060	4000	144.85	182	174	51.1	.060
4500	159.85	203	238	46.1	.080	4500	159.85	213	224	48.8	.080
5000	174.85	243	335	42.0	.105	5000	174.85	253	282	47.2	.100
6000	204.85	310	492	38.7	.140	6000	204.85	321	421	43.3	.140
7000	234.85	377	638	37.2	.185	7000	234.85	385	549	41.2	.185
8000	264.85	437	781	35.9	.230	8000	264.85	449	679	39.8	.225
9000	294.85	500	923	35.1	.280	9000	294.85	514	809	38.9	.265
10 000	324.85	560	1063	34.5	.325	10 000	324.85	579	921	38.6	.305
11 000	354.85	623	1200	34.2	.360	11 000	354.85	641	1043	38.1	.350
11 500	369.85	658	1267	34.2	.385	12 000	384.85	715	1178	37.8	.395
12 000	384.85	695	1338	34.2	.410	13 000	414.85	805	1308	38.1	.440
12 500	399.85	741	1408	34.5	.435	14 000	444.85	862	1497	36.5	.500
13 000	414.85	793	1557	33.7	.470	12 300	393.85	889	1916	31.7	.535
11 250	362.35	833	2012	29.3	.505						

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M lb _c ² per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M lb _d ² per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 370						BEAM 382					
0	24.64	23	14	62.0	0.005	0	25.26	24	19	56.5	0.005
2000	84.64	86	63	57.7	.025	1000	55.26	58	41	58.5	.020
3000	114.64	124	104	54.5	.040	2000	85.26	91	67	57.6	.030
3500	129.64	152	138	52.2	.055	3000	115.26	119	97	54.9	.040
4000	144.64	180	183	49.7	.065	4000	145.26	168	156	52.0	.060
4500	159.64	213	232	47.9	.085	5000	175.26	227	244	48.2	.090
5000	174.64	247	299	45.3	.100	6000	205.26	292	354	45.2	.125
6000	204.64	312	432	41.9	.145	7000	235.26	355	480	42.5	.165
7000	234.64	377	568	39.9	.190	8000	265.26	417	602	40.9	.205
8000	264.64	440	697	38.7	.235	9000	295.26	478	704	40.4	.240
9000	294.64	495	834	37.3	.285	10 000	325.26	537	805	40.0	.280
10 000	324.64	545	959	36.3	.325	11 000	355.26	598	935	39.0	.320
11 000	354.64	608	1085	35.9	.370	12 000	385.26	666	1041	39.0	.360
12 000	384.64	685	1212	36.1	.415	13 000	415.26	738	1164	38.8	.405
13 000	414.64	794	1499	34.6	.470	14 000	445.26	802	1274	38.6	.440
13 400	426.64	-----	(1704)	-----	.515	15 000	475.26	870	1392	38.5	.490
12 100	387.64	890	1969	31.1	.535	15 270	483.36	-----	(1468)	-----	.525
						15 300	484.26	-----	(1621)	-----	.555
						13 900	442.26	973	2005	32.7	.570
BEAM 371						BEAM 383					
0	24.64	21	22	48.5	0.010	0	25.47	24	22	52.5	0.010
1000	54.64	44	53	45.5	.020	1000	55.47	55	48	53.3	.015
2000	84.64	78	79	49.8	.030	2000	85.47	82	70	53.6	.025
3000	114.64	114	115	49.9	.045	3000	115.47	115	101	53.2	.040
3500	129.64	137	145	48.6	.055	4000	145.47	158	154	50.6	.055
4000	144.64	165	191	46.3	.070	5000	175.47	210	234	47.3	.080
5000	174.64	237	308	43.6	.110	6000	205.47	269	337	44.5	.115
6000	204.64	308	450	40.7	.150	7000	235.47	324	462	41.3	.150
7000	234.64	371	590	38.6	.195	8000	265.47	379	566	40.1	.190
8000	264.64	423	725	36.9	.240	9000	295.47	434	694	38.5	.225
9000	294.64	482	860	35.9	.280	10 000	325.47	486	809	37.5	.265
10 000	324.64	570	991	36.5	.325	11 000	355.47	541	921	37.0	.305
11 000	354.64	640	1120	36.4	.370	12 000	385.47	602	1034	36.8	.340
12 000	384.64	712	1229	36.7	.415	13 000	415.47	659	1139	36.7	.380
13 000	414.64	791	1356	36.9	.465	14 000	445.47	713	1236	36.6	.425
13 500	429.64	838	1461	36.4	.495	15 000	475.47	782	1362	36.5	.465
13 870	440.74	859	1527	36.0	.540	15 920	503.07	-----	(1539)	-----	.520
12 300	393.64	825	1446	36.3	.555	13 900	442.47	914	1662	35.5	.555
BEAM 381						BEAM 393					
0	25.06	23	14	62.0	0.010	0	25.68	28	14	67.0	0.010
1000	55.06	55	39	58.0	.020	1000	55.68	50	36	58.4	.020
2000	85.06	82	62	57.3	.035	2000	85.68	86	60	59.0	.035
3000	115.06	118	89	57.0	.045	3000	115.68	118	85	58.2	.045
3500	130.06	149	111	55.6	.055	4000	145.68	156	116	57.2	.060
4000	145.06	166	145	53.3	.065	5000	175.68	207	178	53.8	.080
4500	160.06	197	186	51.4	.080	6000	205.68	265	260	50.5	.105
5000	175.06	228	239	48.8	.095	7000	235.68	335	354	48.7	.140
6000	205.06	292	342	46.0	.130	8000	265.68	382	460	45.4	.175
7000	235.06	354	462	43.4	.175	9000	295.68	434	542	44.4	.205
8000	265.06	418	583	41.7	.210	10 000	325.68	493	644	43.3	.245
9000	295.06	480	689	41.1	.250	11 000	355.68	549	745	42.4	.275
10 000	325.06	544	793	40.7	.290	12 000	385.68	600	844	41.6	.310
11 000	355.06	611	909	40.2	.325	13 000	415.68	658	933	41.3	.345
12 000	385.06	677	1003	40.3	.370	14 000	445.68	722	1038	41.0	.385
13 000	415.06	753	1115	40.3	.410	15 000	475.68	775	1132	40.7	.420
14 000	445.06	862	1234	41.1	.455	16 000	505.68	848	1224	41.0	.455
15 000	475.06	938	1409	40.0	.505	17 000	535.68	927	1326	41.1	.495
15 240	482.26	-----	(1631)	-----	.565	17 300	544.68	-----	1366	-----	.510
13 610	433.36	1054	1998	34.8	.580	17 510	550.98	-----	1391	-----	.535
						16 000	505.68	927	1321	41.3	.570

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 394						BEAM 406					
0	25.26	26	14	65.0	0.005	0	25.88	24	15	61.5	0.010
1000	55.26	53	39	57.4	.015	1000	55.88	50	39	56.4	.020
2000	85.26	87	65	57.1	.030	2000	85.88	79	63	55.7	.030
3000	115.26	119	96	55.3	.040	3000	115.88	109	85	56.1	.040
4000	145.26	160	144	52.7	.055	4000	145.88	149	126	54.1	.045
5000	175.26	212	222	48.8	.080	5000	175.88	197	188	51.2	.075
6000	205.26	275	311	47.0	.105	6000	205.88	248	267	48.1	.100
7000	235.26	341	414	45.1	.145	7000	235.88	303	359	45.8	.130
8000	265.26	408	523	43.8	.175	8000	265.88	374	458	44.9	.155
9000	295.26	462	629	42.3	.210	9000	295.88	409	532	43.5	.190
10 000	325.26	518	733	41.4	.245	10 000	325.88	466	622	42.9	.220
11 000	355.26	579	836	40.9	.285	11 000	355.88	521	708	42.4	.250
12 000	385.26	627	915	40.7	.310	12 000	385.88	572	798	41.7	.280
13 000	415.26	687	1015	40.4	.350	13 000	415.88	622	879	41.4	.315
14 000	445.26	747	1103	40.4	.385	14 000	445.88	686	966	41.5	.345
15 000	475.26	805	1207	40.0	.420	15 000	475.88	735	1044	41.3	.375
16 000	505.26	877	1308	40.1	.460	16 000	505.88	793	1132	41.2	.405
17 000	535.26	959	1402	40.6	.500	17 000	535.88	856	1221	41.2	.440
17 480	549.66	-----	1451	-----	.535	18 000	565.88	911	1302	41.1	.480
18 000	565.26	1043	1561	40.1	.565	19 000	595.88	974	1393	41.1	.510
18 240	572.46	-----	1626	-----	.585	19 800	619.88	1125	1783	38.7	.585
15 600	493.26	1020	1494	40.6	.620	18 800	574.88	1228	2328	34.5	.635
BEAM 395						BEAM 407					
0	25.47	21	19	52.5	0.095	0	25.68	24	19	56.0	0.010
1000	55.47	50	38	57.0	.015	1000	55.68	48	36	57.3	.020
2000	85.47	84	63	57.1	.025	2000	85.68	75	58	56.3	.030
3000	115.47	113	87	56.5	.035	3000	115.68	107	92	53.8	.045
4000	145.47	148	118	55.7	.050	4000	145.68	151	133	53.2	.060
5000	175.47	195	186	51.2	.070	5000	175.68	195	176	52.5	.075
6000	205.47	253	274	48.1	.095	6000	205.68	246	248	49.8	.100
7000	235.47	312	386	44.7	.125	7000	235.68	298	323	48.0	.130
8000	265.47	364	516	41.3	.165	8000	265.68	351	405	46.4	.155
9000	295.47	420	602	41.1	.195	9000	295.68	403	499	44.7	.185
10 000	325.47	467	684	40.5	.225	10 000	325.68	455	586	43.7	.220
11 000	355.47	525	776	40.3	.255	11 000	355.68	513	684	42.8	.250
12 000	385.47	578	867	40.0	.295	12 000	385.68	563	768	42.3	.280
13 000	415.47	632	961	39.7	.325	13 000	415.68	619	853	42.0	.310
14 000	445.47	691	1039	40.0	.360	14 000	445.68	683	937	42.2	.345
15 000	475.47	740	1140	39.4	.390	15 000	475.68	731	1014	41.9	.375
16 000	505.47	794	1239	39.1	.425	16 000	505.68	793	1097	42.0	.405
17 000	535.47	872	1344	39.3	.465	17 000	535.68	852	1192	41.7	.445
17 430	548.37	-----	1429	-----	.485	18 000	565.68	912	1277	41.7	.480
17 920	563.07	-----	1706	-----	.530	19 000	595.68	979	1366	41.8	.515
16 400	517.47	1058	2126	33.2	.585	20 000	625.68	1077	1520	41.5	.565
BEAM 405						20 280	634.08	-----	1572	-----	.580
BEAM 406						20 410	637.98	-----	1662	-----	.600
BEAM 407						20 450	639.18	-----	1788	-----	.630
BEAM 408						18 400	577.68	1250	2169	36.6	.655
BEAM 409						BEAM 336					
0	25.47	21	14	59.7	0.005	0	24.85	19	17	52.5	0.005
1000	55.47	52	29	64.2	.010	1000	54.85	55	39	58.4	.015
2000	85.47	84	50	62.6	.020	2000	84.85	81	67	54.9	.025
3000	115.47	118	74	61.4	.035	2500	99.85	96	80	54.5	.035
4000	145.47	155	108	59.0	.045	3000	114.85	112	99	53.0	.040
5000	175.47	206	159	56.5	.065	3500	129.85	136	133	50.6	.050
6000	205.47	255	224	53.2	.090	4000	144.85	174	217	44.4	.065
7000	235.47	315	313	50.2	.120	4500	159.85	217	369	37.1	.105
8000	265.47	371	385	49.1	.145	5000	174.85	278	610	31.3	.165
9000	295.47	436	489	47.1	.165	5500	189.85	329	809	28.9	.205
10 000	325.47	486	566	46.2	.210	6000	204.85	371	990	27.3	.255
11 000	355.47	547	651	45.7	.245	6500	219.85	404	1116	26.6	.295
12 000	385.47	611	737	45.3	.275	7000	234.85	439	1256	25.9	.335
13 000	415.47	660	814	44.8	.305	7350	245.35	-----	1357	-----	.365
14 000	445.47	721	886	44.9	.330	5700	195.85	444	1783	20.0	.375
15 000	475.47	779	966	44.6	.360						
16 000	505.47	832	1046	44.3	.390						
17 000	535.47	904	1128	44.5	.425						
18 000	565.47	975	1214	44.5	.465						
19 000	595.47	1077	1380	43.8	.515						
19 720	617.07	-----	1532	-----	.555						
19 950	623.97	-----	1617	-----	.580						
18 000	565.47	1302	2002	39.4	.605						

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M $\frac{bd^3}{12}$ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M $\frac{bd^3}{12}$ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 337						BEAM 349					
0	24.85	17	21	44.6	0.010	0	25.47	13	15	47.2	0.010
1000	54.85	48	44	52.0	.020	1000	55.47	42	39	51.9	.020
2000	84.85	66	63	51.3	.030	2000	85.47	64	60	51.7	.040
3000	114.85	112	115	49.4	.050	3000	115.47	93	84	52.5	.050
3500	129.85	138	156	46.9	.060	4000	145.47	117	111	51.4	.065
4000	144.85	172	236	42.2	.080	4500	160.47	145	149	49.3	.080
4500	159.85	237	472	33.5	.130	5000	175.47	171	207	45.2	.100
5000	174.85	282	639	30.6	.170	5500	190.47	217	321	40.3	.120
5500	189.85	319	815	28.1	.215	6000	205.47	257	456	36.0	.150
6000	204.85	359	993	26.5	.270	7000	235.47	321	706	31.3	.220
6500	219.85	398	1162	25.5	.310	8000	265.47	380	913	29.4	.280
6740	227.05	-----	1241	-----	.340	9000	295.47	433	1087	28.5	.330
5600	192.85	491	1154	29.9	.340	9500	310.47	464	1197	27.9	.360
						10 000	325.47	489	1294	27.4	.390
						10 500	340.47	516	1378	27.2	.415
						11 000	355.47	551	1467	27.3	.440
						11 050	356.97	-----	1516	-----	.465
						9300	304.47	548	1981	21.7	.475
BEAM 338						BEAM 350					
0	24.64	21	19	52.5	0.010	0	25.06	19	21	47.5	0.005
1000	54.64	51	43	54.1	.025	1000	55.06	43	46	48.6	.020
2000	84.64	75	63	54.3	.035	2000	85.06	70	68	49.6	.030
3000	114.64	115	109	51.4	.055	3000	115.06	102	96	51.5	.040
3500	129.64	142	140	50.4	.060	4000	145.06	133	130	50.6	.050
4000	144.64	182	217	45.6	.085	4500	160.06	160	169	48.7	.060
4500	159.64	235	373	38.6	.120	5000	175.06	198	248	44.4	.080
5000	174.64	286	566	33.5	.170	5500	190.06	244	390	38.5	.115
5500	189.64	337	797	29.7	.225	6000	205.06	289	533	35.2	.150
-----	-----	-----	-----	-----	-----	7000	235.06	360	754	32.3	.210
5000	174.64	411	1684	19.6	.330	8000	265.06	418	945	30.7	.265
						8800	289.06	-----	1250	-----	.345
						7500	250.06	498	1597	23.8	.355
BEAM 348						BEAM 360					
0	25.26	23	15	60.4	0.010	0	25.26	23	17	57.5	0.010
1000	55.26	53	38	58.0	.025	1000	55.26	56	43	56.5	.015
2000	85.26	77	56	57.8	.035	2000	85.26	84	65	56.5	.025
3000	115.26	113	85	57.0	.050	3000	115.26	107	87	55.1	.035
3500	130.26	126	103	55.1	.055	4000	145.26	135	111	54.9	.045
4000	145.26	146	127	53.4	.060	4500	160.26	158	130	54.9	.050
4500	160.26	167	168	49.8	.070	5000	175.26	181	162	52.8	.060
5000	175.26	209	253	45.3	.100	5500	190.26	206	222	48.2	.080
5500	190.26	257	362	41.5	.120	6000	205.26	246	330	42.7	.100
6000	205.26	293	472	38.3	.150	7000	235.26	309	508	37.8	.150
7000	235.26	357	656	35.2	.210	8000	265.26	358	643	35.8	.190
8000	265.26	421	865	32.8	.270	9000	295.26	409	786	34.2	.230
9000	295.26	481	1072	31.0	.330	10 000	325.26	455	938	32.6	.275
9370	306.36	-----	1154	-----	.355	11 000	355.26	503	1068	32.2	.320
9620	313.86	-----	1338	-----	.390	12 000	385.26	556	1200	31.7	.360
8000	265.26	534	1726	23.7	.395	12 850	410.76	-----	1362	-----	.400
						10 700	346.26	626	1921	24.6	.430

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 361						BEAM 373					
0	25.47	17	14	54.1	0.010	0	25.47	21	17	55.1	0.010
1000	55.47	45	34	55.9	.015	1000	55.47	50	34	59.6	.020
2000	85.47	68	53	56.2	.030	2000	85.47	81	58	58.3	.035
3000	115.47	92	77	54.6	.035	3000	115.47	108	79	57.8	.055
4000	145.47	119	103	53.6	.050	4000	145.47	139	106	56.8	.075
4500	160.47	134	123	52.1	.055	5000	175.47	188	161	53.9	.100
5000	175.47	152	154	49.7	.065	6000	205.47	253	284	47.1	.140
5500	190.47	184	209	46.8	.075	7000	235.47	310	417	42.7	.175
6000	205.47	222	309	41.8	.105	8000	265.47	366	559	39.6	.220
7000	235.47	282	486	36.8	.150	9000	295.47	417	684	37.9	.255
8000	265.47	338	636	34.7	.195	10 000	325.47	471	807	36.8	.....
9000	295.47	384	769	33.3	.235	11 000	355.47	523	918	36.3	.340
10 000	325.47	429	904	32.2	.275	12 000	385.47	574	1027	35.9	.380
11 000	355.47	478	1039	31.5	.320	13 000	415.47	620	1137	35.3	.420
12 000	385.47	521	1188	30.5	.360	14 000	445.47	676	1241	35.3	.455
12 450	398.97	.....	1309	.....	.390	15 000	475.47	725	1361	34.8	.495
11 500	370.47	537	1484	36.6	.395	15 150	479.97	.....	1376	.....	.505
						12 850	410.97	740	1916	27.9	.525
BEAM 362						BEAM 374					
0	25.06	17	15	52.5	0.010	0	25.68	21	19	52.5	0.010
1000	55.06	48	39	55.4	.015	1000	55.68	49	44	52.5	.....
2000	85.06	75	56	57.1	.025	2000	85.68	77	65	54.3	.020
3000	115.06	106	85	55.4	.040	3000	115.68	107	92	53.8	.030
4000	145.06	138	118	53.9	.050	4000	145.68	139	128	52.1	.040
4500	160.06	157	144	52.2	.060	5000	175.68	188	210	47.2	.060
5000	175.06	183	190	49.0	.070	6000	205.68	250	325	43.5	.095
5500	190.06	215	268	44.5	.090	7000	235.68	313	470	40.0	.140
6000	205.06	257	362	41.5	.110	8000	265.68	364	597	37.9	.175
7000	235.06	320	545	37.0	.160	9000	295.68	419	728	36.5	.220
8000	265.06	381	716	34.7	.205	10 000	325.68	473	856	35.6	.260
9000	295.06	449	906	33.1	.260	11 000	355.68	523	980	34.8	.300
10 000	325.06	484	998	32.7	.290	12 000	385.68	573	1106	34.1	.340
11 000	355.06	545	1145	32.2	.335	13 000	415.68	631	1238	33.7	.380
12 000	385.06	597	1282	31.8	.380	14 000	445.68	690	1380	33.3	.430
12 960	413.86	.....	1468	.....	.430	14 550	462.18	.....	1458	.....	.455
11 100	358.06	651	1896	25.5	.440	12 750	408.18	742	1858	28.5	.475
BEAM 372						BEAM 384					
0	25.68	21	19	52.5	0.010	0	25.26	21	14	59.7	0.010
1000	55.68	53	41	56.2	.020	1000	55.26	47	32	59.5	.020
2000	85.68	82	65	55.9	.030	2000	85.26	75	58	56.3	.030
3000	115.68	111	89	55.5	.040	3000	115.26	103	84	55.2	.040
4000	145.68	143	125	53.4	.055	4000	145.26	130	108	54.6	.050
5000	175.68	190	195	49.4	.075	5000	175.26	170	159	51.7	.070
6000	205.68	246	299	45.2	.110	6000	205.26	220	236	48.2	.090
7000	235.68	304	429	41.4	.145	7000	235.26	276	357	43.6	.120
8000	265.68	359	562	39.0	.190	8000	265.26	332	489	40.4	.155
9000	295.68	413	668	38.2	.230	9000	295.26	380	610	38.3	.195
10 000	325.68	460	786	36.9	.265	10 000	325.26	423	716	37.1	.230
11 000	355.68	514	901	36.3	.310	11 000	355.26	477	829	36.5	.270
12 000	385.68	561	1026	35.4	.345	12 000	385.26	521	935	35.8	.300
13 000	415.68	618	1138	35.2	.390	13 000	415.26	565	1038	35.3	.335
14 000	445.68	667	1248	34.8	.430	14 000	445.26	610	1137	34.9	.370
14 650	465.18	.....	1325	.....	.455	15 000	475.26	661	1231	34.9	.405
14 870	471.78	.....	1385	.....	.470	16 000	505.26	710	1345	34.5	.445
12 850	411.18	752	1921	28.2	.505	16 660	525.06	.....	1455	.....	.480
						16 700	526.06	.....	1480	.....	.490
						16 750	527.76	.....	1540	.....	.500
						16 840	530.46	.....	1653	.....	.520
						14 300	454.26	815	2089	28.1	.550

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 385						BEAM 397					
0	25.68	21	15	58.1	0.010	0	25.47	21	15	58.1	0.010
1000	55.68	48	36	57.3	.020	1000	55.47	52	31	62.7	.020
2000	85.68	77	58	56.9	.030	2000	85.47	78	50	61.1	.030
3000	115.68	103	80	56.3	.040	3000	115.47	106	70	60.2	.040
4000	145.68	132	111	54.3	.050	4000	145.47	132	91	59.2	.050
5000	175.68	176	159	52.5	.070	5000	175.47	168	120	58.4	.065
6000	205.68	223	231	49.1	.090	6000	205.47	207	169	55.0	.080
7000	235.68	275	345	44.4	.125	7000	235.47	257	258	49.9	.105
8000	265.68	333	480	40.9	.160	8000	265.47	304	371	45.0	.135
9000	295.68	386	603	39.1	.200	9000	295.47	349	477	42.3	.165
10 000	325.68	436	721	37.7	.230	10 000	325.47	398	574	40.9	.195
11 000	355.68	485	831	36.8	.270	11 000	355.47	441	667	39.8	.225
12 000	385.68	537	952	36.0	.300	12 000	385.47	484	747	39.3	.255
13 000	415.68	583	1053	35.6	.340	13 000	415.47	528	836	38.7	.290
14 000	445.68	634	1169	35.2	.370	14 000	445.47	569	930	38.0	.320
15 000	475.68	678	1270	34.8	.410	15 000	475.47	612	1019	37.5	.350
16 000	505.68	746	1415	34.5	.450	16 000	505.47	656	1113	37.1	.380
16 120	509.28	-----	1441	-----	.460	17 100	538.47	712	1231	36.6	.420
16 720	527.28	-----	1559	-----	.485	18 000	565.47	771	1340	36.5	.455
14 300	454.68	849	2186	28.0	.525	19 000	595.47	828	1477	35.9	.495
						19 960	624.27	-----	1718	-----	.555
						19 880	621.87	-----	1800	-----	.570
						17 300	544.47	962	2313	29.4	.595
BEAM 386						BEAM 398					
0	25.47	19	17	52.5	0.005	0	26.09	21	14	59.7	0.010
1000	55.47	48	39	55.4	.015	1000	56.09	48	39	55.4	.020
2000	85.47	75	62	54.7	.025	2000	86.09	77	60	56.2	.030
3000	115.47	107	84	55.9	.035	3000	116.09	103	74	58.1	.040
4000	145.47	138	113	54.9	.050	4000	146.09	133	99	57.2	.055
5000	175.47	172	157	52.3	.065	5000	176.09	169	137	55.3	.070
6000	205.47	228	238	49.0	.085	6000	206.09	213	195	52.3	.090
7000	235.47	306	359	46.0	.130	7000	236.09	267	296	47.4	.120
8000	265.47	352	467	43.0	.165	8000	266.09	321	376	46.0	.150
9000	295.47	403	585	40.8	.205	9000	296.09	369	468	44.1	.185
10 000	325.47	450	692	39.9	.240	10 000	326.09	415	564	42.4	.215
11 000	355.47	506	798	38.8	.275	11 000	356.09	461	667	40.9	.250
12 000	385.47	552	911	37.7	.315	12 000	386.09	507	747	40.4	.280
13 000	415.47	608	1033	37.1	.350	13 000	416.09	554	839	39.8	.310
14 000	445.47	653	1125	36.7	.380	14 000	446.09	605	932	39.4	.345
15 000	475.47	709	1241	36.4	.415	15 000	476.09	647	1015	38.9	.370
16 000	505.47	775	1391	35.8	.465	16 000	506.09	696	1118	38.4	.400
14 000	445.47	822	1974	29.4	.510	17 000	536.09	747	1193	38.5	.430
						18 000	566.09	883	1294	38.3	.470
						18 930	593.99	-----	1458	-----	.510
						19 000	596.09	898	1538	36.9	.525
						19 100	599.09	-----	1655	-----	.550
						16 900	533.09	952	2089	31.3	.565
BEAM 396						BEAM 408					
0	25.47	19	21	47.5	0.010	0	26.09	23	17	57.5	0.005
1000	55.47	45	41	52.5	.020	1000	56.09	52	32	62.0	.015
2000	85.47	68	60	53.3	.030	2000	86.09	76	53	59.1	.025
3000	115.47	98	82	54.4	.040	3000	116.09	106	72	59.5	.035
4000	145.47	128	104	55.1	.050	4000	146.09	131	94	58.3	.045
5000	175.47	160	138	53.7	.065	5000	176.09	161	120	57.3	.055
6000	205.47	208	195	51.6	.080	6000	206.09	204	174	54.0	.070
7000	235.47	250	273	47.8	.105	7000	236.09	229	250	49.9	.090
8000	265.47	308	376	45.0	.135	8000	266.09	302	338	47.2	.120
9000	295.47	358	475	42.9	.170	9000	296.09	354	426	45.4	.145
10 000	325.47	401	574	41.1	.195	10 000	326.09	400	513	43.8	.175
11 000	355.47	446	670	39.9	.230	11 000	356.09	451	600	42.9	.205
12 000	385.47	488	756	39.2	.255	12 000	386.09	487	674	41.9	.235
13 000	415.47	534	841	38.8	.295	13 000	416.09	536	747	41.8	.260
14 000	445.47	578	920	38.6	.320	14 000	446.09	570	805	41.4	.285
15 000	478.47	627	1019	38.1	.355	15 000	476.09	617	894	40.9	.315
16 000	505.47	666	1091	37.9	.380	16 000	506.09	667	974	40.6	.345
17 000	535.47	716	1186	37.6	.410	17 000	536.09	707	1050	40.2	.375
18 000	565.47	764	1284	37.3	.440	18 000	566.09	753	1137	39.8	.405
18 630	584.37	807	1359	37.3	.475	19 000	596.09	810	1215	40.0	.435
19 000	595.47	834	1443	36.6	.485	20 000	626.09	857	1297	39.8	.465
19 650	614.97	-----	1602	-----	.535	21 000	656.09	915	1385	39.8	.500
17 000	535.47	911	2128	30.0	.550	21 840	681.29	-----	1462	-----	.525
						22 000	686.09	-----	1504	-----	.540
						20 000	626.09	978	2135	31.4	.570

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² , per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² , per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 409						BEAM 340					
0	26.29	23	15	60.4	0.010	0	24.85	21	14	59.7	0.010
1000	56.29	47	36	56.7	.015	1000	54.85	45	39	53.7	.020
2000	86.29	71	55	56.5	.025	2000	84.85	72	62	53.6	.030
3000	116.29	95	74	56.3	.035	2500	99.85	85	77	53.5	.040
4000	146.29	124	96	56.4	.045	3000	114.85	102	92	52.5	.045
5000	176.29	156	120	56.5	.055	3500	129.85	120	116	50.8	.050
6000	206.29	196	168	53.9	.075	4000	144.85	145	161	47.4	.050
7000	236.29	248	232	51.7	.100	4500	159.85	199	325	38.0	.105
8000	266.29	295	311	48.7	.125	5000	174.85	257	585	30.5	.165
9000	296.29	340	400	45.9	.150	5500	189.85	296	749	28.3	.210
10 000	326.29	388	492	44.1	.180	6000	204.85	329	884	27.1	.250
11 000	356.29	434	576	42.9	.205	6500	219.85	361	1029	25.9	.290
12 000	386.29	476	662	41.8	.240	5500	189.85	378	1600	19.1	.335
13 000	416.29	518	739	41.2	.270						
14 000	446.29	563	821	40.7	.290						
15 000	476.29	608	892	40.5	.320						
16 000	506.29	656	973	40.2	.350						
17 000	536.29	702	1051	40.0	.380						
18 000	566.29	749	1127	39.9	.405						
19 000	596.29	794	1200	39.8	.440						
20 000	626.29	858	1301	39.7	.470						
21 000	656.29	914	1397	39.5	.500						
21 300	665.29		1436		.520						
22 000	686.29	1004	1596	38.6	.550						
22 350	696.79		1826		.595						
20 000	626.29	1114	2388	31.8	.625						
BEAM 410						BEAM 341					
0	25.47	23	15	60.4	0.010	0	24.85	17	15	52.5	0.005
1000	55.47	56	38	59.4	.020	1000	54.85	43	38	53.1	.015
2000	85.47	82	53	60.7	.030	2000	84.85	67	65	50.6	.025
3000	115.47	108	77	58.4	.040	2500	99.85	83	75	52.5	.035
4000	145.47	133	99	57.2	.050	3000	114.85	99	92	51.7	.040
5000	175.47	167	133	55.7	.065	3500	129.85	112	109	50.3	.045
6000	205.47	210	183	53.4	.080	4000	144.85	135	142	48.2	.055
7000	235.47	260	256	50.4	.110	4500	159.85	191	268	41.6	.090
8000	265.47	315	350	47.4	.140	5000	174.85	265	585	31.1	.155
9000	295.47	367	446	45.1	.170	5500	189.85	305	771	28.3	.205
10 000	325.47	411	532	43.6	.195	6000	204.85	344	949	26.6	.250
11 000	355.47	457	615	42.6	.220	6500	219.85	384	1144	25.2	.300
12 000	385.47	499	699	41.6	.250	6680	225.25		(1212)		.320
13 000	415.47	546	774	41.4	.280	5250	182.35	338	1080	23.8	.330
14 000	445.47	590	855	40.8	.305						
15 000	475.47	638	939	40.4	.340						
16 000	505.47	682	1017	40.1	.365						
17 000	535.47	725	1094	39.9	.390						
18 000	565.47	772	1173	39.7	.420						
19 000	595.47	838	1258	40.0	.460						
20 000	625.47	898	1349	40.0	.490						
21 000	655.47	961	1472	39.5	.525						
21 640	674.67		1568		.560						
21 690	676.17		1610		.575						
19 800	619.47	1080	2163	33.3	.600						
BEAM 339						BEAM 351					
0	24.85	17	15	52.5	0.010	0	25.06	19	14	57.1	0.010
1000	54.85	43	38	53.1	.020	1000	55.06	47	31	60.2	.020
2000	84.85	68	60	53.3	.030	2000	85.06	71	55	56.5	.030
2500	99.85	83	72	53.5	.035	3000	115.06	100	77	56.5	.040
3000	114.85	98	91	52.0	.040	3500	130.06	116	89	56.6	.050
3500	129.85	118	113	51.0	.050	4000	145.06	132	104	55.9	.055
4000	144.85	148	173	46.1	.060	4500	160.06	157	144	52.2	.065
4500	159.85	216	347	38.4	.110	5000	175.06	197	215	47.8	.085
5000	174.85	261	526	33.2	.155	5500	190.06	236	337	41.1	.110
5500	189.85	309	720	30.1	.200	6000	205.06	282	479	37.1	.150
6000	204.85	349	892	28.1	.245	7000	235.06	349	682	33.8	.205
6500	219.85	396	1127	26.0	.280	8000	265.06	404	872	31.6	.260
5850	200.35		2037		.390	9000	295.06	461	1046	30.6	.315
						10 000	325.06	519	1241	29.5	.370
						7850	260.56	517	1759	22.7	.395

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 352						BEAM 364					
0	25.47	19	24	44.4	0.010	0	25.06	17	14	54.1	0.010
1000	55.47	45	41	52.5	.020	1000	55.06	43	36	54.4	.020
2000	85.47	70	65	51.8	.030	2000	85.06	68	55	55.3	.030
3000	115.47	101	91	52.5	.040	3000	115.06	94	80	53.9	.040
3500	130.47	115	106	52.0	.045	4000	145.06	127	113	52.9	.050
4000	145.47	133	128	51.0	.050	5000	175.06	160	162	49.7	.065
4500	160.47	158	171	48.1	.065	6000	205.06	210	267	44.0	.090
5000	175.47	197	256	43.4	.085	7000	235.06	270	455	37.3	.135
6000	205.47	268	458	36.9	.140	8000	265.06	321	629	33.8	.175
7000	235.47	339	663	33.8	.190	9000	295.06	377	801	32.0	.225
8000	265.47	388	843	31.5	.245	10 000	325.06	420	950	30.7	.270
9000	295.47	443	1003	30.6	.300	11 000	355.06	466	1094	29.9	.315
10 000	325.47	497	1164	29.9	.345	12 000	385.06	513	1229	29.5	.350
10 800	334.47	-----	1220	-----	.380	13 000	415.06	569	1448	28.2	.410
8450	278.97	451	1080	29.4	.430	13 100	418.06	-----	1543	-----	.430
						11 400	367.06	571	1925	22.9	.445
BEAM 353						BEAM 365					
0	25.06	19	17	52.5	0.010	0	25.26	19	12	60.7	0.010
1000	55.06	47	36	56.7	.015	1000	55.26	45	34	56.9	.020
2000	85.06	77	60	56.2	.025	2000	85.26	66	55	54.6	.030
3000	115.06	103	80	56.3	.035	3000	115.26	96	77	55.4	.040
3500	130.06	120	96	55.5	.040	4000	145.26	119	101	54.1	.050
4000	145.06	133	111	54.5	.050	5000	175.26	157	150	51.2	.065
4500	160.06	157	147	51.7	.055	6000	205.26	215	267	44.6	.100
5000	175.06	188	207	47.6	.075	7000	235.26	282	438	39.2	.145
6000	205.06	265	414	39.0	.130	8000	265.26	337	576	36.9	.180
7000	235.06	327	607	35.0	.185	9000	295.26	387	718	35.0	.230
8000	265.06	387	788	32.9	.245	10 000	325.26	437	843	34.1	.270
9000	295.06	438	950	31.6	.305	11 000	355.26	481	956	33.5	.310
9830	319.96	-----	1078	-----	.360	12 000	385.26	532	1080	33.0	.350
8300	274.06	436	1002	30.3	.370	13 000	415.26	588	1239	32.2	.400
						10 600	343.26	592	1812	24.6	.425
BEAM 363						BEAM 375					
0	25.47	19	17	52.5	0.010	0	25.06	19	12	60.7	0.005
1000	55.47	42	39	51.9	.015	1000	55.06	45	32	58.4	.015
2000	85.47	61	60	50.4	.025	2000	85.06	69	53	56.6	.025
3000	115.47	90	77	54.0	.035	3000	115.06	92	77	54.6	.040
4000	145.47	119	106	52.9	.050	4000	145.06	122	106	53.6	.050
5000	175.47	153	147	51.0	.065	5000	175.06	157	147	51.7	.065
6000	205.47	209	256	45.0	.090	6000	205.06	204	220	48.1	.090
7000	235.47	269	426	38.7	.135	7000	235.06	267	362	42.5	.130
8000	265.47	330	595	35.7	.175	8000	265.06	324	511	38.8	.165
9000	295.47	387	747	34.1	.225	9000	295.06	376	650	36.7	.205
10 000	325.47	432	884	32.8	.265	10 000	325.06	422	776	35.2	.240
11 000	355.47	484	1024	32.1	.310	11 000	355.06	478	899	34.7	.285
12 000	385.47	530	1149	31.6	.350	12 000	385.06	523	1024	33.8	.320
13 000	415.47	583	1299	31.0	.395	13 000	415.06	573	1152	33.2	.365
13 530	431.37	-----	1429	-----	.445	14 000	445.06	625	1270	33.0	.405
11 130	359.37	613	1967	23.8	.450	15 000	475.06	683	1415	32.6	.445
						15 780	498.46	-----	1579	-----	.500
						12 900	412.06	644	1362	32.1	.510

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ³ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 376						BEAM 388					
0	24.85	16	10	62.0	0.019	0	25.26	17	15	52.5	0.010
1000	54.85	43	36	54.4	.020	1000	55.26	42	36	53.8	.020
2000	84.85	68	56	54.9	.030	2000	85.26	66	55	54.6	.030
3000	114.85	94	79	54.2	.040	3000	115.26	95	74	56.3	.040
4000	144.85	125	109	53.4	.055	4000	145.26	120	99	54.8	.050
5000	174.85	165	164	50.2	.070	5000	175.26	157	140	52.8	.065
6000	204.85	216	243	47.1	.100	6000	205.26	200	217	47.9	.090
7000	234.85	273	368	42.6	.135	7000	235.26	255	325	44.0	.120
8000	264.85	329	518	38.9	.175	8000	265.26	311	453	40.6	.160
9000	294.85	372	643	36.6	.215	9000	295.26	359	585	38.0	.190
10 000	324.85	425	762	35.8	.255	10 000	325.26	410	704	36.8	.225
11 000	354.85	470	884	34.7	.295	11 000	355.26	450	832	35.1	.265
12 000	384.85	511	983	34.2	.330	12 000	385.26	497	930	34.8	.295
13 000	414.85	560	1101	33.7	.375	13 000	415.26	542	1031	34.4	.330
14 000	444.85	599	1205	33.2	.410	14 000	445.26	590	1137	34.2	.365
14 990	474.55	-----	1328	-----	.470	15 000	475.26	630	1232	33.8	.395
12 850	410.35	593	1193	33.2	.475	16 000	505.26	680	1340	33.7	.435
						17 000	535.26	-----	1516	-----	.485
						15 000	475.26	758	1930	28.2	.500
BEAM 377						BEAM 389					
0	24.85	17	22	43.5	0.010	0	25.47	17	15	52.5	0.005
1000	54.85	45	43	51.4	.020	1000	55.47	47	39	54.8	.015
2000	84.85	69	68	50.3	.025	2000	85.47	69	60	53.7	.025
3000	114.85	96	91	51.4	.035	3000	115.47	101	82	55.2	.035
4000	144.85	123	116	51.5	.050	4000	145.47	130	106	55.0	.050
5000	174.85	156	161	49.2	.065	5000	175.47	164	138	54.3	.065
6000	204.85	205	239	46.2	.090	6000	205.47	216	210	50.7	.085
7000	234.85	263	373	41.3	.120	7000	235.47	273	299	47.7	.115
8000	264.85	322	520	38.3	.165	8000	265.47	331	412	44.6	.155
9000	294.85	374	643	36.8	.205	9000	295.47	383	528	42.0	.185
10 000	324.85	428	774	35.6	.245	10 000	325.47	432	650	39.9	.225
11 000	354.85	478	899	34.7	.285	11 000	355.47	484	762	38.9	.260
12 000	384.85	528	1027	33.9	.325	12 000	385.47	532	863	38.1	.295
13 000	414.85	571	1142	33.3	.360	13 000	415.47	580	966	37.5	.325
14 000	444.85	627	1267	33.1	.405	14 000	445.47	629	1072	37.0	.365
15 000	474.85	693	1448	32.4	.455	15 000	475.47	680	1171	36.8	.395
15 360	485.65	-----	1543	-----	.490	16 000	505.47	731	1272	36.5	.435
12 650	404.35	637	1357	31.9	.500	16 980	534.87	-----	1463	-----	.485
						14 350	455.97	806	2046	28.2	.510
BEAM 387						BEAM 399					
0	25.47	19	17	52.5	0.010	0	25.47	17	15	52.5	0.005
1000	55.47	45	36	55.6	.020	1000	55.47	47	34	58.0	.015
2000	85.47	73	56	56.7	.030	2000	85.47	69	53	56.6	.025
3000	115.47	101	77	56.7	.040	3000	115.47	98	74	56.9	.035
4000	145.47	132	99	57.1	.050	4000	145.47	127	97	56.7	.045
5000	175.47	169	138	55.1	.065	5000	175.47	159	126	55.8	.060
6000	205.47	219	195	52.9	.085	6000	205.47	198	173	53.3	.075
7000	235.47	278	285	49.4	.115	7000	235.47	246	244	50.3	.100
8000	265.47	338	390	46.5	.145	8000	265.47	297	335	47.0	.125
9000	295.47	398	521	43.3	.190	9000	295.47	349	446	43.9	.160
10 000	325.47	450	612	42.4	.225	10 000	325.47	399	544	42.3	.190
11 000	355.47	499	711	41.3	.255	11 000	355.47	444	634	41.2	.220
12 000	385.47	554	817	40.4	.295	12 000	385.47	492	723	40.5	.245
13 000	415.47	604	920	39.6	.325	13 000	415.47	540	814	39.9	.275
14 000	445.47	657	1026	39.0	.365	14 000	445.47	587	896	39.6	.310
15 000	475.47	701	1126	38.4	.400	15 000	475.47	630	979	39.2	.335
16 090	505.47	788	1249	38.7	.440	16 000	505.47	678	1068	38.8	.365
16 880	531.87	-----	1607	-----	.525	17 000	535.47	726	1154	38.6	.395
14 500	460.47	910	2140	29.8	.545	18 000	565.47	778	1250	38.4	.430
						19 000	595.47	828	1338	38.2	.460
						19 650	614.97	-----	1496	-----	.495
						17 400	547.47	940	2048	31.4	.525

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 400						BEAM 413					
0	25.68	17	14	54.1	0.005	0	25.88	16	17	47.9	0.010
1000	55.68	42	32	56.6	.015	1000	55.88	40	38	51.2	.020
2000	85.68	62	51	54.7	.025	2000	85.88	59	58	50.4	.030
3000	115.68	90	72	55.6	.035	3000	115.88	87	75	53.7	.040
4000	145.68	114	92	55.4	.045	4000	145.88	109	96	53.2	.050
5000	175.68	147	126	53.8	.060	5000	175.88	141	125	53.1	.060
6000	205.68	187	174	51.8	.075	6000	205.88	176	162	52.1	.075
7000	235.68	223	239	48.3	.100	7000	235.88	216	212	50.5	.095
8000	265.68	277	337	45.1	.125	8000	265.88	266	291	47.7	.120
9000	295.68	316	429	42.4	.155	9000	295.88	315	376	45.5	.145
10 000	325.68	361	533	40.4	.185	10 000	325.88	362	458	44.1	.175
11 000	355.68	401	629	39.0	.215	11 000	355.88	404	538	42.9	.200
12 000	385.68	441	720	38.0	.245	12 000	385.88	441	617	41.7	.230
13 000	415.68	485	809	37.5	.270	13 000	415.88	483	692	41.1	.260
14 000	445.68	527	894	37.1	.305	14 000	445.88	524	764	40.7	.285
15 000	475.68	569	974	36.9	.330	15 000	475.88	562	836	40.2	.310
16 000	505.68	606	1056	36.5	.360	16 000	505.88	602	918	39.6	.340
17 000	535.68	648	1140	36.3	.390	17 000	535.88	638	991	39.1	.365
18 000	565.68	694	1229	36.1	.420	18 000	565.88	683	1068	39.0	.395
19 000	595.68	741	1313	36.1	.455	19 000	595.88	725	1149	38.7	.425
20 000	625.68	-----	1415	-----	.495	20 000	625.88	767	1236	38.3	.455
17 500	550.68	828	2041	28.9	.530	21 000	655.88	810	1316	38.1	.480
						22 000	685.88	901	1550	36.8	.555
						20 000	625.88	854	1491	36.4	.580
BEAM 401						BEAM 342					
0	25.47	17	19	46.9	0.010	0	24.44	19	19	49.9	0.005
1000	55.47	43	38	53.1	.015	1000	54.44	43	38	53.1	.015
2000	85.47	64	58	52.5	.025	1500	69.44	57	53	51.6	.020
3000	115.47	94	79	54.2	.035	2000	84.44	69	63	52.1	.025
4000	145.47	122	102	54.5	.045	3000	114.44	91	89	50.6	.030
5000	175.47	157	140	52.8	.060	3500	129.44	110	103	51.6	.040
6000	205.47	196	198	49.7	.080	4000	144.44	134	138	49.2	.050
7000	235.47	243	273	47.1	.105	4500	159.44	166	219	43.2	.070
8000	265.47	293	371	44.1	.135	5000	174.44	217	368	37.1	.100
9000	295.47	347	475	42.2	.165	5500	189.44	260	561	31.7	.160
10 000	325.47	391	585	40.0	.195	6000	204.44	325	872	27.1	.220
11 000	355.47	437	687	38.9	.225	6280	212.84	-----	1091	-----	.250
12 000	385.47	474	769	38.1	.250	5300	183.44	389	1781	15.9	.320
13 000	415.47	520	860	37.7	.285						
14 000	445.47	560	945	37.2	.310						
15 000	475.47	602	1031	36.8	.335						
16 000	505.47	649	1113	36.8	.370						
17 000	535.47	689	1202	36.5	.400						
18 000	565.47	740	1290	36.4	.430						
19 000	595.47	802	1456	35.5	.475						
19 380	606.87	-----	1578	-----	.505						
17 450	548.97	842	2055	29.1	.515						
BEAM 412						BEAM 343					
0	25.47	17	15	52.5	0.005	0	24.44	21	17	55.1	0.010
1000	55.47	42	36	53.8	.010	1000	54.44	45	43	51.4	.020
2000	85.47	66	55	54.6	.020	1500	69.44	59	60	49.6	.025
3000	115.47	85	77	52.5	.030	2000	84.44	74	72	50.8	.035
4000	145.47	114	97	53.9	.040	2500	99.44	88	84	51.0	.040
5000	175.47	141	125	53.1	.055	3000	114.44	102	99	50.8	.045
6000	205.47	178	159	52.8	.070	3500	129.44	118	115	50.6	.050
7000	235.47	218	207	51.3	.090	4000	144.44	135	142	48.7	.060
8000	265.47	267	289	48.0	.110	4500	159.44	168	200	45.7	.085
9000	295.47	318	369	46.3	.140	5000	174.44	226	386	36.9	.135
10 000	325.47	368	468	44.0	.170	5500	189.44	282	603	31.9	.185
11 000	355.47	409	557	42.4	.195	5800	198.44	-----	773	-----	.265
12 000	385.47	442	634	41.1	.220	5100	177.44	307	740	29.3	.345
13 000	415.47	481	723	40.0	.250						
14 000	445.47	519	802	39.3	.280						
15 000	475.47	569	896	38.8	.310						
16 000	505.47	604	979	38.2	.340						
17 000	535.47	646	1050	38.1	.360						
18 000	565.47	691	1128	38.0	.390						
19 000	595.47	733	1207	37.8	.420						
20 000	625.47	781	1292	37.7	.455						
21 000	655.47	828	1383	37.5	.490						
22 000	685.47	878	1492	37.0	.530						

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 344						BEAM 356					
0	24.64	24	17	58.6	0.010	0	24.44	23	19	54.9	0.005
1000	54.64	55	39	58.4	.020	1000	54.44	47	36	56.7	.020
2000	84.64	84	65	56.5	.035	2000	84.44	75	58	56.3	.030
3000	114.64	120	101	54.3	.045	3000	114.44	101	84	54.7	.040
3500	129.64	138	126	52.3	.055	3500	129.44	117	97	54.6	.045
4000	144.64	170	183	48.1	.075	4000	144.44	133	115	53.7	.050
4500	159.64	223	332	40.2	.115	4500	159.44	155	140	52.5	.060
5000	174.64	293	610	32.5	.175	5000	174.44	179	176	50.4	.070
5500	189.64	338	786	30.1	.215	5500	189.44	219	268	45.0	.090
6000	204.64	382	947	28.8	.275	6000	204.44	277	448	38.2	.135
6500	219.64	420	1111	27.5	.325	7000	234.44	354	711	33.3	.200
6800	228.64	-----	1169	-----	.365	8000	264.44	416	921	31.1	.260
5700	195.64	413	1113	27.1	.415	9000	294.44	477	1123	29.8	.320
						9950	322.94	-----	1431	-----	.380
						8300	273.44	571	2209	20.5	.435
BEAM 354						BEAM 366					
0	24.64	19	17	52.5	0.010	0	24.85	19	14	57.1	0.010
1000	54.64	45	39	53.7	.020	1000	54.85	43	34	55.8	.020
2000	84.64	74	62	54.3	.030	2000	84.85	71	56	56.0	.030
3000	114.64	100	85	54.1	.040	3000	114.85	98	82	54.4	.040
4000	144.64	131	121	51.9	.050	3500	129.85	112	101	52.5	.050
5000	174.64	178	193	47.9	.075	4000	144.85	125	113	52.5	.055
6000	204.64	271	424	39.0	.136	4600	162.85	142	130	52.1	.060
7000	234.64	345	674	33.9	.200	5000	174.85	159	145	52.3	.070
8000	264.64	411	901	31.3	.260	6000	204.85	203	205	49.8	.080
9000	294.64	488	1142	30.0	.320	7000	234.85	277	386	41.8	.130
9600	312.64	-----	1456	-----	.370	8000	264.85	338	600	36.0	.180
8400	276.64	596	2207	21.3	.450	9000	294.85	396	785	33.5	.230
						10 000	324.85	441	954	31.6	.270
						11 000	354.85	488	1096	30.8	.310
						12 000	384.85	547	1236	30.7	.360
						13 000	414.85	596	1374	30.2	.400
						13 950	443.35	-----	1562	-----	.470
						11 000	354.85	651	2248	22.5	.490
BEAM 355						BEAM 367					
0	24.64	19	19	49.9	0.010	0	25.26	16	19	45.3	0.010
1000	54.64	43	39	52.5	.020	1000	55.26	43	36	54.4	.020
2000	84.64	68	60	53.3	.030	2000	85.26	69	56	55.3	.025
3000	114.64	94	80	53.9	.040	3000	115.26	93	80	55.3	.035
3500	129.64	109	94	53.7	.050	4000	145.26	125	111	52.9	.045
4000	144.64	127	115	52.5	.050+	5000	175.26	165	156	51.4	.065
5000	174.64	166	168	49.7	.070	6000	205.26	214	244	46.7	.090
6000	204.64	257	434	37.1	.120	7000	235.26	273	371	42.4	.125
7000	234.64	332	709	31.9	.190	8000	265.26	334	561	37.3	.175
8000	264.64	398	921	30.2	.250	9000	295.26	393	723	35.2	.220
9000	294.64	457	1111	29.2	.300	10 000	325.26	441	860	33.9	.260
10 000	324.64	513	1306	28.2	.360	11 000	355.26	492	1009	32.8	.305
10 450	338.14	-----	1444	-----	(.420)	12 000	385.26	539	1137	32.2	.345
8200	270.64	545	2046	21.0	.430	13 000	415.26	595	1279	31.7	.390
						13 870	441.36	-----	1439	-----	.465
						10 850	350.76	642	2265	22.1	.465

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 368						BEAM 380					
0	25.06	19	14	57.1	0.010	0	24.64	16	17	47.9	0.005
1000	55.06	54	22	71.0	.020	1000	54.64	47	39	54.8	.020
2000	85.06	86	34	71.7	.030	2000	84.64	74	62	54.3	.030
3000	115.06	115	56	67.2	.040	3000	114.64	104	87	54.3	.040
3500	130.06	131	72	64.6	.050	4000	144.64	136	120	53.1	.055
4000	145.06	150	87	63.3	.055	5000	174.64	180	173	50.9	.070
4500	160.06	166	106	61.0	.060	6000	204.64	229	248	48.0	.095
5000	175.06	187	130	59.0	.070	7000	234.64	288	371	43.7	.130
6000	205.06	237	200	54.2	.090	8000	264.64	347	532	39.5	.175
7000	235.06	311	364	46.1	.135	9000	294.64	401	685	36.9	.215
8000	265.06	374	547	40.6	.185	10 000	324.64	454	831	35.3	.260
9000	295.06	431	703	38.0	.235	11 000	354.64	504	954	34.6	.300
10 000	325.06	481	843	36.3	.275	12 000	384.64	552	1082	33.8	.335
11 000	355.06	534	976	35.3	.320	13 000	414.64	608	1224	33.2	.380
12 000	385.06	581	1103	34.5	.365	13 750	437.14	-----	1366	-----	.420
13 000	415.06	635	1232	34.0	.405	14 000	444.64	691	1568	30.6	.460
13 890	441.76	-----	1390	-----	-----	12 100	387.64	702	1974	26.2	.470
10 800	349.06	692	2174	24.2	.480						
BEAM 378						BEAM 390					
0	26.28	23	28	45.7	0.015	0	26.69	28	22	55.5	0.010
1000	56.28	42	47	46.9	.025	1000	56.69	49	33	59.9	.020
2000	86.28	64	68	48.7	.040	2000	86.69	55	70	44.1	.030
3000	116.28	88	94	48.4	.050	3000	116.69	82	71	53.5	.040
4000	146.28	117	132	46.9	.065	4000	146.69	114	86	57.0	.050
5000	176.28	161	190	46.0	.080	5000	176.69	146	105	58.3	.065
6000	206.28	210	260	44.7	.110	6000	206.69	195	163	54.5	.080
7000	236.28	277	377	42.3	.150	7000	236.69	246	225	52.3	.105
8000	266.28	331	495	40.1	.195	8000	266.69	313	322	49.3	.145
9000	296.28	389	619	38.6	.235	9000	296.69	369	427	46.3	.180
10 000	326.28	443	743	37.4	.275	10 000	326.69	423	539	44.0	.220
11 000	356.28	493	859	36.5	.315	11 000	356.69	480	635	43.0	.260
12 000	386.28	542	973	35.8	.355	12 000	386.69	530	727	42.2	.290
13 000	416.28	593	1090	35.2	.395	13 000	416.69	583	825	41.4	.330
14 000	446.28	648	1210	34.9	.440	14 000	446.69	636	915	41.0	.365
14 230	453.18	-----	-----	-----	-----	15 000	476.69	686	1013	40.4	.405
11 700	377.28	724	1926	27.3	.500	16 000	506.69	733	1105	39.9	.435
						16 980	536.09	-----	-----	-----	-----
						14 400	458.69	813	1896	30.0	.510
BEAM 379						BEAM 391					
0	25.06	26	15	63.5	0.005	0	25.47	26	12	68.3	0.005
1000	55.06	51	41	55.2	.015	1000	55.47	52	29	64.2	.015
2000	85.06	77	62	55.4	.025	2000	85.47	78	51	60.6	.025
3000	115.06	107	87	55.1	.040	3000	115.47	103	75	57.8	.035
4000	145.06	134	118	53.1	.055	4000	145.47	127	92	58.0	.045
5000	175.06	171	168	50.4	.070	5000	175.47	158	125	55.9	.060
6000	205.06	216	239	47.4	.090	6000	205.47	201	193	51.0	.080
7000	235.06	282	361	43.9	.130	7000	235.47	245	280	46.7	.105
8000	265.06	341	499	40.6	.170	8000	265.47	321	390	45.1	.140
9000	295.06	393	632	38.4	.210	9000	295.47	370	513	41.9	.170
10 000	325.06	446	749	37.3	.255	10 000	325.47	436	622	41.2	.210
11 000	355.06	501	870	36.5	.295	11 000	355.47	480	737	39.4	.245
12 000	385.06	551	993	35.7	.335	12 000	385.47	525	853	38.1	.275
13 000	415.06	604	1104	35.3	.375	13 000	415.47	573	973	37.1	.310
14 000	445.06	657	1234	34.7	.420	14 000	445.47	620	1080	36.5	.345
14 850	470.56	-----	1364	-----	.480	15 000	475.47	663	1186	35.9	.380
12 000	385.06	648	1274	33.7	.505	16 000	505.47	714	1291	35.6	.415
						17 000	535.47	760	1391	35.4	.455
						17 440	548.67	-----	1487	-----	.490
						14 500	460.47	808	2087	27.9	.515

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 392						BEAM 404					
0	25.26	21	14	59.7	0.005	0	25.47	19	17	52.5	0.010
1000	55.26	43	44	49.6	.015	1000	55.47	43	39	52.5	.020
2000	85.26	65	78	48.7	.025	2000	85.47	68	60	53.3	.030
3000	115.26	89	91	49.4	.035	3000	115.47	96	79	54.8	.040
4000	145.26	115	120	48.9	.050	4000	145.47	120	101	54.3	.050
5000	175.26	145	154	48.5	.060	5000	175.47	147	126	53.8	.060
6000	205.26	184	221	45.5	.085	6000	205.47	186	171	52.1	.075
7000	235.26	236	309	43.3	.105	7000	235.47	236	239	49.7	.100
8000	265.26	292	422	40.9	.140	8000	265.47	289	333	46.5	.125
9000	295.26	357	564	38.8	.185	9000	295.47	335	431	43.8	.155
10 000	325.26	408	667	37.9	.220	10 000	325.47	388	537	42.0	.190
11 000	355.26	464	768	37.6	.260	11 000	355.47	442	646	40.6	.220
12 000	385.26	520	884	37.0	.295	12 000	385.47	485	737	39.7	.255
13 000	415.26	570	986	36.6	.325	13 000	415.47	535	826	39.3	.285
14 000	445.26	623	1094	36.3	.365	14 000	445.47	592	920	39.1	.320
15 000	475.26	673	1202	35.9	.400	15 000	475.47	631	998	38.8	.345
16 000	505.26	728	1309	35.7	.440	16 000	505.47	678	1084	38.5	.375
17 000	535.26	809	1533	34.5	.495	17 000	535.47	722	1174	38.1	.405
17 250	542.76	-----	1668	-----	.525	18 000	565.47	780	1274	38.0	.445
14 400	457.26	894	2528	26.1	.575	19 000	595.47	826	1374	37.5	.475
						20 000	625.47	896	1568	36.4	.525
						20 200	631.47	-----	1771	-----	-----
						18 300	574.47	962	2166	30.7	.575
BEAM 402						BEAM 414					
0	26.90	37	19	66.0	0.010	0	25.26	23	19	54.9	0.010
1000	56.90	54	30	64.3	.015	1000	55.26	47	36	56.7	.020
2000	86.90	81	46	63.9	.030	2000	85.26	77	58	57.0	.030
3000	116.90	109	61	64.0	.040	3000	115.26	101	75	57.3	.040
4000	146.90	137	83	62.3	.050	4000	145.26	129	96	57.4	.050
5000	176.90	169	108	61.2	.060	5000	175.26	161	121	57.1	.060
6000	206.90	206	145	58.8	.075	6000	205.26	196	157	55.5	.075
7000	236.90	247	195	55.9	.095	7000	235.26	245	221	52.6	.095
8000	266.90	299	277	51.9	.120	8000	265.26	289	287	50.2	.120
9000	296.90	352	372	48.6	.155	9000	295.26	342	374	47.8	.145
10 000	326.90	405	445	47.6	.185	10 000	325.26	395	470	45.7	.175
11 000	356.90	449	570	44.1	.215	11 000	355.26	441	554	44.3	.205
12 000	386.90	497	661	42.9	.250	12 000	385.26	489	643	43.2	.235
13 100	419.90	551	764	41.9	.285	13 000	415.26	538	733	42.3	.265
14 000	446.90	592	844	41.2	.315	14 000	445.26	581	817	41.6	.295
15 000	476.90	633	928	40.5	.345	15 000	475.26	626	892	41.2	.325
16 000	506.90	680	1014	40.1	.375	16 000	505.26	674	976	40.8	.355
17 000	536.90	727	1102	39.7	.410	17 000	535.26	719	1048	40.7	.385
18 000	566.90	777	1186	39.6	.440	18 000	565.26	761	1130	40.3	.415
19 000	596.90	823	1295	38.9	.475	19 000	595.26	810	1222	39.8	.445
19 920	624.50	-----	-----	-----	-----	20 000	625.26	861	1315	39.6	.480
17 050	538.40	899	1938	31.7	.550	21 000	655.26	948	1569	37.7	.525
						21 410	667.56	-----	1916	-----	.585
						18 700	586.26	1068	2441	30.4	.615
BEAM 403						BEAM 415					
0	25.88	23	14	62.0	0.010	0	26.69	15	15	49.1	0.005
1000	55.88	54	29	65.1	.020	1000	56.69	37	38	49.2	.015
2000	85.88	84	48	63.5	.040	2000	86.68	56	53	51.1	.025
3000	115.88	110	70	61.1	.055	3000	116.69	79	71	52.5	.035
4000	145.88	135	96	58.4	.070	4000	146.69	107	92	53.8	.045
5000	175.88	163	121	57.4	.085	5000	176.69	132	115	53.5	.055
6000	205.88	211	181	53.8	.110	6000	206.69	171	152	52.8	.070
7000	235.88	252	244	50.8	.130	7000	236.69	212	200	51.5	.090
8000	265.88	308	344	47.2	.160	8000	266.69	258	258	50.0	.115
9000	295.88	357	456	43.9	.200	9000	296.69	304	334	47.6	.140
10 000	325.88	406	568	41.7	.230	10 000	326.69	355	423	45.6	.170
11 100	358.88	457	679	40.2	.265	11 000	356.69	401	503	44.4	.200
12 000	388.88	502	766	39.6	.300	12 050	388.19	452	597	43.1	.230
13 000	415.88	550	862	38.9	.325	13 000	416.69	493	673	42.3	.260
14 000	445.88	594	961	38.2	.360	14 000	446.69	540	748	41.9	.285
15 000	475.88	642	1058	37.8	.390	15 000	476.69	581	822	41.4	.315
16 000	505.88	692	1152	37.5	.425	16 000	506.69	625	896	41.1	.340
17 000	535.88	740	1244	37.3	.455	17 000	536.69	668	970	40.8	.370
18 000	565.88	791	1345	37.0	.490	18 000	566.69	716	1050	40.6	.400
19 000	595.88	849	1475	36.5	.525	19 000	596.69	757	1121	40.3	.430
19 860	621.68	-----	1675	-----	-----	20 000	626.69	810	1222	39.9	.460
17 100	538.88	763	1827	29.5	.595	21 000	656.69	845	1397	37.7	.500
						21 440	669.89	-----	-----	-----	-----
						19 250	604.19	973	2295	29.8	.585

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M $\frac{bd^2}{4}$ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M $\frac{bd^2}{4}$ lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 416						BEAM 419					
0	25.26	21	17	55.1	0.010	0	20.31	45	32	58.4	0.015
1000	55.26	50	38	57.0	.020	500	35.31	97	60	61.7	.035
2000	85.26	75	56	57.1	.030	1000	50.31	134	87	60.6	.045
3000	115.26	103	79	56.6	.040	1500	65.31	177	123	59.0	.060
4000	145.26	133	103	56.3	.055	2000	80.31	226	162	58.3	.080
5000	175.26	167	132	55.8	.065	2500	95.31	272	217	55.7	.095
6000	205.26	207	173	54.5	.085	3000	110.31	337	318	51.4	.125
7000	235.26	257	238	51.9	.105	3500	125.31	426	480	47.0	.165
8000	265.26	308	315	49.5	.125	4000	140.31	505	629	44.5	.210
9000	295.26	366	402	47.7	.160	4500	155.31	588	744	44.1	.255
10 000	325.26	418	487	46.2	.190	5000	170.31	666	897	42.6	.305
11 000	355.26	467	579	44.7	.215	5500	185.31	765	1062	41.9	.350
12 000	385.26	522	682	43.4	.250	6000	200.31	840	1205	41.1	.410
13 000	415.26	565	759	42.7	.275	6390	212.01	-----	1294	-----	.445
14 000	445.26	609	839	42.1	.305	5100	173.31	799	1171	40.6	.455
15 000	475.26	662	928	41.7	.340						
16 000	505.26	704	1000	41.3	.365						
17 000	535.26	752	1082	41.0	.395						
18 000	565.26	797	1168	40.6	.425						
19 000	595.26	855	1267	40.3	.460						
20 000	625.26	904	1366	39.8	.495						
21 000	655.26	1008	1651	37.9	.560						
19 000	595.26	1124	2485	31.2	.635						
BEAM 417						BEAM 429					
0	20.73	42	34	55.1	0.015	0	21.14	37	24	60.7	0.010
500	35.73	75	65	53.6	.030	1000	51.14	106	70	60.2	.035
1000	50.73	107	97	52.5	.045	2000	81.14	179	126	58.7	.060
1500	65.73	143	123	53.8	.055	2500	96.14	227	166	57.7	.075
2000	80.73	179	161	52.7	.070	3000	111.14	274	210	56.6	.090
2500	95.73	229	209	52.3	.090	3500	126.14	321	260	55.3	.110
3000	110.73	285	296	49.1	.115	4000	141.14	377	326	53.6	.135
3500	125.73	365	439	45.4	.155	4500	156.14	444	403	52.4	.160
4000	140.73	454	595	43.3	.205	5000	171.14	516	499	50.8	.190
4500	155.73	531	728	42.2	.260	5500	186.14	585	595	49.6	.225
5000	170.73	600	853	41.3	.305	6000	201.14	658	699	48.5	.275
5500	185.73	688	1009	40.5	.370	7000	231.14	802	913	46.8	.350
5900	197.73	-----	1169	-----	.440	8000	261.14	954	1125	45.9	.420
4600	158.73	683	1015	40.2	.445	8500	276.14	1073	1311	45.0	.485
						8700	282.14	-----	1405	-----	.520
						7400	243.14	1155	1848	38.5	.540
BEAM 418						BEAM 430					
0	20.93	45	29	60.6	0.010	0	21.14	41	26	61.4	0.010
500	35.93	82	55	59.8	.025	1000	51.14	123	82	60.1	.040
1000	50.93	113	80	58.5	.040	2000	81.14	196	138	58.6	.060
1500	65.93	145	108	57.3	.050	2500	96.14	243	179	57.6	.080
2000	80.93	182	147	55.4	.060	3000	111.14	281	226	55.5	.100
2500	95.93	228	188	54.8	.085	3500	126.14	330	284	53.7	.125
3000	110.93	276	248	52.7	.105	4000	141.14	378	345	52.3	.145
3500	125.93	346	349	49.8	.135	4500	156.14	453	426	51.3	.175
4000	140.93	449	533	45.7	.190	5000	171.14	524	509	50.7	.210
4500	155.93	522	677	43.5	.240	5500	186.14	603	609	49.7	.240
5000	170.93	591	829	41.6	.285	6000	201.14	652	691	48.6	.275
5500	185.93	674	976	40.8	.335	7000	231.14	805	885	47.6	.350
5900	191.93	-----	1132	-----	.385	8000	261.14	953	1089	46.7	.420
5000	170.93	762	1564	32.8	.420	8500	276.14	1072	1236	46.5	.475
						8760	283.94	-----	1362	-----	.520
						7700	252.14	1219	1769	40.8	.540

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 431						BEAM 443					
0	20.93	52	24	68.3	0.010	0	20.73	43	32	57.2	0.020
500	35.93	94	41	69.6	.035	1000	50.73	113	82	57.9	.050
1000	50.93	130	68	65.6	.045	2000	80.73	196	140	58.3	.070
1500	65.93	169	97	63.6	.060	2500	95.73	234	168	58.2	.085
2000	80.93	202	126	61.6	.080	3000	110.73	286	200	58.9	.105
2500	95.93	244	159	60.6	.090	3500	125.73	335	243	58.0	.120
3000	110.93	282	198	58.8	.110	4000	140.73	385	284	57.6	.135
3500	125.93	331	260	56.0	.130	4500	155.73	446	330	57.5	.160
4000	140.93	391	313	55.6	.155	5000	170.73	508	386	56.8	.180
4500	155.93	454	383	54.2	.175	6000	200.73	644	526	55.0	.240
5000	170.93	518	474	52.2	.210	7000	230.73	776	679	53.3	.295
5500	185.93	589	556	51.5	.245	8000	260.73	928	807	53.5	.355
6000	200.93	657	655	50.1	.280	9000	290.73	1069	928	53.5	.415
6500	215.93	726	733	49.8	.305	10 000	320.73	1258	1060	54.3	.495
7000	230.93	788	821	49.0	.345	10 500	335.73	1385	1188	53.8	.530
7500	245.93	878	920	48.8	.395	11 000	350.73	1488	1292	53.5	.575
8000	260.93	948	1010	48.4	.430	11 470	364.83	-----	1458	-----	.625
8500	275.93	1032	1113	48.1	.465	10 000	320.73	1595	1826	46.6	.630
8940	289.13	-----	1234	-----	.505						
7500	245.93	1013	1087	48.2	.525						
BEAM 441						BEAM 453					
0	20.52	50	27	64.9	0.015	0	20.52	50	29	63.3	0.015
1000	50.52	135	72	65.3	.035	1000	50.52	136	77	63.8	.040
2000	80.52	230	130	63.9	.070	2000	80.52	223	137	61.9	.065
2500	95.52	277	168	62.3	.090	3000	110.52	318	207	60.6	.110
3000	110.52	333	207	61.7	.110	4000	140.52	437	308	58.7	.140
3500	125.52	388	253	60.5	.130	5000	170.52	570	427	57.2	.195
4000	140.52	455	313	59.3	.150	6000	200.52	711	557	56.1	.250
4500	155.52	522	376	58.1	.170	7000	230.52	886	685	56.4	.320
5000	170.52	594	443	57.3	.200	8000	260.52	1046	826	55.9	.380
5500	185.52	673	508	57.0	.230	9000	290.52	1242	959	56.4	.440
6000	200.52	740	574	56.3	.255	10 000	320.52	1440	1096	56.8	.510
7000	230.52	921	713	56.4	.315	11 000	350.52	1654	1246	57.0	.590
8000	260.52	1104	884	55.5	.385	11 300	359.52	1818	1332	57.7	.640
9000	290.52	1277	1029	55.4	.445	11 470	364.62	1962	1465	57.3	.680
10 000	320.52	1487	1215	55.0	.525	11 700	371.52	2082	1684	55.3	.740
10 500	335.52	1690	1414	54.5	.585	10 400	332.52	2161	1976	52.2	.760
9700	311.52	1807	1810	50.0	.620						
BEAM 442						BEAM 454					
0	20.73	47	27	63.4	0.015	0	20.93	50	36	58.3	0.020
1000	50.73	120	67	64.2	.040	1000	50.93	137	87	61.2	.035
2000	80.73	201	121	62.4	.065	2000	80.93	216	140	60.7	.065
2500	95.73	249	159	61.1	.085	3000	110.93	313	214	59.4	.095
3000	110.73	299	198	60.2	.100	4000	140.93	427	306	58.2	.135
3500	125.73	347	236	59.5	.120	5000	170.93	561	431	56.5	.185
4000	140.73	398	280	58.7	.135	6000	200.93	707	547	56.4	.235
4500	155.73	462	335	58.0	.160	7000	230.93	850	679	55.6	.295
5000	170.73	525	397	56.9	.190	8000	260.93	1030	827	55.5	.365
6000	200.73	661	523	55.8	.240	9000	290.93	1212	968	55.6	.425
7000	230.73	801	655	55.0	.295	10 000	320.93	1431	1126	56.0	.515
8000	260.73	963	800	54.6	.360	11 000	350.93	1728	1357	56.0	.635
9000	290.73	1143	933	55.1	.425	11 130	354.83	2027	1655	55.1	.765
10 000	320.73	1309	1070	55.0	.490	10 400	332.93	2073	1646	55.7	.800
10 500	335.73	1471	1186	55.4	.540						
10 750	343.23	1506	1231	55.0	.560						
10 900	347.73	-----	1335	-----	.595						
9800	314.73	1616	1713	48.6	.600						

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 455						BEAM 467					
0	20.93	43	31	57.9	0.010	0	20.93	43	29	59.5	0.015
1000	50.93	111	84	56.9	.040	1000	50.93	108	79	57.8	.035
2000	80.93	185	138	57.3	.065	2000	80.93	181	123	59.6	.065
3000	110.93	269	200	57.4	.095	3000	110.93	261	181	59.1	.090
4000	140.93	375	280	57.2	.130	4000	140.93	350	251	58.2	.120
5000	170.93	495	386	56.2	.175	5000	170.93	452	340	57.0	.160
6000	200.93	622	491	55.9	.225	6000	200.93	559	436	56.2	.200
7000	230.93	784	639	55.1	.290	7000	230.93	700	537	56.6	.250
8000	260.93	929	786	54.2	.350	8000	260.93	806	655	55.2	.320
9000	290.93	1082	942	53.5	.420	9000	290.93	941	786	54.5	.375
10 000	320.93	1268	1097	53.6	.500	10 000	320.93	1084	903	54.6	.430
11 000	350.93	1542	1335	53.6	.595	11 000	350.93	1228	1012	54.8	.495
11 450	364.43	1713	1508	53.2	.665	12 000	380.93	1412	1132	55.5	.555
12 000	380.93	1882	1986	48.7	.720	12 500	395.93	1509	1193	55.9	.600
						13 000	410.93	1600	1246	56.2	.635
						13 500	425.93	1726	1318	56.7	.690
						13 950	439.93	1946	1562	55.5	.780
						14 100	443.93	1762	1562	55.5	.845
						12 900	407.93	2158	1997	51.9	.850
BEAM 465						BEAM 477					
0	20.73	57	32	64.2	0.015	0	21.14	57	26	68.7	0.015
1000	50.73	146	79	64.9	.040	1000	51.14	126	68	64.9	.040
2000	80.73	232	128	64.4	.070	2000	81.14	202	115	63.7	.065
3000	110.73	316	188	62.7	.100	3000	111.14	278	174	61.5	.090
4000	140.73	415	260	61.5	.130	4000	141.14	375	239	61.1	.120
5000	170.73	528	357	59.7	.175	5000	171.14	461	316	59.3	.155
6000	200.73	659	463	58.7	.225	6000	201.14	572	409	58.3	.195
7000	230.73	806	578	58.2	.275	7000	231.14	694	504	57.9	.235
8000	260.73	975	713	57.8	.330	8000	261.14	828	612	57.5	.280
9000	290.73	1142	832	57.8	.385	9000	291.14	975	709	57.9	.335
10 000	320.73	1321	957	58.0	.460	10 000	321.14	1141	821	58.2	.380
11 000	350.73	1508	1077	58.3	.515	11 000	351.14	1307	938	58.2	.460
12 000	380.73	1790	1231	59.3	.605	12 000	381.14	1475	1050	58.4	.520
12 500	395.73	2039	1444	58.5	.700	13 000	411.14	1668	1179	58.6	.575
13 000	410.73	2240	1632	57.8	.750	14 000	441.14	2077	1409	59.6	.705
13 100	413.73	2240	1632	57.8	.750	14 500	456.14	2298	1545	59.8	.765
12 000	380.73	2643	2256	54.0	.875	14 870	467.24	2684	1925	58.2	.885
						13 700	432.14	3024	2455	55.2	.955
BEAM 466						BEAM 478					
0	20.93	54	31	63.6	0.015	0	20.93	47	24	66.0	0.015
1000	50.93	128	79	61.9	.040	1000	50.93	118	67	63.8	.035
2000	80.93	194	125	60.8	.060	2000	80.93	197	115	63.1	.055
3000	110.93	286	193	59.7	.090	3000	110.93	278	158	62.4	.085
4000	140.93	376	262	58.9	.120	4000	140.93	370	227	62.0	.120
5000	170.93	491	369	57.1	.165	5000	170.93	468	303	60.7	.150
6000	200.93	616	477	56.3	.210	6000	200.93	574	383	60.0	.185
7000	230.93	750	562	57.2	.270	7000	230.93	693	477	59.2	.230
8000	260.93	894	680	56.8	.330	8000	260.93	822	573	58.9	.280
9000	290.93	1041	802	56.5	.390	9000	290.93	963	696	58.0	.330
10 000	320.93	1187	911	56.6	.450	10 000	320.93	1113	812	57.8	.380
11 000	350.93	1374	1046	56.8	.510	11 000	350.93	1297	930	58.2	.435
12 000	380.93	1566	1176	57.1	.590	12 000	380.93	1467	1043	58.5	.515
12 500	395.93	1727	1291	57.2	.630	13 000	410.93	1661	1198	58.2	.580
12 820	405.53	1933	1379	56.2	.670	14 000	440.93	1958	1403	58.3	.690
13 000	410.93	1933	1506	56.2	.700	14 500	455.93	2285	1641	58.2	.815
13 080	413.33	1933	1544	56.2	.720	14 900	458.63	2387	1701	58.4	.870
13 460	424.73	1933	1906	56.2	.810	13 500	425.93	2390	1648	59.2	.885
12 400	392.93	2373	2198	51.9	.830						

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd: lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflec- tion, inches	Applied Load, lbs.	M bd: lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflec- tion, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 479						BEAM 491					
0	20.93	48	26	64.7	0.015	0	21.34	45	31	59.1	0.015
1000	50.93	117	65	64.3	.045	1000	51.34	112	77	59.4	.045
2000	80.93	195	115	62.8	.070	2000	81.34	179	113	60.2	.065
3000	110.93	275	162	62.9	.090	3000	111.34	252	156	60.3	.090
4000	140.93	368	231	61.4	.125	4000	141.34	328	219	60.0	.110
5000	170.93	457	296	60.7	.155	5000	171.34	411	282	59.3	.145
6000	200.93	566	396	59.4	.195	6000	201.34	511	344	59.8	.180
7000	230.93	689	475	59.2	.235	7000	231.34	615	438	58.4	.210
8000	260.93	809	573	58.5	.275	8000	261.34	755	530	58.8	.260
9000	290.93	959	677	58.6	.355	9000	291.34	884	622	58.7	.310
10 000	320.93	1088	768	58.6	.400	10 000	321.34	1020	711	58.9	.350
11 000	350.93	1254	880	58.8	.455	11 000	351.34	1175	827	58.7	.415
12 000	380.93	1418	997	58.7	.510	12 000	381.34	1329	918	59.2	.465
13 000	410.93	1598	1097	59.3	.590	13 000	411.34	1506	1029	59.4	.515
14 000	440.93	1818	1243	59.4	.650	14 000	441.34	1765	1145	60.6	.610
14 500	455.93	2008	1340	60.0	.700	15 000	471.34	2109	1313	61.6	.700
14 800	465.83	2153	1455	59.7	.775	15 500	486.34	2335	1417	62.2	.770
14 800	464.93	2279	1624	58.4	.805	15 950	499.84	.....	.....	.....	.830
15 000	470.93	2464	1735	57.9	.845	16 000	501.34	2748	1646	62.5	.860
15 170	476.03	.....	1969	.....	.875	16 350	511.84	.....	.....	.....	.930
15 600	428.93	2679	2215	54.7	.885	16 410	513.64	.....	1993	.....	1.000
						14 800	465.34	3923	2477	61.3	1.115
BEAM 489						BEAM 420					
0	21.14	61	31	66.2	0.005	0	20.52	45	27	62.3	0.015
1000	51.14	133	68	66.2	.030	1000	50.52	113	75	60.2	.045
2000	81.14	217	115	65.3	.060	2000	80.52	184	137	57.3	.070
3000	111.14	305	164	65.1	.085	2500	95.52	228	185	55.2	.085
4000	141.14	400	229	63.6	.110	3000	110.52	268	234	53.4	.105
5000	171.14	508	297	63.1	.150	3500	125.52	315	313	50.2	.125
6000	201.14	628	381	62.3	.185	4000	140.52	381	398	48.9	.155
7000	231.14	792	482	62.2	.235	4500	155.52	461	564	45.0	.195
8000	261.14	910	573	61.4	.270	5000	170.52	541	745	42.1	.245
9000	291.14	1083	672	61.7	.330	5500	185.52	614	933	39.7	.295
10 000	321.14	1250	769	61.9	.380	6000	200.52	674	1085	38.3	.345
11 000	351.14	1423	858	62.2	.435	6120	204.12	.....	1265	.....	.395
12 000	381.14	1650	983	62.7	.510	5500	185.52	760	1557	32.8	.415
13 000	411.14	1844	1094	62.8	.575						
14 000	441.14	2112	1219	63.4	.650						
15 000	471.14	2510	1381	64.5	.755						
15 100	474.14	.....	.....	.....	.800						
15 320	480.74	.....	.....	.....	.855						
15 500	486.14	3172	1805	63.7	.905						
15 750	493.64	.....	2046	.....	.980						
14 200	447.14	3718	2168	63.2	.990						
BEAM 490						BEAM 421					
0	21.34	45	32	58.4	0.015	0	21.34	42	27	61.1	0.010
1000	51.34	116	75	60.6	.025	1000	51.34	106	79	57.4	.040
2000	81.34	199	121	62.2	.055	2000	81.34	165	133	55.4	.065
3000	111.34	278	174	61.5	.080	2500	96.34	205	171	54.5	.080
4000	141.34	363	239	60.3	.110	3000	111.34	244	210	53.7	.095
5000	171.34	452	304	60.3	.140	3500	126.34	280	258	52.0	.115
6000	201.34	580	383	60.2	.175	4000	141.34	330	337	49.5	.140
7000	231.34	700	479	59.4	.225	4500	156.34	404	492	45.1	.185
8000	261.34	829	574	59.1	.265	5000	171.34	482	711	40.4	.240
9000	291.34	967	682	59.3	.315	5500	186.34	543	875	38.3	.280
10 000	321.34	1126	769	59.4	.375	5880	197.74	.....	1044	.....	.340
11 000	351.34	1291	860	60.0	.440	5100	174.34	623	1475	29.7	.380
12 000	381.34	1459	954	60.5	.495						
13 000	411.34	1641	1055	60.9	.545						
14 000	441.34	1891	1176	61.7	.640						
15 000	471.34	2215	1318	62.7	.720						
15 500	486.34	2414	1417	63.0	.765						
15 700	492.34	.....	.....	.....	.850						
15 820	495.94	.....	.....	.....	.....						
16 000	501.34	3242	1974	62.2	1.005						
14 600	459.34	3629	2152	62.8	1.090						

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 422						BEAM 434					
0	20.93	47	31	60.2	0.015	0	21.14	42	29	58.9	0.015
1000	50.93	114	79	59.0	.040	1000	51.14	100	65	60.7	.035
2000	80.93	182	142	56.2	.070	2000	81.14	164	115	58.8	.060
2500	95.93	224	188	54.3	.085	3000	111.14	230	171	57.4	.080
3000	110.93	264	238	52.6	.105	3500	126.14	266	203	56.8	.100
3500	125.93	316	297	51.5	.130	4000	141.14	304	232	56.7	.110
4000	140.93	367	378	49.3	.150	4500	156.14	342	272	55.7	.130
4500	155.93	445	554	44.5	.200	5000	171.14	390	321	54.8	.150
5000	170.93	520	757	40.7	.250	5500	186.14	434	386	52.9	.170
5500	185.93	596	959	38.3	.305	6000	201.14	511	463	52.4	.200
5840	196.13	-----	1070	-----	.340	6500	216.14	561	545	50.7	.230
5860	196.73	-----	1197	-----	.360	7000	231.14	612	619	49.7	.260
5300	179.93	678	1450	31.8	.380	8000	261.14	728	826	46.8	.325
						9000	291.14	842	1065	44.2	.400
						9270	299.24	-----	1200	-----	.435
						8200	267.14	910	1526	37.3	.445
BEAM 432						BEAM 444					
0	21.55	42	29	58.9	0.015	0	21.34	42	31	57.3	0.015
1000	51.55	95	74	56.3	.035	1000	51.34	100	67	60.0	.035
2000	81.55	158	126	55.7	.060	2000	81.34	164	111	59.6	.060
3000	111.55	227	178	56.1	.090	3000	111.34	232	168	58.0	.090
4000	141.55	294	253	53.8	.115	4000	141.34	306	229	57.2	.115
4500	156.55	344	311	52.5	.140	5000	171.34	385	316	54.9	.150
5000	171.55	398	376	51.4	.160	6000	201.34	471	427	52.4	.190
5500	186.55	451	463	49.3	.180	7000	231.34	575	562	50.6	.240
6000	201.55	495	540	47.8	.205	8000	261.34	665	697	48.8	.290
7000	231.55	614	762	44.6	.260	9000	291.34	772	855	47.5	.345
8000	261.55	736	974	43.1	.330	10 000	321.34	879	997	46.8	.400
8730	283.45	815	1162	41.2	.400	11 000	351.34	991	1138	46.5	.460
8810	285.85	-----	1219	-----	.420	12 000	381.34	1111	1285	46.4	.515
7800	255.55	783	1138	40.8	.430	9900	318.34	1163	1956	37.3	-----
BEAM 433						BEAM 445					
0	21.76	39	27	59.3	0.010	0	21.34	37	27	58.0	0.015
1000	51.76	92	72	56.2	.035	1000	51.34	93	72	56.4	.040
2000	81.76	145	118	55.2	.060	2000	81.34	154	123	55.6	.060
3000	111.76	202	173	53.8	.080	3000	111.34	205	168	54.9	.080
4000	141.76	267	248	51.8	.110	4000	141.34	279	238	54.0	.115
4500	156.76	314	294	51.7	.130	5000	171.34	356	333	51.8	.150
5000	171.76	351	340	50.8	.150	6000	201.34	449	434	50.9	.190
5500	186.76	396	410	49.2	.170	7000	231.34	529	564	48.4	.235
6000	201.76	450	497	47.5	.200	8000	261.34	628	718	46.7	.285
6500	216.76	500	583	46.2	.230	9000	291.34	723	862	45.6	.335
7000	231.76	554	687	44.6	.260	10 000	321.34	819	995	45.1	.385
8000	261.76	652	872	42.8	.320	11 000	351.34	931	1164	44.4	.455
9000	291.76	778	1101	41.4	.400	11 750	373.84	-----	1381	-----	.525
9400	303.76	-----	1214	-----	.440	9900	318.34	1068	1991	34.9	.535
9400	303.76	-----	1231	-----	.450						

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 446						BEAM 458					
0	21.34	42	26	62.0	0.015	0	21.55	38	34	52.5	0.015
1000	51.34	105	74	58.6	.040	1000	51.55	108	74	59.4	.035
2000	81.34	166	118	58.5	.060	2000	81.55	172	120	58.8	.060
3000	111.34	238	174	57.7	.085	3000	111.55	243	179	57.6	.090
4000	141.34	313	253	55.3	.115	4000	141.55	319	239	57.2	.115
5000	171.34	388	338	53.5	.150	5000	171.55	402	318	55.8	.150
6000	201.34	478	455	51.2	.190	6000	201.55	496	412	54.6	.190
7000	231.34	576	586	49.6	.235	7000	231.55	611	532	53.5	.240
8000	261.34	674	737	47.7	.285	8000	261.55	708	663	51.6	.290
9000	291.34	783	899	46.6	.340	9000	291.55	812	797	50.5	.340
10 000	321.34	888	1044	45.9	.395	10 000	321.55	919	938	49.5	.390
11 000	351.34	1014	1209	45.6	.450	11 000	351.55	1043	1079	49.2	.445
12 000	381.34	1159	1482	43.9	.535	12 000	381.55	1183	1221	49.2	.510
10 300	330.34	1182	1831	39.2	.560	12 920	409.15	-----	1405	-----	.570
						13 000	411.55	1384	1515	47.7	.590
						13 200	417.55	-----	1610	-----	.620
						12 200	387.55	1471	1976	42.7	.625
BEAM 456						BEAM 468					
0	21.14	42	27	61.1	0.015	0	21.34	37	29	56.3	0.010
1000	51.14	110	72	60.5	.040	1000	51.34	93	63	59.6	.025
2000	81.14	173	115	60.1	.065	2000	81.34	155	97	61.4	.045
3000	111.14	242	166	59.4	.090	3000	111.34	220	140	61.1	.070
4000	141.14	318	222	58.9	.120	4000	141.34	289	191	60.2	.105
5000	171.14	405	313	56.4	.150	5000	171.34	366	255	58.9	.125
6000	201.14	495	409	54.8	.190	6000	201.34	448	333	57.4	.160
7000	231.14	593	532	52.7	.235	7000	231.34	550	427	56.3	.200
8000	261.14	697	668	51.1	.280	8000	261.34	646	520	55.4	.235
9000	291.14	806	802	50.1	.330	9000	291.34	753	624	54.7	.305
10 000	321.14	916	932	49.6	.385	10 000	321.34	847	721	54.0	.345
11 000	351.14	1020	1062	49.0	.435	11 000	351.34	964	822	54.0	.395
12 000	381.14	1184	1244	48.8	.500	12 000	381.34	1063	918	53.7	.440
12 500	396.14	-----	1482	-----	.550	13 000	411.34	1185	1024	53.6	.490
11 200	357.14	1325	1809	42.3	.565	14 000	441.34	1317	1128	53.9	.550
						14 560	458.14	-----	1188	-----	.585
						13 600	429.34	1434	1130	55.9	.630
BEAM 457						BEAM 469					
0	21.76	32	24	57.0	0.010	0	21.34	35	27	56.5	0.015
1000	51.76	93	67	58.1	.035	1000	51.34	95	65	59.4	.035
2000	81.76	145	111	56.6	.055	2000	81.34	158	108	59.4	.055
3000	111.76	216	156	58.0	.080	3000	111.34	222	154	59.0	.080
4000	141.76	283	215	56.8	.115	4000	141.34	292	212	58.0	.110
5000	171.76	362	285	56.0	.140	5000	171.34	378	275	57.9	.135
6000	201.76	454	388	53.9	.180	6000	201.34	463	361	56.2	.175
7000	231.76	549	504	52.1	.225	7000	231.34	557	460	54.8	.215
8000	261.76	643	641	50.1	.270	8000	261.34	656	564	53.8	.255
9000	291.76	739	776	48.8	.320	9000	291.34	758	668	53.2	.295
10 000	321.76	834	901	48.1	.365	10 000	321.34	865	769	52.9	.345
11 000	351.76	942	1029	47.5	.415	11 000	351.34	974	875	52.7	.395
12 000	381.76	1055	1173	47.4	.470	12 000	381.34	1081	979	52.5	.440
13 000	411.76	1181	1320	47.2	.535	13 000	411.34	1222	1096	52.7	.500
14 000	441.76	1348	1571	46.2	.615	14 000	441.34	1360	1209	52.9	.555
11 550	368.26	1239	1366	47.6	.645	14 550	457.84	-----	1296	-----	.595
						12 900	408.34	1608	2002	44.5	.665

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 470						BEAM 492					
0	21.14	35	31	53.3	0.015	0	21.55	32	27	54.2	0.015
1000	51.14	98	74	56.9	.035	1000	51.55	95	67	58.7	.035
2000	81.14	166	116	58.9	.050	2000	81.55	153	106	59.1	.060
3000	111.14	227	166	57.7	.070	3000	111.55	218	149	59.4	.080
4000	141.14	303	221	57.8	.100	4000	141.55	289	200	59.1	.105
5000	171.14	380	285	57.2	.130	5000	171.55	364	250	59.3	.130
6000	201.14	466	369	55.8	.160	6000	201.55	440	308	58.8	.160
7000	231.14	568	474	54.5	.200	7000	231.55	520	374	58.1	.190
8000	261.14	662	574	53.5	.240	8000	261.55	610	453	57.4	.225
9000	291.14	765	687	52.7	.280	9000	291.55	703	538	56.6	.255
10 000	321.14	870	807	51.9	.320	10 000	321.55	801	626	56.1	.295
11 000	351.14	980	926	51.4	.365	11 000	351.55	899	708	55.9	.335
12 000	381.14	1090	1044	51.1	.450	12 000	381.55	999	797	55.6	.375
13 000	411.14	1246	1178	51.4	.510	13 000	411.55	1112	887	55.6	.415
14 000	441.14	1399	1344	51.0	.570	14 000	441.55	1236	978	55.8	.455
14 250	448.64	-----	1402	-----	.600	15 000	471.55	1355	1067	55.9	.500
14 500	456.14	-----	1509	-----	.620	16 000	501.55	1487	1164	56.1	.550
15 000	471.14	1662	1747	48.7	.670	17 000	531.55	1694	1347	55.7	.615
13 500	426.14	1724	2156	44.4	.700	18 000	561.55	1906	1545	55.2	.680
						14 000	441.55	1754	1385	55.9	.605
						15 000	471.55	1814	1439	55.8	.625
						16 000	501.55	1877	1497	55.6	.650
						17 000	531.55	1944	1559	55.5	.675
						18 000	561.55	2056	1667	55.2	.740
						18 060	563.35	-----	1726	-----	.760
						18 060	563.35	-----	1950	-----	.795
						17 000	531.55	2301	2316	49.8	.820
BEAM 480						BEAM 493					
0	21.55	35	26	57.4	0.020	0	21.96	42	29	58.9	0.015
1000	51.55	100	65	60.7	.040	1000	51.96	103	68	60.1	.055
2000	81.55	163	108	60.1	.060	2000	81.96	157	104	60.2	.075
3000	111.55	224	156	58.9	.080	3000	111.96	223	144	60.8	.095
4000	141.55	295	202	59.3	.105	4000	141.96	279	186	60.0	.120
5000	171.55	369	260	58.7	.135	5000	171.96	345	236	59.4	.145
6000	201.55	443	323	57.8	.165	6000	201.96	418	291	59.0	.175
7000	231.55	521	393	57.0	.195	7000	231.96	503	354	58.7	.200
8000	261.55	614	479	56.2	.235	8000	261.96	591	429	57.9	.240
9000	291.55	702	562	55.5	.270	9000	291.96	681	504	57.5	.275
10 000	321.55	792	651	54.9	.310	10 000	321.96	783	585	57.2	.315
11 000	351.55	883	742	54.3	.345	11 000	351.96	879	662	57.0	.355
12 000	381.55	985	838	54.0	.390	12 000	381.96	978	745	56.8	.390
13 000	411.55	1078	928	53.7	.430	13 000	411.96	1103	851	56.4	.440
14 000	441.55	1184	1019	53.7	.470	14 000	441.96	1193	935	56.1	.475
15 000	471.55	1297	1125	53.6	.515	15 000	471.96	1324	1024	56.4	.525
16 000	501.55	1478	1280	53.6	.580	16 000	501.96	1436	1116	56.3	.565
16 650	521.05	-----	1547	-----	.645	17 000	531.96	1596	1224	56.6	.625
15 000	471.55	1750	2068	45.8	.685	17 410	544.26	-----	1311	-----	.670
						17 850	557.46	1866	1431	56.6	.730
						17 880	558.36	-----	1600	-----	.785
						16 800	525.96	2034	1680	54.8	.805
BEAM 482						BEAM 494					
0	20.93	35	24	59.3	0.015	0	21.76	42	26	62.0	0.010
1000	50.93	99	58	63.0	.030	1000	51.76	104	65	61.6	.035
2000	80.93	160	94	62.9	.050	2000	81.76	170	108	61.1	.060
3000	110.93	225	138	62.0	.075	3000	111.76	234	149	61.1	.080
4000	140.93	294	190	60.8	.095	4000	141.76	302	197	60.5	.100
5000	170.93	362	244	59.8	.115	5000	171.76	377	255	59.6	.130
6000	200.93	437	308	58.7	.140	6000	201.76	452	308	59.5	.165
7000	230.93	517	379	57.7	.215	7000	231.76	534	374	58.8	.195
8000	260.93	615	463	57.0	.250	8000	261.76	628	453	58.1	.225
9000	290.93	711	549	56.4	.285	9000	291.76	721	533	57.5	.260
10 000	320.93	804	632	56.0	.325	10 000	321.76	809	614	56.9	.295
11 000	350.93	903	713	55.9	.350	11 000	351.76	909	697	56.6	.340
12 000	380.93	1011	793	56.0	.400	12 000	381.76	1011	781	56.4	.375
13 000	410.93	1122	885	55.9	.440	13 000	411.76	1126	868	56.5	.415
14 000	440.93	1226	974	55.7	.480	14 000	441.76	1240	956	56.5	.455
15 000	470.93	1355	1063	56.0	.525	15 000	471.76	1367	1046	56.6	.505
16 000	500.93	1511	1183	56.1	.580	16 000	501.76	1501	1149	56.6	.555
16 650	520.43	-----	1366	-----	.635	17 000	531.76	1746	1374	56.0	.635
17 000	530.93	1782	1520	54.0	.665	17 500	546.76	-----	1515	-----	.685
17 300	539.93	-----	1677	-----	.700	17 800	555.76	2005	1651	54.8	.725
17 500	545.93	-----	1785	-----	.775	17 950	560.26	-----	1706	-----	.765
16 100	503.93	2069	2190	48.6	.810	18 000	561.76	2135	1769	54.7	.780
						18 140	565.96	-----	1807	-----	.805
						16 300	510.76	2239	2200	50.4	.830

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 423						BEAM 435					
0	21.34	37	29	56.3	0.010	0	20.93	37	29	56.3	0.010
1000	51.34	90	67	57.3	.030	1000	50.93	100	72	58.0	.035
2000	81.34	148	108	57.8	.050	2000	80.93	153	115	57.2	.050
2500	96.34	177	132	57.3	.065	2500	95.93	191	140	57.6	.065
3000	111.34	214	169	55.9	.080	3000	110.93	229	169	57.5	.080
3500	126.34	246	202	55.0	.090	3500	125.93	259	195	57.0	.090
4000	141.34	282	243	53.7	.105	4000	140.93	296	231	56.2	.105
4500	156.34	328	308	51.6	.125	4500	155.93	329	270	54.9	.120
5000	171.34	381	398	48.9	.150	5000	170.93	379	328	53.6	.140
5500	186.34	458	603	43.2	.210	5500	185.93	432	405	51.6	.165
6000	201.34	536	788	30.5	.260	6000	200.93	479	480	49.9	.190
6500	216.34	591	933	38.8	.310	7000	230.93	577	646	47.2	.240
6610	219.64	-----	1101	-----	.360	8000	260.93	673	831	44.8	.300
5100	174.34	602	1897	24.1	.400	9000	290.93	786	1019	43.6	.370
						9500	305.93	-----	1210	-----	.420
						7650	250.43	863	1798	32.4	.440
BEAM 424						BEAM 436					
0	21.14	32	21	60.1	0.015	0	21.34	32	29	52.5	0.015
1000	51.14	84	56	60.0	.035	1000	51.34	88	65	57.4	.035
2000	81.14	133	99	57.2	.055	2000	81.34	138	113	54.9	.055
2500	96.14	171	126	57.6	.065	2500	96.34	172	137	55.7	.070
3000	111.14	206	162	56.0	.080	3000	111.34	199	159	55.6	.080
3500	126.14	239	195	55.0	.095	3500	126.34	230	188	55.0	.090
4000	141.14	274	238	53.5	.110	4000	141.34	266	224	54.2	.110
4500	156.14	325	328	49.7	.135	4500	156.34	298	267	52.8	.125
5000	171.14	392	467	45.6	.175	5000	171.34	337	326	50.8	.140
5500	186.14	464	680	40.6	.225	5500	186.34	383	390	49.5	.160
6000	201.14	525	848	38.2	.280	6000	201.34	430	470	47.8	.190
6460	214.94	-----	945	-----	.335	7000	231.34	533	655	44.9	.240
5200	177.14	489	855	36.4	.340	8000	261.34	631	863	42.2	.305
						9000	291.34	724	1072	40.3	.375
						9300	300.34	-----	1202	-----	.410
						8000	261.34	699	1096	38.9	.420
BEAM 425						BEAM 437					
0	21.14	45	34	56.9	0.010	0	20.93	30	27	52.5	0.015
1000	51.14	98	77	55.9	.035	1000	50.93	90	67	57.3	.035
2000	81.14	154	128	54.6	.060	2000	80.93	143	113	55.8	.055
2500	96.14	183	157	53.8	.070	2500	95.93	173	138	55.6	.065
3000	111.14	211	191	52.5	.080	3000	110.93	207	171	54.8	.080
3500	126.14	248	232	51.7	.100	3500	125.93	239	203	54.1	.095
4000	141.14	289	294	49.6	.120	4000	140.93	277	244	53.2	.110
4500	156.14	335	381	46.8	.140	4500	155.93	318	296	51.8	.130
5000	171.14	409	585	41.1	.190	5000	170.93	361	350	50.7	.150
5500	186.14	476	756	38.6	.240	6000	200.93	451	501	47.3	.200
6000	201.14	534	904	37.1	.290	7000	230.93	545	675	44.7	.255
6320	210.74	-----	1029	-----	.330	8000	260.93	634	867	42.2	.315
5100	174.14	499	899	35.7	.350	9000	290.93	738	1056	41.1	.380
						9500	307.43	-----	1253	-----	.435
						8200	266.93	828	1668	33.2	.455

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 447						BEAM 459					
0	20.73	35	24	59.3	0.010	0	21.14	34	22	60.6	0.015
1000	50.73	90	65	58.0	.030	1000	51.14	86	56	60.6	.030
2000	80.73	151	106	58.7	.050	2000	81.14	140	103	57.6	.050
3000	110.73	211	144	59.4	.070	3000	111.14	202	144	58.4	.075
4000	140.73	277	195	58.7	.100	4000	141.14	258	188	57.9	.095
5000	170.73	345	258	57.2	.125	5000	171.14	326	248	56.8	.120
6000	200.73	429	342	55.6	.160	6000	201.14	397	325	55.0	.150
7000	230.73	514	431	54.4	.190	7000	231.14	485	432	52.9	.190
8000	260.73	603	549	52.3	.230	8000	261.14	574	545	51.3	.230
9000	290.73	690	680	50.4	.280	9000	291.14	665	672	49.7	.275
10 000	320.73	784	815	49.0	.335	10 000	321.14	770	800	49.0	.325
11 000	350.73	882	938	48.5	.385	11 000	351.14	868	926	48.4	.370
12 000	380.73	986	1096	47.4	.440	12 000	381.14	959	1051	47.7	.415
12 600	398.73	-----	1354	-----	.500	13 000	411.14	1075	1195	47.4	.470
10 700	341.73	1086	1826	37.3	.510	13 730	433.04	-----	1315	-----	.525
						12 000	381.04	1245	1436	46.4	.620
BEAM 448						BEAM 460					
0	21.14	34	19	63.9	0.010	0	21.14	34	24	58.5	0.010
1000	51.14	92	60	60.4	.030	1000	51.14	90	63	58.7	.030
2000	81.14	137	97	58.5	.050	2000	81.14	140	99	58.6	.050
3000	111.14	185	137	57.5	.075	3000	111.14	196	140	58.3	.070
4000	141.14	253	188	57.4	.100	4000	141.14	253	191	57.0	.095
5000	171.14	317	248	56.1	.130	5000	171.14	318	256	55.4	.120
6000	201.14	379	330	53.5	.155	6000	201.14	398	345	53.6	.150
7000	231.14	478	448	51.6	.195	7000	231.14	480	446	51.9	.190
8000	261.14	561	578	49.3	.240	8000	261.14	566	569	49.9	.230
9000	291.14	639	715	47.2	.290	9000	291.14	658	711	48.1	.280
10 000	321.14	727	851	46.1	.340	10 000	321.14	744	839	47.0	.330
11 000	351.14	826	995	45.4	.395	11 000	351.14	830	961	46.3	.370
12 000	381.14	916	1120	45.0	.445	12 000	381.14	914	1096	45.5	.420
12 830	406.04	-----	1311	-----	.515	13 000	411.14	1006	1234	44.9	.470
10 700	342.14	895	1197	42.8	.520	13 980	440.54	-----	1385	-----	.530
						12 250	388.64	1144	1937	37.1	.550
BEAM 449						BEAM 461					
0	21.14	32	26	55.1	0.010	0	20.93	32	26	55.1	0.015
1000	51.14	92	63	59.3	.030	1000	50.93	86	58	59.8	.035
2000	81.14	146	106	57.9	.050	2000	80.93	138	104	57.0	.060
3000	111.14	204	149	57.7	.070	3000	110.93	206	147	58.3	.080
4000	141.14	264	195	57.5	.090	4000	140.93	266	202	56.9	.105
5000	171.14	334	262	56.0	.120	5000	170.93	336	267	55.7	.135
6000	201.14	401	338	54.3	.150	6000	200.93	425	352	54.7	.170
7000	231.14	490	455	51.9	.190	7000	230.93	519	462	52.9	.220
8000	261.14	581	573	50.3	.230	8000	260.93	609	576	51.4	.260
9000	291.14	669	701	48.8	.280	9000	290.93	714	708	50.2	.310
10 000	321.14	764	839	47.7	.330	10 000	320.93	815	832	49.5	.360
11 000	351.14	845	976	46.4	.380	11 000	350.93	913	959	48.8	.410
12 000	381.14	944	1109	46.0	.430	12 000	380.93	1014	1084	48.3	.460
13 000	411.14	-----	1376	-----	.510	13 000	410.93	1117	1221	47.8	.525
11 000	351.14	1167	2484	32.0	.580	13 100	413.93	-----	1272	-----	.570
						11 500	365.93	1118	1205	48.1	.580

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 471						BEAM 483					
0	21.14	41	26	61.4	0.010	0	21.34	35	24	59.3	0.010
1000	51.14	92	60	50.4	.030	1000	51.34	93	63	59.6	.030
2000	81.14	149	97	60.6	.050	2000	81.34	147	94	61.0	.050
3000	111.14	205	138	59.8	.070	3000	111.34	203	138	59.5	.070
4000	141.14	273	186	59.5	.095	4000	141.34	263	181	59.3	.095
5000	171.14	337	244	58.0	.120	5000	171.34	327	229	58.8	.120
6000	201.14	409	306	57.2	.145	6000	201.34	401	292	57.8	.145
7000	231.14	495	376	56.8	.180	7000	231.34	474	362	56.7	.175
8000	261.14	587	451	56.5	.215	8000	261.34	552	432	56.1	.210
9000	291.14	681	550	55.3	.255	9000	291.34	643	520	55.3	.240
10 000	321.14	781	662	54.1	.300	10 000	321.34	737	609	54.8	.280
11 000	351.14	880	768	53.4	.340	11 000	351.34	831	703	54.2	.325
12 000	381.14	969	870	52.7	.380	12 000	381.34	930	802	53.7	.365
13 000	411.14	1074	988	52.1	.425	13 000	411.34	1021	892	53.4	.405
14 000	441.14	1182	1109	51.6	.475	14 000	441.34	1134	1003	53.1	.455
15 000	471.14	1308	1270	50.7	.535	15 000	471.34	1219	1091	52.8	.490
15 400	483.14	-----	1545	-----	.585	16 000	501.34	1371	1232	52.7	.550
13 400	423.14	1585	2831	35.9	.690	17 000	531.34	-----	1638	-----	.655
						15 900	498.34	1658	2065	44.5	.665
BEAM 472						BEAM 484					
0	21.14	35	21	62.4	0.015	0	21.76	37	21	63.7	0.010
1000	51.14	90	65	58.0	.035	1000	51.76	86	58	59.8	.030
2000	81.14	142	104	57.8	.055	2000	81.76	142	92	60.6	.050
3000	111.14	198	142	58.2	.075	3000	111.76	200	133	60.0	.070
4000	141.14	261	188	58.2	.100	4000	141.76	261	178	59.5	.095
5000	171.14	320	239	57.2	.125	5000	171.76	321	227	58.6	.115
6000	201.14	394	299	56.8	.150	6000	201.76	388	289	57.3	.145
7000	231.14	466	373	55.5	.180	7000	231.76	463	359	56.3	.175
8000	261.14	548	467	54.0	.220	8000	261.76	541	444	54.9	.205
9000	291.14	631	566	52.7	.260	9000	291.76	624	530	54.1	.240
10 000	321.14	721	670	51.8	.300	10 000	321.76	710	624	53.2	.275
11 000	351.14	810	781	50.9	.340	11 000	351.76	797	716	52.7	.315
12 000	381.14	902	891	50.3	.385	12 000	381.76	895	812	52.4	.355
13 000	411.14	1009	1012	49.9	.435	13 000	411.76	992	908	52.2	.395
14 000	441.14	1119	1156	49.2	.485	14 000	441.76	1093	1003	52.1	.440
15 000	471.14	1273	1381	48.0	.565	15 000	471.76	1199	1101	52.1	.480
15 570	488.24	-----	1561	-----	.640	16 000	501.76	1314	1200	52.3	.530
13 500	426.14	1423	2070	40.7	.660	17 000	531.76	1433	1308	52.3	.585
						17 550	548.26	-----	1540	-----	-----
						15 750	494.26	1526	1432	51.6	.685
BEAM 473						BEAM 485					
0	21.14	32	24	57.0	0.010	0	21.55	37	22	62.7	0.010
1000	51.14	90	62	59.1	.030	1000	51.55	87	55	61.3	.030
2000	81.14	145	101	59.0	.055	2000	81.55	145	94	60.7	.050
3000	111.14	198	140	58.6	.075	3000	111.55	203	133	60.4	.075
4000	141.14	266	195	57.7	.105	4000	141.55	265	176	60.1	.095
5000	171.14	330	250	56.9	.130	5000	171.55	329	224	59.5	.120
6000	201.14	405	323	55.7	.160	6000	201.55	400	280	58.8	.145
7000	231.14	491	417	54.1	.195	7000	231.55	477	345	58.0	.175
8000	261.14	578	516	52.8	.230	8000	261.55	560	421	57.1	.210
9000	291.14	667	626	51.6	.275	9000	291.55	645	497	56.5	.245
10 000	321.14	757	735	50.7	.315	10 000	321.55	738	586	55.7	.280
11 000	351.14	854	846	50.2	.360	11 000	351.55	846	687	55.2	.325
12 000	381.14	965	978	49.7	.415	12 000	381.55	937	779	54.6	.365
13 000	411.14	1051	1082	49.3	.460	13 000	411.55	1034	875	54.2	.405
14 000	441.14	1146	1195	49.0	.500	14 000	441.55	1137	971	53.9	.445
14 920	468.74	-----	1368	-----	.570	15 000	471.55	1249	1067	53.9	.490
15 000	471.14	1340	1566	46.1	.590	16 100	504.55	1396	1219	53.4	.545
13 400	423.14	1481	2316	39.0	.660	17 000	531.55	1574	1482	51.5	.615
						15 700	492.55	1923	2641	42.1	.745

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 495						BEAM 426					
0	21.34	41	21	66.2	0.015	0	20.73	35	24	59.3	0.015
1000	51.34	94	55	63.2	.035	1000	50.73	98	75	56.6	.040
2000	81.34	150	85	63.8	.055	2000	80.73	153	121	56.0	.065
3000	111.34	207	121	63.2	.075	2500	95.73	186	152	55.0	.075
4000	141.34	272	164	62.4	.095	3000	110.73	226	191	54.2	.090
5000	171.34	335	209	61.6	.120	3500	125.73	263	231	53.2	.105
6000	201.34	406	258	61.2	.140	4000	140.73	304	285	51.7	.125
7000	231.34	478	313	60.4	.165	4500	155.73	362	378	48.9	.155
8000	261.34	556	376	59.6	.195	5000	170.73	433	525	45.2	.195
9000	291.34	652	448	59.3	.230	5500	185.73	513	723	41.5	.245
10 000	321.34	740	523	58.6	.260	6000	200.73	579	889	39.5	.295
11 000	351.34	838	603	58.2	.300	6460	214.53	1161	-----	-----	-----
12 000	381.34	914	679	57.4	.330	5000	170.73	655	1696	27.9	.375
13 000	411.34	1024	762	57.3	.370						
14 000	441.34	1104	834	57.0	-----						
15 000	471.34	1198	915	56.7	.445						
16 000	501.34	1318	1002	56.8	.485						
17 000	531.34	1409	1079	56.6	.520						
18 100	564.34	1521	1174	56.4	.565						
19 000	591.34	1675	1313	56.0	.620						
19 730	613.24	-----	1602	-----	.680						
18 100	564.34	1821	1950	48.3	.690						
BEAM 496						BEAM 427					
0	21.96	35	24	59.3	0.015	0	20.52	39	27	59.3	0.015
1000	51.96	91	58	61.2	.030	1000	50.52	97	72	57.5	.040
2000	81.96	145	91	61.4	.050	1500	65.52	127	97	56.7	.050
3000	111.96	205	130	61.2	.070	2000	80.52	158	123	56.2	.065
4000	141.96	265	169	61.0	.090	2500	95.52	191	154	55.4	.075
5000	171.96	321	210	60.4	.110	3000	110.52	226	190	54.3	.095
6000	201.96	382	260	59.5	.135	3500	125.52	262	227	53.6	.110
7000	231.96	448	316	58.7	.165	4000	140.52	314	291	51.9	.135
8000	261.96	520	383	57.6	.195	4500	155.52	378	388	49.4	.160
9000	291.96	589	453	56.5	.225	5000	170.52	465	556	45.5	.210
10 000	321.96	665	526	55.8	.255	5500	185.52	539	670	44.6	.260
11 000	351.96	741	603	55.1	.290	6000	200.52	609	802	43.1	.305
12 000	381.96	828	691	54.5	.325	6500	215.52	680	926	42.4	.385
13 000	411.96	908	773	54.0	.360	4700	161.52	703	1800	28.1	.410
14 000	441.96	1004	862	53.8	.400						
16 000	501.96	1190	1031	53.6	.475						
17 000	531.96	1294	1120	53.6	.515						
18 000	561.96	1392	1217	53.4	.560						
19 000	591.96	1493	1320	53.1	.605						
19 520	607.56	-----	1443	-----	.650						
19 700	612.96	-----	1579	-----	.690						
17 500	546.96	(1833)	2340	43.9	.745						
BEAM 497						BEAM 428					
0	21.55	34	15	69.7	0.015	0	20.93	37	26	58.8	0.015
1000	51.55	91	53	63.2	.035	1000	50.93	95	68	58.3	.035
2000	81.55	141	85	62.4	.055	1500	65.93	129	94	57.9	.050
3000	111.55	199	121	62.2	.075	2000	80.93	156	118	56.9	.060
4000	141.55	251	152	62.3	.095	2500	95.93	190	145	56.7	.070
5000	171.55	309	198	61.0	.115	3000	110.93	222	178	55.5	.085
6000	201.55	373	246	60.3	.140	3500	125.93	262	217	54.7	.100
7000	231.55	442	304	59.3	.170	4000	140.93	314	284	52.5	.125
8000	261.55	512	362	58.6	.195	4500	155.93	375	368	50.5	.165
9000	291.55	586	427	57.8	.225	5000	170.93	442	494	47.2	.190
10 000	321.55	667	497	57.3	.260	5500	185.93	514	639	44.6	.235
11 000	351.55	750	568	56.9	.290	6000	200.93	586	809	42.0	.285
12 000	381.55	835	641	56.6	.320	6400	212.93	-----	949	-----	-----
13 000	411.55	921	715	56.3	.360	4800	164.93	1053	921	53.3	.430
14 000	441.55	1010	786	56.2	.395						
15 000	471.55	1098	865	55.9	.430						
16 000	501.55	1196	942	55.9	.470						
17 000	531.55	1286	1015	55.9	.510						
18 000	561.55	1400	1109	55.8	.555						
19 000	591.55	1499	1191	55.7	.595						
20 000	621.55	1655	1385	54.4	.690						

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 438						BEAM 450					
0	19.90	41	27	60.5	0.015	0	20.52	39	24	62.0	0.015
1000	49.90	103	70	59.4	.040	1000	50.52	99	62	61.5	.035
2000	79.90	166	115	59.1	.060	2000	80.52	163	103	61.3	.060
2500	94.90	202	144	58.4	.080	3000	110.52	229	144	61.2	.080
3100	112.90	247	178	58.1	.090	4000	140.52	295	197	59.9	.105
3500	124.90	277	207	57.3	.105	5000	170.52	370	270	57.8	.135
4000	139.90	322	243	57.0	.120	6000	200.52	463	373	55.4	.175
4500	154.90	366	289	55.9	.140	7000	230.52	570	504	53.1	.220
5000	169.90	419	349	54.6	.160	8000	260.52	678	648	51.1	.270
5500	184.90	476	417	53.3	.185	9000	290.52	785	793	49.7	.320
6000	199.90	530	489	52.0	.210	10 000	320.52	903	957	48.5	.380
7000	229.90	652	692	48.5	.275	11 000	350.52	1010	1104	47.8	.440
8000	259.90	775	904	46.2	.350	12 000	380.52	1122	1272	46.9	.500
9000	289.90	901	1125	44.5	.425	10 500	335.52	1283	2079	38.2	.570
9500	304.90	-----	1325	-----	-----						
8000	259.90	1019	1860	35.4	.510						
BEAM 439						BEAM 451					
0	20.52	39	27	59.3	0.015	0	20.52	42	21	66.7	0.015
1000	50.52	97	72	57.5	.035	1000	50.52	102	60	63.0	.035
2000	80.52	158	115	57.8	.055	2000	80.52	167	99	62.8	.055
2500	95.52	187	138	57.6	.070	3000	110.52	231	147	61.1	.080
3000	110.52	222	164	57.5	.085	4000	140.52	300	200	60.0	.105
4000	140.52	289	222	56.5	.110	5000	170.52	376	272	58.1	.135
4500	155.52	333	267	55.5	.130	6000	200.52	466	369	55.8	.170
5000	170.52	379	326	53.8	.150	7000	230.52	566	497	53.3	.215
6000	200.52	483	463	51.1	.195	8000	260.52	669	646	50.9	.265
7000	230.52	600	648	48.1	.260	9000	290.52	775	798	49.3	.320
8000	260.52	709	836	45.9	.325	10 000	320.52	878	961	47.7	.375
9000	290.52	816	1009	44.7	.390	11 000	350.52	987	1120	46.9	.430
9930	318.42	-----	1174	-----	-----	12 000	380.52	-----	1297	-----	-----
7400	242.52	744	933	44.4	.475	10 300	329.52	1134	1834	38.2	.510
BEAM 440						BEAM 452					
0	20.52	37	26	58.8	0.015	0	20.31	37	24	60.7	0.010
1000	50.52	99	70	58.7	.040	1000	50.31	100	60	62.5	.030
2000	80.52	156	115	57.5	.060	2000	80.31	164	108	60.2	.050
3000	110.52	217	164	57.0	.085	3000	110.31	228	152	60.0	.080
3500	125.52	253	195	56.5	.100	4000	140.31	299	207	59.1	.100
4000	140.52	289	224	56.3	.115	5000	170.31	369	277	57.1	.130
4500	155.52	331	265	55.5	.135	6000	200.31	451	368	55.1	.170
5000	170.52	377	323	53.9	.155	7000	230.31	547	479	53.3	.210
6000	200.52	482	474	50.4	.210	8000	260.31	648	615	51.3	.265
7000	230.52	600	667	47.4	.270	9000	290.31	747	750	49.9	.315
8000	260.62	710	863	45.1	.340	10 000	320.31	848	894	48.7	.370
9000	290.52	813	1034	44.0	.410	11 000	350.31	955	1039	47.9	.425
9850	316.02	-----	1183	-----	-----	12 000	380.31	1079	1227	46.8	.505
7900	257.52	936	1879	33.2	.500	10 900	347.31	1216	1991	37.9	.570

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 462						BEAM 474					
0	21.95	42	15	73.3	0.015	0	22.16	43	20	67.2	0.015
1000	51.95	84	43	66.3	.035	1000	52.16	100	56	64.1	.045
2000	81.95	163	81	66.8	.060	2000	82.16	164	93	63.7	.065
3000	111.95	219	122	64.2	.080	3000	112.16	226	131	63.4	.085
4000	141.95	275	182	60.2	.110	4000	142.16	296	181	62.0	.115
5000	171.95	340	251	57.6	.140	5000	172.16	373	241	60.7	.145
6000	201.95	405	326	55.4	.170	6000	202.16	457	319	58.9	.180
7000	231.95	489	423	53.7	.210	7000	232.16	552	418	56.9	.220
8000	261.95	603	538	52.9	.255	8000	262.16	650	527	55.2	.260
9000	291.95	684	653	51.2	.300	9000	292.16	749	633	54.2	.305
10 000	321.95	775	793	49.4	.355	10 000	322.16	851	760	52.9	.350
11 000	351.95	877	928	48.6	.405	11 000	352.16	956	868	52.4	.395
12 000	381.95	971	1053	48.0	.455	12 000	382.16	1064	997	51.6	.450
13 000	411.95	1065	1186	47.3	.510	13 000	412.16	1179	1150	50.6	.505
13 900	438.95					14 000	442.16	1353	1370	49.7	.580
11 500	366.95	1059	1261	45.6	.600	14 480	456.56				
						13 100	415.16	1424	1883	43.1	.650
BEAM 463						BEAM 475					
0	20.73	37	29	56.3	0.010	0	21.14	39	24	62.0	0.015
1000	50.73	95	75	56.0	.030	1000	51.14	89	58	60.6	.035
2000	80.73	152	123	55.2	.055	2000	81.14	142	97	59.4	.055
3000	110.73	212	171	55.4	.075	3000	111.14	203	142	58.9	.075
4000	140.73	281	219	56.2	.105	4000	141.14	260	185	58.5	.095
5000	170.73	344	272	55.8	.130	5000	171.14	320	241	57.0	.125
6000	200.73	424	347	55.0	.165	6000	201.14	384	301	56.1	.150
7000	230.73	503	439	53.4	.200	7200	237.14	480	397	54.7	.190
8000	260.73	596	561	51.5	.245	8000	261.14	548	472	53.7	.225
9000	290.73	691	696	49.8	.295	9000	291.14	631	571	52.5	.265
10 000	320.73	787	829	48.7	.345	10 000	321.14	733	684	51.7	.315
11 000	350.73	886	959	48.0	.395	11 000	351.14	818	785	51.0	.355
12 000	380.73	989	1089	47.6	.450	12 000	381.14	915	896	50.5	.405
13 000	410.73	1095	1226	47.2	.510	13 000	411.14	1010	1007	50.1	.450
13 350	421.23		1303			14 000	441.14	1110	1121	49.7	.505
11 500	365.73	1116	1169	48.8	.575	15 000	471.14	1217	1246	49.4	.565
						15 250	478.64		1285		
						13 900	438.14	1208	1200	50.1	.620
BEAM 464						BEAM 476					
0	20.52	39	27	59.3	0.010	0	20.73	42	26	62.0	0.015
1000	50.52	100	65	60.7	.030	1000	50.73	104	65	61.6	.040
2000	80.52	162	106	60.5	.055	2000	80.73	168	106	61.3	.060
3000	110.52	226	152	59.8	.075	3000	110.73	231	150	60.6	.085
4000	140.52	295	207	58.8	.110	4000	140.73	302	200	60.2	.115
5000	170.52	374	272	57.9	.135	5000	170.73	374	258	59.2	.140
6000	200.52	452	350	56.4	.180	6000	200.73	457	337	57.5	.175
7000	230.52	560	460	54.9	.220	7000	230.73	550	431	56.1	.215
8000	260.52	667	579	53.5	.265	8000	260.73	657	538	55.0	.280
9000	290.52	758	699	52.0	.315	9000	290.73	755	658	53.4	.305
10 000	320.52	857	824	51.0	.360	10 000	320.73	872	802	52.1	.355
11 000	350.52	964	962	50.1	.415	11 000	350.73	973	916	51.5	.405
12 000	380.52	1065	1087	49.5	.470	12 000	380.73	1085	1044	50.9	.455
13 000	410.52	1187	1238	49.0	.535	13 000	410.73	1223	1215	50.2	.515
13 250	418.02		1379			14 000	440.73	1374	1462	48.4	.585
11 500	365.52	1215	1262	49.0	.630	14 240	447.93		1668		
						13 050	412.23	1587	2296	40.9	.695

Appendix II—Log Sheets of Concrete Beams—Continued

Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches	Applied Load, lbs.	M bd ² lbs. per sq. in.	Deformation, millionths of inch per inch		K, per cent	Deflection, inches
		Upper Fiber	Steel Fiber					Upper Fiber	Steel Fiber		
BEAM 486						BEAM 498					
0	21.95	34	34	60.4	0.010	0	21.34	39	22	64.0	0.015
1000	51.95	93	85	62.6	.030	1000	51.34	97	55	63.7	.035
2000	81.95	149	144	61.1	.055	2000	81.34	152	92	62.3	.055
3000	111.95	216	202	62.0	.080	3000	111.34	210	128	62.1	.075
4000	141.95	281	270	61.2	.100	4100	144.34	277	169	62.1	.095
5000	171.95	352	335	61.5	.125	5000	171.34	336	207	61.9	.120
6000	201.95	431	421	60.7	.155	6000	201.34	404	255	61.3	.145
7000	231.95	514	518	59.8	.185	7000	231.34	481	311	60.7	.170
8000	261.95	603	626	58.9	.220	8000	261.34	578	379	60.4	.205
9000	291.95	699	740	58.3	.260	9000	291.34	666	462	59.1	.245
10 000	321.95	796	853	57.9	.300	10 000	321.34	756	545	58.1	.275
11 000	351.95	903	978	57.6	.345	11 000	351.34	842	622	57.5	.310
12 000	381.95	1010	1108	57.2	.385	12 000	381.34	924	704	56.8	.355
13 000	411.95	1122	1241	57.0	.430	13 000	411.34	1026	790	56.5	.385
14 000	441.95	1229	1368	56.8	.480	14 000	441.34	1119	879	56.0	.425
15 000	471.95	1347	1501	56.8	.525	15 000	471.34	1231	976	55.8	.470
16 000	501.95	1524	1730	56.2	.595	16 000	501.34	1324	1058	55.6	.505
17 000	531.95	1677	2222	51.6	.675	17 000	531.34	1445	1147	55.7	.555
15 500	486.95	1883	2949	46.8	.720	18 000	561.34	1590	1256	55.9	.610
						19 000	591.34	1747	1479	54.1	.675
						19 250	598.84	1665			
						17 400	543.34	1782	1576	53.1	.795
BEAM 487						BEAM 499					
0	21.14	37	22	62.7	0.015	0	23.19	44	15	74.4	0.010
1000	51.14	91	58	61.2	.030	1000	53.19	94	47	66.7	.030
2100	84.14	150	94	61.5	.055	2000	83.19	149	78	65.7	.050
3000	111.14	202	132	60.4	.075	3100	116.19	204	113	64.4	.070
4000	141.14	260	171	60.3	.095	4000	143.19	266	146	64.5	.090
5000	171.14	319	214	59.8	.115	5100	176.19	335	192	63.6	.115
6000	201.14	387	265	59.3	.145	6000	203.19	393	231	63.0	.140
7000	231.14	461	330	58.3	.170	7000	233.19	465	292	61.4	.165
8000	261.14	538	409	56.8	.205	8000	263.19	533	359	59.8	.195
9000	291.14	619	484	56.1	.240	9000	293.19	608	433	58.4	.225
10 000	321.14	714	576	55.4	.275	10 000	323.19	682	503	57.6	.255
11 000	351.14	792	656	54.7	.310	11 000	353.19	768	571	57.4	.290
12 000	381.14	889	752	54.2	.350	12 000	383.19	848	669	55.9	.325
13 000	411.14	970	836	53.7	.390	13 000	413.19	928	760	55.0	.365
14 000	441.14	1079	932	53.6	.435	14 000	443.19	1000	848	54.1	.400
15 000	471.14	1151	1015	53.1	.470	15 000	473.19	1110	922	54.6	.435
16 000	501.14	1242	1103	53.0	.520	16 000	503.19	1209	1002	54.7	.480
17 000	531.14	1360	1207	53.0	.570	17 000	533.19	1311	1096	54.5	.520
18 000	561.14	1456	1350	51.9	.620	18 000	563.19	1426	1210	54.1	.570
15 600	489.14	1400	1299	51.9	.680	19 000	593.19	1584	1445	52.3	.630
						19 800	617.19				
						17 500	548.19	1797	2289	44.0	.725
BEAM 488						BEAM 500					
0	21.14	35	21	62.4	0.015	0	21.34	39	19	67.2	0.015
1000	51.14	92	55	62.7	.035	1000	51.34	102	53	65.7	.030
2000	81.14	155	96	61.7	.055	2000	81.34	154	85	64.4	.055
3000	111.14	210	132	61.4	.075	3100	114.34	215	126	63.1	.075
4000	141.14	274	176	60.8	.100	4000	141.34	265	166	61.4	.095
5000	171.14	332	221	60.0	.120	5000	171.34	333	210	61.3	.120
6000	201.14	402	280	59.0	.145	6000	201.34	402	255	61.2	.140
7000	231.14	478	349	57.8	.175	7000	231.34	462	306	60.2	.170
8000	261.14	550	424	56.5	.210	8000	261.34	537	371	59.2	.200
9000	291.14	639	515	55.4	.245	9000	291.34	606	438	58.1	.230
10 000	321.14	721	607	54.3	.285	10 000	321.34	682	509	57.2	.260
11 000	351.14	808	696	53.7	.325	11 000	351.34	771	595	56.5	.300
12 000	381.14	898	785	53.4	.365	12 000	381.34	860	672	56.1	.335
13 000	411.14	998	877	53.2	.405	13 000	411.34	950	754	55.8	.370
14 000	441.14	1096	971	53.0	.450	14 000	441.34	1037	832	55.5	.405
15 000	471.14	1200	1070	52.9	.490	15 000	471.34	1120	908	55.2	.445
16 000	501.14	1300	1174	52.5	.535	16 000	501.34	1222	993	55.2	.485
17 000	531.14	1422	1320	51.9	.595	17 000	531.34	1320	1089	54.8	.525
17 850	556.64		1603			18 000	561.34	1428	1198	54.4	.570
15 500	486.14	1632	2179	42.8	.685	19 000	591.34	1577	1385	53.2	.635
						19 760	614.14		1658		
						17 900	558.34	2001	2600	43.5	.805

Appendix III—Additional Beam Data

1:2:4 GRANITE CONCRETE BEAMS

No. of Beam	Cross Section	First Crack	Crack of Failure	No. of Beam	Cross Section	First Crack	Crack of Failure
	Inches	Ft in	Ft in		Inches	Ft in	Ft in
162	8.00x11.00	0 8	1 2	169	8.00x11.13	.....	2 6
163	8.06x11.19	1 6	0 6	170	8.06x11.13	.....	1 6
164	8.06x11.00	0 4	0 4	180	8.00x11.13	.....	0 4
174	8.00x10.88	0 3	0 6	181	8.06x11.06	.....	1 10
175	8.00x10.88	0 6	1 6	182	8.06x11.06	.....	1 6
176	7.94x10.94	0 8	0 6	192	8.00x11.00	.....	1 2
186	7.94x11.25	1 0	2 0	193	8.00x10.94	.....	0 6
187	8.00x11.00	0 4	0 10	194	8.06x11.19	.....	1 2
188	8.06x11.19	0 9	1 0	204	8.00x11.19	.....	0 10
198	8.00x11.06	0 6	1 0	205	8.06x11.06	.....	0 10
199	8.00x11.00	0 0	1 3	206	8.06x11.06	.....	0 11
200	8.00x11.19	.....	0 10	216	8.06x11.00	.....	0 5
210	8.00x11.06	0 10	0 6	217	8.06x11.13	.....	0 11
211	8.00x11.25	0 5	1 10	218	8.00x11.06	.....	0 10
212	8.00x10.94	0 6	0 0	231	8.00x11.13	.....	0 7
222	8.00x11.00	0 2	0 0	232	8.00x11.19	.....	0 5
223	8.00x11.06	1 1	0 1	233	8.00x11.00	.....	0 0
224	8.00x11.06	.....	0 2	240	8.00x11.13	.....	1 5
237	8.00x11.00	.....	1 6	....	.....	.....	.....
238	8.06x10.88	0 10	1 1	242	8.06x11.00	.....	1 0
239	8.13x11.00	0 8	1 3	171	8.00x11.25	0 1	0 1
165	8.00x11.00	0 6	0 6	172	8.06x11.00	0 0	0 0
166	8.00x11.00	0 6	0 1	173	8.06x11.13	.....	1 5
167	8.00x11.00	0 5	1 8	183	8.06x11.13	.....	1 0
177	8.00x11.00	0 2	1 4	184	8.06x11.13	.....	1 1
178	8.13x10.94	0 0	1 3	185	8.06x11.25	.....	1 4
179	8.00x11.13	0 0	1 3	195	8.06x11.13	.....	1 9
189	8.00x11.00	0 2	0 2	196	8.06x11.13	.....	1 0
190	8.00x11.00	0 3	1 6	197	8.00x11.13	.....	1 3
191	7.94x11.06	2 0	0 2	207	8.00x11.13	.....	0 2
201	8.00x11.13	.....	0 3	208	8.06x11.00	.....	0 5
202	8.00x11.06	0 4	0 0	209	8.06x11.13	.....	2 1
203	8.00x11.00	0 5	0 5	219	8.06x11.19	.....	2 3
213	8.00x11.06	.....	2 1	220	8.06x11.19	.....	0 1
214	8.00x11.00	.....	0 11	221	8.06x11.19	.....	1 2
215	7.94x11.00	0 0	0 0	228	8.06x11.00	.....	0 3
225	8.00x11.00	.....	0 5	229	8.00x11.19	.....	1 2
226	8.00x11.13	.....	0 11	230	8.06x11.16	.....	1 8
227	8.00x11.00	0 6	1 3	234	8.00x11.00	.....	0 7
243	8.00x11.13	.....	0 0	235	8.06x11.00	.....	1 7
244	8.06x11.06	0 8	1 9	236	8.06x11.00	.....	1 1
245	8.00x11.13	.....	0 11				

Appendix III—Additional Beam Data—Continued.

1:2:4 LIMESTONE CONCRETE BEAMS

No. of Beam	Cross Section	First Crack	Crack of Failure	No. of Beam	Cross Section	First Crack	Crack of Failure
	Inches	Ft in	Ft in		Inches	Ft in	Ft in
256	8.00x11.00	.....	0 8	252	8.00x11.06	.....	0 4
257	8.00x11.06	0 7	0 7	253	8.06x11.13	.....	0 7
261	8.00x11.38	0 2	2 0	254	8.13x11.31	.....	0 6
262	8.00x11.25	0 6	1 10	267	8.06x11.13	.....	0 6
263	8.00x11.50	.....	1 0	268	8.06x11.19	.....	1 11
273	8.06x11.25	1 9	1 2	269	8.06x11.13	.....	1 6
274	8.00x11.50	1 6	1 0	279	8.00x11.06	.....	1 7
275	8.00x11.31	0 2	0 4	280	8.06x11.13	.....	0 7
285	7.94x11.25	0 8	1 7	281	8.06x11.06	.....	0 2
286	8.06x11.13	.....	1 3	291	8.06x11.13	.....	0 3
287	8.13x11.38	.....	0 2	292	8.06x11.13	.....	0 9
297	8.00x11.31	0 8	0 3	293	8.06x11.13	.....	0 3
298	8.00x11.00	.....	1 4	303	8.13x11.00	.....	1 2
299	7.94x11.38	0 6	0 0	304	8.00x11.19	.....	0 0
318	8.00x11.25	.....	0 11	305	8.00x11.31	.....	0 0
319	8.00x11.06	.....	0 0	315	8.06x11.13	.....	0 8
320	8.06x11.06	.....	0 6	316	8.06x11.31	.....	1 1
321	8.00x11.13	.....	0 7	317	8.06x11.19	.....	0 2
322	8.06x10.94	.....	1 6	327	8.06x11.13	0 1	0 5
323	7.94x11.25	.....	0 2	328	8.06x11.13	.....	1 11
249	8.06x11.13	.....	2 0	...	.....	.....	.....
250	8.06x11.13	0 2	0 2	246	8.06x11.13	.....	1 1
251	8.00x11.13	0 7	0 4	247	8.13x11.19	.....	0 1
264	8.00x11.13	.....	1 5	248	8.06x11.06	.....	2 1
265	8.00x11.13	.....	0 2	270	8.06x11.25	.....	0 7
266	8.00x11.06	.....	0 3	271	8.00x11.38	.....	1 3
276	8.00x11.00	.....	2 0	272	8.06x11.31	.....	0 0
277	8.00x11.25	0 5	0 2	282	8.00x11.31	.....	0 7
278	8.00x11.13	.....	1 10	283	8.06x11.31	.....	0 7
288	8.06x11.06	.....	1 3	284	7.94x11.25	.....	1 1
289	8.00x11.06	0 5	1 3	294	7.94x11.38	.....	0 2
290	8.00x11.19	.....	1 8	295	8.06x11.31	.....	0 10
300	8.00x11.13	.....	1 2	296	8.06x11.25	.....	0 5
301	8.00x11.19	0 9	0 2	306	8.00x11.00	.....	0 0
302	8.00x11.00	.....	0 5	307	8.13x11.31	1 7	0 9
312	8.13x10.94	.....	0 11	308	7.94x11.25	.....	0 2
313	8.00x11.13	.....	1 4	309	8.00x11.19	.....	1 6
314	8.06x11.06	.....	1 5	310	8.06x11.00	1 7	1 5
324	8.00x11.06	.....	1 2	311	8.13x11.06	.....	0 4
325	8.06x11.25	.....	0 7	330	8.06x11.19	2 0	1 7
326	8.00x11.06	.....	0 8	331	8.06x11.00	.....	1 1
				332	7.94x11.06	.....	0 10

Appendix III—Additional Beam Data—Continued.

1:2:4 GRAVEL CONCRETE BEAMS

No. of Beam	Cross Section	First Crack	Crack of Failure	No. of Beam	Cross Section	First Crack	Crack of Failure
	Inches	Ft in	Ft in		Inches	Ft in	Ft in
333	8.00x10.94	0 5	1 2	339	8.06x11.06	0 6	0 6
334	8.13x10.94	0 4	0 1	340	8.06x11.19	.....	0 10
335	8.06x11.19	1 6	1 6	341	8.06x11.00	.....	1 8
345	8.00x11.00	.....	1 2	351	8.06x11.13	.....	0 5
346	8.00x11.00	.....	0 8	352	8.06x11.25	.....	1 4
347	8.00x11.00	.....	0 0	353	8.06x11.06	.....	1 3
357	8.00x11.00	.....	1 0	363	8.06x11.13	0 9	0 9
358	8.00x10.94	0 0	0 5	364	8.06x11.25	.....	1 1
359	8.00x11.13	.....	1 6	365	8.06x11.06	.....	0 6
369	8.06x11.00	0 8	1 2	375	8.00x11.19	1 7	1 5
370	8.00x11.00	0 4	0 0	376	8.06x11.19	.....	1 4
371	7.94x10.81	.....	1 10	377	8.06x11.06	.....	1 5
381	7.88x11.00	.....	0 7	387	8.06x11.00	.....	0 3
382	8.06x11.00	0 8	1 1	388	8.00x11.25	.....	0 6
383	8.00x11.06	.....	0 10	389	8.06x11.00	.....	1 2
393	8.00x10.94	.....	1 6	399	8.06x11.00	.....	0 0
394	8.00x10.88	0 5	1 6	400	8.00x11.31	.....	0 8
395	8.00x11.13	.....	0 5	401	8.00x11.06	0 0	1 3
405	7.94x10.94	0 4	0 8	.....	.....	.....	.....
406	8.00x10.94	1 9	0 2	412	8.06x11.13	0 7	1 3
407	8.00x10.88	.....	0 3	413	8.06x11.06	.....	2 0
336	8.00x11.13	1 8	1 2	342	7.94x11.13	0 6	0 6
337	8.06x11.19	0 7	1 6	343	8.06x10.94	.....	1 5
338	8.06x11.06	1 8	0 2	344	8.06x10.88	.....	1 3
348	8.00x11.00	.....	0 11	354	8.00x11.00	.....	0 0
349	8.00x11.19	.....	0 5	355	8.06x11.00	.....	0 5
350	8.00x11.00	.....	0 11	356	8.00x11.06	.....	1 2
360	8.00x11.06	.....	0 6	366	7.94x11.13	.....	0 1
361	8.06x11.25	1 10	1 1	367	8.06x11.06	.....	1 1
362	8.00x11.00	1 11	1 2	368	8.06x10.94	.....	0 10
372	8.00x11.06	.....	0 5	378	8.00x10.88	.....	0 3
373	8.00x11.13	.....	1 0	379	8.00x11.00	.....	1 3
374	8.00x11.06	.....	0 3	380	7.94x11.06	.....	0 4
384	8.06x11.06	.....	0 2	390	8.06x11.00	.....	0 9
385	8.00x11.06	.....	0 7	391	8.06x11.13	.....	0 8
386	8.00x11.00	0 3	0 8	392	8.06x10.94	.....	0 8
396	8.00x11.06	1 0	0 0	402	8.06x11.00	.....	0 6
397	8.00x11.13	.....	0 3	403	8.06x11.00	.....	1 5
398	8.06x10.94	.....	0 5	404	8.00x11.06	0 0	0 7
408	8.00x11.06	.....	1 2	414	8.00x10.94	.....	0 6
409	8.00x11.13	1 9	0 8	415	8.00x11.00	.....	0 11
410	8.00x11.13	.....	0 7	416	8.06x10.88	0 6	0 5

Appendix III—Additional Beam Data—Continued

1:2:4 CINDER CONCRETE BEAMS

No. of Beam	Cross Section	First Crack	Crack of Failure	No. of Beam	Cross Section	First Crack	Crack of Failure
	Inches	Ft in	Ft in		Inches	Ft in	Ft in
417	8.00x10.94	0 7	1 4	423	8.06x11.06	0 0	0 10
418	8.00x11.00	.....	0 10	424	8.00x11.13	.....	1 8
419	8.00x11.00	.....	1 7	425	8.06x11.06	.....	1 10
429	8.00x11.00	0 10	0 0	435	8.00x11.00	0 6	0 7
430	8.00x10.94	0 9	0 5	436	8.06x11.19	.....	1 9
431	8.00x10.88	1 6	1 6	437	8.00x11.13	.....	0 5
441	8.00x10.81	1 7	1 2	447	8.06x11.13	.....	0 9
442	8.00x10.94	.....	1 0	448	8.00x11.31	.....	1 5
443	8.00x11.00	.....	1 2	449	8.06x11.13	.....	0 7
453	7.88x10.94	.....	0 3	459	8.00x11.19	.....	0 3
454	8.00x11.00	.....	1 4	460	8.06x11.19	.....	0 7
455	8.00x10.94	.....	0 5	461	8.00x11.00	.....	1 10
465	8.00x10.88	.....	0 3	471	8.00x11.13	.....	0 10
466	8.00x11.06	.....	0 6	472	8.00x11.19	.....	0 3
467	7.94x10.94	.....	0 2	473	8.00x11.06	.....	0 5
477	7.94x11.00	.....	1 0	483	8.06x11.13	.....	0 2
478	8.00x11.06	.....	1 10	484	8.00x11.25	.....	2 0
479	8.00x11.00	.....	1 0	485	8.06x11.06	.....	0 11
489	8.00x10.88	0 7	0 9	495	8.06x11.06	1 10	1 2
490	8.00x11.13	.....	0 6	496	8.00x11.19	.....	0 5
491	7.94x11.44	.....	0 3	497	8.06x11.06	.....	1 3
420	7.94x11.06	0 3	0 3	426	7.94x11.00	.....	0 10
421	8.00x11.13	.....	0 2	427	7.94x10.94	.....	0 4
422	8.00x11.06	.....	0 2	428	8.00x10.88	0 6	1 3
432	8.00x11.06	.....	1 10	438	8.00x10.88	.....	0 1
433	8.00x11.19	0 2	1 11	439	8.00x10.88	.....	1 6
434	8.06x11.13	.....	0 11	440	8.06x10.88	.....	0 7
444	8.06x11.06	.....	0 8	450	8.06x10.81	0 0	0 7
445	8.13x11.19	0 6	0 8	451	8.00x11.19	.....	0 9
446	8.00x11.13	.....	0 2	452	7.94x11.00	.....	0 6
456	8.00x11.06	.....	0 10	462	7.94x11.13	.....	1 8
457	7.94x11.19	.....	1 6	463	8.00x11.00	.....	1 3
458	8.06x11.00	.....	0 10	464	8.06x10.81	.....	1 5
468	8.00x11.00	.....	1 3	474	8.06x10.81	.....	0 5
469	8.00x11.00	.....	.....	475	8.00x11.13	.....	1 5
470	8.00x11.19	0 5	0 2	476	7.94x10.88	.....	0 3
480	8.00x11.06	1 6	0 5	486	8.00x10.81	.....	0 8
...	.....	.....	.....	487	8.00x11.19	.....	1 8
482	8.00x11.13	2 0	0 2	488	8.00x11.06	.....	0 8
492	8.00x11.06	.....	0 10	498	8.00x10.94	.....	2 0
493	8.13x11.19	1 4	1 4	499	8.06x11.00	.....	1 2
494	8.00x11.00	.....	0 0	500	7.94x11.06	.....	0 5