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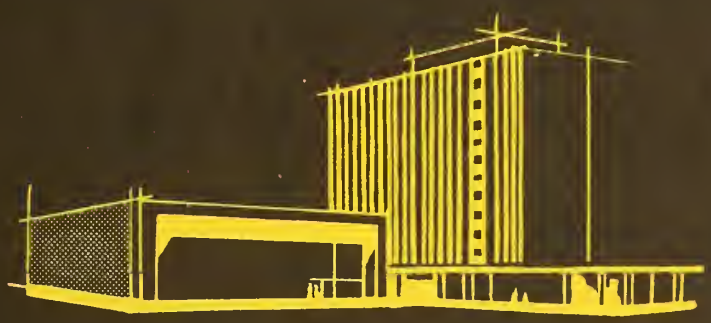

Interrelations Between Cement & Concrete Properties

PART 6

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The Building Science Series

The Building Science Series disseminates technical information developed at the National Bureau of Standards on building materials components, systems and whole structures. The Series presents research results, test methods and performance criteria related to the structura and environmental functions and the durability and safety characteristics of building elements and systems.

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Interrelations Between Cement and Concrete Properties, Part 6

Compilation of Data from Laboratory Studies

James R. Clifton and Robert G. Mathey

Building Research Division
Institute for Applied Technology
National Bureau of Standards
Washington, D.C. 20234

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Contents

Section 14. Compilation of Data from Laboratory Studies

James R. Clifton and Robert G. Mathey

Data are presented on the properties of portland cements, mortars and concretes from a long term study reported principally by Blaine and Arni. These data are from laboratory and exposure plot studies and cover a wide range of properties of cements and concretes. A total of 199 different cements were included in the study.

Key words: Cement; Chemical composition; concrete; durability; material properties; physical properties.

Contents

1. Introduction

The study of the interrelations between cement and concrete properties was started in 1953. The objectives of this long time study were threefold. First, to review the properties of cements being produced at that time. Secondly, to study the extent to which specifications tests could predict the properties of cements and concretes at later ages, and finally, to develop, if possible, better tests for these predictions. To facilitate these objectives, 199 portland cements of various specification types were procured from different manufacturers and geographical areas. These cements were used in preparing neat paste, mortar and concrete test specimens that were subjected to many and various laboratory tests. The results of these tests and chemical analyses of the cements are presented in chapters 2 and 3. Concrete specimens were also prepared for long time exposure to weathering at Langley, Virginia. The latter portion of the investigation, which is intended to evaluate the relative resistance of concretes to weathering and outdoor exposure, has not been completed and will be reported at a later time.

The principal investigators of the study, Interrelations Between Cements and Concrete Properties, R. L. Blaine and H. T. Arni, have reported their work in 13 papers that have been published or are scheduled for publication [1, 2, 3, 4, 5].[1] They presented the results of their work, statistically evaluating correlations between different variables and the properties of the cements, mortars and concretes. The reports on this significant and broad research

[1] Figures in brackets indicate literature references at the end of the paper.

did not include the presentation of test data from the many and various tests.

The need for making the data from the laboratory tests available became evident from requests from other investigators interested in the study. Furthermore, plans have been made to conduct a field study on the properties of the concretes made from the 199 different cements and exposed to natural weather conditions for nearly 17 years. The purpose of the field study is to relate the performance of the exposed concretes with the laboratory investigations in order to determine if the field performance can be predicted from the laboratory studies. Therefore, since these data will be used in evaluating field performance and other investigators may find use for the data, their publication appears desirable.

The following publications are those resulting from the study of Interrelations Between Cement and Concrete Properties [1, 2, 3, 4, 5].

PART 1 Building Science Series 2
Section 1 Materials and techniques
Section 2 Water requirements of portland cement
Section 3 Occurrence of minor and trace elements in portland cement

PART 2 Building Science Series 5
Section 4 Variables associated with expansion in the potential sulfate expansion test
Section 5 Heat of hydration of portland cement
Section 6 Variables associated with small autoclave expansion values of portland cements

PART 3 Building Science Series 8
Section 7 Compressive strength of test mortars
Section 8 Compressive strength of steam-cured portland cement mortars

PART 4 Building Science Series 15
Section 9 Shrinkage of hardened portland cement pastes
Seetion 10 Shrinkage and expansion of concrete

PART 5 Building Science Series (to be published)
Section 11 Freeze-thaw durability of concrete
Section 12 Water-loss and absorption of concrete
Section 13 Dynamic Young's Modulus of elasticity of concretes

All of the available data on the properties of the cements and concretes are presented in chapters 2 and 3, respectively. A brief description is given regarding data presented in each of 15 tables. Readers are advised to refer to the appropriate Sections of the papers by Blaine, Arni et al. for a more complete description of the tests, test methods, material properties and physical properties of the test specimens.

2. Cement Data

The cements were investigated, including the usual specification acceptance tests and in addition determination of minor and trace elements. Other tests were performed such as strength at ages up to 10 years and sulfate expansion on cement mortars and shrinkage tests of neat cement bars. Test data on cements and mortars are given in tables 2.1 to 2.10. The descriptive material pertaining to each of the following tables includes the preparation of test specimens and the methods of testing.

The cement numbers given in the following tables were designated from a chronological order of chemical composition testing and this notation conforms with the designation of all test specimens.

The cements were classified as to type principally on the basis of their chemical composition. The letter A following the type of cement listed in the tables indicates an air-entraining cement. Cements were separated into different types according to the following criteria:

Type V. Portland cements that contain a maximum of the following amounts of major constituents: 50 percent tricalcium silicate, 5 percent tricalcium aluminate, 4 per cent magnesium oxide, and 20 percent the amount of aluminoferrite plus twice the tricalcium aluminate content.

Type IV. Those portland cements containing a maximum of 35 percent tricalcium silicate and 7 percent tricalcium aluminate, and a minimum of 40 percent dicalcium silicate.

Type III. Mortars made from these portland cements developed a minimum one day compressive strength of 1250 psi and a minimum seven day strength of 2500.

Type II. This classification included portland cements having a minimum of 21 percent silicon dioxide and maximum contents of 50 percent tricalcium silicate and 8 percent tricalcium aluminate.

Type I. Portland cements that did not meet the requirements for any type described as Type II through Type V.

Miscellaneous. Natural portland-pozzolan and portland-blast furnace slag cements were included in this category.

In view of present accepted practice in this country, the units used in this paper are those commonly used in this technological field. Furthermore, these units correspond to those reported by Blaine and Arni in their publications "Interrelations Between Cement and Concrete Properties." In recognition of the position of the USA as a signatory to the General Conference on Weights and Measures, which gave official status to the metric SI system of units in 1960, we assist readers interested in making use of the coherent SI units, by giving conversion factors applicable to U.S. units used in this paper.

Length	1 in = 0.0254* meter
	1 ft = 0.3048* meter
Weight	1 lb = 0.4536 kilogram
Temperature	°F = 9/5° C + 32
Energy	cal_{th} = 4.184 joules
Stress, Pressure	1 psi = 6895 newton/meter^2
Density	lb/ft^3 = 16.02 kilogram/meter^3

* Exactly.

2.1. Chemical Analyses—Major Constituents in Cements—Table 2.1

The percent content of the major constituents of the cements listed in table 2.1 were determined by using the optional methods outlined in Federal Specification SS–C–158C [6], except that the SO_3 determinations were made by the gravimetric method, Na_2O and K_2O were determined by the standard Federal and ASTM flame-photometric method [6, 7], and SrO_2 was determined by the flame-photometric method described by Diamond [8].

The nomenclature used in table 2.1 has its normal connotation. The letters C, A, F, and S represents CaO, Al_2O_3, Fe_2O_3, and SiO_2, respectively. The abbreviation T. Alk. is the total alkali, expressed in terms of percent Na_2O, which on a molecular basis equals percent $Na_2O + 0.658$ percent K_2O. The ignition loss, signified by Loss, and the insoluble residue, denoted by Insol., were determined using methods described in Federal Specification and ASTM test methods for portland cements [6, 7].

TABLE 2.1. *Chemical analyses—major constituents in cements*

No.	Percent of major constituents															
	SiO_2	Al_2O_3	Fe_2O_3	CaO	SO_3	MgO	Loss	Insol.	Na_2O	K_2O	T. Alk.	C_3A	C_3S	C_2S	C_4AF	SrO
Type I																
1	19.6	7.0	3.0	63.2	2.2	3.0	0.7	0.2	0.38	0.91	0.98	13	51	18	9	0.29
2	22.6	5.0	2.3	63.4	1.8	3.8	.8	.3	.11	.29	.30	9	44	31	7	.19
3	22.2	5.3	1.7	63.2	2.3	3.7	.6	.4	.20	.60	.59	11	44	31	5	.23
4	19.2	7.2	3.1	63.1	2.4	3.3	.7	.3	.40	.53	.75	14	51	16	9	.36
5	20.6	6.5	3.3	63.0	2.3	2.8	.6	.4	.34	.71	.81	12	45	25	10	.30
6	20.3	6.3	2.3	63.2	1.9	3.5	1.8	.4	.30	.62	.71	13	52	19	7	.38
7	20.6	6.2	2.3	63.1	2.1	4.0	.7	.3	.39	.56	.76	13	49	22	7	.39
8	19.8	7.0	2.5	63.4	2.4	3.2	.9	.4	.34	.59	.73	14	50	19	8	.35
9	20.2	7.0	2.6	62.7	2.1	3.0	1.1	.4	.38	.88	.96	14	45	24	8	.38
10	20.7	5.9	2.1	65.3	1.8	.9	2.9	.5	.16	.55	.52	12	61	14	6	.23
11	20.6	6.3	2.4	62.5	2.3	3.7	1.0	.2	.24	.81	.77	13	45	25	7	.36
12	20.0	7.2	2.5	62.5	2.3	3.1	1.6	.2	.40	.65	.83	15	44	24	8	.36
13	20.1	7.1	2.4	62.7	2.3	3.0	1.6	.3	.39	.63	.80	15	45	24	7	.33
14	19.7	7.1	2.7	63.3	1.8	2.9	1.1	.3	.26	.89	.85	14	51	18	8	.28
15	22.3	6.8	2.8	60.4	2.4	2.9	1.4	.3	.11	1.00	.77	13	20	49	8	.05
16	20.7	6.3	2.6	62.7	1.7	3.8	1.1	.2	.33	.70	.79	12	47	24	8	.36
17	22.2	5.0	2.7	63.4	1.9	3.2	.7	.3	.12	.68	.57	9	46	29	8	.25
18	21.7	5.7	2.1	62.5	2.0	3.5	1.5	.4	.28	.53	.63	12	42	30	6	.31
19	21.1	6.2	2.3	63.3	1.9	3.5	.7	.2	.37	.77	.88	13	47	25	7	.37
20	21.3	5.4	2.6	63.2	2.5	2.9	1.0	.4	.25	1.00	.91	10	48	25	8	.06
21	20.4	6.9	3.0	65.1	2.0	1.4	.6	.0	.07	.44	.36	13	54	18	9	.07
22	22.0	5.1	2.5	64.9	2.3	1.8	.8	.1	.23	.36	.47	9	52	24	8	.10
23	22.5	5.2	2.6	65.7	1.5	1.4	.6	.0	.38	.02	.39	9	54	24	8	.17
25	21.0	6.1	3.3	65.5	1.2	1.9	.7	.1	.06	.42	.34	11	58	17	10	.02
26	20.7	6.0	3.5	63.6	1.6	3.3	.6	.0	.24	.49	.56	10	52	20	11	.19
27	20.8	6.6	3.1	64.9	2.0	.8	1.0	.2	.08	.33	.30	12	52	20	9	.26
28	22.8	5.5	2.2	65.2	1.6	.8	.9	.0	.13	.28	.31	11	47	30	7	.14
29	20.7	6.1	3.3	64.1	2.0	1.7	1.1	.1	.15	.61	.55	11	52	20	10	.28
30	20.6	5.8	3.3	66.4	1.5	.8	.6	.1	.10	.37	.34	10	66	9	10	.18
31	21.7	6.1	2.0	66.0	1.6	1.2	.9	.3	.04	.20	.17	13	55	21	6	.17
32	21.3	5.0	3.4	64.2	1.7	2.7	.8	.0	.16	.53	.51	8	56	19	10	.21
33	21.2	6.4	2.7	64.0	1.8	1.5	1.1	.2	.19	.76	.69	12	47	25	8	.16
34	21.2	5.8	2.6	63.1	1.9	2.5	2.0	.3	.14	.49	.46	11	48	25	8	.04
35	20.5	5.6	4.0	63.2	1.8	3.5	.8	.0	.22	.52	.56	8	53	19	12	.23
36	21.8	4.5	2.3	63.6	1.4	4.3	1.5	.3	.13	.41	.40	8	56	20	7	.12
37	22.4	5.3	2.9	64.5	1.7	.7	1.7	.3	.23	.40	.49	9	48	28	9	.13
38	21.2	6.1	2.4	65.3	2.1	1.4	.9	.1	.08	.45	.38	12	54	20	7	.22
39	21.1	6.5	2.7	64.6	1.4	1.6	1.0	.2	.21	.78	.72	13	51	22	8	.14
40	21.8	5.8	2.6	63.7	2.2	1.6	1.0	.1	1.22	.08	1.28	11	45	29	8	.14
41	21.2	6.6	2.7	62.8	1.9	2.8	.8	.1	0.71	.75	1.20	13	41	30	8	.12

42	22.7	4.0	2.7	63.5	1.7	3.5	1.2	.1	.15	.49	.47	3	57	20	8	.05
43	24.6	2.9	3.0	65.6	1.8	.9	1.0	.0	.12	.22	.26	3	51	32	9	.09
44	21.7	4.7	3.1	64.1	1.7	1.9	2.0	.2	.45	.48	.77	7	55	21	9	.11
45	20.8	5.3	3.2	64.2	2.0	1.9	1.6	.0	.50	.55	.86	9	57	17	10	.14
46	23.5	5.4	.4	66.6	1.8	.4	1.8	.2	.05	.01	.06	14	51	29	1	.06
47	24.4	3.1	3.2	65.4	1.7	1.0	.9	.2	.11	.13	.20	3	52	31	10	.09
48	24.4	3.3	2.0	66.2	1.3	1.8	.8	.0	.12	.26	.29	5	55	28	6	.07
49	21.1	6.3	2.8	64.6	1.6	1.3	1.3	.1	.22	.87	.79	12	52	22	9	.05
50	20.7	5.5	3.5	61.1	2.1	4.8	1.5	.2	.13	.81	.66	9	43	27	11	.10
51	21.9	5.7	2.5	63.0	2.0	2.8	1.0	.3	.38	.82	.92	11	42	31	8	.09
52	21.0	6.1	3.0	63.0	1.9	2.9	1.2	.2	.14	.70	.60	11	46	26	9	.04
54	21.4	5.8	2.2	65.0	2.2	1.8	.6	.2	.17	.80	.70	12	54	21	7	.10
55	20.4	5.6	3.3	64.2	1.6	3.5	1.0	.3	.07	.32	.28	9	59	14	10	.10
56	21.0	5.8	2.9	63.4	2.2	2.6	1.2	.2	.21	.94	.83	10	49	23	9	.05
57	20.8	6.4	2.2	63.8	1.9	2.7	1.9	.6	.10	.17	.21	13	50	22	7	.05
58	22.5	5.6	.4	65.1	1.4	2.8	2.1	.2	.00	.10	.07	14	52	26	1	.07
59	24.4	4.3	.4	64.9	1.5	1.1	3.2	.1	.01	.33	.23	11	45	36	1	.04
71	21.8	4.9	3.6	64.4	1.4	2.6	.5	.1	.48	.53	.83	7	54	22	11	.08
73	22.5	4.6	3.6	64.4	1.5	1.4	1.0	.2	.30	.70	.76	6	51	26	11	.09
124	22.5	4.7	3.2	65.2	1.5	1.3	1.4	.2	.01	.28	.19	7	54	24	10	.05
125	21.5	6.0	2.8	64.5	1.6	1.2	1.4	0.1	0.12	0.80	0.65	11	50	24	8	0.04
126	22.1	5.3	2.5	63.0	1.4	3.5	1.5	.1	.07	.83	.62	10	45	29	8	.02
127	20.8	6.0	3.1	63.2	2.2	3.2	.9	.2	.32	.54	.68	11	48	24	9	.09
128	19.3	7.0	2.5	63.4	2.1	3.0	1.7	.1	.24	.86	.81	14	54	15	8	.28
129	21.8	5.8	2.4	65.7	1.9	1.1	1.1	.2	.02	.15	.12	11	54	22	7	.06
130	23.0	4.8	1.8	66.6	1.8	.9	.7	.0	.38	.04	.41	10	56	24	5	.17
131	20.3	5.4	3.7	61.9	2.3	4.1	2.3	.4	.06	.31	.26	8	50	21	11	.06
132	21.3	5.8	3.1	65.6	1.6	1.2	1.1	.2	.06	.28	.24	10	57	18	9	.09
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134	21.1	5.4	3.4	63.5	1.7	3.7	.8	.2	.09	.52	.43	9	52	21	10	.13
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138	22.7	4.6	3.0	64.8	1.5	.3	2.1	.1	.53	.05	.56	7	52	26	9	.24
139	23.1	5.3	2.1	65.3	1.5	.5	1.4	.6	.04	.35	.27	11	47	31	6	.04
140	20.9	4.6	3.2	62.8	1.6	4.1	2.4	.4	.04	.45	.34	7	57	17	10	.05
141	20.0	7.4	3.5	62.9	2.0	1.4	1.6	1.0	.08	.86	.65	14	43	25	11	.09
142	20.2	6.4	3.3	63.0	2.0	2.2	2.2	.2	.10	.85	.66	12	50	20	10	.07
143	20.6	6.4	2.8	62.4	1.7	3.2	2.3	.2	.09	.40	.35	12	46	24	9	.13
144	21.6	6.1	3.2	64.6	1.3	1.2	1.5	.5	.06	.16	.17	11	50	25	10	.05
145	20.7	6.2	3.7	63.0	2.6	1.2	2.0	.1	.06	.40	.32	10	45	26	11	.11
146	20.3	5.6	3.6	62.9	2.8	1.3	2.7	.2	.11	.55	.47	9	51	20	11	.14
147	21.8	4.4	3.1	64.2	1.9	3.3	.8	.1	.16	.45	.46	6	56	20	9	.10
148	22.6	4.5	3.3	65.0	1.9	1.2	1.0	.1	.26	.47	.57	6	52	25	10	.05
149	21.1	6.1	2.1	66.4	1.8	1.2	1.0	.1	.07	.34	.29	13	61	15	6	.12
150	21.0	4.7	2.4	63.7	2.4	3.8	1.0	.2	.14	.71	.61	8	58	17	7	.05
151	20.8	5.2	3.2	63.5	1.8	3.8	1.6	.2	.11	.13	.20	8	56	18	10	.04
152	21.2	6.0	2.3	66.0	1.9	.9	1.0	.1	.08	.43	.36	12	58	17	7	.07
153	23.4	2.9	3.0	65.4	2.1	.5	2.1	.1	.12	.20	.25	3	59	23	9	.09
154	21.5	6.2	2.6	64.2	2.0	1.8	1.1	.4	.51	.22	.65	12	47	26	8	.16

TABLE 2.1. *Chemical analyses—major constituents in cements*—Continued

No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	SO_3	MgO	Loss	Insol.	Na_2O	K_2O	T. Alk.	C_3A	C_3S	C_2S	C_4AF	SrO
	Percent of major constituents															
Type I																
155	22.0	5.5	2.1	64.3	1.8	2.1	1.2	.1	.22	.78	.73	11	49	26	6	.04
156	20.4	6.6	3.6	61.8	2.3	4.3	1.0	.2	.08	.21	.22	11	41	28	11	.10
157	21.4	5.7	3.0	63.8	1.8	2.0	1.7	.3	.23	.39	.49	10	49	25	9	.26
158	21.9	4.3	3.0	66.8	1.4	1.7	.8	.2	.04	.14	.13	6	68	11	9	.14
159	21.9	6.0	1.8	64.9	2.1	1.0	1.0	.3	.10	.81	.63	13	49	26	6	.28
160	21.4	6.0	3.2	64.1	1.7	2.2	.6	.3	.14	.66	.57	10	49	24	10	.07
161	20.9	5.8	2.3	63.6	2.6	2.8	1.2	.2	.12	.90	.71	12	50	22	7	.05
Type IA																
53	21.0	5.1	2.9	62.0	2.0	4.6	1.4	.4	.24	.79	.76	9	49	24	9	.03
60	23.2	4.5	1.9	64.0	1.8	3.5	.9	.1	.10	.25	.26	9	46	32	6	.15
61	20.2	6.2	3.4	63.4	2.2	2.8	.7	.2	.35	.59	.74	11	52	19	10	.30
62	20.0	7.2	2.4	61.7	2.3	2.9	2.3	.2	.39	.64	.81	15	41	27	7	.33
63	21.1	5.8	2.8	63.0	2.1	2.5	1.7	.5	.32	.48	.64	11	47	25	9	.29
64	20.7	6.2	2.3	62.4	1.9	4.1	1.6	.2	.13	.52	.47	13	45	25	7	.26
65	21.9	5.8	2.6	62.5	2.0	3.5	.7	.3	.42	.92	1.03	11	40	33	8	.14
66	21.5	4.6	2.7	63.7	1.7	4.0	1.4	.1	.22	.46	.52	8	56	19	8	.04
162	20.5	5.7	3.5	63.2	2.3	2.6	1.1	.1	.31	.81	.84	9	52	20	11	.15
Type II																
24	22.2	4.8	3.0	62.3	1.7	4.5	1.3	.2	.14	.61	.54	8	44	30	9	.11
67	22.3	4.9	3.6	62.5	1.5	4.2	.5	.2	.23	.36	.47	7	43	32	11	.33
68	23.5	4.3	3.1	64.5	1.5	1.7	.8	.3	.28	.48	.60	6	46	33	9	.08
69	22.7	4.5	3.7	64.2	1.7	1.9	.7	.2	.28	.47	.58	6	48	29	11	.08
70	23.2	4.3	3.2	64.2	1.7	1.5	1.1	.2	.29	.60	.68	6	47	31	10	.10
72	22.8	4.5	3.2	64.7	1.8	1.2	.6	.2	.29	.56	.66	7	50	28	10	.09
74	21.9	5.0	4.5	62.9	1.4	2.6	.8	.2	.15	.75	.64	6	46	29	14	.04
75	22.9	4.2	4.3	62.1	1.5	3.7	.6	.1	.17	.42	.45	4	40	36	13	.13
76	21.9	4.7	4.0	62.6	1.8	3.2	1.1	.1	.07	.17	.18	6	46	28	12	.04
77	22.1	5.3	4.9	64.1	1.5	.9	.7	.3	.05	.28	.23	6	46	29	15	.16
78	22.0	5.0	4.8	63.9	1.8	1.0	.8	.1	.17	.47	.48	5	47	28	15	.21
79	22.4	4.9	4.4	63.3	1.6	2.0	1.0	.3	.07	.53	.42	6	44	31	13	.07
80	24.5	4.2	2.6	64.6	1.3	1.4	.7	.0	.34	.25	.50	7	41	39	8	.06
81	21.7	5.4	5.2	63.4	1.7	1.4	.9	.0	.40	.19	.53	6	44	29	16	.17
82	22.3	4.6	3.8	61.3	1.6	4.5	1.2	.0	.52	.27	.70	6	39	35	12	.06
83	23.0	4.2	2.6	63.0	1.8	3.6	1.7	.2	.19	.42	.47	7	45	32	8	.04
84	21.9	4.5	3.6	61.1	1.6	4.7	2.0	.1	.57	.25	.73	6	43	30	11	.04
85	22.8	4.3	2.9	62.9	1.8	4.4	.9	.1	.21	.38	.46	6	44	32	9	.05
86	22.7	4.0	2.7	62.3	1.7	4.6	1.6	.1	.17	.49	.49	6	45	31	8	.05
87	21.3	5.6	4.8	63.2	1.7	1.7	1.1	.1	.56	.00	.56	7	47	26	15	.12

88	23.2	4.2	3.6	64.1	1.8	1.7	.9	.1	.11	.16	.22	5	46	32	11	.06
89	22.9	4.4	3.7	63.1	1.8	1.6	1.4	.2	.05	.65	.48	5	43	33	11	.06
90	23.6	4.3	2.9	65.0	1.4	1.6	1.0	.1	.11	.13	.20	6	48	32	9	.05
91	22.2	4.9	3.8	63.8	1.5	2.2	.9	.1	.29	.44	.58	7	48	28	12	.04
92	22.6	4.3	4.5	63.9	1.7	1.6	.6	.1	.24	.16	.35	4	48	29	14	.05
93	22.1	4.9	3.6	63.6	1.4	2.2	1.6	.2	.53	.26	.70	7	49	26	11	.07
94	22.7	5.0	3.2	64.5	1.3	1.5	.6	.1	.48	.30	.68	8	47	30	10	.34
95	21.8	5.5	5.0	62.7	1.6	1.8	.8	.2	.25	.60	.64	6	41	32	15	.08
96	21.7	5.2	3.4	62.6	1.7	4.0	.6	.4	.14	.63	.55	8	45	28	10	.08
97	22.5	4.8	3.6	62.2	1.5	4.0	1.0	.2	.10	.49	.42	7	40	34	11	.07
98	21.2	5.4	3.5	62.4	1.8	4.6	0.7	0.3	0.14	0.49	0.46	8	46	26	11	0.10
99	22.2	4.6	4.4	62.2	1.8	4.1	.4	.2	.10	.52	.44	5	42	32	13	.10
101	22.9	4.5	3.6	64.4	1.7	1.6	.8	.3	.06	.31	.26	6	48	30	11	.06
163	23.3	4.6	4.2	64.1	1.7	.7	.7	.1	.51	.06	.55	5	42	35	13	.16
164	22.0	5.2	4.5	64.5	1.5	1.2	1.1	.3	.03	.16	.14	6	50	26	14	.08
165	21.8	4.8	4.8	62.3	1.6	3.5	.8	.2	.08	.60	.47	5	44	29	15	.12
166	21.6	4.5	3.9	62.6	1.9	4.0	1.2	.1	.13	.60	.52	5	49	25	12	.15
167	22.1	5.2	3.5	64.4	1.5	1.2	1.6	.2	.01	.32	.22	8	50	26	11	.04
168	21.5	4.7	3.7	62.4	2.3	3.2	1.5	.2	.17	.62	.58	6	47	26	11	.11
169	21.5	4.8	3.6	62.2	2.3	3.2	1.8	.2	.15	.60	.54	7	47	26	11	.11
170	21.9	4.6	3.9	62.8	1.9	3.0	1.4	.2	.04	.55	.40	6	47	27	12	.05
171	23.3	4.4	2.8	64.3	1.5	.3	2.4	.1	.50	.05	.53	7	47	31	9	.26
172	21.0	5.9	4.8	62.4	1.7	1.8	1.8	.1	.11	.74	.60	8	43	28	15	.05
173	21.4	5.6	4.0	61.8	2.0	2.3	2.3	.2	.14	.35	.37	8	40	31	12	.16
174	22.6	4.4	4.1	64.1	2.0	.6	1.6	.1	.16	.48	.48	5	48	29	13	.12
175	23.0	4.7	3.0	64.5	1.5	1.6	1.0	.2	.11	.55	.47	7	48	30	9	.12
176	22.0	4.7	4.0	62.5	1.7	3.2	1.4	.1	.10	.20	.23	6	45	29	12	.04
177	22.7	4.9	3.6	63.4	1.6	1.6	1.0	.2	.10	.80	.63	7	43	33	11	.11
178	21.4	5.1	4.5	63.4	2.3	1.3	1.7	.1	.04	.40	.30	6	48	25	14	.21
179	21.5	5.2	4.3	63.7	1.7	1.0	1.5	.8	.16	.65	.59	6	50	24	13	.10
Type IIA																
100	22.4	5.1	3.0	63.4	1.9	2.8	1.0	.4	.06	.59	.45	8	44	31	9	.09
Type III																
102	19.5	6.0	3.5	64.0	2.3	3.4	1.0	.1	.24	.48	.56	10	60	11	11	.21
103	23.5	3.3	2.9	65.6	2.2	.8	1.4	.0	.12	.16	.23	4	55	26	9	.10
104	22.1	4.1	1.8	66.3	2.4	1.7	1.4	.2	.06	.10	.13	8	65	14	5	.05
105	22.2	4.2	2.9	64.1	1.8	1.6	2.3	.1	.45	.23	.60	6	55	22	9	.03
106	22.5	3.9	2.7	63.0	2.1	2.1	2.8	.3	.23	.18	.35	6	49	28	8	.05
180	20.4	6.3	2.7	65.3	2.3	1.3	1.4	.4	.02	.13	.11	12	58	15	8	.07
181	20.4	5.8	3.5	65.5	1.9	1.2	1.6	.3	.05	.20	.18	9	63	11	11	.08
182	20.3	5.8	2.5	63.6	2.6	3.5	1.6	.3	.08	.54	.44	11	55	17	8	.13
183	20.2	5.0	3.1	63.2	2.5	4.0	1.4	.1	.13	.70	.59	8	59	13	9	.15
184	21.0	4.3	3.0	64.1	2.5	3.2	1.6	.3	.10	.38	.35	6	61	14	9	.12
185	20.6	5.3	2.2	64.0	2.4	3.5	1.6	.1	.07	.50	.40	10	58	15	7	.06
186	20.3	4.4	4.0	64.5	2.2	1.3	2.1	.2	.24	.68	.69	5	67	8	12	.08
187	20.6	4.7	3.2	65.4	2.2	1.7	1.8	.1	.24	.46	.54	7	67	9	10	.09
188	19.5	6.1	3.2	63.5	2.7	1.9	2.4	.2	.09	.75	.58	11	57	13	10	.06
189	21.0	4.9	4.7	63.9	2.3	1.3	1.2	.1	.05	.38	.30	5	54	20	14	.18

TABLE 2.1. *Chemical analyses—major constituents in cements*—Continued

No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	SO_3	MgO	Loss	Insol.	Na_2O	K_2O	T. Alk.	C_3A	C_3S	C_2S	C_4AF	SrO
	Percent major constituents															
Type III																
190	20.1	6.2	3.5	62.5	3.5	1.2	2.1	.1	.07	.64	.49	11	45	24	11	.11
191	21.9	4.9	1.3	67.4	1.9	.9	1.3	.1	.13	.11	.20	11	68	12	4	.06
192	21.4	4.4	3.4	65.6	2.2	1.3	1.1	.1	.23	.42	.51	6	64	13	10	.09
193	19.6	5.6	3.4	63.8	2.5	1.3	3.4	.2	.10	.47	.41	9	61	10	10	.18
Type IIIA																
194	21.6	4.2	3.1	64.5	2.3	1.4	2.0	.2	.20	.51	.54	6	59	17	9	.09
195	19.2	6.4	2.6	63.5	2.8	2.9	2.0	.8	.31	.48	.63	13	58	12	8	.32
Type IV																
107	23.2	5.2	4.1	63.2	1.8	1.0	.9	.0	.15	.39	.41	7	36	40	12	.14
108	25.2	3.3	3.3	64.0	1.7	.9	.9	.0	.17	.26	.34	3	37	44	10	.08
196	23.7	4.8	4.5	62.5	1.5	1.7	.6	.2	.23	.43	.51	5	31	45	14	----
Type V																
109	25.3	2.8	3.6	63.8	1.5	1.1	.9	.1	.04	.29	.23	1	39	43	11	.10
110	24.8	3.1	4.4	63.1	1.8	1.6	.8	.3	.01	.28	.19	1	36	44	13	.05
111	23.7	2.7	3.3	62.9	1.6	3.9	1.0	.0	.12	.48	.44	2	49	31	10	.04
112	24.6	3.6	2.9	64.5	2.0	.8	1.0	.1	.11	.22	.25	5	42	39	9	.09
113	22.5	3.8	4.0	62.2	1.7	3.9	1.5	.0	.37	.17	.48	3	46	30	12	.07
114	24.6	3.4	3.2	64.8	1.7	.8	.9	.2	.08	.16	.19	4	44	37	10	.09
115	24.2	3.8	3.1	64.6	1.4	1.4	.9	.0	.12	.50	.45	5	45	36	9	.03
116	24.6	3.6	2.5	65.0	1.4	1.8	.8	.1	.12	.30	.32	5	46	36	8	.07
117	24.2	3.7	3.0	64.5	1.4	1.7	1.1	.1	.39	.15	.49	5	45	36	9	.06
118	24.2	4.0	3.7	64.3	1.4	1.4	.6	.2	.22	.31	.42	4	42	38	11	.10
119	23.0	4.2	4.7	63.9	1.7	1.1	.8	.2	.64	.25	.80	3	45	32	14	.25
197	23.3	3.3	3.6	63.0	1.8	3.2	1.1	.2	.10	.38	.35	3	46	32	11	----
Miscellaneous												Mn_2O_3		"S"		
120	----	----	----	----	----	----	8.7	12.8	----	----	----	----	----	----	----	.09
121	26.9	7.8	2.2	56.3	1.7	1.4	2.2	3.7	.70	.41	.97	----	----	----	----	.15
122	28.7	5.1	2.7	58.3	1.5	.9	1.9	9.6	.12	.17	.23	----	----	----	----	.08
123	25.2	7.9	2.8	57.8	2.2	2.4	.3	.3	----	----	----	0.6		0.4	----	----
198	24.8	8.8	2.5	54.4	1.8	4.4	.8	.6	.21	.50	.54	.67		.63	----	.10
199	24.9	6.6	1.7	59.3	1.4	3.3	1.8	.4	.08	.71	.55	.11		.23	----	.04
200	29.4	5.8	1.6	50.5	2.6	7.6	.5	.3	.24	.52	.58	.08		.57	----	.06
201	24.5	8.8	2.5	54.4	2.1	4.4	.8	.6	.22	.52	.56	.63		.59	----	.10
202	24.8	7.1	3.1	59.0	2.0	2.5	.3	.3	.10	.20	.23	.38		.34	----	.08
203	25.5	7.7	2.5	57.4	2.2	1.9	1.2	.3	.08	.48	.40	.52		.41	----	.08

2.2. Spectrochemical Analyses—Minor Constituents in Cement—Table 2.2

Results of the chemical analyses of minor constituents are reported in table 2.2. The cements were examined by a semiquantitative spectrochemical method. The notation of concentration used in table 2.2 includes the following: VW, 0.001–0.01 percent; L, less than; T, trace; FT, faint trace; ?, questionable detection; and —, not detected. All numerical values were estimated by comparison with synthetic standards and concentrations were reported in steps of 1, 2, 5, and 10, etc.

TABLE 2.2. *Spectrochemical analyses—minor constituents in cement*

Percent of minor constituents

No.	Ag	B	Ba	Co	Cr	Cs	Cu	Li	Mn	Mo	Ni	P	Pb	Rb	Sb	Sn	Ti	V	Zn	Zr
Type I																				
1	?	VW	0.02	L.001	0.01	L.005	0.01	L.005	0.05	-------	0.002	0.5	-------	0.005	------	------	0.2	0.01	------	0.01
2	?	VW	.01	L.001	.001	L.005	.005	L.005	.05	-------	.001	------	-------	?	------	------	.1	.01	------	.01
3	?	VW	.01	L.001	.005	L.005	.002	L.005	.02	-------	.001	------	-------	L.005	------	------	.1	.01	------	.01
4	?	VW	.01	L.001	.005	L.005	.002	L.005	.1	-------	.002	.5	-------	L.005	------	------	.2	.01	------	.01
5	?	VW	.01	.001	.002	L.005	.01	L.005	.05	-------	.002	?	-------	L.005	------	------	.2	.01	------	.01
6	?	VW	.01	L.001	.002	L.005	.002	L.005	.05	-------	.002	?	-------	L.005	------	------	.1	.01	------	.01
7	?	VW	.01	L.001	.002	L.005	.002	L.005	.05	-------	.002	?	L.001	L.005	------	------	.2	.01	------	.01
8	?	VW	.01	L.001	.002	L.005	.002	L.005	.05	-------	.001	.5	L.001	.005	------	------	.1	.01	------	.01
9	?	VW	.01	L.001	.002	L.005	.005	L.005	.1	-------	.001	.5	L.001	.005	------	------	.2	.01	------	.01
10	?	VW	.01	L.001	.005	L.005	.005	L.005	.05	-------	.002	------	L.001	L.005	------	------	.2	.01	------	.01
11	T	VW	.01	L.001	.002	L.005	.001	L.005	.05	-------	.001	------	-------	.005	------	------	.1	L.01	------	.005
12	?	VW	.01	.001	.005	L.005	.001	L.005	.1	-------	.001	------	-------	L.005	------	------	.1	L.01	------	.005
13	?	VW	.01	L.001	.002	L.005	.001	L.005	.1	-------	.001	------	L.001	L.005	------	------	.1	L.01	------	.005
14	?	VW	.02	L.001	.01	L.005	.005	L.005	.05	-------	.001	.5	?	.005	------	------	.2	.01	------	.01
15	?	VW	.01	L.001	.005	L.005	.005	L.005	.1	-------	.001	------	?	.005	------	------	.2	.01	------	.01
16	?	VW	.01	L.001	.005	L.005	.002	L.005	.1	-------	.001	.5	?	.005	------	------	.2	.02	------	.01
17	?	VW	.01	L.001	.01	L.005	.005	L.005	.02	?	.001	------	L.001	.005	------	------	.2	.02	------	.01
18	?	VW	.01	L.001	.002	L.005	.005	L.005	.02	-------	L.001	------	-------	L.005	------	------	.1	L.01	------	.005
19	?	VW	.01	L.001	.005	L.005	.005	L.005	.05	-------	L.001	?	-------	.005	------	------	.2	.01	------	.01
20	?	VW	.01	L.001	.005	L.005	.002	L.005	.05	-------	.001	------	-------	.005	------	------	.2	.02	------	.01
21	?	VW	L.01	L.001	.005	L.005	.005	L.005	.1	-------	.005	------	L.001	.005	------	------	.2	.02	L.01	.01
22	?	VW	.01	.005	.005	L.005	.01	L.005	.05	L.001	.001	------	.02	L.005	------	VW	.2	.02	------	.01
23	?	VW	.01	L.001	.005	L.005	.002	L.005	.1	-------	L.001	------	L.001	L.005	------	------	.5	.02	------	.05
25	?	VW	.01	.001	.005	L.005	.002	L.005	.1	-------	.001	------	.005	L.005	------	------	.2	.01	------	.01
26	?	VW	.01	.001	.005	L.005	.005	L.005	.1	-------	.005	------	.01	.005	------	------	.5	.01	------	.01
27	?	VW	.1	.001	.005	L.005	.01	L.005	.02	.001	.01	------	L.001	L.005	------	------	.2	.02	------	.01
28	?	VW	.01	L.001	.005	L.005	.005	L.005	.05	-------	.002	------	.001	L.005	------	------	.5	.02	------	.01
29	?	VW	.05	.001	.005	L.005	.005	L.005	.1	-------	.01	------	L.001	.005	------	------	.5	.02	------	.01
30	?	VW	.01	.005	.02	L.005	.005	L.005	.2	-------	.01	------	L.001	L.005	------	------	.5	.05	------	.05
31	?	VW	.05	L.001	.02	L.005	.005	L.005	.05	-------	.005	------	L.001	L.005	------	------	.2	.01	------	.02
32	?	VW	.05	L.001	.02	L.005	.005	L.005	.1	.001	.01	------	.01	.005	------	------	.5	.02	------	.03
33	?	VW	.05	L.001	.02	L.005	.005	L.005	.1	-------	.005	------	L.001	.005	------	------	.2	.01	------	.01
34	?	VW	.02	L.001	.01	L.005	.005	L.005	.2	-------	.005	------	L.001	L.005	------	VW	.2	.02	------	.01
35	------	VW	.02	L.001	.01	L.005	.005	L.005	.1	-------	.01	------	.02	.005	------	------	.2	L.01	------	.02
36	------	VW	.02	L.001	.02	L.005	.002	L.005	.5	-------	.005	------	L.001	L.005	------	------	.2	L.01	------	.02
37	------	VW	.05	L.001	.01	L.005	.005	L.005	.1	-------	.01	------	L.001	L.005	------	------	.1	.01	------	.02
38	------	VW	.02	L.001	.005	L.005	.002	L.005	.2	-------	.005	------	?	L.005	------	------	.1	.01	------	.01
39	------	VW	.05	L.001	.005	L.005	.005	L.005	.1	-------	.002	------	L.001	.005	------	?	.2	.02	------	.005
40	------	VW	.01	L.001	.01	L.005	.002	.01	.1	.02	.01	------	-------	?	------	------	.2	.02	------	.01
41	------	VW	.01	L.001	.005	L.005	.005	.01	.05	.05	.005	------	L.001	.002	------	------	.2	.02	------	.01

42	?	VW	.01	L.001	.01	L.005	.01	.01	.2	.001	.005	------	.05	.001	------	------	.2	.01	------	.01
43	?	VW	.2	?	.01	L.005	.02	.01	.1	?	.002	?	?	L.001	------	------	.2	.1	------	.002
44	------	VW	.01	L.001	.01	L.005	.01	.01	.05	.001	.001	------	L.001	.001	------	?	.2	.01	------	.005
45	------	VW	.02	------	.001	L.005	.01	.01	.05	?	L.001	------	L.001	L.001	------	?	.2	.005	------	.01
46	------	VW	.01	?	L.001	L.005	*	L.005	.01	------	.002	------	?	?	------	?	.1	.005	------	.01
47	------	VW	.2	.002	.02	L.005	.02	L.005	.05	------	.005	?	L.001	L.005	------	------	.2	.05	------	.01
48	------	VW	.02	.001	.005	L.005	.002	L.005	.05	------	.002	------	L.001	?	------	------	.1	L.01	------	.01
49	*	VW	.05	.002	.005	L.005	.005	L.005	.2	------	.001	------	.001	L.005	------	------	.2	.01	------	.005
50	------	VW	.05	.005	.005	L.005	.02	L.005	.05	.001	.001	------	------	L.005	------	------	.2	.01	------	.005
51	------	VW	.01	.001	.005	L.005	.02	L.005	.05	------	.001	------	L.001	L.005	------	VW	.2	.01	.05	.005
52	------	VW	.05	.001	.005	L.005	.005	L.005	.1	------	.002	------	L.001	L.005	------	------	.2	.01	------	.005
54	------	VW	.02	L.001	.005	L.005	.01	L.005	.05	?	.002	------	.002	L.005	------	?	.2	.01	.1	.02
55	------	VW	.1	L.001	.002	L.005	.005	L.005	.02	------	.001	------	L.001	L.005	------	------	.2	.01	------	.01
56	------	VW	.01	L.001	.005	L.005	.01	L.005	.05	------	.001	------	?	L.005	------	?	.2	L.01	------	.01
57	------	VW	.02	.001	.01	L.005	.002	L.005	.05	------	.005	------	.002	.005	------	------	.2	L.01	------	.01
58	------	VW	L.01	?	.002	L.005	.001	L.005	L.01	------	.002	------	------	?	------	?	.2	L.01	------	.02
59	?	VW	L.01	?	.002	L.005	*	L.005	L.01	------	.001	------	------	L.005	------	VW	.2	L.01	------	.01
71	T	VW	.01	.001	.002	L.005	.005	L.005	.02	------	.001	------	?	L.005	------	------	.1	L.01	------	.01
73	?	VW	.1	L.001	.01	L.005	.005	L.005	.05	------	.005	?	L.001	.005	------	------	.2	.02	------	.01
124	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
125	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
126	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
127	T	VW	.01	L.001	.005	L.005	.002	L.005	.5	------	.01	?	?	L.005	------	T	.1	L.01	------	L.01
128	FT	VW	.2	L.001	.01	L.005	.001	L.005	.05	?	.01	.1	?	L.005	------	?	.2	L.01	------	L.01
129	?	T	.01	L.001	.01	L.005	.005	L.005	.05	------	L.001	------	L.001	L.005	------	T	.2	L.01	------	.01
130	------	T	.02	L.001	.005	L.005	*	L.005	.1	------	L.001	------	?	?	------	------	.1	L.01	------	L.01
131	------	T	.02	L.001	.005	L.005	.002	L.005	.02	?	L.001	------	L.001	L.005	------	T	.1	L.01	?	L.01
132	------	T	.005	L.001	.005	L.005	.005	L.005	.01	*	.001	.5	L.001	L.005	------	T	.2	.01	?	L.01
133	?	T	.02	L.001	.005	L.005	.002	L.005	.05	------	.002	------	L.001	L.005	------	T	.2	L.01	------	.01
134	FT	VW	.02	.002	.005	L.005	.002	L.005	.1	------	.005	------	?	L.005	------	T	.2	.05	------	.01
135	?	T	.01	L.001	.005	L.005	.01	L.005	.02	------	.001	.5	.001	L.005	------	T	.1	L.01	.1	L.01
136	?	T	.02	L.001	.005	L.005	.001	L.005	.02	------	.002	------	L.001	L.005	------	------	.2	L.01	------	L.01
137	FT	T	.02	?	.01	L.005	.002	L.005	.05	------	.001	------	L.001	L.005	------	------	.2	L.01	------	L.01
138	FT	VW	.005	L.001	.005	L.005	.01	L.005	.05	------	L.001	------	L.001	?	------	T	.2	L.01	.1	.5
139	FT	T	.05	.001	.005	L.005	.002	L.005	.05	------	.002	------	?	L.005	------	------	.2	.01	------	L.01
140	FT	T	.01	L.001	.005	L.005	.002	L.005	.05	------	.002	------	L.001	L.005	------	------	.2	L.01	------	L.01
141	?	VW	.01	L.001	.005	L.005	.005	L.005	.05	?	.002	------	L.002	.01	------	T	.2	L.01	?	L.01
142	?	VW	.01	L.001	.01	L.005	.005	L.005	.05	------	.01	------	?	.005	------	?	.2	.01	------	L.01
143	T	VW	.02	?	.005	L.005	.005	L.005	.5	?	L.001	------	L.001	L.005	------	T	.2	L.01	------	L.01
144	FT	T	.01	L.001	.01	L.005	.01	L.005	.1	------	.002	------	L.001	?	------	T	.5	.01	------	L.01
145	FT	T	.05	L.001	.005	L.005	.005	L.005	.1	*	.005	------	L.001	.005	------	------	.2	.02	------	L.01
146	FT	T	.05	L.001	.005	L.005	.005	L.005	.1	?	.002	------	L.001	L.005	------	------	.2	.01	------	L.01
147	FT	VW	.02	L.001	.01	L.005	.005	L.005	.1	?	.005	------	L.001	L.005	------	------	.2	.01	------	L.01
148	?	VW	.02	L.001	.005	L.005	.001	L.005	.02	------	L.001	------	L.001	L.005	------	?	.1	L.01	------	.01
149	?	VW	.01	L.001	.01	L.005	.002	L.005	.05	------	.001	.1	L.001	L.005	------	------	.2	.01	------	L.01

* L.001

TABLE 2.2. *Spectrochemical analyses—minor constituents in cement*—Continued

Percent of Minor constituents

No.	Ag	B	Ba	Co	Cr	Cs	Cu	Li	Mn	Mo	Ni	P	Pb	Rb	Sb	Sn	Ti	V	Zn	Zr
Type I																				
150	T	VW	.01	.01	.01	L.005	.002	L.005	.05	------	.01	------	?	.005	------	T	.2	.02	------	.01
151	T	VW	.02	?	.005	L.005	.01	L.005	.5	------	L.001	------	L.001	?	------	VW	.2	L.01	------	L.01
152	?	VW	.01	L.001	.005	L.005	.002	L.005	.1	------	.001	.1	L.001	L.005	------	?	.2	.01	------	L.01
153	T	T	.1	L.001	.01	L.005	.02	L.005	.02	*	.005	?	L.001	?	------	T	.1	.02	?	?
154	?	T	.02	L.001	.01	L.001	.01	L.005	.02	------	.002	?	L.001	?	------	VW	.1	L.01	------	L.01
155	?	T	.02	L.001	.01	L.005	.002	L.005	.01	L.001	.005	------	L.001	.005	------	T	.1	L.01	------	L.01
156	T	VW	.02	?	.005	L.005	.002	L.005	T	?	.001	------	.001	?	------	T	.1	L.01	------	L.01
157	FT	T	.02	L.001	.01	L.005	.002	L.005	.2	------	.01	------	?	L.005	------	T	.2	.01	------	.01
158	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
159	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
160	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
161	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
Type IA																				
53	*	VW	.05	L.001	.005	L.005	.001	L.005	.5	?	.001	------	------	?	------	?	.5	L.01	------	.01
60	?	VW	.01	L.001	.001	L.005	.002	L.005	.02	------	.005	------	------	?	------	------	.2	.01	------	.01
61	?	VW	.01	.005	.01	L.005	.005	L.005	.1	------	.001	------	------	L.005	------	------	.1	.01	------	.01
62	?	VW	.01	L.001	.002	L.005	.001	L.005	.1	------	.001	------	------	L.005	------	------	.1	L.01	------	.005
63	T	VW	.01	L.001	.002	L.005	L.001	L.005	.05	------	.001	------	------	L.005	------	------	.1	L.01	------	.005
64	T	VW	.01	.001	.002	L.005	.001	L.005	.05	------	.002	------	------	L.005	------	------	.2	L.01	------	.01
65	------	VW	.01	L.001	.01	L.005	.001	L.005	.1	------	.001	?	?	?	------	------	.2	.02	------	.005
66	------	VW	.02	L.001	.005	L.005	.002	L.005	.05	------	.001	------	?	L.005	------	------	.2	L.01	------	.005
162	FT	T	.02	L.001	.01	L.005	.005	L.005	.1	L.001	.005	------	L.001	L.005	------	T	.2	L.01	------	L.01
Type II																				
24	?	VW	.01	L.001	.01	L.005	.005	L.005	.05	------	.005	------	L.001	.005	------	T	.2	.02	------	.01
67	?	VW	.01	.002	.001	L.005	.005	L.005	.02	------	.001	------	------	L.005	------	------	.05	L.01	------	.005
68	T	VW	.01	.001	.01	L.005	.001	L.005	.05	------	.001	------	L.001	L.005	------	------	.1	.01	------	.005
69	T	VW	.01	.001	.005	L.005	.001	L.005	.05	?	.002	------	L.001	L.005	------	------	.2	.01	------	.01
70	?	VW	.02	.001	.002	L.005	.001	L.005	.05	------	.001	------	L.001	L.005	------	------	.5	.01	------	.01
72	T	VW	.01	L.001	.01	L.005	.001	L.005	.05	------	.001	------	L.001	.005	------	------	.2	.01	------	.01
74	?	VW	.01	L.001	.001	L.005	.01	L.005	.02	------	L.001	------	?	.005	------	------	.1	.01	------	.01
75	?	VW	L.01	L.001	.005	L.005	.005	L.005	.1	------	.005	------	L.001	.005	------	?	.05	.01	------	.01
76	?	VW	.05	?	.005	L.005	.005	L.005	.5	L.001	.002	------	L.001	L.005	------	T	.2	.01	------	.01
77	?	VW	.05	L.001	.005	L.005	.002	L.005	.05	------	.002	------	L.001	L.005	------	------	.1	.01	------	.01
78	------	VW	.05	L.001	.01	L.005	.01	L.005	.1	------	.005	------	.02	.005	------	------	.2	L.01	L.01	.05
79	------	VW	.01	L.001	.005	L.005	.001	L.005	.1	------	.001	------	L.001	L.005	------	------	.5	.02	------	.05
80	------	VW	.01	.001	.01	L.005	.005	.005	.1	------	.005	------	L.001	L.001	------	------	.2	.01	------	.005
81	------	VW	.01	.001	.01	L.005	.05	.01	.05	.05	.005	------	L.001	L.001	------	?	.2	.01	------	.01
82	------	VW	.01	.001	.01	L.005	.002	.01	.1	.05	.01	------	------	?	------	?	.2	.05	------	.005

83		VW	.02	L.001	.01	L.005	.01	.01	.1		.005		L.001	.001		?	.1	.005		.01
84	?	VW	.05	.001	.005	L.005	.005	.02	.05		.005		L.001	L.001			.1	.01		.005
85		VW	.01	L.001	.005	L.005	.01	.01	.05		.005		L.001	.001		?	.1	.01		.01
86		VW	.02	L.001	.005	L.005	.01	.01	.1	.005	.005		.005	.001			.1	.005	?	.005
87		VW	.02	.001	.01	.005	.05	.02	.05	.005	.01			?		?	.1	.02	.05	.005
88		VW	.01	.005	.005	L.005	.05	L.005	.05	?	.002		.001	?	VW	VW	.2	L.01	.2	.01
89		VW	.02	.002	.005	L.005	.01	L.005	.2		.002		.001	.005			.1	L.01	.1	.01
90		VW	.02	.002	.005	L.005	.02	L.005	.02	L.001	.002		.001	?	VW	VW	.2	.01	.05	.01
91		VW	.01	.002	.01	L.005	.01	L.005	.05		.005		L.001	L.005			.2	L.01		.01
92		VW	.02	.005	.01	L.005	.05	L.005	.02	L.001	.001		.01	?	VW	VW	.1	L.01	.2	.01
93		VW	.01	.005	.01	L.005	.02	L.005	.1	L.001	.005		.005	L.005	VW	VW	.2	L.01	.05	.02
94		VW	.01	L.001	.01	L.005	.02	L.005	.05		.005		.01	L.005	VW	VW	.5	.02	.1	.01
95		VW	L.01	.002	.002	L.005	.05	L.005	.1		.001		.001	L.005			.2	L.01	.1	.005
96		VW	.02	L.001	.002	L.005	.001	L.005	.02		.001		L.001	L.005			.2	L.01		.005
97		VW	.05	L.001	.01	L.005	.005	L.005	.1	?	.002		.001	L.005			.2	.01		.005
98		VW	.02	L.001	.005	L.005	.002	L.005	.02		.002		L.001	L.005			.2	.01		.01
99		VW	.05	?	.005	L.005	.002	L.005	.1		.001		?	L.005			.2	L.01		.01
101		VW	L.01	.001	.005	L.005	.02	L.005	.1		.002	?	L.001	L.005		VW	.2	L.01	.1	.01
163		T	.05	L.001	.005	L.005	L.001	L.005	.1	L.001	L.001		L.001	?		?	.2	.01		.01
164		T	.005	L.001	.01	L.005	.02	L.005	.02	?	.001		L.001	L.005		T	.2	.01	.02	.01
165	FT	VW	.02	.002	.005	L.005	.002	L.005	.1	?	.005		?	L.005		?	.2	.05		.01
166	FT	T	.02	L.001	.002	L.005	.002	L.005	.05		.001		L.001	L.005			.2	.01		.01
167	?	T	.01	L.001	.005	L.005	.01	L.005	.02	L.001	.001	.2	.002	L.005		VW	.05	L.01	.1	L.01
168		T	.02	L.001	.002	L.005	.002	L.005	.02		.001		L.001	L.005			.05	L.01	.1	L.01
169	?	T	.02	L.001	.005	L.005	.002	L.005	.05		.001		L.001	L.005			.1	L.01		L.01
170	FT	T	.01	L.001	.005	L.005	.002	L.005	.05		.001		L.001	L.005			.2	L.01		L.01
171	FT	VW	.005	L.001	.005	L.005	.01	L.005	.05		L.001		L.001	?		T	.2	L.01	.1	.2
172	?	VW	.01	.005	.02	L.005	.005	L.005	.05	L.001	.005		?	.005		T	.2	L.01		L.01
173	T	VW	.02	L.001	.01	L.005	.005	L.005	.5	L.001	.005		.002	L.005		T	.2	L.01		L.01
174	FT	T	.02	.005	.01	L.005	.01	L.005	.2		.01		L.001	L.005		T	.2	.05	L.01	.01
175	?	VW	.02	L.001	.01	L.005	.002	L.005	.05		.002		L.001	L.005		T	.2	.02		L.01
176	T	VW	.02	?	.005	L.005	.001	L.005	.5		L.001		L.001	?		VW	.1	L.01		L.01
177	?	VW	.02	L.001	.002	L.005	.005	L.005	.05		.001		L.001	.005		T	.1	L.01		L.01
178	T	T	.02	L.001	.002	L.005	.005	L.005	.1		.005	?	L.001	L.005			.1	L.01		L.01
179	T	T	.02	L.001	.01	L.005	.01	L.005	.05	.001	.02		L.001	L.050		T	.1	.05	.05	L.01
Type IIA																				
100		VW	.02	L.001	.002	L.005	.002	L.005	.05		.002		?	L.005			.2	L.01		.05
Type III																				
102		VW	.01	L.001	.002	L.005	.002	L.005	.1		.002		.005	.005			.2	.01		.01
103		VW	.05	L.001	.01	L.005	.01	.01	.05	.005	.01	.5	?	L.001		?	.1	.1		.005
104		VW	.01	L.001	.005	L.005	.005	L.005	.05		.005		L.091	?	?	VW	.2	L.01		.005
105		VW	.01	L.001	.01	L.005	.01	L.005	.05		.005		.005	L.005	VW	VW	.2	L.01	.1	.005
106		VW	.01	L.001	.005	L.005	.01	L.005	.05		.005		.001	?	VW	VW	.2	L.01	.05	.005

* L.001

TABLE 2.2. *Spectrochemical analyses—minor constituents in cement*—Continued

Percent of minor constituents

No.	Ag	B	Ba	Co	Cr	Cs	Cu	Li	Mn	Mo	Ni	P	Pb	Rb	Sb	Sn	Ti	V	Zn	Zr
Type III																				
180	FT	T	.01	L.001	.02	L.005	.01	L.005	.1	-------	.01	?	L.061	L.005	------	T	.2	L.01	.02	.01
181	------	T	.005	L.001	.005	L.005	.01	L.005	.01	-------	.001	?	L.001	L.005	------	T	.2	.01	.01	L.01
182	FT	VW	.02	L.001	.005	L.005	.002	L.005	.1	-------	.002	------	L.001	L.005	------	?	.1	L.01	------	L.01
183	?	VW	.02	?	.001	L.005	.002	L.005	.05	-------	L.001	------	L.001	L.005	------	------	.1	L.01	------	L.01
184	?	T	.02	L.001	.005	L.005	.002	L.005	.05	-------	.001	------	L.001	?	------	------	.1	L.01	------	L.01
185	FT	T	.01	L.001	.005	L.005	.002	L.005	.02	-------	.002	------	L.001	L.005	------	------	.2	L.01	------	L.01
186	FT	T	.05	L.001	.005	L.005	.002	L.005	.1	-------	.002	------	L.001	L.001	------	------	.2	.01	------	L.01
187	?	VW	.01	L.001	.01	L.005	.005	L.005	.05	L.001	.002	------	L.001	L.005	------	------	.2	.01	?	L.01
188	?	VW	.01	L.001	.005	L.005	.005	L.005	.02	L.001	.001	------	?	.005	------	------	.2	L.01	------	L.01
189	FT	T	.02	L.001	.005	L.005	.005	L.005	.2	?	.005	------	?	L.005	------	------	.1	L.01	------	L.01
190	FT	VW	.02	.001	.005	L.005	.005	L.005	.2	L.001	.01	------	L.001	.005	------	T	.2	L.01	------	L.01
191	?	T	.01	L.001	.002	L.005	.01	L.005	.02	?	.001	------	L.001	?	------	T	.05	L.01	------	L.01
192	FT	VW	.02	L.001	.005	L.005	.002	L.005	.05	-------	.001	------	L.001	L.005	------	?	.05	L.01	------	L.01
193	T	T	.05	L.001	.002	L.005	.002	L.005	.1	L.001	.005	------	L.001	L.005	------	T	.1	L.01	------	L.01
Type IIIA																				
194	T	T	.02	L.001	.002	L.005	.002	L.005	.05	-------	.002	?	L.001	L.005	------	------	.1	L.01	------	L.01
195	FT	VW	.01	L.001	.005	L.005	.002	L.005	.05	-------	.001	1	?	L.005	------	T	.2	L.01	------	L.01
Type IV																				
107	?	VW	L.01	.001	.005	L.005	.01	L.005	.1	?	.005	------	.01	L.005	------	------	.5	.02	L.01	.02
108	?	VW	.2	L.001	.01	L.005	.01	L.005	.05	-------	.01	?	-------	L.005	------	------	.5	.05	.02	.01
196	FT	T	.01	.002	.01	L.005	.01	L.005	.05	?	.01	------	L.001	L.005	------	------	.5	.05	------	L.01
Type V																				
109	?	VW	.05	L.001	.02	L.005	.01	L.005	.1	.005	.01	------	L.001	L.005	------	VW	.1	.1	L.01	.02
110	?	VW	.05	L.001	.01	L.005	.002	L.005	.1	-------	.002	------	L.001	L.005	------	------	1.0	.05	------	.1
111	?	VW	.005	L.001	.005	L.005	.02	.01	.2	.05	.005	------	.05	.001	------	?	.2	.01	------	.01
112	?	VW	.1	L.001	.02	L.005	.01	.01	.05	?	.005	?	-------	L.001	------	------	.2	.1	------	.005
113	------	VW	.02	.001	.01	L.005	.005	.01	.05	.005	.01	?	?	?	------	?	.1	.05	------	.005
114	------	VW	.1	?	.02	L.005	.01	L.005	.05	-------	.005	?	?	L.005	------	------	.2	.05	------	.01
115	------	VW	.02	?	.005	L.005	.005	L.005	.02	-------	.002	------	L.001	L.005	------	------	.2	L.01	------	.01
116	------	VW	.02	?	.005	L.005	.005	L.005	.1	-------	.002	------	L.001	L.005	------	------	.2	L.01	------	.01
117	------	VW	.01	.005	.01	L.005	.01	L.005	.1	?	.005	------	.002	?	VW	VW	.2	L.01	.05	.01
118	------	VW	.01	L.001	.005	L.005	.01	L.005	.05	-------	.005	------	.001	?	VW	VW	.2	L.01	.05	.005
119	------	VW	.05	.001	.005	L.005	.002	L.005	.1	-------	.001	------	L.001	L.005	------	------	.2	.01	------	.01
197	T	T	.02	L.001	.01	L.005	.02	L.005	.05	L.001	.001	------	L.001	L.005	------	T	.05	L.01	?	L.01

Miscellaneous																				
120	------	VW	.01	L.001	.005	L.005	.002	L.005	.2	-------	.005	------	.001	.01	------	VW	.1	L.01	.05	.005
121	------	VW	.01	L.001	.01	L.005	.01	.01	.05	.001	.001	------	L.001	.002	------	?	.2	.01	------	.01
122	------	VW	.1	L.001	.02	L.005	.01	.02	.05	.005	.01	?	L.001	.001	------	?	.1	.1	?	.005
123	*	VW	.05	L.001	.01	L.005	.002	L.005	.5	-------	.002	------	L.001	L.005	------	?	.2	L.01	------	.005
198	T	VW	.02	L.001	.005	L.005	.002	L.005	.5	L.001	.001	------	L.001	L.005	------	T	.2	L.01	------	L.01
199	FT	T	.05	L.001	.005	L.005	.002	L.005	.1	-------	.002	------	L.001	L.005	------	------	.2	L.01	------	L.01
200	FT	VW	.02	L.001	.01	L.005	.01	L.005	.1	L.001	.002	------	L.001	.005	------	T	.1	.01	?	L.01
201	T	VW	.02	L.001	.01	L.005	.002	L.005	.5	-------	.002	------	L.001	L.005	------	------	.2	L.01	------	L.01
202	T	VW	.01	?	.002	L.005	.002	L.005	.2	-------	.001	------	L.001	?	------	T	.2	L.01	------	L.01
203	T	VW	.05	L.001	.005	L.005	.005	L.005	.5	-------	.005	------	L.001	L.005	------	VW	.2	L.01	?	L.01

* L.001

2.3. Cement Fineness—Table 2.3

Values of the fineness of the cements given in cm^2/g were determined by the air-permeability and Wagner turbidimeter methods and are denoted as APF and Wagner respectively in table 2.3.

TABLE 2.3. *Cement fineness*

Fineness			Fineness			Fineness			Fineness		
No.	APF cm^2/g	Wagner cm^2/g	No.	APF cm^2/g	Wagner cm^2/g	No.	APF cm^2/g	Wagner cm^2/g	No.	APF cm^2/g	Wagner cm^2/g
Type I						**Type II**			**Type III**		
1	3560	1865	58	3650	2010	24	3310	1950	102		2460
2	3300	1800	59	4390	2160	67	2980	1710	103	3960	2280
3	3220	1815	71	3060	1720	68	3340	1790	104	5850	2890
4	3350	1780	73	3340	1850	69	3430	1890	105	4580	2240
5	3350	1915	124	3320	1790	70	3480	1785	106	4980	2210
6	3640	1795	125	3210	1620	72	3310	1880	180	4640	2340
7	3660	2030	126	3320	1750	74	3000	1740	181	4040	2150
8	3590	1840	127	3280	2060	75	3320	1970	182	4930	2550
9	3410	1700	128	3060	1510	76	3560	2090	183	4620	2390
10	3590	1630	129	3210	1710	77	3370	1910	184	4380	2330
11	3480	1710	130	3440	1940	78	3390	1950	185	4540	2440
12	3660	1730	131	3530	1760	79	3590	1950	186	4750	2310
13	3560	1750	132	3190	1810	80	3040	1820	187	4870	2390
14	3360	1750	133	3470	1950	81	3560	1910	188	4940	2260
15	3390	1730	134	3020	1830	82	3310	1910	189	4800	2560
16	3390	1730	135	3030	1550	83	3240	1880	190	5060	1990
17	3060	1680	136	3160	1800	84	3700	1820	191	5900	2750
18	3670	1840	137	3230	1720	85	3360	1860	192	4550	2550
19	3260	1720	138	3070	1790	86	3560	1940	193	4400	1830
20	3360	1630	139	3230	1600	87	3270	1710			
21	3070	1650	140	3200	1540	88	3550	1940			
22	3060	1750	141	3330	1500	89	3360	1880	**Type IIIA**		
23	3220	1840	142	3210	1320	90	3590	1990			
25	2880	1630	143	3580	1660	91	3060	1690	194	4950	2420
26	3030	1670	144	3560	1790	92	3520	1830	195	4590	2390
27	3310	1660	145	3340	1660	93	3350	1820			
28	3070	1800	146	3840	1770	94	3230	1840			
29	3070	1580	147	3270	1840	95	3290	1870	**Type IV**		
30	3080	1800	148	3160	1620	96	3130	1760			
31	3230	1770	149	3160	1760	97	3580	2070	107		2000
32	3170	1780	150	2930	1530	98	3360	1820	108	3430	1910
33	3120	1730	151	3690	1750	99	3150	2000	196	3160	1530
34	3450	1760	152	2930	1650	101	3400	1785		2920	
35	3170	1850	153	3750	2040	163	3680	2200	**Type V**		
36	3250	1750	154	3520	1900	164	3330				
37	3200	1720	155	3210	1580	165	3420	1920	109	3270	1910
38	2980	1560	156	3700	1700	166	3330	1650	110	3470	2100
39	3220	1600	157	3160	1580	167	3420	1720	111	3310	1850
40	3310	1680	158	3050	1710	168	3190	1620	112	3190	1830
41	2990	1600	159	3770	1870	169	3270	1670	113	3270	1880
42	3500	1880	160	3050		170	3320	1930	114	3140	1820
43	3120	1760	161	3480		171	3610	2060	115	3220	1900
44	3020	1440				172	3320	1600	116	3380	1900
45	3290	1560				173	3790	1940	117	3660	1910
46	4020	2350	**Type IA**			174	3360		118	2910	1770
47	3140	1840	53	3250	1620	175	3260	1880	119	3090	1910
48	3120	1780	60	3250	1775	176	4060	2030	197	3280	2020
49	3170	1600	61	3160	1815	177	3070	1580	**Miscel-laneous**		
50	3580	1800	62	3410	1640	178	3410	1700			
51	3110	1640	63	3640	1760	179	3440	1770			
52	3170	1780	64	3480	1750	**Type IIA**			120	5750	
54	3110	1860	65	2990	1570				121	5850	2170
55	3690	1970	66	3750	2070	100	3380	1850	122	4000	2000
56	3050	1680	162	3190	1530				123	3810	2200
57	3680	1740							198		

2.4. Water Requirements of Portland Cement —Table 2.4

The water requirements of portland cement to yield normal consistency neat cement pastes and to produce 1:2.75 cement to graded Ottawa sand mortars and 1:4 cement to standard Ottawa sand mortars of standard consistencies were determined by procedures outlined in Federal Test Method Standards SS–C–158C [6] and the corresponding ASTM methods of test for Hydraulic Cement Mortars [9, 10, 11] that were in effect during the time of the tests. The tolerances on the flow values were less than those permitted by the specifications in that the amount of water required for a flow of 90±5 was used for the 1:4 mortars and the amount of water required for a flow of 110±5 was used for the 1:2.75 mortars. Three batches of 1:2.75 cement to graded Ottawa sand mortars were made from each of the cements to obtain the required number of test specimens, and the results were averaged.

The values reported for water used for the 1:4 cement to 20–30 Ottawa sand mortar as well as those for the neat cement pastes were generally the results from single determinations. The quantities of water needed to produce the indicated consistencies are expressed in percent by weight of the dry cement in table 2.4.

TABLE 2.4. *Water requirements of portland cement*

No.	Water requirements[1] Neat portland cement pastes[2] (percent)	1:2.75 Cement to graded Ottawa sand mortars[3] (percent)	1:4 Cement to standard Ottawa sand mortars[3] (percent)	Air contents of 1:4 mortars (percent)
Type I				
1	23.6	48.0	71	9.2
2	25.0	50.0	70	6.9
3	26.0	50.0	70	9.2
4	23.0	50.0	73	8.3
5	25.6	48.0	70	7.7
6	23.6	49.0	73	7.9
7	25.0	48.0	71	7.9
8	24.0	49.0	70	8.5
9	24.6	48.0	70	8.4
10	24.6	48.0	71	6.5
11	24.0	47.0	71	9.3
12	26.6	49.0	71	8.7
13	26.2	49.0	70	9.3
14	24.0	47.0	67	13.2
15	25.0	48.0	73	8.2
16	23.0	48.0	70	8.7
17	26.0	47.0	73	7.5
18	25.6	48.0	72	7.0
19	23.0	47.0	73	9.4
20	23.0	48.0	70	10.1
21	25.6	51.8	75	7.4
22	25.8	53.4	72	6.1
23	25.8	52.0	74	4.4
25	25.8	47.1	74	5.4
26	24.8	48.1	74	5.1
27	25.6	48.0	74	5.0
28	24.2	49.0	77	6.1
29	24.0	49.0	77	5.4
30	25.6	47.7	77	5.3
31	24.6	50.0	72	5.9
32	24.0	48.0	73	6.5
33	25.6	49.0	73	6.4
34	25.8	47.8	73	7.0
35	24.0	47.6	73	5.9
36	23.6	47.6	75	4.5
37	26.2	48.6	76	4.1
38	24.6	48.0	76	6.8
39	25.6	48.0	74	6.4
40	24.0	50.7	70	11.2
41	25.5	49.3	72	9.3
42	24.0	50.0	68	11.6
43	22.5	49.3	72	8.0
44	24.0	50.0	70	13.2
45	23.5	50.0	72	8.3
46	24.0	55.7	72	6.1
47	23.2	48.3	71	8.6
48	23.6	47.5	72	5.7
49	25.4	49.6	72	8.1
50	23.0	48.7	73	9.3
51	24.6	49.1	73	8.6
52	24.0	48.8	74	6.9
54	26.2	48.7	72	7.0
55	23.4	48.9	73	5.1
56	24.8	49.1	73	9.6
57	25.0	47.9	73	6.5
58	22.6	47.2	73	9.8
59	24.6	47.7	73	7.7
71	22.0	46.0	67	10.4
73	24.6	46.0	71	7.8
124	23.2	47.3	72	8.4
125	25.0	48.7	72	8.6
126	23.8	48.7	72	7.2
127	23.6	50.7	70	6.6
128	23.4	50.0	70	10.1
129	24.0	48.7	70	6.3
130	24.4	49.8	70	6.6
131	24.6	47.9	70	6.3
132	23.4	48.1	70	6.1
133	25.0	48.1	70	8.3
134	24.4	48.4	70	7.7

TABLE 2.4. *Water requirements of portland cement*—Continued

No.	Water requirements[1] Neat portland cement pastes[2] (percent)	1:2.75 Cement to graded Ottawa sand mortars[3] (percent)	1:4 Cement to standard Ottawa sand mortars[3] (percent)	Air contents of 1:4 mortars (percent)
Type I				
135	23.8	48.9	70	7.1
136	25.0	48.7	70	6.2
137	26.0	48.4	70	6.8
138	25.6	47.5	70	6.2
139	24.0	48.9	70	6.9
140	24.4	48.9	70	6.9
141	25.0	50.0	70	8.1
142	25.0	47.8	70	7.2
143	24.6	48.4	70	7.1
144	23.0	48.1	70	6.6
145	25.0	48.9	70	9.0
146	24.6	48.9	70	6.8
147	22.6	46.5	70	8.5
148	25.2	47.3	70	6.0
149	26.0	48.1	70	5.8
150	24.2	47.3	70	8.8
151	25.0	47.3	70	7.2
152	25.4	48.1	70	6.6
153	26.0	48.1	70	9.2
154	24.4	48.9	70	5.8
155	24.2	48.9	70	6.3
156	26.4	47.6	72	6.6
157	24.4	47.8	70	5.2
158	22.6	46.8	70	6.0
159	24.4	48.7	70	5.9
160	24.2	47.0	70	7.4
161	26.0	47.9	70	7.1
Type IA				
53	24.2	48.8	61	20.4
60	24.0	44.0	56	20.3
61	24.0	48.0	57	20.9
62	25.6	46.0	60	20.3
63	27.0	46.0	60	18.9
64	23.6	45.0	57	18.7
65	24.6	46.6	55	26.2
66	25.2	45.8	62	16.9
162	25.2	46.5	57	20.3
Type II				
24	25.0	46.4	74	7.0
67	23.0	49.0	71	6.0
68	24.0	47.0	69	9.7
69	23.0	46.0	71	7.1
70	24.0	46.0	68	10.8
72	25.4	48.0	71	6.4
74	24.6	46.0	72	8.6
75	25.6	50.0	75	5.0
76	22.8	46.0	74	4.9
77	24.0	50.0	73	5.6

TABLE 2.4. *Water requirements of portland cement*—Continued

No.	Water requirements[1] Neat portland cement pastes[2] (percent)	1:2.75 Cement to graded Ottawa sand mortars[3] (percent)	1:4 Cement to standard Ottawa sand mortars[3] (percent)	Air contents of 1:4 mortars (percent)
Type II				
78	23.6	47.1	75	5.4
79	25.6	46.0	74	3.0
80	23.5	50.0	70	8.2
81	23.5	49.3	70	9.9
82	25.0	50.0	72	7.3
83	25.0	50.0	72	8.3
84	25.0	50.0	72	7.8
85	25.0	49.3	68	11.6
86	24.0	50.0	70	9.0
87	24.5	49.3	72	6.9
88	23.2	49.6	73	5.1
89	24.8	47.8	71	6.3
90	23.2	48.8	73	4.8
91	24.0	48.5	73	6.0
92	23.0	49.6	72	8.7
93	23.0	49.3	72	8.9
94	23.4	48.8	70	8.4
95	21.4	47.3	71	10.0
96	24.4	49.4	74	8.4
97	23.6	48.2	73	5.1
98	23.2	48.9	73	5.9
99	23.2	47.7	73	6.0
101	22.0	46.5	74	6.3
163	23.0	48.7	70	6.8
164	23.4	46.2	—	6.1
165	24.2	48.1	70	5.1
166	23.0	49.2	70	6.8
167	24.2	48.7	70	6.8
168	24.4	48.7	70	6.0
169	24.4	48.7	70	6.2
170	25.4	47.9	70	5.2
171	28.0	48.1	70	5.7
172	25.6	47.3	67	8.2
173	25.0	45.9	70	7.1
174	26.0	47.3	70	5.2
175	24.0	47.3	70	5.7
176	24.0	47.9	70	6.2
177	23.6	49.2	70	6.0
178	23.2	47.0	70	5.7
179	24.0	46.5	70	5.6
Type IIA				
100	24.6	47.3	55	22.8
Type III				
102	28.6	48.9	75	4.3
103	23.5	50.0	72	9.7
104	26.2	49.8	74	7.4
105	26.4	47.5	73	6.5
106	24.2	48.9	75	6.0

TABLE 2.4. *Water requirements of portland cement*—Continued

No.	Water requirements[1] Neat portland cement pastes[2] (percent)	1:2.75 Cement to graded Ottawa sand mortars[3] (percent)	1:4 Cement to standard Ottawa sand mortars[3] (percent)	Air contents of 1:4 mortars (percent)
Type III				
180	26.0	49.2	70	6.2
181	27.0	47.5	70	6.1
182	29.2	48.9	70	5.5
183	28.0	49.2	70	5.3
184	28.0	48.7	70	7.7
185	28.6	48.7	70	6.4
186	28.0	47.8	67	9.0
187	28.0	47.8	67	8.3
188	28.4	47.5	70	5.8
189	25.0	46.3	66	8.9
190	28.4	47.3	65	11.5
191	31.0	49.5	70	9.3
192	28.4	47.3	70	6.2
193	26.0	45.9	61	11.0
Type IIIA				
194	27.2	44.6	58	17.6
195	28.0	45.2	56	18.8
Type IV				
107	22.4	51.2	75	3.9
108	23.0	46.0	72	8.1
196	22.6	50.0	----	8.5
Type V				
109	23.6	48.6	73	6.0
110	26.4	46.4	73	5.8
111	24.0	51.2	68	10.2
112	23.0	49.3	72	7.5
113	25.0	50.0	72	8.7
114	23.6	47.2	71	6.0
115	23.8	48.0	73	5.4
116	24.0	47.5	73	5.4
117	23.0	48.0	72	5.2
118	22.0	47.2	72	6.3
119	25.4	48.9	71	6.3
197	25.0	50.0	72	6.8

TABLE 2.4. *Water requirements of portland cement*—Continued

No.	Water requirements[1] Neat portland cement pastes[2] (percent)	1:2.75 Cement to graded Ottawa sand mortars[3] (percent)	1:4 Cement to standard Ottawa sand mortars[3] (percent)	Air contents of 1:4 mortars (percent)
Miscellaneous				
120	35.0	----	----	----
121	28.0	----	----	----
122	24.0	----	----	----

[1] The amount of water needed to produce the required consistency is expressed as a percent of the weight of the dry cement.
[2] For normal consistency.
[3] For standard consistency.

2.5. Potential Sulfate Expansion Test of Portland Cement Prisms—Table 2.5

The potential sulfate expansion tests of portland cement prisms were conducted by essentially adhering to the recommendations of the Working Committee on Sulfate Resistance of ASTM Committee C–1 on Cement and the proposed published method of test [12]. In this method, sufficient gaging plaster was added to the cements to make the SO_3 content 7.0 percent by weight of the cements. The 1:2.75 (cement-plaster to graded Ottawa sand) mortars were mixed with water in a mechanical mixer. The percent of mixing water (by weight of cement and gypsum) was 54 percent for types I, II, IIIA, IV, and V cements; 52 percent for types IA and IIA; and 56 percent for type III cement.

The mortars were placed in 1×1×10-in molds and cured at 95–100 percent relative humidity for 24 hours, then the prisms were removed from the molds and the length of the prisms recorded. Specimens were stored in water and length measurements were made at ages 7, 14, 28, 56, and 84 days, and at 6 months. The data on the expansion of the portland cement prisms are expressed as a percent of the length based on the 24-hour measurements and are listed in table 2.5. In general, these data are average values for three specimens.

Instead of the recommended six specimens, only three were molded because a special plastic tape was used to line the molds which facilitated release of the specimens and reduced breakage.

TABLE 2.5. *Potential sulfate expansion test of portland cement prisms*

Data No.	SO_3[1]	Wt Gyp[2]	Percent expansion							"Notes"
			7 d	14 d	21 d	28 d	56 d	84 d	6 mo	
Type I										
1	2.2	37	0.043	0.068	0.092	0.113	0.236	0.323	0.331	
2	1.8	40	.023	.037	.045	.054	.080	.103	.199	
3	2.3	36	.047	.073	.093	.111	.189	.267	.992	Warped.
4	2.4	36	.038	.060	.078	.097	.189	.333	.624	
5	2.3	36	.042	.068	.091	.109	.196	.282	.289	
6	1.9	39	.032	.053	.068	.084	.147	.213	.852	Warped.
7	2.1	38	.035	.059	.077	.097	.187	.304	.690	
8	2.4	36	.036	.060	.080	.102	.200	.349	.615	
9	2.1	38	.033	.053	.067	.079	.127	.193	.301	
10	1.8	40	.032	.054	.071	.085	.138	.198	.646	Warped.
11	2.3	36	.047	.073	.094	.110	.182	.285	.307	
12	2.3	36	.062	.106	.147	.184	.419	.844	.848	Warped.
13	2.3	36	.076	.129	.180	.219	.490	.660	.671	Warped.
14	1.8	32	.042	.065	.065	.065	.068	.068	.069	
15	2.4	32	.040	.076	.084	.099	.174	.273	.461	
16	1.7	41	.033	.052	.064	.072	.117	.160	.390	
17	1.9	39	.028	.042	.052	.058	.085	.108	.180	
18	2.0	38	.036	.057	.069	.079	.127	.173	.541	
19	1.9	39	.032	.052	.066	.075	.129	.190	.474	
20	2.5	35	.051	.078	.095	.111	.174	.235	.722	
21	2.0	38	.032	.053	.070	.086	.167	.322	.603	Warped.
22	2.3	36	.021	.033	.043	.048	.075	.096	.206	
23	1.5	42	.024	.033	.043	.048	.071	.089	.156	
25	1.2	44	.032	.046	.058	.068	.103	.137	.307	
26	1.6	41	.030	.043	.056	.067	.117	.138	.281	
27	2.0	38	.038	.059	.079	.096	.199	.250	.440	Warped.
28	1.6	41	.035	.052	.067	.078	.136	.161	.375	
29	2.0	38	.022	.030	.038	.044	.074	.085	.173	
30	1.5	42	.012	.021	.027	.032	.054	.064	.120	
31	1.6	41	.042	.079	.109	.142	.372	.545		Warped and cracked—112 days.
32	1.7	41	.023	.035	.043	.049	.077	.089	.158	
33	1.8	40	.063	.100	.131	.163	.392	.436	.439	
34	1.9	39	.055	.083	.104	.124	.190	.246	.689	Warped.
35	1.8	40	.033	.048	.061	.072	.104	.132	.258	
36	1.4	43	.017	.024	.030	.035	.047	.061	.100	
37	1.7	41	.028	.042	.053	.061	.088	.099	.167	
38	2.1	38	.034	.053	.069	.075	.176	.221	.850	Warped.
39	1.4	43	.056	.090	.118	.145	.369	.463	.497	Warped.
40	2.2	37	.028	.041	.052	.063	.095	.122	.225	
41	1.9	39	.061	.096	.120	.146	.253	.398	.414	
42	1.7	41	.018	.023	.028	.033	.048	.053	.076	
43	1.8	40	.012	.015	.018	.021	.026	.030	.036	
44	1.7	41	.025	.034	.041	.049	.067	.083	.128	
45	2.0	38	.030	.043	.052	.062	.084	.103	.169	
46	1.8	40	.046	.086	.151	.285				Deteriorated.
47	1.7	41	.012	.015	.016	.019	.025	.028	.034	
48	1.3	43	.013	.018	.020	.023	.031	.036	.055	
49	1.6	41	.038	.063	.085	.092	.152	.205	.469	Warped.
50	2.1	38	.030	.045	.054	.064	.087	.106	.177	
51	2.0	38	.039	.058	.071	.085	.120	.154	.331	

TABLE 2.5. *Potential sulfate expansion test of portland cement prisms*—Continued

Data No.	SO_3[1]	Wt Gyp[2]	Percent expansion							"Notes"
			7 d	14 d	21 d	28 d	56 d	84 d	6 mo	
Type I										
52	1.9	39	.035	.052	.067	.077	.116	.156	.359	
54	2.2	37	.029	.046	.058	.071	.113	.158	.495	
55	1.6	41	.018	.028	.035	.037	.058	.072	.131	
56	2.2	37	.019	.032	.039	.041	.063	.077	.146	
57	1.9	39	.063	.106	.136	.170	.287	.422	-------	Extremely warped (0.850) 140 days.
58	1.4	43	.127	.295	.910	-------	-------	-------	-------	Deteriorated.
59	1.5	42	.067	.098	.121	.147	.298	.621	-------	Deteriorated at 112 days.
71	1.4	43	.016	.027	.028	.032	.045	.053	.075	
73	1.5	42	.017	.031	.033	.036	.051	.055	.073	
124	1.5	42	.016	.023	.028	.032	.043	.051	.073	
125	1.6	41	.039	.059	.075	.089	.138	.178	.326	
126	1.4	43	.033	.049	.058	.066	.101	.128	.253	
127	2.2	37	.033	.051	.065	.075	.116	.153	.302	
128	2.1	38	.042	.064	.084	.103	.187	.351	.612	Warped at 112 days.
129	1.9	39	.034	.052	.065	.079	.126	.171	.502	Warped at 196 days.
130	1.8	40	.028	.042	.054	.066	.103	.138	.327	
131	2.3	36	.019	.026	.032	.036	.050	.059	.088	
132	1.6	41	.028	.039	.049	.056	.077	.093	.124	
133	2.0	38	.046	.068	.088	.106	.183	.267	.328	
134	1.7	41	.026	.038	.048	.054	.075	.092	.150	
135	1.4	43	.025	.035	.046	.049	.067	.079	.120	
136	1.7	41	.036	.057	.074	.086	.155	.203	.813	Warped at 168 days.
137	2.1	38	.059	.104	.146	.177	.215	.218	.226	
138	1.5	42	.055	.091	.125	.151	.291	.330	.367	
139	1.5	42	.047	.075	.099	.115	.179	.210	.350	
140	1.6	41	.019	.034	.044	.050	.071	.081	.122	
141	2.1	38	.083	.150	.218	.290	.663	.911	-------	Warped at 56 days.
142	2.0	38	.052	.081	.105	.126	.205	.286	.392	Warped at 140 days.
143	-------	-------	-------	-------	-------	-------	-------	-------	-------	
144	1.3	43	.093	.168	.226	.281	.468	.645	.913	Warped at 84 days.
145	2.6	35	.038	.055	.064	.076	.104	.129	.215	
146	2.8	33	.023	.035	.041	.047	.067	.075	.114	
147	1.9	39	.017	.025	.029	.033	.044	.052	.079	
148	1.9	39	.026	.040	.047	.053	.074	.089	.130	
149	1.8	40	.049	.074	.097	.126	.234	.344	.372	
150	2.4	36	.028	.032	.041	.050	.067	.081	.138	
151	-------	-------	-------	-------	-------	-------	-------	-------	-------	
152	1.9	39	.040	.058	.076	.094	.155	.227	.257	
153	2.1	38	.015	.016	.018	.023	.025	.025	.035	
154	-------	-------	-------	-------	-------	-------	-------	-------	-------	
155	1.8	40	.051	.076	.096	.115	.175	.233	.558	
156	2.3	36	.033	.052	.065	.079	.121	.152	.158	
157	1.9	39	.029	.044	.056	.067	.103	.135	.233	
158	1.4	43	.003	.007	.012	.014	.025	.033	.053	
159	2.3	36	.047	.076	.103	.140	.204	.207	.210	
160	1.7	41	.034	.051	.063	.075	.116	.155	.317	
161	2.6	35	.035	.051	.065	.077	.116	.152	.282	
Type IA										
53	2.0	38	.024	.036	.045	.052	.069	.086	.138	
60	1.8	40	.026	.041	.049	.055	.077	.097	.158	
61	2.2	37	.051	.081	.098	.116	.180	.246	.269	
62	2.3	36	.049	.111	.155	.194	.423	.609	.613	
63	2.1	38	.043	.067	.079	.090	.125	.160	.296	

TABLE 2.5. *Potential sulfate expansion test of portland cement prisms*—Continued

Data No.	SO_3[1]	Wt Gyp[2]	Percent expansion							"Notes"
			7 d	14 d	21 d	28 d	56 d	84 d	6 mo	
Type IA										
64	1.9	39	.038	.061	.080	.094	.153	.215	.674	Warped.
65	2.0	38	.041	.060	.076	.087	.127	.168	.373	
66	1.7	41	.021	.032	.040	.047	.060	.076	.121	
162	2.3	36	.036	.053	.066	.076	.107	.134	.178	
Type II										
24	1.7	41	.021	.027	.034	.038	.053	.064	.096	
67	1.5	42	.025	.036	.044	.050	.066	.082	.118	
68	1.5	42	.015	.023	.027	.031	.041	.051	.070	
69	1.7	41	.019	.028	.033	.036	.048	.060	.084	
70	1.7	41	.018	.031	.032	.036	.049	.058	.080	
72	1.8	40	.021	.034	.036	.040	.056	.066	.096	
74	1.4	43	.020	.035	.036	.040	.059	.067	.102	
75	1.5	42	.018	.025	.029	.033	.045	.054	.071	
76	1.8	40	.023	.031	.038	.043	.061	.069	.100	
77	1.5	42	.028	.039	.046	.053	.074	.083	.117	
78	1.8	40	.021	.029	.035	.039	.052	.058	.084	
79	1.6	41	.025	.035	.042	.047	.063	.069	.094	
80	1.3	43	.024	.033	.040	.046	.065	.078	.116	
81	1.7	41	.023	.032	.037	.045	.064	.076	.103	
82	1.6	41	.027	.038	.047	.054	.076	.089	.121	
83	1.8	40	.018	.026	.031	.039	.052	.062	.089	
84	1.6	41	.020	.029	.032	.040	.052	.060	.082	
85	1.8	40	.018	.026	.032	.039	.052	.059	.084	
86	1.7	41	.017	.023	.027	.035	.045	.053	.078	
87	1.7	41	.022	.033	.039	.047	.064	.076	.109	
88	1.8	40	.014	.020	.022	.028	.039	.045	.064	
89	1.8	40	.020	.028	.030	.035	.048	.055	.080	
90	1.4	43	.016	.023	.027	.030	.042	.050	.072	
91	1.5	42	.016	.022	.027	.029	.042	.048	.071	
92	1.7	41	.013	.018	.021	.025	.032	.036	.052	
93	1.4	43	.019	.027	.031	.033	.046	.057	.077	
94	1.3	43	.018	.028	.031	.037	.053	.066	.094	
95	1.6	41	.026	.035	.041	.045	.055	.066	.092	
96	1.7	41	.019	.028	.033	.036	.051	.059	.093	
97	1.5	42	.023	.032	.037	.043	.055	.064	.088	
98	1.8	40	.027	.041	.051	.055	.082	.101	.190	
99	1.8	40	.021	.028	.034	.036	.047	.056	.077	
101	1.7	41	.020	.029	.033	.035	.045	.053	.076	
163	1.7	41	.021	.026	.031	.036	.049	.053	.076	
164	1.5	42	.025	.032	.041	.045	.058	.064	.084	
165	1.6	41	.027	.041	.047	.051	.064	.072	.085	Warped at 140 days.
166	1.9	39	.019	.028	.034	.037	.048	.055	.069	Warped at 140 days.
167	1.5	42	.026	.039	.047	.051	.065	.076	.094	Warped at 140 days.
168	2.3	36	.023	.036	.045	.050	.066	.077	.096	Warped at 140 days.
169	2.3	36	.020	.033	.040	.046	.063	.072	.093	Warped at 140 days.
170	1.9	39	.028	.038	.045	.051	.068	.083	.121	Warped at 168 days.
171	1.5	39	.030	.040	.046	.048	.060	.068	.083	Warped at 168 days.
172	1.7	41	.034	.048	.056	.062	.081	.099	.119	Warped at 168 days.
173	2.0	38	.036	.047	.057	.063	.080	.092	.114	Warped at 168 days.
174	2.0	38	.023	.034	.041	.046	.060	.070	.095	Warped at 168 days.
175	1.5	42	.035	.051	.064	.077	1.05	.135	.217	Warped at 168 days.
176	1.7	41	.022	.030	.037	.045	.059	.071	.099	Warped at 168 days.
177										
178										
179	1.7	41	.024	.036	.045	.054	.074	.091	.127	Warped at 168 days.

TABLE 2.5. *Potential sulfate expansion test of portland cement prisms*—Continued

Data No.	SO_3[1]	Wt Gyp[2]	Percent expansion							"Notes"
			7 d	14 d	21 d	28 d	56 d	84 d	6 mo	
Type IIA										
100	1.9	39	.024	.038	.049	.054	.076	.093	.143	
Type III										
102	2.3	36	.031	.047	.060	.071	.112	.120	.120	
103	2.2	37	.012	.018	.019	.022	.027	.031	.038	
104	2.4	36	.014	.022	.027	.032	.049	.061	.097	
105	1.8	40	.031	.043	.050	.057	.079	.095	.127	
106	2.1	38	.016	.023	.025	.028	.039	.046	.059	
180	2.4	36	.043	.070	.090	.113	.248	.292	.296	Warped at 140 days.
181	1.9	39	.019	.029	.035	.039	.045	.044	.044	Warped at 140 days.
182	2.6	35	.039	.059	.077	.096	.146	.149	.151	Warped at 140 days.
183	2.5	35	.023	.033	.040	.044	.061	.072	.082	Warped at 168 days.
184	2.5	35	.015	.023	.029	.032	.046	.058	.080	Warped at 168 days.
185	2.4	36	.032	.052	.068	.080	.146	.256	.342	Warped at 140 days.
186	2.3	36	.015	.020	.024	.023	.031	.039	.044	Warped at 140 days.
187	2.2	37	.017	.024	.029	.030	.042	.053	.080	Warped at 168 days.
188	2.7	34	.053	.066	.083	.093	.105	.110	.110	Warped at 168 days.
189	2.3	36	.027	.031	.035	.039	.052	.060	.066	Warped at 168 days.
190	3.5	28	.046	.055	.065	.074	.086	.088	.086	Warped at 168 days.
191										
192	2.2	37	.021	.025	.030	.034	.044	.045	.063	Warped at 168 days.
193	2.5	35	.031	.039	.053	.062	.095	.118	.218	Warped at 168 days.
Type IIIA										
194										
195	2.8	33	.058	.072	.095	.118	.147	.148	.147	Warped at 168 days.
Type IV										
107	1.8	40	.030	.041	.050	.056	.078	.094	.140	
108	1.7	41	.021	.028	.031	.033	.043	.050	.059	
196	1.5	42	.034	.040	.048	.054	.070	.074	.099	Warped at 168 days.
Type V										
109	1.5	42	.014	.019	.022	.024	.032	.037	.046	
100	1.8	40	.018	.021	.025	.029	.032	.038	.046	
111	1.6	41	.016	.020	.024	.029	.038	.043	.058	
112	2.0	38	.023	.030	.034	.038	.046	.054	.066	
113	1.7	41	.019	.024	.027	.031	.041	.046	.059	
114	1.7	41	.016	.020	.021	.024	.033	.036	.045	
115	1.4	43	.022	.030	.034	.038	.052	.060	.083	
116	1.4	43	.014	.020	.023	.027	.037	.041	.061	
117	1.4	43	.012	.016	.019	.021	.031	.036	.044	
118	1.4	43	.013	.019	.021	.023	.032	.040	.051	
119	1.7	41	.019	.026	.031	.033	.041	.046	.061	
197	1.8	40	.013	.018	.022	.026	.033	.039	.050	Warped at 168 days.
Miscellaneous										
120										
121	1.7	41	.078	.114	.134	.141	.149	.153	.155	
122	1.5	42	.015	.022	.027	.028	.034	.038	.046	
123	2.2	37	.048	.072	.092	.106	.134	.137	.138	
198	1.8	40	.083	.133	.174	.211	.271	.275	.280	
199	1.8	40	.081	.122	.165	.199	.287	.293	.296	
200	2.6	35	.035	.047	.051	.056	.061	.064	.073	
201	1.4	42	.070	.111	.139	.160	.260	.355	.392	
202	2.0	38	.046	.072	.090	.100	.167	.244	.324	
203	2.2	37	.070	.092	.102	.113	.144	.181	.354	

[1] Percent SO_3 content of cements, by weight, as determined from procured samples.

[2] Weight of gypsum, in grams, added to the cements in order to make the SO_3 content 7.0 percent by weight of the cements.

2.6. Autoclave Expansion and Heat of Hydration of Portland Cements—Table 2.6

Results of autoclave expansion tests of neat portland cement pastes of normal consistency are listed in table 2.6. These were conducted in accordance with Federal Specifications [6] and ASTM methods [13].

Table 2.6 also includes heat of hydration values determined at 7 and 28 days and 1 year by the heat of solution method described in Federal Specifications [6] and ASTM test methods [14]. Duplicate tests were made on most of the cements studied.

TABLE 2.6. *Autoclave expansion and heat of hydration of portland cements*

Data No.	Autoclave expansion (percent)	Heat of hydration (cal/g)		
		7 d	28 d	1 yr
Type I				
1	0.43	82	88	103
2	.13	66	80	94
3	.45	78	87	97
4	.23	86	95	104
5	.30	82	88	104
6	.35	80	90	103
7	.26	85	92	105
8	.48	81	89	104
9	.49	75	84	99
10	.44	76	90	103
11	.22	83	92	102
12	.37	83	89	101
13	.38	81	87	103
14	.19	84	92	109
15	.07	69	83	99
16	.20	76	85	99
17	.19	74	82	99
18	.27	73	85	97
19	.20	79	84	103
20	.27	75	85	101
21	.14	82	100	
22	.08	74	84	
23	.05	71	90	
25	.05	79	94	
26	.29	79	93	
27	.25	85	94	
28	.14	73	89	
29	.09	67	82	
32	.04	76	91	
33	.09	89	103	
34	.09	75	88	
35	.25	78	94	
36	.09	69	86	
37	.09	71	89	
38	.02	85	100	
39	.33	92	100	
40	.13	71	79	95
41	.32	73	85	103
42	.08	59	72	92
43	−.01	60	67	87
44	.09	66	76	92
45	.13	67	82	98
46	.02	84	93	107
47	−.03	61	67	—
48	−.01	60	73	—
49	.28	87	93	104
50	.20	68	78	89
51	.10	76	84	95
52	.15	77	84	100
54	.08	85	93	104
55	.13	70	85	96
56	.04	65	76	90
57	.07	74	88	106
58	.11	72	85	103
59	.02	65	79	93
71	.07	61	82	95
73	.02	69	79	95
124	.00	61	75	92
125	.15	77	90	103
126	.16	71	84	98
127	.20	81	88	101
128	.34	—	—	—
129	.02	75	94	107
130	.01	81	91	105
131	.20	67	83	96
132	.01	71	89	104
133	.44	89	96	108
134	.07	72	93	109
135	.01	62	82	95
136	.11	79	96	108
137	.20	59	76	91
138	.02	72	84	96
139	.10	71	87	101
140	.22	61	82	90
141	.50	82	90	101
142	.18	75	88	98
143	.10	73	90	103
144	.22	73	92	105
145	.01	69	84	95
146	.01	67	81	96
147	.04	69	79	96
148	.02	74	90	99
149	.12	90	107	115
150	.02	77	84	101
151	.09	71	85	98
152	.19	83	103	115
153	.02	65	72	89
154	.13	71	88	98
155	.18	81	92	104
156	.16	77	94	103
157	.12	75	87	100
158	.02	69	85	100
159	.07	86	96	105

TABLE 2.6. *Autoclave expansion and heat of hydration of portland cements*—Continued

Data No.	Autoclave expansion (percent)	Heat of hydration (cal/g)		
		7 d	28 d	1 yr
Type I				
160	.06	80	95	105
161	.17	69	79	87
Type IA				
53	.53	65	77	93
60	.14	66	83	96
61	.29	82	91	104
62	.30	80	90	105
63	.14	67	80	93
64	.24	73	93	107
65	.17	75	80	93
66	.08	69	84	95
162	.11	—	—	—
Type II				
24	.13	64	74	—
67	.11	63	80	93
68	.00	58	73	93
69	.00	71	84	98
70	.01	61	76	88
72	.00	73	82	95
74	.03	69	83	94
75	.12	56	71	
76	.04	58	78	
77	.00	60	74	
78	.00	69	84	
79	.01	68	83	
80	.01	64	79	93
81	.01	67	79	93
82	.38	62	74	89
83	.09	64	77	94
84	.24	56	72	88
85	.16	66	80	92
86	.21	58	74	89
87	.01	64	77	92
88	.00	58	71	
89	.00	60	69	
90	.00	59	71	
91	.01	61	78	
92	.01	61	70	
93	.01	61	78	
94	.04	69	79	
95	.08	49	70	85
96	.13	67	82	98
97	.15	62	74	88
98	.13	71	83	94
99	.07	62	69	89
101	.01	67	78	93
163	.00	63	81	88
164	.00	64	82	97
166	.08	66	78	98
167	.02	62	81	93
168	.10	—	—	—
169	.09	69	83	92

TABLE 2.6. *Autoclave expansion and heat of hydration of portland cements*—Continued

Data No.	Autoclave expansion (percent)	Heat of hydration (cal/g)		
		7 d	28 d	1 yr
Type II				
170	.06	69	81	97
171	.02	61	76	90
172	.04	69	81	90
173	.01	56	73	89
174	.02	64	76	89
175	.06	73	86	98
176	.06	—	—	—
177	.05	69	80	93
178	.09	64	76	91
179	.06	71	84	94
Type IIA				
100	.11	64	83	94
Type III				
102	.25	90	106	—
103	−.01	70	79	95
104	−.01	82	94	—
105	.06	77	84	—
106	−.01	68	75	—
180	.01	89	101	112
181	.02	83	98	105
182	.08	94	106	114
183	.09	83	93	110
184	.00	87	92	108
185	.06	89	98	114
186	.01	80	86	103
187	.01	77	88	101
188	.08	88	96	107
189	−.03	71	83	96
190	.01	81	89	96
191	.06	95	106	113
192	.07	83	92	103
193	.05	72	82	—
Type IIIA				
194	.07	—	—	—
195	.06	90	97	112
Type IV				
107	.03	63	75	—
108	−.04	56	69	—
196	.01	49	68	82
Type V				
109	.00	41	50	—
110	−.04	50	65	—
111	.11	54	66	87
112	.00	56	65	86
113	.13	60	71	86
114	−.03	57	65	
115	.01	57	72	
116	.01	59	75	
117	−.01	57	69	
118	.02	49	64	

TABLE 2.6. *Autoclave expansion and heat of hydration of portland cements*—Continued

Data No.	Autoclave expansion (percent)	Heat of hydration (cal/g)		
		7 d	28 d	1 yr
Type V				
119	.00	63	76	91
197	.10	60	71	91
Miscellaneous				
120	−.04	—	—	—
121	.00	73	84	97
122	−.03	62	70	87
123	.01	67	81	89
198	.03	67	94	112
199	.10	65	82	96
200	.03	63	70	81
201	.05	77	85	106
202	.01	68	87	98
203	.01	62	92	—

2.7. Compressive Strength of Portland Cement Mortars—Table 2.7

The compressive strength of two-inch mortar cubes that were tested at different ages and subjected to different storage environments are given in table 2.7. Three 9-cube batches of the 1:2.75 (cement to graded Ottawa sand) mortar were made and tested in accordance with Federal Specifications [6] and ASTM test methods [11], except that the amount of water required for a percentage flow of 110±5 was used.

After the initial curing for 22 to 24 hours in molds at 95 to 100 percent relative humidity, most of the specimens were stored in water and tested at the ages of 1, 3, 7, and 28 days and at 1, 5, and 10 years. Compressive strengths of specimens stored in water for 1, 5, and 10 years are listed under Water in table 2.7. One set of specimens was stored continuously for one year in a "moist" cabinet at 95 to 100 percent relative humidity and the compressive strengths are listed under Moist. The term "Air" under compressive strength, represents the strengths of the specimens stored in water for 6 days, then in laboratory air at 50±5 percent relative humidity for 49 weeks and finally stored in water 2 weeks prior to testing. Three cubes were tested in compression at each age, and after each of the various storage conditions.

The initial and final sets, designated by I and F set, given in units of hours and minutes in table 2.7 respectively, and were determined in accordance with Federal specifications [6]. The air content of the mortar was determined in accordance with ASTM test methods [10].

TABLE 2.7. *Compressive strength of portland cement mortars*

No.	I Set (h)	F Set (h)	Compressive Strength, psi									
			Air (percent)	1 d	3 d	7 d	28 d	1 Year			5 Years	10 Years
								Air	Water	Moist	Water	Water
Type I												
1	3:05	5:55	9.2	780	2350	3830	5280	5620	5730	6380	5050	
2	4:00	7-20	6.9	690	1540	2630	5400	5180	6790	7380	6670	
3	3:35	6:50	9.2	880	1960	3320	5200	5420	6080	6380	5380	
4	3:05	5:50	8.3	780	1980	3510	5200	5140	4900	5850	4470	
5	2:55	5:45	7.7	860	2010	3180	4660	4980	5650	6380	5210	
6	2:45	5:35	7.9	760	1800	2880	4670	5020	5370	5720	4950	
7	3:25	5:40	7.9	1040	2680	4220	5850	5960	5925	6130	4875	
8	3:10	5:45	8.5	1070	2202	3330	4700	5080	5310	5870	4270	
9	2:50	5:25	8.4	780	1900	2980	4510	4980	4970	5370	4670	
10	3:40	5:35	6.5	730	1980	3090	4270	4640	4980	5430	5010	
11	3:10	6:15	9.3	970	2280	3550	5000	5460	5660	6040	4660	
12	4:15	7:20	8.7	795	1980	3130	4580	5020	5140	5790	4840	
13	4:25	7:25	9.9	760	1880	3000	4390	4990	5280	5580	4670	
14	2:50	5:00	13.1	870	2240	3580	4720	4780	4780	5210	4050	
15	2:40	4:50	8.2	1100	1900	2800	4110	4920	5480	5660	5600	
16	2:10	4:15	8.7	800	2010	3310	4820	5390	5420	5325	4920	
17	3:20	6:35	7.5	930	2110	3100	4980	5320	6550	6640	6030	
18	2:50	5:45	7.0	990	2080	3270	4850	5520	6030	6420	5720	
19	3:30	5:50	9.4	1060	2315	3630	5030	5460	5570	5660	4820	
20	3:05	5:30	10.1	1080	2340	3600	4570	5090	4780	5130	4670	
21	2:30	4:20	7.4	1040	2810	3970	5670	5475	5670	6240	5640	
22	2:50	6:20	6.1	1050	2710	3820	5590	5900	6175	6680	6675	
23	3:00	6:20	4.4	890	2680	3730	5770	5640	7160	6720	6525	
25	2:55	6:00	5.4	630	2170	3770	5720	5020	5880	6210	6375	
26	3:00	5:55	5.1	690	2400	4260	5800	5930	6220	6440	6220	
27	3:45	6:15	5.0	1360	2960	3730	6170	4570	7350	6780	6625	
28	3:40	5:50	6.1	960	2270	3630	6160	5290	6510	7020	7350	
29	3:20	5:45	5.4	970	1730	2710	4060	4540	4930	5120	5510	
30	3:15	5:05	5.3	1080	2810	4120	5420	5710	5710	6220	6025	
31	3:50	6:15	5.9	800	2300	3700	4870	4880	5610	5590	5980	
32	3:05	5:50	6.5	1190	1930	3180	4850	4870	5690	6130	6480	
33	3:15	6:00	6.4	1050	2410	3670	5450	4870	5610	5900	5830	
34	6:10	8:30	7.0	830	2260	3030	4880	4880	5520	5350	5810	
35	2:50	5:20	5.9	790	2330	3650	5620	5510	5980	5930	6230	
36	2:50	5:15	4.5	930	1900	2880	4540	5070	5710	5680	6680	

TABLE 2.7. *Compressive strength of portland cement mortars*—Continued

No.	I Set (h)	F Set (h)	Compressive Strength, psi									
			Air (percent)	1 d	3 d	7 d	28 d	1 Year			5 Years	10 Years
								Air	Water	Moist	Water	Water
Type I												
37	3:15	6:30	4.1	710	1970	2960	4630	4820	6190	5560	5700	----------
38	2:50	5:15	6.8	1170	2300	3810	5420	5860	6150	6210	6475	----------
39	2:50	6:20	6.4	910	2260	3140	4670	3920	5110	4290	5010	----------
40	2:30	5:00	11.2	870	1950	2700	4020	4460	4875	5670	4790	4230
41	4:00	6:45	9.3	860	2170	3020	4100	4625	5080	6000	4625	4160
42	4:30	6:30	11.6	825	1620	2680	4130	5420	6625	6500	5670	5590
43	4:45	7:00	8.0	770	2000	2610	4470	4790	6420	6290	5500	5810
44	3:15	5:45	13.2	970	1470	3180	4660	4420	4960	5500	4125	3700
45	3:15	5:45	8.3	940	1970	3480	4890	5290	5500	6375	4125	4080
46	2:45	5:15	6.1	1270	3050	4070	6430	6420	6275	7920	5580	5460
47	4:25	7:25	8.6	740	1790	2540	3760	4230	5520	6080	6010	----------
48	4:30	6:30	5.7	1070	1830	2510	4330	4440	6170	6660	6675	6650
49	2:55	7:05	8.1	990	2570	4060	6020	5580	6350	6625	5960	5760
50	2:45	5:35	9.3	1130	2150	3025	4880	5350	5730	5525	5225	5140
51	3:40	6:35	8.6	960	1935	3110	4850	5290	5630	6080	5620	5150
52	3:20	5:45	6.9	1045	2210	3245	5425	5525	6475	6580	6490	5510
54	3:00	6:10	7.0	1720	3310	4900	6790	6400	7180	7280	7175	6175
55	3:15	7:10	5.1	990	2480	3975	6140	5825	6650	7360	6210	5920
56	3:25	7:20	9.6	1230	2095	2700	4280	4980	5190	5425	5210	5610
57	3:10	7:05	6.5	940	2240	3200	5275	5375	6110	6825	—	5320
58	2:40	6:25	9.8	1180	2265	2980	4590	4785	6380	6865	6270	5930
59	2:20	6:05	7.7	810	1870	2890	4640	5335	6140	6920	6050	6130
71	3:45	5:25	10.4	570	1470	2720	4830	4940	5620	5970	5140	----------
73	3:45	6:00	7.8	800	1870	3020	4740	4880	6510	6510	6200	----------
124	3:15	7:15	8.4	810	2050	3120	5175	5825	7765	7710	7790	7280
125	3:45	7:45	8.6	670	2100	3410	5580	5830	6160	6160	5775	5000
126	3:30	7:30	7.2	710	1650	3050	5660	5175	6050	6210	6210	5250
127	3:20	7:20	6.6	950	1995	3310	4790	5070	5130	6175	4580	3960
128	4:05	7:05	10.1	1155	2300	3320	4730	4425	5910	5590	4790	3560
129	4:15	6 50	6.3	875	2110	3340	5630	5070	6820	7870	7020	5810
130	3:35	7:25	6.6	995	2190	3940	5960	5265	6565	7750	6360	5580
131	4:05	6:35	6.3	600	2015	2950	4400	5680	6210	7110	5870	5990
132	3:30	7:15	6.1	875	2750	3940	6200	5550	7180	8340	6810	6160
133	3:25	7:15	8.3	1130	3050	4580	6030	5010	6750	6250	6260	4720
134	4:50	8:05	7.7	755	1980	3150	5750	5660	6120	6680	6325	5790

135	4:20	7:35	7.1	550	1600	2810	4590	4610	6225	7300	6525	6370
136	4:00	7:00	6.2	1055	2185	3990	5775	5920	6480	7100	6350	6160
137	3:30	7:20	6.8	840	1880	3275	4380	5210	5340	5985	4590	3716
138	3:30	7:15	6.2	500	1425	2465	5040	5290	7120	6960	6990	6770
139	3:40	7:10	6.9	770	1835	2810	4340	4375	5710	6565	5530	—
140	4:30	7:15	6.9	580	1675	2470	3280	3875	5260	5730	5350	—
141	3:15	7:15	8.1	840	1630	2200	3100	3650	4140	4530	3725	3390
142	4:00	7:15	7.2	805	2140	3020	4620	4910	5660	6040	5350	4810
143	4:00	7:15	7.1	735	1770	2930	4820	4825	6065	6875	6000	5080
144	3:15	6:45	6.6	120	550	2370	3260	3950	4620	5600	4730	3985
145	4:25	7:30	9.0	940	1930	2820	4515	4790	5540	6120	5175	4875
146	3:40	7:35	6.8	760	1940	2975	4710	5080	5990	6720	6180	5715
147	3:35	7:00	8.5	1120	2015	2665	4940	5020	6130	6320	6310	5615
148	3:30	6:40	6.0	1110	2025	3760	6275	6230	7300	8100	7230	6175
149	3:40	6:40	5.8	960	2900	4140	6175	6210	----------	7370	6075	5310
150	3:30	6:30	8.8	1080	2210	2860	4280	5380	5800	6230	5930	5675
151	3:30	6:40	7.2	660	1590	2850	4960	5420	6410	7400	5670	5365
152	3:45	7:15	6.6	805	2490	3705	5610	5900	6430	7410	5520	5515
153	4:45	8:00	9.2	950	2520	3610	4950	5140	6970	8080	6975	6500
154	3:10	7:25	5.8	750	1665	3200	5325	5280	5810	6875	5950	5075
155	3:15	7:20	6.3	940	2460	4075	5570	5560	6590	6730	5490	5450
156	3:20	7:00	6.6	1040	2345	3745	5930	6390	6640	7430	6350	5750
157	3:35	6:55	5.2	1020	2470	3950	5460	5590	6890	7550	6510	5935
158	3:00	5:40	6.0	930	2240	3220	5270	4980	6610	7120	6660	6860
159	3:15	4:30	5.9	1505	3220	4800	6040	5780	6750	7380	6160	6385
160	3:30	7:00	7.4	960	2510	3900	5510	5580	6400	6880	5980	5615
161	3:30	7:15	7.1	1480	2900	4020	5180	5530	6300	6620	6210	5275
Type IA												
53	3:15	6:30	20.4	695	1360	2120	3525	4630	4425	4580	4250	3950
60	4:00	6:15	20.3	620	1330	2350	4410	4890	5930	5830	5710	----------
61	2:45	5:35	20.9	750	1710	2830	4010	4740	4450	5180	3800	----------
62	4:05	7:10	20.3	630	1410	2230	3320	4120	3950	4570	3720	----------
63	4:35	7:35	18.9	660	1650	2500	3730	4610	5090	5090	4625	----------
64	3:55	7:00	18.7	680	1680	2820	4600	5090	5450	5600	4810	----------
65	3:55	6:50	26.2	625	1110	1650	2480	3420	3080	3275	3275	2920
66	3:20	6:25	16.9	1260	2070	3220	5125	5630	5925	6600	5980	6020
162	4:30	7:35	20.3	830	1510	2240	3310	3875	3890	4370	3110	3375
Type II												
24	2:55	6:10	7.0	1160	2080	2830	4330	7340	6025	5680	6530	----------
67	4:35	7:40	6.0	370	1020	1980	3880	4050	6100	5920	5030	----------
68	3:45	6:50	9.7	720	1770	2970	4700	4970	6490	7240	6180	----------
69	4:50	7:30	7.1	810	2080	3250	4950	5125	6740	6930	6600	----------
70	3:40	6:45	10.8	780	1820	2770	4860	5320	6390	6880	6270	----------
72	4:05	6:25	6.4	960	1990	3110	5350	5450	6080	6630	5930	----------
74	3:20	5:25	8.6	760	1540	2850	5340	5040	6230	6290	5830	----------
75	2:55	4:00	5.0	930	1770	2590	4540	5140	7390	7270	7250	7460
76	4:00	5:40	4.9	570	1260	2600	4780	5420	7250	6470	7150	----------
77	3:35	6:25	5.6	860	1830	2820	5210	4730	6630	6440	6830	----------

TABLE 2.7. *Compressive strength of portland cement mortars*—Continued

No.	I Set (h)	F Set (h)	Compressive Strength, psi									
			Air (percent)	1 d	3 d	7 d	28 d	1 Year			5 Years	10 Years
								Air	Water	Moist	Water	Water
Type II												
78	2:00	4:50	5.4	1030	2340	3330	5870	5490	6140	6520	7170	----------
79	4:45	7:05	3.0	1150	2330	3300	3990	5860	6370	7400	7260	----------
80	3:45	6:15	8.2	680	1790	2750	5140	6420	8040	8375	8210	6630
81	3:30	5:30	9.9	860	2070	3010	5025	5420	6460	7170	6670	5580
82	4:30	7:15	7.3	625	1710	2670	4370	5210	6960	6875	6670	5780
83	3:15	6:00	8.3	820	1970	2690	4720	5920	6920	6960	6710	5770
84	3:00	6:00	7.8	710	1450	2410	4240	4830	5875	5920	5375	4340
85	3:00	6:00	11.6	840	1700	2570	4750	5500	6250	6210	4920	4840
86	3:00	6:15	9.0	840	1570	2400	5080	5300	6400	6500	6670	5675
87	3:30	6:30	6.9	630	1580	2360	5040	4660	6125	6000	6040	5050
88	4:05	6:35	5.1	960	1810	2620	4340	4520	6370	6700	7140	----------
89	3:50	6:05	6.3	960	1840	2580	4370	4890	6090	6160	6175	----------
90	3:35	5:50	4.8	1080	1990	3200	5120	4990	6630	6940	6925	7610
91	4:20	6:50	6.0	860	1830	2560	4410	4680	5510	5760	5775	5960
92	2:55	4:40	8.7	830	1700	2300	4130	4320	6030	6450	6775	6770
93	4:15	6:00	8.9	800	1950	2990	4580	5150	5820	5980	6180	5840
94	4:00	5:45	8.4	970	2170	3520	5160	4960	5720	6360	6020	5310
95	3:00	6:00	10.0	475	1055	1730	4210	4330	6150	6450	6010	----------
96	3:25	5:50	8.4	925	1910	3290	5825	5780	7140	7280	6890	6900
97	3:15	6:40	5.1	650	1680	2660	5220	5730	7350	7680	7175	7710
98	2:55	5:45	5.9	940	2045	3455	5810	5525	6310	6800	6150	5070
99	3:00	5:25	6.0	1010	2070	2890	5730	5410	7550	7475	6510	7025
101	3:50	8:00	6.3	870	2005	3200	5425	6030	7640	7930	----------	6710
163	2:55	6:50	6.8	650	1720	2770	5510	4500	6715	7510	6690	5880
164	3:30	8:00	6.1	850	2220	3305	5770	5310	7660	8770	7475	----------
165	4:05	7:50	5.1	740	1890	2920	5880	5340	6980	7660	7250	6010
166	3:30	8:00	6.8	910	1890	3140	4925	5190	5910	6890	6525	5670
167	4:25	7:30	6.8	630	1635	2945	4970	4610	7650	7570	7150	6750
168	5:00	8:00	6.0	970	2080	2940	5250	5375	6630	6910	6550	5830
169	4:45	7:50	6.2	940	2070	2985	5225	5775	6560	6780	6760	6070
170	3:30	6:50	5.2	890	2045	3020	5650	5830	7350	7490	6130	6670
171	3:45	6:50	5.7	710	1740	3000	5990	5800	7960	8240	7310	7530
172	4:00	7:00	8.2	500	1675	3020	4850	4730	6640	6775	6130	6125
173	3:45	7:00	7.1	610	1470	2370	4390	4640	6225	6890	6425	5565
174	3:20	6:50	5.2	920	1990	2840	4550	5310	7030	7870	7080	6685

175	3:45	6:25	5.7	630	1950	3190	5900	5520	7660	7890	6970	6985
176	3:30	7:00	6.2	360	1015	1560	4450	4775	6375	7220	6200	6665
177	3:30	7:50	6.0	640	1570	2755	4940	4875	5960	6510	5425	5460
178	3:45	7:15	5.7	760	1860	2840	4640	5480	6370	7400	6460	5850
179	3:45	7:00	5.6	1020	2420	4025	5475	5220	6860	7860	6690	5865
Type IIA												
100	3:35	7:30	22.8	670	1460	2020	3710	4060	4975	5330	----------	4385
Type III												
102	3:05	5:25	4.3	1740	4530	5870	6850	6610	6760	6640	6690	----------
103	3:45	6:00	9.7	1520	3370	4250	5840	6420	8170	8080	7290	6775
104	1:45	3:15	7.4	2470	3910	5900	6360	6400	6740	7740	7050	6150
105	4:20	5:50	6.5	1540	3630	4600	5870	6170	6340	7460	6730	6110
106	3:10	5:25	6.0	1300	2660	3660	5330	6230	7460	7450	8025	----------
180	3:35	7:20	6.2	1675	4075	5825	7720	6880	7730	8570	7020	5890
181	3:30	7:30	6.1	1625	4090	5425	7400	6125	6540	7960	6525	5450
182	3:00	6:00	5.5	2125	4825	6410	7675	7400	7010	8175	6740	6050
183	3:25	6:25	5.3	2570	4410	5570	7125	6925	6990	7450	6710	5970
184	3:15	7:10	7.7	2030	4210	5425	6970	6740	7250	8010	7360	6720
185	2:45	7:15	6.4	2090	3830	5380	6500	6790	6900	7930	6350	5370
186	3:35	7:40	9.0	1980	3360	4760	5830	5925	6490	7075	6375	5775
187	4:30	7:00	8.3	2060	3470	4850	6220	6415	6975	7580	6350	5790
188	3:15	7:30	5.8	2290	4310	5390	6710	7325	7390	8750	6970	6450
189	3:40	7:00	8.9	1690	3180	4210	6320	6125	7480	7975	7090	6060
190	2:25	6:35	11.5	1725	2360	4120	4620	4710	5490	5800	5810	5585
191	2:00	6:15	9.3	2735	4310	6065	6860	6725	6820	7500	6525	5485
192	5:10	8:00	6.2	2150	4720	7650	7720	6960	7220	8790	7880	7200
193	3:30	6:50	11.0	1460	3110	4360	5920	6340	7080	7575	6590	6090
Type IIIA												
194	3:40	7:05	17.6	1520	3070	3980	5370	5670	6680	6830	6610	5840
195	3:35	7:00	18.8	1750	3550	5250	5690	6000	5250	6520	5020	4000
Type IV												
107	2:50	3:40	3.9	710	1660	2590	6130	5410	7425	7750	7530	----------
108	5:40	7:40	8.1	620	1380	2020	3780	3950	6600	7150	7770	----------
196	4:10	8:25	8.5	500	1100	1670	4620	3920	6330	6420	7250	----------
Type V												
109	2:55	7:45	6.0	600	1200	1600	3320	3740	7360	6820	7650	----------
110	6:25	8:50	5.8	830	1830	2440	4380	5020	7290	6270	7700	----------
111	4:30	6:45	10.2	860	1675	2125	4375	4790	6375	5875	5580	5420
112	4:30	7:00	7.5	590	1640	2510	3870	5210	7420	7040	7250	6230
113	3:00	6:00	8.7	650	1775	2460	4080	5330	7210	7040	6125	5660
114	5:00	7:30	6.0	940	1830	2520	4120	4510	6370	7080	6820	----------
115	3:25	6:25	5.4	860	1710	2810	4810	5020	6660	7120	7225	6370
116	3:15	6:15	5.4	920	1740	2650	4940	5040	6310	6670	7090	6930
117	4:05	6:05	5.2	910	1840	2510	4240	4760	5800	6580	6640	6510
118	2:15	4:45	6.3	720	1400	2060	4020	4140	5480	5960	6600	----------

TABLE 2.7. *Compressive strength of portland cement mortars*—Continued

No.	I Set (h)	F Set (h)	Compressive Strength, psi									
			Air (percent)	1 d	3 d	7 d	28 d	1 Year			5 Years	10 Years
								Air	Water	Moist	Water	Water
Type V												
119	4:25	7:20	6.3	965	2065	3170	4965	6050	7275	7230	7125	6150
197	5:30	8:30	6.8	925	2070	2750	4580	5040	6830	6250	6825	----------
Miscellaneous												
120	0:20	6:10	----------	150	770	1460	5380	5340	7560	7450	8740	----------
121	3:00	6:00	7.4	910	1780	2460	4620	4960	6500	5830	5540	5610
122	3:15	6:15	8.7	840	2000	3050	4330	4800	6000	6040	7000	6140
123	4:10	7:35	17.6	775	1535	2280	4680	5000	6490	6600	6375	6380
198	3:40	7:00	7.3	790	1810	3070	5600	5450	8080	7870	7240	----------
199	2:50	6:40	6.4	960	1890	2960	5470	5050	7590	7550	7300	7766
200	3:50	7:00	7.0	890	2410	4050	5625	5760	7110	7490	8510	8185
201	3:50	6:40	18.2	750	1740	2540	4930	4520	6875	6360	6200	6041
202	4:10	7:10	15.9	850	1780	2630	5160	5040	7030	6990	7110	6100
203	6:20	11:30	17.0	300	1030	1785	3300	3470	5110	5320	5160	5125

2.8. Compressive Strength of Steam-Cured Portland Cement Mortars—Table 2.8

Specimens for the compressive strength test of steam-cured mortars were prepared by mixing the following percentages, by weight, of materials: 20–30 Ottawa sand, 29.8 percent; graded Ottawa sand, 28.8 percent; Gopher #0 sand, 8.0 percent; silica flour, 3.5 percent; cement, 19.9 percent; and water, 10.0 percent. The size distribution of the silica flour was measured, using a Coulter counter and the results indicated that 93 percent was finer than 5 μ, and 43 percent was finer than 2 μ. The mortars were mixed and 2-inch cubes were compacted in accordance with the requirements of Federal Test Method Standard SS–C–158 [15]. Eight sets of specimens were cured under different conditions that are described in table 2.8.1. The nomenclature used in table 2.8 is defined in table 2.8.1.

TABLE 2.8. *Compressive strength of steam-cured portland cement mortars*[1]

Data No.	Compressive strength, psi × 10^{-2}							
	AUGR	STMA	AUMA	WAGR	STGR	WAMA	WETS	DRYS
Type I								
1	126	40.4	115	68.2	5.70	85.1		
2	130	37.4	134	71.6	6.08	87.8		
3	136	43.6	131	70.2	65.2	85.9		
5	129	39.1	118	69.0	64.9	77.8		
6	133	37.8	112	68.9	66.2	81.5		
7	143	50.5	122	79.4	78.2	92.6		
8	116	40.2	111	60.1	58.6	80.2		
9	118	36.3	99	63.2	55.9	76.8		
10	136	37.1	101	65.1	59.2	73.4		
11	120	43.5	114	67.6	61.9	75.8		
13	121	31.9	111	63.2	54.0	67.8		
14		41.5	108			83.8		
16	127	41.3	111	67.8	59.1	82.4		
17	132	39.1	131	67.6	58.1	84.1		
18	139	40.1	134	70.2	65.6	84.0		
19	127	44.4	121	71.6	66.3	81.9		
20	128	43.2	132	63.8	62.2	78.8		
22		47.0	125			92.0		
23	136	46.3	129	79.8	65.0	97.8		
25	122	43.2	111	77.0	58.4	93.4		
26	127	47.4	111	80.1	72.5	95.8		
27	142	42.3	129	72.0	58.8	93.1		
28	147	43.9	131	79.9	68.4	95.6		
29	124	39.0	120	63.4	53.0	80.4		
30	144	55.2	120	84.0	81.5	96.6		
31	131			70.2	62.5			
32	132	46.0	116	74.3	74.0	87.9		
33	133	40.3	102	72.6	67.9	82.0		
34		36.9	129			82.5		
35	143	48.1	123	84.2	77.1	95.5		
36	141	43.5	121	75.1	74.9	89.2		
37	139	38.2	129	74.8	65.5	88.6		
38	137	49.1	124	79.4	74.7	96.1		
39	123	41.4	109	67.0	62.7	88.0		
40	122	33.5	114	58.6	52.3	71.0		
41	115	37.6	104	65.1	56.8	76.8		
42	141	36.1	143	68.9	61.7	86.1		
43	132	34.1	126	64.0	52.8	76.4		
44	112	31.8	120	58.7	51.0	70.1		
45	123	39.8	138	65.8	59.4	82.4		
47	131	33.6	135	65.2	53.5	76.6		
48	134	36.2	130	72.8	58.9	82.6		
49	123	42.8	123	72.9	66.3	88.4		
51	127			67.0	66.3			
52	131	40.1	120	69.4	63.2	81.5		

TABLE 2.8. *Compressive strength of steam-cured portland cement mortars*[1]—Continued

Data No.	Compressive strength, psi × 10^{-2}							
	AUGR	STMA	AUMA	WAGR	STGR	WAMA	WETS	DRYS
Type I								
54	138			80.6	73.4			
55	149			84.4	76.3			
56	127	37.3	114	61.1	59.7	73.5		
57	133	39.6	128	67.1	57.8	80.4		
71	114	38.1	107	70.9	66.2	81.0		
73	119			74.1	60.9			
128	105	37.2	116	59.4	52.8	72.2	39.8	58.5
129	143	42.8	134	80.5	68.8	97.6	49.4	75.3
130	147	48.8	134	84.4	77.8	101	55.1	80.4
131	127	37.3	142	67.7	62.2	78.8	40.8	63.2
132	149	50.0	128	90.1	75.5	100	59.7	86.7
133	138	49.8	129	78.0	73.2	96.7	50.2	74.4
134	138	46.9	119	80.6	72.6	94.8	53.6	77.2
135	131	33.9	129	64.2	49.4	80.0	37.9	60.2
136	142	53.4	131	81.2	83.9	104	60.0	84.1
137	139	45.0	129	71.4	72.7	87.0	48.9	75.4
138	122	32.4	128	71.0	57.6	82.3	42.8	62.8
139	134	35.5	132	66.0	55.5	77.7	39.2	62.1
140	117	30.1	112	56.4	44.8	70.2	36.2	55.2
142	130	38.8	134	60.8	60.1	82.3	39.4	61.5
143	131	32.6	128	64.8	58.0	76.0	37.3	60.0
144	137	28.7	126	56.0	55.9	71.8	37.0	60.3
145	124	34.6	122	68.2	59.8	78.5	42.5	65.0
146	131	39.0	134	71.8	63.8	84.3	42.9	66.0
147	128	39.5	120	70.4	79.1	82.0	45.5	68.8
148	140	49.1	128	89.8	82.2	104	59.0	85.1
149	144	55.2	128	80.4	73.2	101	61.5	89.7
150	134	41.0	118	68.4	67.8	81.2	46.1	69.6
151	130	36.3	127	73.7	58.4	82.1	46.7	72.0
152	135	51.0	124	84.2	76.8	96.6	56.3	84.0
153	152	41.3	141	74.1	57.8	87.9	46.8	70.5
155	136			76.1	62.6			
156	139	45.3	147	72.0	65.8	96.7	51.1	77.8
157	136	42.2	122	77.9	63.8	87.4	46.4	71.2
158		42.7	115			87.2	50.9	80.0
159		49.4	122			87.0	52.7	77.8
160		47.7	119			94.0	49.2	74.0
161		50.3	131			89.8	47.2	74.0
Type IA								
53	120	34.4	119	58.2	56.0	76.8		
60	120	33.8	118	66.6	56.2	74.1		
61	119	40.5	116	60.7	56.6	78.5		
63	121	35.2	131	65.0	52.5	78.4		
64	121	39.9	126	70.9	58.7	85.9		
65	94	30.9	96	47.8	44.8	60.9		
66	139	44.9	159	69.7	67.7	87.6		
162		34.7	102			71.4	43.2	62.3
Type II								
24	125	37.2	112	69.4	59.9	78.5		
67	120	33.1	125	68.2	56.0	81.8		
69	145	41.5	138	77.0	64.9	88.4		
70	125	38.4	114	73.8	59.4	85.0		
72	128	49.8	126	79.4	72.6	98.0		

TABLE 2.8. *Compressive strength of steam-cured portland cement mortars*[1]—Continued

Data No.	Compressive strength, psi × 10^{-2}							
	AUGR	STMA	AUMA	WAGR	STGR	WAMA	WETS	DRYS
Type II								
75	145	35.6	132	72.8	57.3	82.6		
76	136	30.1	138	71.5	56.1	74.5		
77	145	37.3	131	76.2	62.8	87.1		
78	138	43.2	129	81.4	72.7	95.1		
79	150	43.5	137	78.9	75.4	94.9		
80	139	37.8	131	81.2	65.2	89.8		
81	135	40.3	139	70.0	66.8	87.1		
82	128	33.5	135	64.3	57.2	76.4		
83	153	39.5	146	75.6	61.8	89.0		
84	131	30.4	124	62.2	56.9	73.1		
85	138	39.6	135	77.0	66.4	89.5		
86	133	32.5	132	67.4	58.9	78.8		
87	115	35.8	132	67.6	64.0	87.8		
88	138	31.5	138	66.7	55.3	77.2		
89	141	37.9	129	72.6	62.2	84.5		
90	143	38.5	135	77.9	62.4	87.1		
91	127	36.4	129	68.6	60.3	80.2		
92		32.6	129			75.9		
93	110	37.0	124	67.6	58.0	80.8		
94	115	39.1	118	72.5	59.1	83.0		
95	99.0	30.0	113	56.9	46.9	73.2		
96	134	46.1	111	77.0	66.9	85.1		
97	141	31.8	138	74.0	59.7	79.0		
98	136	39.9	136	73.6	60.4	88.1		
99	129	38.1	126	77.4	60.1	86.0		
101		36.9	128			85.1	50.2	76.8
163	134	41.1	131	79.5	70.8	94.2	51.6	74.4
164	159	44.0	138	83.3	64.2	96.2	51.8	85.8
165	123	43.4	136	84.8	69.0	94.2	54.1	77.8
166	126	36.6	125	70.2	63.7	80.8		
167	139	35.9	136	72.7	53.7	84.3	43.2	65.2
168	139	43.0	144	76.9	65.2	93.7	46.9	73.4
169	137	40.7	140	72.7	66.4	89.2	43.2	69.2
170	154	45.2	144	79.4	71.0	95.0	50.1	78.6
171	133	33.6	133	79.6	60.2	86.4	43.8	65.7
172	128	28.9	129	70.1	58.6	85.6	42.9	66.6
173	131	29.5	130	66.0	51.4	81.0	37.7	59.5
174	149	37.1	134	70.5	62.4	81.6	44.5	71.0
175	132	42.2	130	77.0	63.4	92.0	51.3	73.8
177	118	43.4	114	73.8	62.2	82.0	49.4	73.2
178	128	31.5	123	68.2	57.0	73.4	42.1	65.1
179	128	44.8	121	78.6	68.3	93.1	51.9	75.6
Type IIA								
100	129	33.0	131	62.2	52.0	79.2		
Type III								
103	175	49.0	140	80.9	76.1	91.4		
104	159	60.9	141	89.8	97.7	107		
105	139			78.2	69.6			
106	143	39.0	140	74.4	55.6	89.6		
180	170	63.1	139	96.5	86.9	118	72.6	99.9
181	156	62.8	145	91.6	93.2	106	68.6	96.2
182	161	68.6	153	94.1	95.5	115	75.2	99.9
183	157	64.9	142	89.7	93.6	108	63.4	93.9
184	154	61.6	141	87.6	84.0	104	67.6	94.2
185	168	67.2	145	91.0	95.4	110	70.2	99.9

TABLE 2.8 *Compressive strength of steam-cured portland cement mortars*[1]—Continued

Data No.	Compressive strength, psi × 10^{-2}							
	AUGR	STMA	AUMA	WAGR	STGR	WAMA	WETS	DRYS
Type III								
186	152	60.2	132	86.7	88.3	99.5	61.2	85.6
187	148	58.2	130	84.7	89.4	99.1	----	----
188	163	59.4	146	91.5	88.0	104	58.4	86.3
189	163	50.2	143	86.7	80.2	95.3	59.3	89.3
190	138	50.4	145	75.6	73.1	97.5	57.1	87.2
191	170	71.6	138	93.4	99.9	107	----	----
192	150	68.2	145	92.2	93.0	112	69.5	92.6
193	143	47.1	130	77.3	70.1	92.8	52.4	76.0
Type IIIA								
195	136	57.6	127	78.3	78.4	96.5	58.8	81.0
Type IV								
107	148	37.5	156	86.5	64.0	99.0	----	----
108	----	29.0	134	----	----	74.8	----	----
196	115	25.8	116	71.0	47.2	73.0	34.1	55.3
Type V								
109	129	22.6	136	50.0	42.2	61.8	----	----
110	----	29.4	152	68.4	48.6	80.8	----	----
111	135	31.6	147	62.8	52.5	78.9	----	----
112	136	27.5	133	62.2	47.9	70.6	----	----
113	----	32.4	135	62.5	50.1	75.5	----	----
114	144	30.4	131	66.3	51.3	73.2	----	----
115	143	35.2	130	77.6	58.8	85.8	----	----
116	144	36.8	139	79.8	61.1	86.4	----	----
117	----	31.2	133	----	----	71.3	44.4	60.8
118	119	----	----	64.2	51.7	----	----	----
119	114	44.0	115	81.5	56.4	86.8	----	----
197	138	32.8	139	66.8	61.6	78.2	41.1	65.5

[1] See table 2.8.1 for explanation of curing conditions of 2-inch mortar cubes that correspond to the headings of the columns in this table.

TABLE 2.8.1. *Curing conditions of specimens listed in table 2.8*

	AUGR	STMA	AUMA	WAGR	STGR	WAMA	WETS	DRY
Time in molds at 23°C, h	5	24	24	24	5	24	24	24
Time to reach temp or press, h	3–3½	½	3½	----	4–4½	----	½	½
Temperature, °C	----	71	----	23	66	23	66	66
Pressure, atm	10	1	10	1	1	1	1	1
Time at temp or press, h	11	7½	4	----	12–13	----	24	24
Time to cool, h	3	2–3	3	----	1	----	1	1
Temp of drying, °C	105	----	105	----	23	23	----	23
Time for drying, days	1	----	1	----	27	14	----	12
Time at 100% R. H., days	----	----	----	28	----	14	----	----
Age at test, days	4	2	4	28	28	28	4	14
Condition at test	dry	wet	dry	wet	dry	dry	wet	dry

2.9. Shrinkage and Cracking of Hardened Portland Cement Pastes—Table 2.9

Prisms and annular (ring) specimens made from neat portland cement pastes were tested to determine the shrinkage and the time of cracking, respectively. The shrinkage data presented in table 2.9 were determined from measurements of length changes of 1×1×10-inch (effective-gage-length) nonrestrained shrinkage specimens. The ring specimens had an inside diameter of 3¼-inch, a cross section of 1×1-inch and were restrained by a steel disk which was used for molding the specimen. Both types of specimens were cured in the molds at 73±1 °F and 95 to 100 percent relative humidity for 24 hours. Specimens were then removed from the molds (with the exception of the steel disk) and exposed to laboratory air at 73 °F and 50±5 percent relative humidity.

The length of each prism was measured when removed from the mold and at time intervals of 15 and 30 minutes; 1, 3, 6, and 24 hours; 7 and 28 days; 6 months and 1 year. Length measurements of the prisms were also determined at the time the ring specimens broke. Shrinkage values of the prisms given in table 2.9 are expressed as a percentage of length changes based on the length of the prisms at age 24 hours, the age at which they were removed from the molds. This table also includes the time for the ring specimen to break from shrinkage after the outer brass mold ring and backing plate of the mold were removed following 24 hours of curing.

TABLE 2.9. *Shrinkage and cracking of hardened portland cement pastes*

Data No.	Ring cracking elapsed time [1]	Percent shrinkage [2]	Percent shrinkage									
			15 min	30 min	1 h	3 h	6 h	24 h	7 d	28 d	6 mo	1 yr
Type I												
1	0:36	0.015	0.011	0.014	0.019	0.022	0.037	0.104	0.239	0.362	0.426	0.433
2	21:29	.041	.008	.011	.013	.017	.023	.050	.121	.191	.228	.239
3	8:27	.040	.008	.010	.013	.017	.034	.068	.131	.203	.244	.243
4	3:47	.027	.010	.014	.018	.021	.034	.071	.157	.268	.329	.335
5	0:40	.019	.012	.016	.028	.033	.048	.112	.251	.369	.436	.438
6	9:40	.039	.009	.012	.015	.022	.030	.059	.151	.233	.265	.280
7	0:56	.015	.009	.012	.015	.025	.033	.068	.097	.237	.273	.290
8	0:41	.016	.009	.012	.019	.030	.040	.082	.165	.252	.289	.297
9	2:38	.021	.007	.011	.014	.022	.030	.066	.156	.268	.324	.351
10	14:40	.039	.004	.009	.013	.018	.023	.053	.142	.252	.299	.319
11	1:05	.018	.010	.014	.018	.028	.038	.083	.193	.299	.342	.367
12	3:05	.027	.010	.013	.017	.027	.038	.081	.184	.271	.297	.311
13	4:00	.033	.011	.015	.020	.030	.040	.083	.180	.262	.292	.306
14	0:18	.018	.012	.018	.022	.035	.046	.102	.211	.359	.431	.458
15	2:31	.026	.008	.011	.016	.030	.044	.091	.160	.232	.282	.305
16	1:23	.017	.009	.012	.015	.023	.031	.068	.166	.277	.333	.354
17	6:37	.035	.012	.015	.019	.027	.033	.065	.145	.228	.272	.292
18	5:07	.027	.008	.011	.014	.021	.029	.063	.137	.215	.246	.260
19	1:41	.017	.008	.010	.013	.021	.031	.047	.151	.260	.326	.344
20	1:41	.015	.007	.009	.014	.024	.035	.071	.137	.125	.273	.292
21	6:15	.044	.017	.021	.025	.032	.040	.066	.132	.205	.253	.254
22	6:02	.030	.007	.009	.012	.020	.029	.071	.141	.217	.284	.288
23	45:17	.126	.006	.009	.011	.024	.030	.060	.144	.221	.282	.286
25	6:42	.045	.012	.016	.020	.032	.040	.080	.190	.272	.335	.354
26	11:17	.046	.010	.014	.015	.016	.026	.057	.155	.237	.305	.306
27	13:15	.043	.006	.012	.016	.020	.027	.049	.113	.170	.227	.227
28	22:27	.059	.010	.014	.017	.024	.031	.056	.117	.181	.223	.222
29	3:07	.020	.008	.010	.012	.020	.028	.059	.117	.193	.257	.254
30	18:51	.045	.011	.014	.017	.025	.031	.049	.104	.177	.224	.225
31	12:15	.050	.008	.011	.015	.026	.033	.058	.124	.188	.237	.234
32	2:50	.021	.008	.010	.014	.022	.030	.069	.150	.260	.345	.345
33	0:25	.018	.013	.018	.027	.042	.058	.129	.301	.342	.524	.518
34	7:03	.038	.009	.012	.015	.021	.036	.076	.163	.219	.283	.278
35	21:07	.045	.012	.015	.018	.023	.030	.055	.146	.228	.302	.290
36	7:45	.040	.013	.015	.018	.025	.036	.064	.140	.215	.272	.269
37	14:24	.052	.010	.013	.017	.023	.029	.062	.152	.236	.277	.277
38	7:53	.036	.011	.014	.017	.024	.031	.062	.136	.214	.264	.266
39	0:48	.023	.014	.019	.025	.038	.053	.130	.354	.525	.601	.617
40	4:00	.026	.007	.009	.013	.023	.033	.076	.167	.274	.329	.354
41	0:35	.016	.011	.015	.021	.031	.049	.123	.285	.451	.523	.551

42	8:00	.040	.007	.010	.012	.018	.025	.064	.139	.214	.249	.256
43	9:23	.040	.008	.011	.013	.019	.028	.074	.172	.243	.279	.300
44	16:38	.046	.010	.011	.013	.017	.022	.057	.136	.200	.245	.274
45	4:35	.025	.007	.010	.014	.021	.030	.067	.131	.208	.243	.265
46	0:11	.012	.013	.017	.024	.034	.046	.072	.122	.176	.206	.222
47												
48	15:32	.050	.005	.006	.008	.017	.026	.067	.155	.223	.279	.288
49	2:10	.023	.010	.013	.017	.026	.035	.073	.174	.284	.357	.360
50	10:55	.034	.008	.011	.014	.019	.025	.053	.155	.247	.313	.322
51	11:11	.040	.010	.012	.016	.021	.028	.059	.150	.223	.302	.296
52	2:58	.019	.006	.008	.014	.019	.027	.062	.149	.256	.338	.328
54	5:40	.025	.009	.010	.018	.019	.027	.053	.129	.210	.253	.252
55	1:25	.019	.010	.013	.017	.025		.086	.162	.266	.342	.344
56	13:25		.008	.011	.013	.017	.023	.053	.139	.195	.210	.207
57	14:35		.013	.015	.018	.022		.064	.141	.209	.272	.265
58	1:27	.022	.011	.014	.019	.032	.043	.085	.166	.227	.263	.268
59	8:44	.043	.011	.014	.019	.027	.036	.087	.158	.233	.267	.271
71	15:35	.042	.006	.008	.010	.016	.025	.057	.163	.271	.328	.357
73	4:10	.030	.010	.015	.018	.027	.034	.070	.181	.286	.337	.363
124	8:05	.031	.008	.012	.015	.019	.025	.043	.100	.156	.190	.198
125	5:43	.027	.008	.010	.013	.019	.027	.061	.150	.241	.295	.305
126	13:21		.008	.011	.014	.020	.027	.055	.159	.228	.379	.388
127	4:41	.055	.013	.019	.026	.040	.063	.146	.288	.373	.431	.440
128	0:07	.014	.024	.032	.046	.078	.104	.200	.347	.431	.487	.489
129	23:23	.062	.010	.018	.020	.026	.033	.063	.124	.171	.200	.205
130	29:05	.063	.008	.010	.012	.019	.027	.059	.126	.202	.250	.255
131	16:14	.045	.007	.010	.011	.015	.021	.059	.153	.209	.256	.263
132	17:13	.043	.012	.017	.020	.025	.027	.050	.093	.141	.165	.172
133	0:35	.014	.009	.013	.017	.028	.035	.078	.157	.238	.278	.274
134	11:37	.035	.007	.010	.013	.020	.025	.055	.137	.216	.260	.269
135	25:15	.050	.007	.010	.012	.016	.020	.048	.112	.158	.201	.212
136	8:39	.038	.010	.012	.016	.023	.031	.066	.146	.220	.242	.260
137	10:07	.040	.010	.013	.017	.025	.033	.056	.118	.185	.198	.221
138	7.50	.042	.010	.016	.022	.031	.038	.063	.118	.196	.224	.234
139	18:40	.048	.009	.012	.015	.021	.026	.054	.127	.196	.204	.224
140	25:30	.047	.007	.009	.011	.014	.018	.045	.136	.206	.239	.267
141	2:33	.028	.011	.016	.022	.039	.055	.122	.225	.320	.350	.359
142	3:08	.030	.010	.014	.018	.029	.042	.087	.191	.285	.336	.346
143	8:47	.037	.009	.011	.014	.020	.029	.068	.160	.247	.288	.300
144	10:17	.046	.011	.016	.019	.027	.036	.066	.160	.232	.267	.285
145	12:33	.044	.008	.011	.014	.019	.026	.065	.142	.198	.233	.243
146	15:03	.047	.009	.011	.013	.017	.022	.066	.168	.227	.259	.261
147	4:09	.026	.010	.013	.016	.023	.031	.067	.137	.220	.284	.291
148	8:16	.041	.011	.014	.017	.025	.035	.062	.143	.259	.316	.329
149	13:43	.048	.016	.021	.024	.030	.035	.060	.128	.193	.218	.225
150	2:32	.029	.011	.015	.020	.032	.045	.100	.188	.269	.322	.335
151	18:33	.045	.011	.014	.016	.020	.026	.051	.135	.187	.213	.223
152	19:40	.056	.011	.015	.020	.028	.035	.060	.109	.170	.206	.214
153	3:55	.040	.013	.017	.022	.032	.049	.126	.239	.311	.345	.352
154	12:30	.036	.007	.009	.010	.014	.021	.052	.129	.207	.239	.245

TABLE 2.9. *Shrinkage and cracking of hardened portland cement pastes*—Continued

Data No.	Ring cracking elapsed time [1]	Percent shrinkage [2]	Percent shrinkage									
			15 min	30 min	1 h	3 h	6 h	24 h	7 d	28 d	6 mo	1 yr
Type I												
155	1:39	.022	.011	.015	.018	.028	.039	.086	.196	.299	.340	.344
156	10:21	.038	.007	.011	.013	.018	.024	.056	.130	.180	.202	.207
Type IA												
53	8:45	.030	.007	.008	.011	.017	.024	.063	.137	.209	.262	.265
60	12:25	.035	.007	.010	.012	.017	.020	.057	.156	.218	.264	.277
61	1:50	.025	.011	.015	.019	.027	.029	.088	.236	.343	.415	.425
62	3:29	.032	.005	.014	.018	.030	.044	.094	.202	.281	.331	.338
63	10:25	.036	.008	.012	.013	.018	.025	.071	.160	.218	.259	.263
64	10:35	.056	.005	.011	.013	.018	.025	.062	.151	.233	.278	.293
65	2:15	.017	.006	.010	.013	.020	.033	.080	.174	.270	.328	.347
66	17:10	.062	.009	.011	.014	.022	.032	.073	.156	.233	.275	.280
162	1:27	.020	.009	.012	.017	.028	.042	.087	.160	.253	.285	.306
Type II												
24	2:33	.013	.002	.003	.007	.018	.025	.067	.166	.174	.348	.360
67	28:10	.058	.006	.008	.010	.014	.022	.052	.145	.207	.266	.304
68	12:00	.039	.008	.011	.014	.019	.024	.048	.123	.211	.246	.268
69	11:25	.045	.012	.015	.018	.025	.032	.064	.142	.222	.259	.273
70	13:05	.035	.008	.010	.012	.017	.023	.050	.114	.179	.212	.232
72	7:25	.031	.011	.013	.018	.024	.030	.054	.119	.185	.217	.242
74	6:15	.030	.006	.011	.018	.020	.029	.068	.200	.304	.369	----------
75	19:40	.039	.006	.009	.011	.014	.020	.043	.130	.206	.263	.271
76	16:45	.032	.008	.010	.011	.015	.017	.040	.114	.167	.237	.234
77	22:00	.046	.007	.009	.013	.020	.026	.048	.109	.162	.238	.242
78	13:20	.036	.009	.010	.013	.017	.025	.048	.108	.181	.216	.218
79	12:25	.039	.006	.008	.011	.016	.024	.055	.119	.188	.236	.251
80	16:30	.059	.007	.009	.013	.020	.035	.071	.169	.248	.301	.330
81	26:25	.043	.008	.010	.013	.016	.020	.043	.111	.172	.191	.211
82	15:35	.045	.008	.014	.017	.021	.025	.055	.174	.280	.330	.347
83	7:10	.035	.008	.011	.013	.022	.030	.065	.144	.221	.260	.272
84	15:10	.039	.010	.011	.013	.017	.027	.046	.117	.212	.259	.270
85	4:05	.024	.008	.010	.013	.022	.030	.063	.138	.209	.248	.249
86	6:50	.028	.007	.009	.012	.018	.026	.065	.140	.214	.258	.259
87	16:10	.033	.008	.011	.013	.017	.023	.053	.139	.195	.230	.244
90	10:15	.036	.008	.010	.013	.019	.031	.049	.127	.197	.242	.251
91	16:35	.035	.008	.010	.012	.015	.021	.042	.095	.165	.223	.230
92	17:47	.036	.007	.009	.010	.013	.019	.040	.101	.167	.215	.221

93	16:20	.037	.009	.011	.013	.017	.020	.050	.137	.206	.264	.282
94	6:41	.030	.009	.012	.015	.021	.029	.059	.182	.294	.372	.383
95												
96	0:30	.013	.006	.013	.017	.027	.038	.076	.156	.255	.338	.330
97	10:45	.035	.004	.007	.010	.019	.027	.060	.149	.215	.263	.261
98	6:55	.041	.011	.014	.018	.025	.031	.070	.191	.273	.329	.339
99	6:10		.010	.013	.015	.021		.070	.160	.253	.310	.299
101			.008	.010	.012	.016	.022	.049	.137	.193	.236	.246
163	15:13	.041	.008	.010	.013	.019	.025	.050	.109	.173	.218	.226
164	16:47	.046	.010	.015	.018	.022	.028	.054	.105	.158	.192	.201
165	14:01	.037	.004	.006	.010	.016	.024	.052	.112	.190	.231	.240
166	10:26	.030	.007	.010	.013	.018	.019	.066	.140	.213	.248	.252
167	19:10	.040	.007	.010	.012	.015	.018	.045	.104	.146	.181	.194
168	8:23	.035	.008	.010	.012	.018	.028	.072	.152	.226	.265	.271
169	10:32	.043	.007	.010	.013	.019	.028	.076	.164	.235	.275	.283
170	9:48	.032	.008	.011	.013	.019	.025	.053	.137	.200	.220	.240
171	29:09	.062	.007	.009	.011	.014	.017	.054	.135	.188	.204	.226
172	15:57	.054	.007	.010	.013	.018	.025	.072	.173	.252	.306	.335
173	19:17	.045	.010	.012	.015	.017	.021	.051	.151	.219	.254	.261
174	13:54	.041	.008	.011	.013	.018	.025	.061	.124	.189	.223	.232
175	14:14	.052	.012	.016	.020	.028	.036	.066	.150	.227	.261	.273
176	20:50	.048	.008	.010	.012	.016	.022	.052	.132	.291	.245	.266
177	8:03	.039	.009	.014	.017	.026	.034	.065	.169	.273	.333	.349
178	16:19	.041	.009	.013	.015	.018	.024	.062	.137	.196	.233	.237
Type IIA												
100	7:47	.036	.010	.015	.017	.024	.031	.075	.171	.246	.305	.300
Type III												
102	1:10	.021	.012	.013	.020	.029	.037	.067	.157	.275	.336	.331
103	0:19	.016	.013	.019	.028	.040	.067	.132	.227	.298	.345	.360
104	0:11	.009	.010	.015	.020	.033	.050	.101	.172	.223	.274	.281
105	1:14	.018	.010	.013	.016	.026	.038	.090	.193	.275	.333	.330
106	5:20	.026	.007	.010	.012	.016	.027	.071	.162	.220	.274	.270
180	4:12	.025	.008	.010	.013	.021	.030	.065	.133	.186	.220	.222
181	5:51	.037	.007	.016	.020	.029	.038	.066	.118	.189	.234	.241
182	0:35	.016	.009	.014	.020	.031	.041	.077	.145	.225	.266	.265
183	0:39	.012	.007	.011	.015	.023	.032	.076	.151	.241	.292	.283
184	9:01	.051	.008	.011	.017	.028	.040	.097	.203	.275	.308	.326
185	1:35	.021	.010	.013	.017	.029	.040	.082	.156	.236	.273	.275
186	10:56	.040	.008	.010	.014	.020	.028	.066	.152	.231	.280	.283
187	19:30	.059	.006	.012	.016	.022	.028	.072	.154	.232	.270	.292
188	0:30	.014	.010	.014	.019	.032	.047	.094	.176	.261	.305	.306
189	6:09	.032	.009	.013	.016	.023	.031	.064	.143	.208	.243	.246
190	4:57	.028	.010	.014	.017	.025	.035	.093	.192	.257	.293	.298
191	0:04	.005	.012	.015	.019	.027	.032	.056	.138	.197	.255	.260
192	1:32	.017	.009	.011	.014	.022	.032	.068	.158	.222	.262	.265
193	12:05	.038	.008	.010	.012	.016	.022	.061	.158	.218	.261	.261

TABLE 2.9. *Shrinkage and cracking of hardened portland cement pastes*—Continued

Data No.	Ring cracking elapsed time [1]	Percent shrinkage [2]	Percent shrinkage									
			15 min	30 min	1 h	3 h	6 h	24 h	7 d	28 d	6 mo	1 yr
Type IIIA												
194	2:11	.026	.010	.013	.018	.028	.040	.082	.163	.219	.261	.264
195	1:10	.020	.011	.014	.019	.032	.046	.110	.191	.270	.306	.327
Type IV												
107	18:20	.046	.009	.012	.015	.019	.026	.052	.116	.172	.213	.215
108	13:07	.046	.010	.012	.014	.019	.026	.067	.151	.209	.273	.285
196	11:28	.036	.011	.014	.016	.020	.026	.055	.140	.212	.264	.278
Type V												
109	30:30	.051	.007	.009	.012	.015	.019	.040	.107	.154	.198	.208
110	26:00	.067	.009	.012	.014	.021	.028	.064	.141	.205	.260	.275
111	11:06	.028	.002	.004	.005	.010	.018	.054	.133	.206	.237	.253
112	13:30	.054	.011	.014	.017	.022	.030	.077	.148	.216	.250	.271
113	17:33	.048	.008	.011	.014	.020	.030	.054	.133	.202	.234	.241
114												
115	15:02	.035	.007	.010	.012	.017	.024	.050	.132	.212	.256	.256
116	13:00	.037	.008	.010	.011	.016	.028	.045	.122	.197	.256	.263
117	17:00	.035	.007	.009	.011	.013	.020	.045	.118	.186	.241	.241
118	33:12	.044	.008	.010	.012	.015	.019	.036	.087	.158	.228	.231
119	7:40	.029	.008	.011	.014	.020	.026	.051	.137	.227	.285	.285
197	10:02	.042	.009	.011	.013	.019	.028	.074	.180	.267	.309	.313
Miscellaneous												
120 [3]			.021	.025	.028	.031	.034	.066	.119	.141	.196	.212
121	6:57	.045	.012	.014	.021	.030	.041	.081	.176	.246	.270	.275
122	4:07	.037	.012	.015	.020	.032	.046	.125	.258	.339	.390	.408
123	12:52	.036	.011	.013	.015	.020	.026	.070	.147	.204	.259	.279
198	8:40	.042	.009	.012	.015	.021	.032	.087	.150	.219	.253	.266
199	8:50	.040	.009	.013	.017	.022	.031	.071	.157	.246	.302	.316
200	1:36	.016	.007	.011	.014	.026	.041	.123	.251	.293	.328	.338
201	7:40	.038	.009	.013	.015	.021	.031	.091	.172	.247	.293	.308
202	23:15	.059	.008	.011	.012	.016	.027	.060	.121	.174	.194	.216
203	27:25	.074	.007	.008	.011	.014	.018	.065	.143	.192	.255	.301

[1] Elapsed time given in hours and minutes.
[2] Percent shrinkage of prism at time of cracking of ring specimen.
[3] Broken between 16 and 18 days. 18 day shrinkage 0.132 percent.

2.10. Miscellaneous Strength Tests of Portland Cement Mortars—Table 2.10

The dynamic Young's modulus of elasticity, flexural strength and compressive strength were determined, using 4×4×16-cm prisms of 1:2.75 (cement to graded Ottawa sand) mortar. These data are presented in table 2.10 for tests conducted on prisms at ages 1, 3, and 7 days. Also included in this table are the weights of the prisms and the transverse resonant frequency. These data were compared with the strength properties of the concretes in Part 5, Section 13 of Interrelations between Cement and Concrete Properties [5].

The water requirement to produce 1:2.75 cement to graded Ottawa sand mortar of standard consistency was determined by the procedure outlined in Federal Test Method Standards SS–C–158C [6]. The tolerance on the flow value was less than that permitted by the specifications in that the amount of water required for a flow of 110±5 was used for the 1:2.75 mortar. These data are given in section 2.4.

TABLE 2.10. *Miscellaneous strength tests of portland cement mortars*

No.	1 Day					3 Day					7 Day				
	Wt. g	Freq. cps	psi			Wt. g	Freq. cps	psi			Wt. g	Freq. cps	psi		
			Mod. $\times 10^{-6}$	Flex.	Compr.			Mod. $\times 10^{-6}$	Flex.	Compr.			Mod. $\times 10^{-6}$	Flex.	Compr.
Type I															
1															
2	560	3520	2.123	175	910	560	4380	3.287	410	1950	559	4820	3.974	555	3150
3	555	3550	2.140	185	990	559	4500	3.464	405	2420	562	5000	4.300	685	3580
4	546	2880	1.385	100	530	548	3690	2.283	255	1200	547	4200	2.953	380	1800
5	561	3250	1.813	170	830	565	4370	3.302	425	2060	565	4770	3.934	520	3300
6	551	2890	1.408	105	620	557	4000	2.727	360	1620	572	4800	4.033	555	2890
7	552	3980	2.675	290	1360	560	4900	4.114	605	3120	558	5280	4.760	775	4470
8	560	3940	2.660	235	1260	566	4700	3.826	495	2470	568	5100	4.521	620	3690
9	555	3800	2.452	215	1120	555	4600	3.594	450	2220	556	4930	4.135	585	3150
10	561	3570	2.188	180	940	568	4500	3.520	470	2220	569	4950	4.266	600	3340
11	561	3320	1.892	180	850	564	4400	3.341	435	2150	565	4900	4.161	640	3540
12	566	3500	2.121	200	960	563	4430	3.381	415	2220	567	4950	4.251	585	3600
13	561	3080	1.628	135	680	565	4450	3.424	510	2470	563	5050	4.394	740	4210
14	566	3650	2.307	235	1150	571	4680	3.827	510	2790	569	5100	4.529	765	4520
15	554	4200	2.990	350	1470	558	4820	3.967	540	2450	561	5160	4.571	665	3520
16	570	3500	2.136	215	1080	569	4470	3.479	415	2090	572	4850	4.117	640	3010
17	558	3290	1.848	215	870	558	4400	3.306	385	1980	560	4800	3.948	565	2880
18	567	3230	1.810	225	780	570	4370	3.331	425	2000	570	4840	4.086	535	2780
19	567	3470	2.089	215	930	571	4500	3.538	460	1990	570	4860	4.120	570	2990
20	568	3340	1.939	190	840	570	4290	3.210	360	1920	572	4860	4.134	560	3000
21	567	3390	1.839	190	910	570	4320	3.227	390	1930	569	4860	4.113	620	2870
22	566	3500	2.121	180	1010	564	4450	3.418	455	2320	568	4860	4.105	585	3340
23	564	3400	1.995	235	980	567	4520	3.163	415	2170	566	5010	4.347	635	3220
25	564	3120	1.680	155	570	567	4100	2.917	375	1690	564	4580	3.620	520	2610
26	561	2910	1.454	135	780	565	4280	3.167	350	1900	570	4870	4.137	590	3190
27	567	3400	2.005	225	1070	567	4350	3.283	405	1840	568	4830	4.055	520	2950
28	555	4340	3.199	470	2580	558	4850	4.016	640	3900	561	5200	4.642	850	5720
29	553	3200	1.733	200	900	555	4170	2.953	395	2060	557	4760	3.862	605	3410
30	559	4140	2.932	375	1820	565	4900	4.151	640	3740	563	5330	4.894	865	5330
31	557	3250	1.800	135	680	558	3890	2.584	280	1240	557	4370	3.255	370	1890
32	553	2970	1.493	160	750	555	4150	2.925	340	1600	553	4540	3.488	470	2220
33	555	3800	2.452	290	1510	559	4660	3.714	465	2680	560	5050	4.370	650	3670
34	571	2970	1.541	175	760	576	4080	2.934	285	1720	572	4530	3.592	520	2480
35	556	3220	1.770	200	980	567	4420	3.390	515	2440	563	4850	4.052	640	3810
36	568	2870	1.432	145	760	571	3880	2.630	315	1520	571	4370	3.337	500	2400

37	562	3710	2.367	200	1220	560	4500	3.470	495	2360	557	5000	4.261	710	3820
38	567	3160	1.732	155	810	568	4330	3.259	475	2280	567	4950	4.251	690	4180
39	553	3670	2.279	245	1050	555	4600	3.594	400	2240	558	5060	4.372	675	3530
40	549	2910	1.423	130	680	555	4210	3.010	395	2150	559	4890	4.090	650	3960
41	567	3210	1.788	155	760	570	4410	3.392	485	2510	569	5060	4.458	760	4150
42	572	4050	2.871	345	1750	578	4820	4.109	715	3700	578	5340	5.044	970	5660
43	571	3350	1.961	185	880	578	4100	2.973	355	1830	575	4730	3.937	525	3110
44	574	3700	2.404	250	1350	576	4660	3.828	605	3030	574	5220	4.786	825	5350
45	563	3940	2.674	285	1400	567	4580	3.639	505	2460	570	5130	4.590	710	3880
46	573	3850	2.599	310	1690	579	4840	4.151	670	4120	576	5390	5.121	955	6240
47	566	3750	2.436	280	1360	574	4750	3.963	630	3350	576	5310	4.970	830	5420
48	568	3250	1.836	205	960	570	4240	3.136	470	2200	572	4910	4.220	785	3820
49	565	4120	2.935	330	1730	570	4780	3.985	585	3040	569	5250	4.799	745	4820
50	573	3150	1.740	145	730	571	3870	2.617	270	1410	570	4380	3.346	435	2220
51	569	3750	2.449	305	1350	573	4750	3.956	625	3370	570	5250	4.807	805	5360
52	561	2820	1.365	95	600	565	4300	3.197	385	1930	565	4680	3.787	525	2600
54	559	3170	1.719	170	780	563	4350	3.260	495	2630	564	5000	4.315	695	4490
55	558	3440	2.021	215	1030	562	4500	3.483	400	2450	560	5100	4.457	655	3920
56	561	3350	1.927	200	970	566	4450	3.430	495	2480	566	4900	4.159	------	3990
57	558	3180	1.727	175	790	561	4310	3.189	405	2210	562	4850	4.045	635	3540
58	551	3530	2.101	235	1040	559	4550	3.541	595	2890	558	5060	4.372	810	4570
59	566	3880	2.607	340	1590	573	4930	4.262	785	4840	566	5280	4.829	905	6680
71	547	3460	2.004	235	900	550	4490	3.393	535	2430	551	4880	4.015	670	3550
73	553	2470	1.032	90	460	558	3740	2.388	270	1370	556	4460	3.384	405	2520
124	563	3470	2.074	230	1100	563	4470	3.442	470	2340	558	4860	4.033	660	3500
125	555	3350	1.906	155	810	559	4150	2.946	315	1600	559	4790	3.925	560	3110
126	No Test														
127	557	3550	2.148	225	970	561	4300	3.174	450	2180	562	4750	3.880	685	3660
128	541	3690	2.254	245	1020	548	4640	3.610	525	2540	552	5060	4.325	715	3710
129	554	3700	2.321	245	1080	559	4560	3.557	510	2550	558	5000	4.269	665	3990
130	559	3750	2.405	275	1320	563	4560	3.582	495	2860	560	5040	4.353	730	4540
131	555	3320	1.872	160	790	562	4580	3.608	460	2170	561	5080	4.430	695	3170
132	561	3630	2.262	290	1320	563	4770	3.920	560	3360	563	5160	4.587	805	5180
133	550	3790	2.417	205	1060	552	4800	3.892	655	3430	554	5220	4.619	830	5270
134	561	3560	2.176	250	1250	562	4540	3.545	515	2540	561	5140	4.535	730	4460
135	552	3070	1.592	145	670	555	4270	3.096	385	1980	556	4850	3.713	635	3300
136	560	3800	2.474	250	1380	562	4660	3.735	555	2990	566	5300	4.002	785	5330
137	561	3650	2.287	250	1060	566	4680	3.793	610	3010	568	5050	4.433	865	4560
138	562	3260	1.828	205	930	565	4520	3.532	560	2780	565	5040	4.392	715	4570
139	555	3400	1.963	190	780	559	4390	3.296	505	2150	556	4810	3.936	640	3240
140	553	3240	1.776	150	700	553	4300	3.129	405	1840	555	4800	3.913	650	2960
142	558	3480	2.068	230	920	562	4600	3.639	555	2630	566	5120	4.540	725	4180
144	561	3000	1.545	145	510	565	4220	3.079	405	1660	562	4640	3.703	575	2740
145	546	3630	2.202	235	940	551	4520	3.445	500	2360	555	4900	4.078	650	3400
146	554	3240	1.780	160	800	562	4590	3.623	515	2440	563	5010	4.324	685	3530
152	557	3770	2.422	275	1240	560	4850	4.031	680	3520	561	5250	4.732	910	5410
156	555	3750	2.388	300	1240	561	4610	3.648	565	2890	564	4960	4.246	720	4060
160	557	3660	2.283	225	1050	552	4520	3514	460	2390	565	5020	4.357	655	4010
161	556	4200	3.001	335	1740	559	4890	4090	565	3220	560	5260	4.741	775	4540

TABLE 2.10. *Miscellaneous strength tests of portland cement mortars*—Continued

No.	1 Day					3 Day					7 Day				
	Wt. g	Freq. cps	psi			Wt. g	Freq. cps	psi			Wt. g	Freq. cps	psi		
			Mod. $\times 10^{-6}$	Flex.	Compr.			Mod. $\times 10^{-6}$	Flex.	Compr.			Mod. $\times 10^{-6}$	Flex.	Compr.
Type IA															
53	551	3320	1.858	145	770	560	4560	3.563	540	2660	559	5030	4.328	710	3900
61	560	3210	1.766	180	770	561	4500	3.476	510	2500	566	4810	4.007	725	3700
62	550	3540	2.109	270	1010	557	4470	3.406	575	2670	558	5090	4.424	785	4090
63	559	3250	1.807	160	780	562	4190	3.019	415	1770	562	4910	4.146	780	2980
64	553	3530	2.109	215	960	560	4440	3.378	500	2330	560	4930	4.165	715	3750
65	545	3330	1.849	215	830	552	4360	3.211	455	2290	553	4750	3.818	670	3770
66	554	3650	2.258	290	1030	564	4560	3.589	505	2500	564	4900	4.144	745	3730
162	507	3560	1.966	230	1020	517	4290	2.912	395	1890	519	4640	3.419	515	2810
Type II															
24	561	3200	1.758	185	760	564	4270	3.147	380	1840	565	4690	3.803	600	3040
67	547	3300	1.823	205	850	555	4320	3.169	475	2200	555	4710	3.768	665	3440
68	552	3700	2.312	265	1150	560	4720	3.818	635	3040	562	5200	4.650	880	4860
69	550	3860	2.508	315	1170	555	4570	3.547	535	2630	555	4920	4.089	665	3850
70	546	3490	2.035	215	890	556	4490	3.430	470	2320	555	4900	4.078	670	3580
72	550	3710	2.316	270	1100	559	4640	3.683	605	2720	558	4990	4.252	700	3930
74	557	3870	2.553	295	1150	563	4710	3.822	505	2620	563	5120	4.516	535	3650
75	538	3350	1.848	205	800	546	4340	3.147	430	2100	550	4760	3.813	565	3260
76	558	3430	2.009	200	960	564	4490	3.479	495	2430	563	5050	4.394	655	3840
77	556	3280	1.830	205	850	558	4450	3.381	440	2310	557	4870	4.042	630	3590
78	547	3390	1.924	215	880	550	4400	3.258	450	2050	551	4820	3.917	615	3290
79	546	3320	1.842	170	740	547	4260	3.038	370	1760	547	4750	3.777	580	3160
80	560	3390	1.969	190	890	565	4410	3.362	475	2420	564	4830	4.026	655	3880
81	556	3330	1.887	195	790	557	4290	3.137	470	2100	557	4790	3.911	600	3460
82	539	3610	2.149	245	920	541	4500	3.354	470	2560	543	5010	4.171	670	4000
83	552	3900	2.569	285	1190	559	4550	3.541	505	2310	558	4900	4.100	675	3380
84	552	3250	1.784	190	740	556	4150	2.930	380	1730	555	4750	3.832	515	2990
85	550	3530	2.097	255	920	555	4360	3.228	470	2240	556	4860	4.019	630	3580
86	556	3460	2.037	215	900	557	4400	3.300	500	2290	562	4890	4.112	655	3720
87	555	3750	2.388	275	1150	557	4470	3.406	490	2300	560	4970	4.232	650	3540
88	552	3950	2.635	325	1370	558	4760	3.800	--------	3090	560	5180	4.598	785	4630
89	544	3940	2.584	350	1420	559	4700	3.778	625	2950	559	5100	4.449	705	4330
90	560	3170	1.722	180	740	561	4160	2.971	360	1780	562	4720	3.831	620	3270
91	563	3290	1.865	195	890	568	4330	3.259	445	2360	568	4780	3.971	635	3710
92	548	3560	2.125	180	790	553	4370	3.232	415	1920	549	4810	3.887	595	3020

93	561	3170	1.725	95	630	566	4060	2.855	350	1630	567	4550	3.592	485	2750
94	550	3350	1.889	195	800	554	4580	3.556	485	2450	554	5000	4.238	670	3790
95	547	3200	1.714	175	620	547	4130	2.855	330	1480	545	4540	3.437	465	2180
96	542	3320	1.828	190	780	541	4150	2.851	330	1590	543	4620	3.547	500	2640
97	555	3140	1.674	155	710	554	4360	3.223	360	2050	555	4850	3.995	585	3020
98	552	3070	1.592	150	700	553	4290	3.114	380	1780	551	4740	3.788	550	2670
99	538	2900	1.385	45	520	538	4330	3.087	405	1700	539	4800	3.800	590	2780
101	547	3960	2.625	330	1670	551	4770	3.836	595	3290	548	5050	4.277	740	4520
163	570	3650	2.324	280	1270	568	4510	3.535	535	2850	568	5000	4.345	740	4580
164	563	3410	2.003	205	1060	568	4560	3.614	560	2720	567	5000	4.338	665	4130
165	565	3370	1.963	175	820	565	4360	3.287	440	2250	567	4900	4.166	610	3630
166	553	3540	2.121	235	1030	555	4500	3.439	460	2300	555	5050	4.331	675	3770
167	558	3280	1.837	180	800	556	4410	3.309	460	2150	554	5000	4.238	705	3800
168	557	3760	2.410	235	1150	560	4710	3.790	530	2660	563	5220	4.694	705	4190
169	563	3760	2.436	435	1130	564	4700	3.813	535	2570	564	5150	4.578	790	3930
170	564	3650	2.299	230	1070	569	4600	3.684	505	2420	570	5090	4.519	785	3990
171	560	2810	1.353	90	480	560	4100	2.881	300	1590	569	4980	4.318	650	3720
172	563	3200	1.764	130	650	569	4350	3.295	405	2280	572	4990	4.359	685	3980
173	560	3450	2.040	160	640	562	4360	3.269	430	1780	563	4900	4.136	635	3020
Type IIA															
100	551	3490	2.054	205	950	557	4450	3.375	445	2230	556	5020	4.288	690	3700
Type III															
102	562	3060	1.610	170	680	564	4350	3.266	475	1870	562	4730	3.848	635	2850
103	566	3760	2.449	295	1530	572	4700	3.867	605	3000	573	5070	4.507	785	4370
104	563	3600	2.233	245	1030	565	4550	3.579	515	2200	566	4950	4.317	700	3480
105	554	3390	1.948	215	860	555	4300	3.140	380	1740	555	4700	3.752	610	2860
106	536	3350	1.841	200	850	542	4230	2.968	375	1810	536	4650	3.469	525	2930
180	557	4140	2.921	490	2020	561	4940	4.189	745	4350	566	5340	4.939	920	6540
181	567	4020	2.804	345	1740	574	5020	4.426	775	4550	574	5360	5.046	925	6480
182	568	4300	3.214	475	2230	570	5090	4.519	810	5120	570	5420	5.124	950	6820
183	573	4600	3.710	640	2970	574	5250	4.841	830	5310	580	5570	5.506	1110	7120
184	555	4250	3.068	430	2280	563	5240	4.730	775	5040	563	5470	5.155	900	6420
185	567	4400	3.359	440	2330	568	5200	4.700	770	4920	570	5520	5.315	965	6980
186	553	4370	3.232	460	2260	561	5130	4.518	790	4500	562	5450	5.108	850	5860
187	557	4390	3.285	475	2390	567	5160	4.620	795	4570	569	5450	5.172	935	5820
188	565	4550	3.579	605	2890	570	5350	4.992	900	5730	573	5550	5.401	990	7360
189	564	4450	3.418	535	2560	565	4950	4.236	680	3560	565	5180	4.639	745	5020
190	548	4300	3.101	445	2060	553	5010	4.247	665	4160	558	5330	4.851	925	5620
193	551	4300	3.117	455	1890	558	5060	4.372	740	3980	560	5390	4.978	945	5080
Type IIIA															
195	520	4280	2.915	515	2220	550	4970	4.157	745	4420	531	5260	4.496	810	5560
Type IV															
107	552	3580	2.165	210	950	552	4190	2.965	340	1660	554	4750	3.825	530	2610
108	551	3160	1.684	160	720	552	4220	3.008	405	1870	553	4720	3.770	535	3030

TABLE 2.10. *Miscellaneous strength tests of portland cement mortars*—Continued

No.	1 Day					3 Day					7 Day				
	Wt. g	Freq. cps	psi			Wt. g	Freq. cps	psi			Wt. g	Freq. cps	psi		
			Mod. $\times 10^{-6}$	Flex.	Compr.			Mod. $\times 10^{-6}$	Flex.	Compr.			Mod. $\times 10^{-6}$	Flex.	Compr.
Type V															
109	556	4050	2.791	315	1470	558	4710	3.788	460	2730	558	5130	4.494	625	3660
110	561	3610	2.237	190	990	576	4550	3.649	455	2320	566	5000	4.405	675	3460
111	554	3230	1.769	175	700	558	4220	3.041	470	1960	560	4560	3.563	635	2950
112	553	3300	1.843	185	790	554	4390	3.267	440	2180	555	4810	3.929	615	3100
113	521	3500	1.953	215	910	528	4100	2.716	405	1780	527	4350	3.051	475	2500
115	524	3470	1.931	90	960	529	4150	2.788	330	1760	528	4650	3.494	560	2910
116	508	3390	1.786	190	840	518	4120	2.675	375	1850	518	4540	3.267	535	2890
117	522	3600	2.070	225	940	530	4270	2.957	430	1870	528	4550	3.345	535	2590
118	528	3510	1.991	225	910	535	4340	3.084	450	2120	534	4690	3.594	520	3030
119	531	3650	2.165	245	1016	536	4350	3.104	440	2110	536	4760	3.716	605	3210
Miscellaneous															
120	488	3360	1.686	150	800	494	3990	2.406	315	1420	500	4360	2.908	405	2220
121	521	3760	2.254	275	1390	525	4540	3.311	485	2340	524	4850	3.772	635	3380
122	510	3340	1.741	200	860	513	4100	2.634	335	1530	513	4460	3.123	485	2400
123	504	3320	1.700	160	810	505	4000	2.472	330	1560	507	4390	2.990	425	2280
198	560	3860	2.553	255	1160	563	4620	3.677	570	2740	567	4850	4.081	740	4310
199	560	3950	2.674	300	1450	568	4650	3.758	475	2480	572	5140	4.624	765	3840
201	532	4000	2.605	345	1380	542	4450	3.284	495	2390	540	4570	3.451	670	3420
202	542	3740	2.320	295	1200	549	4300	3.106	480	2220	551	4680	3.693	605	3280
203	534	3290	1.769	170	610	541	4110	2.796	395	1460	543	4530	3.410	610	2410

3. Concrete Data

3.1. Preparation of Concretes

Two series of concretes were made from each of the cements. In one series, concretes were made with a constant water-cement ratio of 0.635. A second series was made in which the water content was changed, if necessary, to obtain concretes having a 5±1-inch slump. In both series the ratio of cement to aggregate was kept constant, and the ratio of fine to coarse aggregate was held at 1:1 by absolute volume. The mix design of the concretes was based on preliminary tests with a particular cement that produced concrete with a 5½-bags-per-cubic-yard cement factor and an air content of 0.75 percent. The coarse aggregate used in the concretes was a high quality rounded quartzite that was obtained from the same source (White Marsh) as the sand. The aggregates were dried, separated by sizes and recombined when batched. The fineness modulus of the sand was 2.92. The gradation of the sand is given in table 3.1.1.

TABLE 3.1.1. *Gradation of sand used in concretes*

Sieve size	Percent
#4–#8	18
#8–#16	17
#16–#30	20
#30–#50	25
#50–#100	14
pass #100	6

The fineness modulus of the coarse aggregate was 6.82, and 4.82 when the coarse and fine aggregates were combined. The gradation of the coarse aggregates is given in table 3.1.2.

TABLE 3.1.2. *Gradation of coarse aggregates used in concretes*

Sieve Size	Percent
¾–1 in	10
½–¾ in	35
⅜–½ in	28

The concrete was mixed in a tilting drum mixer having 1 cubic foot capacity. Prior to mixing, the sand and gravel were soaked overnight. After mixing the sand, gravel and water for 1½ minutes, cement was added and mixing continued for 2 minutes. The mixer was stopped for 3 minutes, after which the concrete was remixed for one additional minute. The mixer was cleaned and moistened for making each batch of concrete. From previous tests it was observed that approximately 3.2 lb of cement-sand-water mortar was retained by the mixer when emptied. Proportioned amounts of the concreting materials were added to the basic mix to provide for buttering the mixer with the quantity of mortar that was retained by the mixer so that batches of concrete delivered contained 18.8 lb of cement, 57.0 lb sand (saturated surface dry), 57.0 lb coarse aggregate (saturated surface dry) and 12.0 lb of water for the constant-water cement ratio concretes, or variable water in the constant slump concretes.

If the first series batch of concrete for any cement using the constant water cement ratio, gave a slump of 5±1 inch, the second series batch was made with the same water cement ratio unless the slump was borderline. Otherwise, the water was adjusted for the second series batch by estimating the amount needed and using the new weight in an attempt to bring the slump within the required limits. For all concretes, the total weight of materials less the butter mortar weight was determined prior to mixing. The batches were discharged into a tared pan, weighed, and adjusted to the predetermined delivered weight by adding mortar scraped from the mixer or removing mortar from the pan.

All concrete specimens of each cement within either series of concretes tested in this study were made from the same batch of concrete. The results of tests of the physical properties of the concretes are given in tables 3.2 to 3.6. The following summaries describe briefly the fabrication and curing of specimens, and methods of test.

3.2. Properties of Fresh Concrete—Table 3.2

The water cement ratio by weight, slump, density, air content and cement content are reported in table 3.2 for the concretes. The slump and weight per cubic foot were determined for each batch of concrete in accordance with the requirements of ASTM Designations C 143–52 [16] and C 138–44 [17]. The air content and cement factors of the batches were calculated in accordance with the requirements of ASTM Designation C 138–44 [17], assuming the specific gravity of all cements was 3.15.

TABLE 3.2 *Properties of fresh concrete*

No. [1]	W/C (by weight)	Slump (in.)	Lb/Ft³	Air content percent (by volume)	Cement content (bags/yd³)
Type I					
1	0.635	3½	144.05	2.30	5.35
1A	.650	5½	144.25	1.85	5.35
2	.635	2⅝	144.55	1.95	5.40
2A	.660	4⅜	144.15	1.75	5.35
3	.635	2⅜	143.75	2.50	5.35
3A	.670	4⅛	143.55	2.10	5.35
4	.635	2	143.55	2.65	5.35
4A	.680	4¼	143.05	2.30	5.30
5	.635	3¾	144.65	1.90	5.40
5A	.645	5⅜	144.25	1.95	5.35
6	.635	3⅛	144.85	1.75	5.40
6A	.655	5¾	144.75	1.45	5.40
7	.635	4⅛	144.95	1.70	5.40
7A	.640	4⅞	145.05	1.55	5.40
8	.635	4⅛	144.25	2.15	5.40
8A	.640	6	144.25	2.05	5.40
9	.635	5⅜	143.25	2.85	5.35
9A	.635	5⅜	143.05	3.00	5.35
10	.635	4⅜	144.55	1.95	5.40
10A	.640	4½	144.25	2.05	5.40
11	.635	6	143.35	2.80	5.35
11A	.625	4⅞	143.65	2.75	5.35
12	.635	3¼	144.55	1.95	5.40
12A	.655	5¾	144.25	1.80	5.35
13	.635	4⅜	143.45	2.70	5.35
13A	.640	5⅞	143.25	2.75	5.35
14	.635	7	141.55	4.00	5.30
14A	.610	4	141.85	4.25	5.30
15	.635	4	144.45	2.05	5.40
15A	.640	4¾	144.25	2.05	5.40
16	.635	3¼	143.85	2.45	5.35
16A	.650	5¼	144.35	1.80	5.35
17	.635	3⅛	144.75	1.85	5.40
17A	.650	5⅛	144.95	1.40	5.40
18	.635	3⅛	144.65	1.90	5.40
18A	.650	5¼	144.35	1.80	5.35
19	.635	4	143.95	2.35	5.35
19A	.640	4½	144.05	2.20	5.35
20	.635	3	143.05	3.00	5.35
20A	.655	5½	142.95	2.70	5.30
21	.635	5	143.95	2.35	5.35
21A	.635	4¼	143.65	2.60	5.35
22	.635	3¾	145.05	1.65	5.40
22A	.645	4¼	145.05	1.45	5.40
23	.635	5½	145.05	1.65	5.40
23A	.635	5½	145.45	1.35	5.45
25	.635	5	143.75	2.50	5.35
25A	.635	4	143.15	2.90	5.35
26	.635	5	144.75	1.85	5.40
26A	.635	3⅜	144.45	2.05	5.40
27	.635	3½	144.55	1.95	5.40
27A	.650	5⅝	144.45	1.75	5.40
28	.635	4	145.85	1.10	5.45
28A	.640	5¼	145.45	1.25	5.45
29	.635	5	144.45	2.05	5.40
29A	.635	4½	143.95	2.35	5.35
30	.635	4¾	144.25	2.15	5.40
30A	.635	4	143.75	2.50	5.35
31	.635	2¾	144.45	2.05	5.40
31A	.655	4	144.75	1.45	5.40
32	.635	5¾	143.95	2.35	5.35
32A	.630	4¼	144.05	2.45	5.40

TABLE 3.2 *Properties of fresh concrete*—Continued

No. [1]	W/C (by weight)	Slump (in.)	Lb/Ft³	Air content percent (by volume)	Cement content (bags/yd³)
Type I					
33	.635	5⅝	144.15	2.25	5.40
33A	.630	4⅛	143.85	2.50	5.35
34	.635	4¾	143.45	2.70	5.35
34A	.635	4¾	143.25	2.85	5.35
35	.635	3¼	145.35	1.40	5.40
35A	.650	4⅜	145.05	1.35	5.40
36	.635	3¾	144.85	1.75	5.40
36A	.645	5½	144.85	1.60	5.40
37	.635	2¾	144.95	1.70	5.40
37A	.655	4	144.95	1.35	5.40
38	.635	3	144.15	1.55	5.40
38A	.660	5¼	144.45	1.55	5.35
39	.635	4	143.65	2.60	5.35
39A [2]					
40	.635	3¾	144.05	2.30	5.35
40A	.645	4⅞	144.15	2.05	5.35
41	.635	3¼	143.65	2.60	5.35
41A	.650	2⅝	143.05	2.70	5.35
42	.635	7⅛	143.45	2.70	5.35
42A	.600	3¾	143.45	3.25	5.35
43	.635	6½	145.45	1.35	5.45
43A	.615	4	145.45	1.70	5.45
44	.635	4⅞	141.05	4.35	5.25
44A	.635	5¼	140.60	4.65	5.25
45	.635	2¾	145.25	1.50	5.40
45A	.655	4¾	145.25	1.10	5.40
46	.635	6	146.35	0.75	5.40
46A	.630	5	146.05	1.00	5.45
47	.635	6¼	143.65	2.60	5.30
47A	.620	5	143.05	3.20	5.35
48	.635	3⅜	144.75	1.85	5.40
48A	.650	5½	145.05	1.40	5.40
49	.635	4	143.95	2.55	5.30
49A	.635	3½	143.95	2.35	5.35
50	.635	5¾	143.55	2.65	5.35
50A	.625	5¾	142.95	3.20	5.35
51	.635	5	143.55	2.65	5.35
51A	.635	5¼	144.35	2.10	5.40
52	.635	6¾	145.15	1.55	5.40
52A	.600	3¼	146.15	1.50	5.45
54	.635	6¾	145.05	1.65	5.40
54A	.610	4¼	145.05	2.10	5.45
55	.635	4¼	145.65	1.20	5.45
55A	.645	5	145.45	1.15	5.40
56	.635	7	142.85	3.10	5.35
56A	.605	3	143.85	3.10	5.30
57	.635	5½	144.95	1.70	5.40
57A	.635	5	144.65	1.90	5.40
58	.635	6	144.45	2.05	5.40
58A	.625	5⅝	144.85	1.95	5.40
59	.635	6¼	146.35	0.75	5.45
59A	.620	4⅛	146.05	1.20	5.45
71	.635	7⅛	142.45	3.40	5.30
71A	.605	4½	143.45	3.25	5.35
73	.635	7½	145.65	2.00	5.45
73A	.600	4¼	145.45	1.20	5.45
124	.635	4¼	145.45	1.35	5.45
124A	.640	5¼	145.45	1.25	5.45
125	.635	3½	144.65	1.90	5.40
125A	.650	4⅛	144.45	1.75	5.40

TABLE 3.2. *Properties of fresh concrete*—Continued

No. [1]	W/C (by weight)	Slump (in.)	Lb/Ft³	Air content percent (by volume)	Cement content (bags/yd³)
Type I					
126	.635	3 7/8	145.85	1.10	5.45
126A	.645	5 1/2	146.05	0.75	5.45
127	.635	2 3/4	145.65	1.20	5.45
127A	.665	4	145.35	0.90	5.40
128	.635	3	144.45	2.05	5.40
128A	.655	4 3/8	144.05	1.95	5.35
129	.635	3	144.65	1.90	5.40
129A	.650	4 1/4	145.45	1.05	5.40
130	.635	3 3/4	145.55	1.30	5.45
130A	.650	5 1/2	145.75	0.85	5.45
131	.635	3 3/4	145.55	1.30	5.45
131A	.645	6	145.95	0.80	5.45
132	.635	6	145.15	1.55	5.40
132A	.630	4 1/8	146.35	0.80	5.45
133	.635	3 1/2	144.55	1.95	5.40
133A	.650	5 7/8	144.05	2.00	5.35
134	.635	3 3/8	145.55	1.30	5.45
134A	.645	4 1/4	145.15	1.35	5.40
135	.635	3	146.15	0.90	5.45
135A	.680	5 3/8	145.55	.55	5.40
136	.635	2 3/4	146.35	.75	5.45
136A	.660	6	146.25	.35	5.45
137	.635	2 7/8	145.95	1.00	5.45
137A	.655	4 1/8	145.55	.90	5.40
138	.635	4	146.15	.90	5.45
138A	.645	5	146.45	.50	5.45
139	.635	2 3/8	145.95	1.00	5.45
139A [2]					
140	.635	2 3/4	144.45	2.05	5.40
140A [2]					
141	.635	2 1/4	144.65	1.90	5.40
141A	.675	4 1/4	144.15	1.55	5.35
142	.635	3 1/8	145.55	1.30	5.45
142A	.650	4 1/8	146.05	0.65	5.45
143	.635	3 1/8	145.85	1.10	5.45
143A	.655	4 3/4	146.25	.45	5.45
144	.635	3	146.45	.70	5.45
144A	.670	5	145.95	.40	5.40
145	.635	2 3/4	144.95	1.70	5.40
145A	.660	4 7/8	144.65	1.45	5.40
146	.635	2 1/8	145.75	1.15	5.45
146A	.670	4 3/4	145.45	0.80	5.40
147	.635	6 1/4	145.15	1.55	5.40
147A	.620	4	145.75	1.35	5.45
148	.635	3 7/8	146.55	.60	5.45
148A	.645	5 1/8	147.00	.10	5.50
149	.635	2	147.00	.30	5.50
149A	.675	6 1/8	146.35	.05	5.45
150	.635	3 3/4	145.45	1.35	5.45
150A	.650	5 3/4	145.15	1.35	5.40
151	.635	3 1/2	145.85	1.10	5.45
151A	.645	4 1/2	145.65	1.00	5.45
152	.635	2 7/8	146.55	.60	5.45
152A	.655	4 3/4	146.35	.35	5.45
153	.635	6 1/8	144.85	1.75	5.40
153A	.620	4	144.95	1.90	5.40
154	.635	2 5/8	145.95	1.00	5.45
154A	.675	4	145.95	.35	5.40
155	.635	3	146.35	.75	5.45
155A	.655	4	145.85	.70	5.45

TABLE 3.2. *Properties of fresh concrete*—Continued

No. [1]	W/C (by weight)	Slump (in.)	Lb/Ft³	Air content percent (by volume)	Cement content (bags/yd³)
Type I					
156	.635	2¾	146.15	.90	5.45
156A	.670	5⅜	145.75	.60	5.40
157	.635	2⅜	145.95	.40	5.40
157A	.680	6⅜	145.95	.25	5.40
158	.635	2⅝	145.15	1.55	5.40
158A	.655	4¼	145.55	1.95	5.35
159	.635	3	145.25	1.50	5.40
159A	.655	4	145.25	1.10	5.40
160	.635	2¾	144.35	2.10	5.40
160A	.660	4⅝	143.85	2.20	5.35
161	.635	2⅛	144.65	1.90	5.40
161A	.705	4⅞	144.45	1.05	5.35
53	.635	7¼	135.10	8.40	5.05
53A	.580	4¾	133.75	10.15	5.05
60	.635	7⅞	135.00	8.45	5.05
60A	.570	5	135.50	9.10	5.10
61	.635	7⅜	134.25	8.95	5.00
61A	.570	4⅝	135.20	9.30	5.10
62	.635	6⅞	134.90	8.50	5.05
62A	.590	3⅜	136.90	7.95	5.15
63	.635	7¼	136.20	7.65	5.10
63A	.595	5	136.40	8.15	5.10
64	.635	7¼	136.60	7.35	5.10
64A	.595	5¼	137.50	7.45	5.15
65	.635	8⅝	131.95	10.50	4.90
65A	.555	5¾	129.65	13.30	4.90
66	.635	7½	136.20	7.65	5.10
66A	.590	5⅞	136.80	8.00	5.15
162	.635	7⅝	135.50	8.10	5.05
162A	.570	4⅜	136.60	8.40	5.15
Type II					
24	.635	7⅜	144.7	2.35	5.35
24A	.640	4⅛	144.0	3.00	5.40
67	.635	2¾	145.65	1.20	5.45
67A	.660	4	145.75	.70	5.40
68	.635	6¾	144.85	1.75	5.40
68A	.615	5¼	144.85	2.15	5.40
69	.635	5⅞	145.65	1.20	5.45
69A	.625	5½	145.45	1.50	5.45
70	.635	7⅜	143.15	2.90	5.35
70A	.600	5	143.45	3.25	5.35
72	.635	5¾	145.85	1.10	5.45
72A	.630	4¼	145.55	1.35	5.45
74	.635	6½	144.45	2.05	5.40
74A	.625	5⅝	144.75	2.00	5.40
75	.635	6½	145.65	1.20	5.45
75A	.620	5¼	145.75	1.40	5.45
76	.635	4½	145.45	1.35	5.45
76A	.635	5½	145.75	1.15	5.45
77	.635	3¾	144.95	1.70	5.40
77A	.650	5	144.85	1.55	5.40
78	.635	5⅛	144.95	1.70	5.40
78A	.635	3⅞	144.75	1.85	5.40
79	.635	5⅞	145.95	1.00	5.45
79A [2]					
80	.635	4	145.85	1.10	5.45
80A	.645	4½	145.95	.85	5.45
81	.635	3½	146.25	.80	5.45
81A	.650	4¾	146.25	.50	5.45

TABLE 3.2. *Properties of fresh concrete*—Continued

No. [1]	W/C (by weight)	Slump (in.)	Lb/Ft³	Air content percent (by volume)	Cement content (bags/yd³)
Type II					
82	.635	5½	146.55	.60	5.45
82A	.635	5½	146.55	.60	5.45
83	.635	6	146.05	.95	5.45
83A	.630	4⅞	146.05	1.00	5.45
84	.635	4½	145.55	1.30	5.45
84A	.635	4⅜	145.75	1.15	5.45
85	.635	7½	142.05	3.65	5.30
85A	.605	5¾	142.05	4.20	5.30
86	.635	5¾	145.65	1.20	5.45
86A	.630	4½	145.75	1.20	5.45
87	.635	4⅝	145.05	1.65	5.40
87A	.635	4½	144.65	1.90	5.40
88	.635	3¼	145.55	1.30	5.45
88A	.650	5⅜	145.65	.90	5.45
89	.635	5½	145.85	1.10	5.45
89A	.635	5½	145.45	1.35	5.45
90	.635	3¼	146.05	.95	5.45
90A	.650	5	146.15	.60	5.45
91	.635	3⅝	144.45	2.05	5.40
91A	.645	4⅛	144.65	1.70	5.40
92	.635	2⅛	145.25	1.50	5.40
92A	.660	4¼	145.45	.90	5.40
93	.635	2½	145.05	1.65	5.40
93A	.660	5½	145.15	1.10	5.40
94	.635	3¾	143.95	2.35	5.35
94A	.645	5¾	144.45	1.85	5.40
95	.635	6½	142.35	3.45	5.30
95A	.600	2	143.75	3.15	5.40
96	.635	4¼	144.75	1.85	5.40
96A	.635	3¾	144.95	1.70	5.40
97	.635	6¾	145.85	1.10	5.45
97A	.610	5½	145.55	1.70	5.45
98	.635	4¾	145.35	1.40	5.40
98A	.635	5½	144.95	1.70	5.40
99	.635	6	147.00	.30	5.50
99A	.625	5¾	146.35	.90	5.45
101	.635	4¾	145.15	1.55	5.40
101A	.635	5¾	145.05	1.65	5.40
163	.635	3⅝	145.85	1.10	5.45
163A	.650	5⅞	146.05	.70	5.45
164	.635	7	146.15	.90	5.45
164A	.620	4½	147.10	.50	5.50
165	.635	5¾	146.55	.60	5.45
165A	.630	4⅝	147.00	.35	5.50
166	.635	3⅞	146.15	.90	5.45
166A	.645	4½	146.15	.70	5.45
167	.635	3⅛	146.05	.95	5.45
167A	.650	4	145.95	.70	5.45
168	.635	3⅛	146.35	.75	5.45
168A	.650	5¼	146.35	.45	5.45
169	.635	3¼	146.15	.90	5.45
169A	.655	4⅞	146.35	.40	5.45
170	.635	3⅝	146.65	.55	5.45
170A	.650	5¼	146.35	.50	5.45
171	.635	3⅜	146.05	.95	5.45
171A	.660	5	146.05	.50	5.45
172	.635	3½	145.75	1.15	5.45
172A	.650	5½	145.35	1.10	5.40
173	.635	3⅞	145.45	1.35	5.45
173A	.645	5½	144.90	1.20	5.40
174	.635	3¼	146.05	.95	5.45
174A	.655	4½	145.95	.65	5.45

TABLE 3.2. *Properties of fresh concrete*—Continued

No. [1]	W/C (by weight)	Slump (in.)	Lb/Ft³	Air content percent (by volume)	Cement content (bags/yd³)
Type II					
175	.635	3 1/8	145.95	1.00	5.45
175A	.655	4 1/4	145.75	.80	5.40
176	.635	2 7/8	145.95	1.00	5.45
176A	.655	4 7/8	146.05	.60	5.45
177	.635	3 3/4	146.55	.60	5.45
177A	.650	5 5/8	146.75	.25	5.45
178	.635	5 1/2	146.45	.70	5.45
178A	.630	5 1/4	146.90	.45	5.50
179	.635	4 1/4	146.35	.75	5.45
179A	.640	4 1/4	146.35	.65	5.45
Type IIA					
100	.635	8 1/8	134.40	8.85	5.00
100A	.560	5 1/8	131.55	11.95	4.95
Type III					
102	.635	3 1/4	145.95	1.00	5.45
102A	.655	5	145.85	.70	5.45
103	.635	7 1/8	142.35	3.45	5.30
103A	.605	5 1/2	142.45	3.65	5.30
104	.635	3 3/8	144.35	2.10	5.40
104A	.655	5	144.15	1.85	5.35
105	.635	6 3/4	144.85	1.10	5.40
105A	.605	4 7/8	144.65	2.35	5.40
106	.635	5 3/8	144.35	2.10	5.40
106A	.635	5 5/8	144.85	1.75	5.40
180	.635	3	145.65	1.20	5.45
180A	.660	4 1/4	145.55	.80	5.40
181	.635	4 5/8	145.65	1.20	5.45
181A	.635	4 5/8	145.45	1.35	5.45
182	.635	2 3/8	145.35	1.40	5.40
182A	.670	4 1/8	145.15	1.00	5.40
183	.635	2 7/8	146.05	.95	5.45
183A	.670	4 5/8	145.75	.60	5.40
184	.635	2 3/4	145.15	1.55	5.40
184A	.670	4 3/8	144.85	1.20	5.40
185	.635	2 1/2	145.55	1.30	5.45
185A	.675	4 1/2	145.15	.90	5.40
186	.635	4 1/2	144.95	1.70	5.40
186A	.635	4 3/4	144.85	1.75	5.40
187	.635	4 1/4	144.75	1.85	5.40
187A	.640	5 3/8	144.95	1.60	5.40
188	.635	2 7/8	145.35	1.40	5.40
188A	.670	4 1/2	144.95	1.15	5.40
189	.635	4 1/4	144.55	1.95	5.40
189A	.640	4 7/8	144.35	2.00	5.40
190	.635	2 5/8	143.35	2.80	5.35
190A	.670	4	142.35	2.90	5.30
191	.635	3	144.85	1.75	5.40
191A	.670	5 5/8	144.25	1.60	5.35
192	.635	3	145.55	1.30	5.45
192A	.670	4 5/8	145.35	.85	5.40
193	.635	5 3/8	143.75	2.50	5.35
193A	.635	5 3/4	143.85	2.45	5.35
Type IIIA					
194	.635	7 3/4	137.10	7.00	5.10
194A	.570	3 5/8	138.90	6.85	5.25
195	.635	7 1/4	136.10	7.70	5.10
195A	.595	4 5/8	137.10	7.70	5.15

TABLE 3.2. *Properties of fresh concrete*—Continued

No. [1]	W/C (by weight)	Slump (in.)	Lb/Ft³	Air content percent (by volume)	Cement content (bags/yd³)
Type VI					
107	.635	6½	145.95	1.00	5.45
107A	.620	4	145.85	1.35	5.45
108	.635	7½	143.35	2.80	5.35
108A	.600	4¾	143.45	3.25	5.35
196	.635	3	144.85	1.75	5.40
196A	.650	4⅝	144.85	1.45	5.40
Type V					
109	.635	4¼	144.85	1.75	5.40
109A	.640	5⅛	144.65	1.80	5.40
110	.635	7⅛	145.25	1.50	5.40
110A	.610	6	145.55	1.75	5.45
111	.635	6¾	143.85	2.45	5.35
111A	.610	5¼	143.75	2.95	5.40
112	.635	7⅜	145.05	1.65	5.40
112A	.610	3¾	145.05	2.10	5.45
113	.635	6¼	145.35	1.40	5.40
113A	.625	4⅞	145.65	1.40	5.45
114	.635	5	145.55	1.30	5.45
114A	.635	4½	145.35	1.40	5.45
115	.635	5½	145.65	1.20	5.45
115A	.635	5½	145.65	1.20	5.45
116	.635	3⅛	145.35	1.40	5.40
116A	.650	5	145.85	.80	5.45
117	.635	3⅜	145.35	1.40	5.40
117A	.645	4⅜	145.45	1.15	5.40
118	.635	5⅜	145.05	1.65	5.40
118A	.635	5⅛	145.05	1.65	5.40
119	.635	5⅜	146.45	.70	5.45
119A	.620	4⅛	145.95	1.20	5.45
197	.635	3¼	146.35	.75	5.45
197A	.650	5½	145.95	.70	5.45
Miscellaneous					
120	.635	3¾	145.05	1.65	5.40
120A	.625	5½	145.35	1.60	5.45
121	.635	2	144.45	2.05	5.40
121A	.675	4½	144.85	1.10	5.40
122	.635	5⅞	144.85	1.75	5.40
122A	.630	5¾	144.35	2.15	5.40
123	.635	7¾	136.70	7.30	5.10
123A	.580	5⅜	137.20	7.85	5.15
Type S—Slag					
198	.635	3¾	145.15	1.55	5.40
198A	.645	4¾	144.75	1.65	5.40
199	.635	4¼	145.25	1.50	5.40
199A	.635	4½	145.25	1.50	5.40
200	.635	2⅜	143.85	2.45	5.35
200A	.675	4⅝	143.35	2.10	5.35
Type SA—Slag					
201	.635	8	137.10	7.00	5.10
201A	.570	4⅛	138.30	7.25	5.20
202	.635	5⅜	139.10	5.65	5.20
202A	.630	4	139.20	5.65	5.20
203	.635	5	136.90	7.15	5.10
203A	.635	6	136.80	7.20	5.10

[1] Concretes having 0.635 W/C ratio listed first for each cement and the concretes with a slump of 5 ±1 inch indicated by the letter A.

[2] Cement available for only one mix.

3.3. Weight and Dimensional Changes of Concretes—Table 3.3

Two 6×8×16-inch concrete blocks for the shrinkage and expansion tests were cast for each of the cements, one block from each of the two series of concretes. One series had a 0.635 water-cement ratio and in the other series the slump was 5±1 inch. These blocks were to be used in outdoor exposure tests after the laboratory measurements were completed. The blocks had a 2-inch depression in the top surface (8×16 inch) to hold rain, melted snow and ice in the outdoor weathering test. Two phosphor-bronze bolts ($\frac{5}{16}$×1½ inch) to serve as gage points were embedded 10 inches apart on each side of the block.

The concrete blocks were cast on their side and remained in the oiled wooden molds covered with wet burlap for the first 24 hours. They were removed from the molds, gage points were drilled in the bolts, and the blocks were placed in a fog room at 100 percent relative humidity for 13 days. The specimens were next exposed to laboratory air at 73 °F and 50±5 percent relative humidity for 8 weeks. Finally, they were immersed in water at 73 °F for 4 weeks.

A 10-inch gage-length Whittemore type strain gage together with an invar-steel reference bar were used to measure length changes between gage points. Initial measurements were made as soon as possible after removal from the molds, and after each curing stage. Specimens were weighed at the time the length change measurements were made. Both the percent of length change and of weight change, given in table 3.3, are relative to the initial measurements.

Values of absorption at 28 days, also given in table 3.3, are values of the percentage gain in weight when air-dried specimens were placed in water and were calculated from the ratio of the weight after 28 day water storage to the weight after air storage.

TABLE 3.3. *Weight and dimensional changes of concretes*
(6×8×16-inch blocks)

No.[1]	Weight change			Absp.	Length change					
					Percent					
	Percent			Percent	Top			Bottom		
	14 d	70 d	98 d	28 d	14 d	70 d	98 d	14 d	70 d	98 d
Type I										
1	0.52	−1.90	+0.34	2.24	0.005	−.034	−.011	0.002	−.033	−.008
1A	.69	−1.90	+.52	2.41	.003	−.037	−.010	.002	−.033	−.007
2	.51	−2.31	+.34	2.66	.010	−.026	−.003	.004	−.026	−.009
2A	.43	−2.74	+.26	2.99	.006	−.029	−.008	.004	−.027	−.010
3	.52	−1.66	+.52	2.18	.008	−.023	−.003	.005	−.020	−.005
3A	.52	−1.99	+.43	2.43	.007	−.024	−.006	.005	−.021	−.004
4	.61	−1.83	+.52	2.35	.006	−.033	−.008	.003	−.033	−.010
4A	.79	−2.14	+.60	2.75	.005	−.039	−.020	.007	−.030	−.015
5	.69	−2.24	+.34	2.59	.008	−.031	−.017	.005	−.029	−.017
5A	.61	−2.34	+.35	2.69	.018	−.021	−.004	.004	−.025	−.014
6	.51	−2.06	+.34	2.40	.015	−.031	−.018	.010	−.022	−.007
6A	.52	−2.16	+.35	2.52	.012	−.025	+.003	.011	−.017	+.006
7	.61	−1.39	+.52	1.91	.009	−.024	−.013	.006	−.023	−.011
7A	.52	−1.65	+.35	2.00	.007	−.033	−.017	.005	−.026	−.011
8	.61	−1.90	+.43	2.34	.005	−.025	+.003	.005	−.022	+.005
8A	.52	−2.07	+.35	2.42	.006	−.030	+.002	.004	−.023	+.006
9	.52	−1.73	+.43	2.16	.012	−.025	+.004	.010	−.019	.000
9A	.52	−1.90	+.43	2.33	.014	−.022	+.010	.008	−.025	−.003
10	.60	−2.16	+.43	2.59	.010	−.025	−.005	.006	−.025	−.006
10A	.52	−2.34	+.26	2.60	.009	−.023	−.004	.005	−.023	−.005
11	.60	−1.97	+.43	2.40	.006	−.027	−.005	.003	−.029	−.011
11A	.61	−1.83	+.43	2.26	.008	−.029	−.006	.003	−.026	−.007
12	.61	−2.09	+.35	2.44	.008	−.027	−.007	.005	−.028	−.008
12A	.68	−2.05	+.34	2.41	.007	−.025	−.004	.005	−.022	−.002
13	.70	−1.92	+.52	2.45	.007	−.021	−.002	.006	−.020	−.001
13A	.52	−2.01	+.35	2.36	.006	−.020	.000	.006	−.021	−.002
14	.70	−1.57	+.70	2.27	.012	−.027	+.001	.004	−.033	−.003
14A	.62	−1.41	+.62	2.03	.005	−.025	−.001	.002	−.034	−.009
15	.60	−1.54	+.51	2.05	.009	−.027	−.003	.006	−.027	−.001
15A	.61	−1.56	+.43	1.99	.009	−.024	.000	.007	−.026	−.002

TABLE 3.3. *Weight and dimensional changes of concretes*—Continued
(6×8×16-inch blocks)

No.[1]	Weight change			Absp.	Length change					
	Percent			Percent	Percent					
					Top			Bottom		
	14 d	70 d	98 d	28 d	14 d	70 d	98 d	14 d	70 d	98 d
Type I										
16	.43	−1.98	+.26	2.24	.020	−.017	+.011	.009	−.025	+.001
16A	.34	−2.23	+.17	2.41	.015	−.025	+.006	.009	−.030	−.003
17	.35	−2.33	+.17	2.51	.008	−.027	−.001	.010	−.021	+.005
17A	.35	−2.43	.00	2.43	.008	−.018	+.005	.011	−.018	+.005
18	.52	−2.16	+.26	2.42	.008	−.025	−.001	.006	−.022	.000
18A	.51	−2.40	+.17	2.57	.007	−.028	−.004	.008	−.021	.000
19	.51	−1.70	+.43	2.15	.005	−.028	−.005	.007	−.017	+.002
19A	.60	−1.64	+.52	2.16	.005	−.025	−.003	.005	−.024	.000
20	.61	−1.65	+.43	2.09	.003	−.027	−.004	.004	−.019	.000
20A	.61	−1.74	+.52	2.26	.010	−.019	+.004	.007	−.018	+.002
21	.61	−2.10	+.44	2.54				.004	−.023	.000
21A	.61	−2.10	+.52	2.62	.001	−.034	−.009	.005	−.023	−.002
22	.59	−1.70	+.51	2.21	.005	−.025	−.005	.006	−.018	.000
22A	.51	−1.96	+.43	2.39				.005	−.022	+.001
23	.60	−2.23	+.34	2.58	.009	−.025	−.003	.005	−.028	−.006
23A	.60	−2.06	+.43	2.49	.008	−.029	−.007	.009	−.022	−.001
25	.61	−2.35	+.43	2.78	.024	−.021	+.009	.005	−.030	−.005
25A	.70	−2.09	+.52	2.61	.009	−.032	−.006	.005	−.030	−.007
26	.60	−2.06	+.51	2.57	.008	−.030	−.006	.005	−.029	−.008
26A	.69	−1.99	+.61	2.60	.010	−.028	−.003	.008	−.025	.000
27	.43	−2.23	+.34	2.57	.002	−.034	−.012	.003	−.024	−.004
27A	.52	−2.34	+.35	2.69	.003	−.037	−.015	.002	−.025	−.004
28	.51	−2.04	+.26	2.30	.014	−.023	+.002	.007	−.022	−.003
28A	.52	−2.25	+.26	2.51	.013	−.024	+.001	.008	−.022	−.001
29	.52	−2.09	+.44	2.53	.033	+.002	+.021	.006	−.021	−.001
29A	.61	−2.09	+.35	2.44	.017	−.016	+.007	.008	−.018	+.004
30	.69	−1.99	+.43	2.42	.007	−.026	.000	.004	−.026	−.002
30A	.78	−1.73	+.61	2.34	.006	−.029	.000	.006	−.021	+.001
31	.60	−2.07	+.35	2.42	.005	−.030	−.006	.002	−.028	−.007
31A	.61	−2.35	+.43	2.78	.005	−.031	−.005	.002	−.026	−.006
32	.69	−1.55	+.60	2.16	.009	−.023	+.003	.006	−.020	+.002
32A	.61	−1.64	+.52	2.16	.011	−.020	+.005	.005	−.023	−.003
33	.61	−1.99	+.43	2.42	.009	−.033	−.004	.006	−.026	.000
33A	.61	−1.91	+.52	2.43	.010	−.028	−.001	.014	−.019	+.006
34	.60	−1.90	+.52	2.41	.017	−.013	+.009	.009	−.015	−.005
34A	.61	−1.91	+.35	2.26	.007	−.020	+.002	.009	−.013	+.004
35	.60	−2.05	+.43	2.48	.009	−.028	−.004	.006	−.027	−.005
35A	.51	−2.14	+.43	2.57	.009	−.029	−.005	.006	−.029	−.006
36	.61	−1.65	+.52	2.17	.010	−.021	−.002	.007	−.014	−.002
36A	.51	−1.70	+.51	2.23	.010	−.019	.000	.006	−.017	−.002
37	.61	−2.51	+.26	2.77	.009	−.033	−.007	.005	−.028	−.007
37A	.60	−2.67	+.17	2.84	.012	−.028	.000	.007	−.030	−.007
38	.69	−1.70	+.51	2.23	.006	−.025	−.007	.006	−.021	−.003
38A	.61	−1.99	+.35	2.33	.006	−.027	−.007	.005	−.021	−.005
39	.69	−1.73	+.60	2.33	.011	−.028	−.003	.006	−.027	−.004
39A[2]										
40	.61	−1.91	+.26	2.17	.008	−.012	+.005	.006	−.005	+.009
40A	.52	−1.91	+.26	2.17	.010	−.012	+.003	.006	−.008	+.006
41	.69	−1.56	+.61	2.17	.012	−.016	+.008	.007	−.017	+.006
41A	.70	−1.75	+.52	2.27	.012	−.024	+.002	.004	−.020	+.010
42	.61	−2.17	+.52	2.69	.016	−.013	+.005	.009	−.016	+.001
41A	.70	−1.83	+.52	2.35	.008	−.016	+.003	.014	−.012	+.008
43	.59	−2.12	+.42	2.55	.007	−.008	+.007	.001	−.014	.000
43A	.51	−1.97	+.51	2.49	.007	−.010	+.005	.006	−.012	+.001
44	.70	−1.94	+.62	2.55	.009	−.010	+.008	.014	−.007	+.008
44A	.53	−1.94	+.53	2.47	.007	−.004	+.012	.007	−.013	+.004
45	.52	−1.90	+.43	2.33	.009	−.015	+.004	.004	−.020	−.002
45A	.52	−2.26	+.35	2.61	.006	−.022	−.002	.005	−.019	+.004

TABLE 3.3. *Weight and dimensional changes of concretes*—Continued
(6×8×16-inch blocks)

No.[1]	Weight change			Absp.	Length change					
	Percent			Percent	Percent					
					Top			Bottom		
	14 d	70 d	98 d	28 d	14 d	70 d	98 d	14 d	70 d	98 d
Type I										
46	.77	−1.28	+.94	2.22	.006	−.015	+.004	.005	−.019	−.001
46A	.69	−1.28	+.86	2.15	.009	−.013	+.007	.005	−.017	+.003
47	.35	−2.60	+.35	2.95	.003	−.020	−.005	.002	−.016	+.000
47A	.35	−2.60	+.26	2.87	.003	−.017	−.003	.002	−.018	−.005
48	.34	−2.23	+.34	2.57				.003	−.017	−.002
48A	.34	−2.16	+.43	2.59				.008	−.011	+.003
49	.60	−1.97	+.69	2.66	.012	−.024	+.003	.005	−.025	−.003
49A	.52	−2.07	+.52	2.60	.020	−.020	+.008	.008	−.026	−.001
50	.44	−2.44	+.44	2.88	.008	−.027	−.002	.007	−.019	+.003
50A	.52	−2.34	+.43	2.78	.007	−.025	−.001	.007	−.022	−.001
51	.61	−1.56	+.61	2.17	.021	−.009	+.010	.011	−.012	+.012
51A	.60	−1.70	+.60	2.29	.008	−.023	+.002	.006	−.015	+.004
52	.60	−2.06	+.43	2.49	.008	−.025	−.003	.006	−.020	−.003
52A	.59	−1.86	+.51	2.37	.021	−.012	+.007	.009	−.017	+.002
54	.60	−1.37	+.60	1.98	.009	−.023	−.004	.007	−.017	+.001
54A	.51	−1.37	+.51	1.89	.012	−.022	−.001	.009	−.017	+.002
55	.34	−2.31	+.17	2.49	.006	−.030	−.003	.004	−.030	−.003
55A	.43	−2.39	+.26	2.65	.008	−.028	−.001	.002	−.027	−.002
56	.44	−2.01	+.35	2.36	.006	−.019	.000	.002	−.018	.000
56A	.52	−1.55	+.52	2.08	.009	−.018	+.002	.007	−.015	+.005
57	.43	−2.69	+.43	3.12	.008	−.028	−.006	.006	−.022	−.003
57A	.44	−2.62	+.44	3.06	.012	−.025	.000	.007	−.025	−.004
58	.78	−1.47	+.78	2.25	.003	−.032	−.013	.007	−.015	+.004
58A	.70	−1.48	+.79	2.27	.007	−.015	+.004	.008	−.014	+.006
59	.43	−1.70	+.43	2.13	.007	−.020	.000	.008	−.015	+.004
59A	.52	−1.64	+.43	2.08	.008	−.013	+.007	.007	−.019	+.002
71	.44	−2.03	+.44	2.47	.012	−.020	+.001	.009	−.026	−.002
71A	.61	−1.74	+.61	2.34	.012	−.016	+.007	.007	−.023	−.002
73	.52	−2.26	+.017	2.43	.013	−.019	+.006	.010	−.019	+.005
73A	.51	−1.97	+.017	2.15	.011	−.019	+.003	.009	−.022	+.005
124	.51	−2.39	+.43	2.82	.007	−.022	−.003	.007	−.022	−.005
124A	.52	−2.44	+.35	2.77	.008	−.024	−.005	.004	−.033	−.015
125	.61	−2.01	+.52	2.53	.014	−.020	+.002	.008	−.021	−.002
125A	.70	−1.92	+.70	2.61	.013	−.020	+.002	.011	−.019	.000
126	.60	−1.80	+.60	2.40	.024	−.015	+.012	.015	−.014	+.003
126A	.60	−1.98	+.52	2.50	.021	−.020	+.007	.009	−.025	−.003
127	.69	−2.07	+.43	2.50	.002	−.030	−.008	.002	−.031	−.012
127A	.69	−2.23	+.34	2.57	.002	−.038	−.015	.001	−.026	−.006
128	.61	−1.61	+.52	2.18	.001	−.029	−.008	.002	−.025	−.006
128A	.53	−1.67	+.53	2.21	.006	−.029	−.005	.003	−.029	−.005
129	.60	−2.15	+.43	2.58	.015	−.019	+.006	.004	−.025	−.005
129A	.61	−2.26	+.35	2.61	.006	−.025	−.004	.005	−.024	−.007
130	.60	−1.97	+.34	2.31	.006	−.026	−.007	.005	−.026	−.005
130A	.68	−2.05	+.34	2.40	.008	−.024	−.004	.005	−.022	−.004
131	.60	−2.06	+.60	2.66	.007	−.013	−.001	.004	−.014	−.001
131A	.52	−2.15	+.43	2.58	.003	−.015	−.003	.005	−.011	.000
132	.60	−2.07	+.52	2.59	.009	−.025	−.005	.005	−.025	−.007
132A	.52	−1.99	+.43	2.43	.004	−.029	−.010	.005	−.021	−.004
133	.70	−1.49	+.61	2.10	.007	−.023	−.001	.004	−.024	−.003
133A	.70	−1.84	+.61	2.45	.011	−.022	+.002	.005	−.026	−.002
134	.52	−1.89	+.43	2.32	.013	−.022	+.002	.007	−.020	.000
134A	.60	−2.07	+.52	2.58	.012	−.020	+.002	.004	−.021	−.002
135	.52	−2.41	+.26	2.66	.003	−.026	−.007	.002	−.022	−.004
135A	.35	−3.03	+.26	3.29	.006	−.029	−.002	.005	−.025	.000

TABLE 3.3. *Weight and dimensional changes of concretes*—Continued
(6×8×16-inch blocks)

No.[1]	Weight change			Absp.	Length change					
					Percent					
	Percent			Percent	Top			Bottom		
	14 d	70 d	98 d	28 d	14 d	70 d	98 d	14 d	70 d	98 d
Type I										
136	.69	−1.72	+.52	2.23	.012	−.025	.000	.006	−.022	.000
136A	.43	−2.05	+.34	2.40	.008	−.030	−.005	.003	−.030	−.004
137	.52	−2.58	+.26	2.83	.010	−.027	−.007	.003	−.029	−.010
137A	.60	−2.57	+.34	2.91	.007	−.032	−.009	.004	−.028	−.009
138	.43	−2.06	+.17	2.23	.014	−.013	+.003	.004	−.022	−.006
138A	.51	−1.97	+.34	2.32	.010	−.018	−.001	.006	−.016	−.002
139	.52	−2.58	+.26	2.84	.009	−.022	−.002	.006	−.021	−.005
139A[2]										
140[2]	.52	−2.61	+.35	2.95	.009	−.016	+.001	.006	−.019	+.001
140A										
141	.52	−2.60	+.52	3.12	.005	−.029	−.003	.004	−.023	−.001
141A	.61	−2.86	+.52	3.38	.008	−.028	−.005	.007	−.017	+.005
142	.77	−1.46	+.60	2.06	.007	−.022	−.006	.005	−.021	−.006
142A	.60	−1.80	+.34	2.15	.008	−.020	−.005	.004	−.022	−.007
143	.60	−1.86	+.34	2.24	.008	−.024	−.003	.004	−.023	−.003
143A	.51	−1.96	+.51	2.47	.008	−.021	+.002	.005	−.020	+.002
144	.52	−2.85	+.35	3.19	.019	−.025	−.001	.006	−.031	−.010
144A	.43	−3.09	+.43	3.52	.006	−.040	−.009	.004	−.034	−.008
145	.61	−1.73	+.43	2.16	.003	−.019	−.003	.001	−.014	.000
145A	.69	−2.32	+.95	3.27	.006	−.016	−.003	.001	−.016	−.002
146	.60	−1.55	+.60	2.15	.002	−.013	−.001	.000	−.016	−.002
146A	.61	−1.74	+.52	2.26	.000	−.019	−.008	−.001	−.014	−.002
147	.60	−1.73	+.60	2.33	.008	−.021	−.010	.004	−.020	−.003
147A	.52	−1.72	+.52	2.24	.010	−.019	+.001	.005	−.020	−.004
148	.68	−1.63	+.51	2.14	.009	−.021	+.001	.002	−.025	−.005
148A	.42	−1.87	+.34	2.20	.003	−.026	−.007	.002	−.023	−.005
149	.51	−1.97	+.34	2.31	.006	−.026	−.005	.003	−.023	−.006
149A	.69	−1.97	+.60	2.57	.003	−.032	−.010	.003	−.024	−.005
150	.60	−1.46	+.69	2.14	.004	−.021	−.002	.004	−.018	+.001
150A	.61	−1.65	+.69	2.34	.007	−.017	+.002	.004	−.020	.000
151	.52	−2.85	+.17	3.02	.011	−.030	−.003	.006	−.028	−.002
151A	.60	−2.66	+.26	2.92	.010	−.027	−.002	.007	−.030	−.004
152	.51	−1.78	+.43	2.21	.012	−.033	−.011	.008	−.021	−.003
152A	.51	−2.21	+.34	2.56	.003	−.030	−.010	.004	−.022	−.005
153	.35	−1.91	+.52	2.43	.004	−.027	−.009	.004	−.022	−.006
153A	.52	−1.73	+.69	2.42	.004	−.026	−.008	.003	−.022	−.006
154	.43	−2.30	+.26	2.56	.005	−.028	−.005	.007	−.029	−.005
154A	.69	−2.58	+.34	2.92	.004	−.034	−.006	.001	−.033	−.008
155	.68	−1.71	+.60	2.31	.004	−.032	−.007	.006	−.029	−.006
155A	.52	−1.98	+.34	2.32	.006	−.028	−.003	.004	−.027	−.004
156	.60	−2.22	+.51	2.74	.003	−.030	−.007	.002	−.025	−.004
156A	.69	−2.32	+.95	3.27	.004	−.029	−.006	.001	−.028	+.010
157	.68	−1.71	+.34	2.05	.003	−.025	−.006	.005	−.026	−.009
157A	.52	−2.16	+.35	2.51	.005	−.023	−.001	.005	−.022	+.001
158	.26	−2.15	+.34	2.49	.003	−.028	−.007	.000	−.023	−.006
158A	.35	−2.19	+.35	2.54	.000	−.028	−.006	−.001	−.024	−.006
159	.61	−1.64	+.78	2.42	.005	−.032	−.008	.000	−.034	−.011
159A	.52	−1.89	+.43	2.32	.002	−.037	−.011	.000	−.032	−.010
160	.70	−2.00	+.69	2.69	.011	−.023	−.001	.009	−.023	−.005
160A	.52	−2.42	+.61	3.03	.008	−.029	−.010	−.002	−.040	−.018
161	.43	−1.72	+.69	2.41	.004	−.021	−.006	.002	−.020	−.007
161A	.44	−2.10	+.61	2.71	.004	−.025	−.012	.010	−.012	+.002

TABLE 3.3. *Weight and dimensional changes of concretes*—Continued
(6×8×16-inch blocks)

No.[1]	Weight change			Absp.	Length change					
					Percent					
	Percent			Percent	Top			Bottom		
	14 d	70 d	98 d	28 d	14 d	70 d	98 d	14 d	70 d	98 d
Type IA										
53	.65	−2.32	+.74	3.07	.021	−.013	+.013	.014	−.015	+.008
53A	.64	−2.01	+.73	2.74	.019	−.014	+.010	.010	−.021	+.004
60	.56	−2.52	+.65	3.17	.012	−.028	.000	.009	−.024	+.004
60A	.55	−2.01	+.46	2.47	.022	−.016	+.005	.026	−.007	+.015
61	.83	−2.30	+.74	3.04	.005	−.042	−.014	.003	−.037	−.013
61A	.55	−1.84	+.46	2.29	.010	−.030	−.010	.006	−.032	−.010
62	.47	−2.32	+.65	2.97	.010	−.027	−.005	.012	−.024	−.004
62A	.46	−1.99	+.54	2.53	.012	−.025	−.007	.007	−.027	+.008
63	.56	−2.50	+.65	3.15	.016	−.023	.000	.008	−.025	−.006
63A	.45	−2.07	+.36	2.43	.015	−.019	+.003	−.001	−.032	−.013
64	.56	−2.37	+.64	3.00	.008	−.034	−.009	.004	−.033	−.010
64A	.45	−2.08	+.63	2.72	.008	−.033	−.010	.008	−.025	.000
65	1.05	−1.81	+1.05	2.86	.077	+.030	+.059	.011	−.027	−.004
65A	.95	−1.51	+.95	2.46	.025	−.013	+.012	.012	−.026	.000
66	.73	−1.82	+.91	2.73	.018	−.018	+.004	----------	−.023	−.001
66A	.73	−1.55	+.82	2.37	.009	−.023	−.003	.005	−.020	.000
162	.74	−1.95	+.84	2.79	.006	−.033	−.007	.001	−.031	−.006
162A	.73	−1.65	+.73	2.39	.005	−.032	−.004	.000	−.028	−.005
Type II										
24	.52	−1.64	+.52	2.16	.007	−.019	−.002	.010	−.011	+.005
24A	.60	−1.38	+.62	1.98	.014	−.011	+.007	.019	−.013	+.004
67	.43	−2.98	+.17	3.16	.010	−.028	−.004	.008	−.026	−.003
67A	.52	−3.11	+.26	3.37	.018	−.022	+.005	.009	−.023	.000
68	.60	−2.13	+.43	2.57	.011	−.016	+.003	.006	−.022	−.002
68A	.52	−2.18	+.35	2.53	.012	−.017	+.004	.007	−.018	.000
69	.52	−2.42	+.17	2.58	.008	−.021	−.001	.006	−.021	−.004
69A	.60	−2.31	+.17	2.47	.007	−.020	−.001	.010	−.015	+.001
70	.61	−2.10	+.44	2.54	.014	−.022	−.001	.014	−.015	+.001
70A	.53	−1.94	+.35	2.29	.009	−.021	−.003	.007	−.015	+.002
72	.51	−1.80	+.34	2.14	.015	−.015	+.004	.005	−.024	−.002
72A	.61	−1.82	+.26	2.08	.019	−.008	+.012	.006	−.023	−.003
74	.43	−1.99	+.35	2.34	.012	−.027	+.001	.009	−.027	.000
74A	.43	−1.99	+.35	2.33	.018	−.023	+.004	.012	−.026	+.001
75	.35	−2.78	+.26	3.04	.013	−.020	+.004	.004	−.025	−.003
75A	.34	−2.66	+.26	2.91	.014	−.018	+.004	.006	−.023	−.002
76	.35	−3.37	+.17	3.54	.007	−.039	−.014	.011	−.028	−.003
76A	.43	−3.13	+.26	3.37	.010	−.031	−.005	.005	−.030	−.008
77	.43	−3.17	+.17	3.35	.009	−.037	−.010	.006	−.031	−.009
77A	.52	−3.11	+.26	3.37	.007	−.040	−.012	.005	−.033	−.009
78	.52	−2.25	+.35	2.60	.011	−.024	−.003	.012	−.029	−.007
78A	.52	−2.16	+.34	2.50	.012	−.030	−.007	.006	−.028	−.007
79	.52	−1.98	+.34	2.32	.005	−.027	−.006	.004	−.022	−.003
79A[2]										
80	.43	−2.16	+.26	2.42	.006	−.027	−.004	.010	−.021	−.001
80A	.43	−2.07	+.17	2.24	.007	−.027	−.002	.009	−.020	+.001
81	.51	−2.57	+.34	2.90	.009	−.026	−.002	.004	−.023	−.004
81A	.60	−2.59	+.35	2.93	.004	−.031	−.008	.005	−.025	−.006
82	.51	−2.57	+.34	2.91	.011	−.019	+.009	.007	−.024	+.001
82A	.52	−2.56	+.26	2.81	.014	−.017	+.008	.007	−.018	+.007
83	.51	−1.87	+.42	2.29	.010	−.017	+.001	.005	−.008	+.011
83A	.60	−1.88	+.43	2.30	.009	−.013	+.005	.004	−.015	+.001
84	.43	−2.58	+.17	2.76	.009	−.020	+.002	.004	−.018	.000
84A	.51	−2.47	+.26	2.73	.009	−.015	+.007	.004	−.020	.000

TABLE 3.3. *Weight and dimensional changes of concretes*—Continued
(6×8×16-inch blocks)

No.[1]	Weight change			Absp.	Length change					
	Percent			Percent	Percent					
					Top			Bottom		
	14 d	70 d	98 d	28 d	14 d	70 d	98 d	14 d	70 d	98 d
Type II										
85	.45	−2.23	+.45	2.68	.007	−.023	+.001	.007	−.017	+.003
85A	.62	−1.86	+.53	2.39	.008	−.022	.000	.007	−.013	+.011
86	.43	−2.14	+.43	2.57	.008	−.019	+.003	.007	−.019	+.003
86A	.44	−2.28	+.44	2.72	.014	−.010	+.012	.012	−.013	+.009
87	.44	−2.27	+.44	2.70	.013	−.020	+.003	.012	−.015	+.002
87A	.52	−2.41	+.26	2.68	.010	−.022	+.002	.003	−.031	−.007
88	.34	−3.10	+.26	3.36	.006	−.023	−.005	.001	−.023	−.006
88A	.35	−3.28	+.35	3.63	.005	−.021	.000	.003	−.020	−.004
89	.43	−2.23	+.34	2.58	.011	−.010	+.005	.008	−.016	+.002
89A	.34	−2.40	+.17	2.57	.007	−.018	−.002	.005	−.019	−.005
90	.43	−2.29	+.25	2.55	.007	−.019	−.001	.004	−.021	−.003
90A	.43	−2.38	+.34	2.72	.007	−.021	−.001	.004	−.022	−.005
91	.51	−2.14	+.51	2.65	.006	−.019	+.002	.004	−.020	+.001
91A	.43	−2.14	+.34	2.49	.006	−.018	+.003	.008	−.015	+.007
92	.26	−3.20	.00	3.20	.011	−.018	+.005	.002	−.022	−.003
92A	.34	−3.42	+.09	3.51	.008	−.020	+.001	.005	−.017	+.001
93	.60	−1.80	+.43	2.23	.012	−.014	+.005	.010	−.011	+.002
93A	.52	−2.06	+.34	2.41	.016	−.007	+.012	.008	−.013	+.001
94	.43	−2.42	+.35	2.76	.016	−.020	+.003	.010	−.022	−.001
94A	.61	−2.16	+.61	2.77	.023	−.017	+.015	.009	−.021	+.004
95	.43	−3.04	+.61	3.65	.010	−.026	−.005	.008	−.022	−.003
95A	.51	−2.74	+.67	3.42	.012	−.022	+.001	.010	−.019	+.001
96	.43	−2.32	+.26	2.58	.010	−.021	.000	.007	−.022	+.001
96A	.43	−2.23	+.51	2.74	.009	−.025	.000	.006	−.026	−.002
97	.43	−2.82	+.34	3.16	.013	−.021	+.001	.008	−.022	+.001
97A	.52	−2.76	+.43	3.20	.010	−.028	+.004	.010	−.022	.000
98	.43	−2.66	+.43	3.09	.014	−.025	−.001	.007	−.030	−.008
98A	.51	−2.57	+.43	3.00	.011	−.029	−.008	.007	−.027	−.005
99	.51	−2.22	+.51	2.73	.010	−.020	.000	.005	−.021	−.008
99A	.34	−2.28	+.51	2.79	.009	−.024	−.003	.005	−.020	−.001
101	.52	−2.34	+.43	2.75	.009	−.019	+.001	.004	−.021	−.007
101A	.52	−2.43	+.35	2.78	.010	−.020	.000	.005	−.020	−.002
163	.60	−2.15	+.52	2.66	.005	−.033	−.009	.001	−.033	−.007
163A	.52	−2.32	+.34	2.67	.011	−.031	−.004	.006	−.026	−.002
164	.51	−2.38	+.34	2.73	.009	−.027	−.003	.003	−.021	.000
164A	.34	−2.22	+.26	2.47	.007	−.028	−.009	.003	−.028	−.012
165	.42	−2.03	+.25	2.29	.008	−.024	−.005	.004	−.028	−.014
165A	.43	−2.06	+.26	2.32	.006	−.031	−.010	.004	−.026	−.012
166	.43	−2.15	+.26	2.41	.001	−.023	−.007	.005	−.020	−.006
166A	.43	−2.03	+.17	2.23	.005	−.024	−.004	.002	−.021	−.003
167	.51	−2.66	+.34	3.00	.007	−.028	−.004	.004	−.025	−.005
167A	.34	−2.81	+.17	2.98	.006	−.024	−.004	.001	−.025	−.004
168	.52	−2.06	+.34	2.40	.006	−.018	+.001	.003	−.019	−.001
168A	.60	−1.97	+.43	2.40	.006	−.021	−.001	.004	−.017	+.001
169	.60	−1.81	+.52	2.32	.009	−.013	+.002	.004	−.015	−.003
169A	.51	−1.96	+.34	2.30	.006	−.017	.000	.002	−.015	−.003
170	.52	−1.81	+.43	2.24	.010	−.021	−.001	.003	−.020	−.004
170A	.52	−1.89	+.34	2.23	.007	−.018	.000	.005	−.020	−.001
171	.52	−1.72	+.26	1.97	.004	−.027	−.010	.004	−.025	−.007
171A	.35	−1.91	+.17	2.08	.011	−.016	+.003	.006	−.021	−.004
172	.52	−1.98	+.34	2.32	.011	−.020	.000	.008	−.023	−.004
172A	.43	−2.34	+.26	2.60	.011	−.025	−.004	.008	−.023	−.004
173	.43	−1.82	+.35	2.16	.002	−.028	−.006	.005	−.021	−.004
173A	.43	−2.25	+.26	2.51	.030	−.002	+.019	.007	−.019	−.002
174	.52	−2.67	+.34	3.02	.005	−.030	−.009	.003	−.028	−.010

TABLE 3.3. *Weight and dimensional changes of concretes*—Continued
(6×8×16-inch blocks)

No.[1]	Weight change			Absp.	Length change					
	Percent			Percent	Percent					
					Top			Bottom		
	14 d	70 d	98 d	28 d	14 d	70 d	98 d	14 d	70 d	98 d
Type II										
174A	.52	−2.77	+.35	3.11	.009	−.025	−.005	.005	−.027	−.008
175	.52	−2.33	+.43	2.76	.009	−.033	+.006	.002	−.038	−.013
175A	.44	−2.62	+.35	2.96	.013	−.028	.000	.003	−.030	−.005
176	.43	−3.03	+.26	3.29	.021	−.026	+.002	.008	−.026	−.002
176A	.43	−3.35	+.26	3.61	.006	−.043	−.012	.009	−.026	−.002
177	.42	−2.29	+.25	2.54	.007	−.033	−.007	.006	−.028	−.008
177A	.43	−2.39	+.43	2.82	.008	−.031	−.006	.004	−.030	−.010
178	.60	−2.41	+.43	2.84	.005	−.024	−.005	.004	−.024	−.007
178A	.60	−2.31	+.43	2.74	.004	−.024	−.004	.001	−.023	−.006
179	.51	−1.97	+.26	2.23	.007	−.028	−.006	.006	−.023	+.015
179A	.43	−2.30	+.17	2.47	.006	−.030	−.007	.005	−.023	−.004
Type IIA										
100	.56	−2.87	+.65	3.52	.021	−.019	+.008	.010	−.024	−.002
100A	.66	−2.26	+.66	2.92	.025	−.016	+.016	.009	−.026	+.001
Type III										
102	.59	−1.53	+.51	2.04	.008	−.030	−.006	.003	−.029	−.006
102A	.60	−1.72	+.52	2.24	.004	−.034	−.009	.003	−.030	−.009
103	.44	−2.02	+.53	2.55	.015	−.017	+.004	.004	−.021	−.001
103A	.43	−1.83	+.43	2.26	.011	−.021	+.003	.004	−.030	−.007
104	.43	−1.98	+.69	2.67	.008	−.027	−.004	.005	−.026	−.005
104A	.43	−2.07	+.60	2.68	.006	−.029	−.008	.006	−.026	−.004
105	.52	−1.65	+.35	2.00	.007	−.024	−.001	.006	−.018	+.004
105A	.61	−1.30	+.52	1.89	.006	−.025	−.002	.003	−.026	−.003
106	.60	−1.97	+.60	2.58	.004	−.016	−.001	.003	−.016	.000
106A	.52	−1.99	+.52	2.51	.007	−.014	+.002	.001	−.021	−.004
180	.52	−1.83	+.78	2.61	.009	−.026	−.008	.005	−.030	−.007
180A	.61	−2.17	+.70	2.87	.008	−.008	−.001	.004	−.031	−.009
181	.52	−1.82	+.61	2.43	.005	−.029	−.005	.001	−.033	−.013
181A	.43	−1.98	+.26	2.24	.003	−.037	−.014	.003	−.034	−.012
182	.61	−2.09	+.78	2.26	−.001	−.043	−.016	−.002	−.035	−.014
182A	.61	−1.74	+.70	2.43	.002	−.039	−.010	.000	−.039	−.010
183	.60	−1.46	+.69	2.15	.006	−.027	−.004	.003	−.026	−.005
183A	.60	−1.72	+.43	2.15	.008	−.027	−.002	.005	−.027	−.006
184	.61	−1.30	+.87	2.16	.010	−.014	+.002	.013	−.003	+.013
184A	.61	−1.56	+.78	2.34	.009	−.012	+.001	.002	−.016	−.001
185	.70	−1.39	+.87	2.27	.009	−.030	−.005	.004	−.028	−.004
185A	.69	−1.73	+.87	2.60	.007	−.033	−.006	.000	−.030	−.008
186	.69	−1.21	+.60	1.81	.002	−.025	−.007	.001	−.021	−.006
186A	.61	−1.38	+.61	1.99	.006	−.017	.000	.001	−.020	−.005
187	.69	−1.47	+.69	2.16	.004	−.025	−.007	.002	−.025	−.006
187A	.60	−1.55	+.60	2.15	.004	−.025	−.005	.001	−.028	−.008
188	.68	−1.28	+.68	1.96	.004	−.029	−.007	.003	−.030	−.009
188A	.70	−1.57	+.61	2.18	.007	−.027	−.005	.002	−.031	−.009
189	.52	−2.17	+.43	2.61	.006	−.031	−.008	.003	−.029	−.008
189A	.61	−2.44	+.35	2.79	.006	−.033	−.008	.003	−.028	−.007
190	.70	−1.57	+.61	2.18	.007	−.023	−.002	.001	−.024	−.006
190A	.70	−1.84	+.61	2.24	.004	−.025	−.006	.002	−.026	−.008
191	.44	−1.74	+.70	2.44	.003	−.035	−.006	.002	−.036	−.011
191A	.52	−1.90	+.69	2.60	.003	−.041	−.010	.001	−.033	−.010
192	.60	−1.29	+.52	1.81	.004	−.031	−.008	.001	−.030	−.010
192A	.60	−1.54	+.34	1.89	.005	−.028	−.005	.001	−.028	−.008
193	.61	−1.67	+.53	2.19	.002	−.026	−.006	.001	−.022	−.004
193A	.70	−1.49	+.61	2.10	.005	−.025	−.005	.002	----------	−.007

TABLE 3.3. *Weight and dimensional changes of concretes*—Continued
(6×8×16-inch blocks)

No.[1]	Weight change			Absp.	Length change					
	Percent			Percent	Percent					
					Top			Bottom		
	14 d	70 d	98 d	28 d	14 d	70 d	98 d	14 d	70 d	98 d
Type IIIA										
194	.55	−1.83	+.64	2.47	.001	−.031	−.011	.001	−.027	−.009
194A	.54	−1.26	+.54	1.80	.001	−.028	−.006	.000	−.030	−.010
195	.64	−1.56	+.92	2.48	.005	−.039	−.012	.003	−.039	−.010
195A	.55	−1.46	+.82	2.28	.004	−.042	−.012	.002	−.040	−.013
Type IV										
107	.43	−2.74	+.26	3.01	.028	−.019	+.010	.009	−.026	−.003
107A	.34	−2.72	+.25	2.98	.012	−.028	−.004	.011	−.026	−.004
108	.43	−3.37	+.26	3.63	.006	−.032	−.011	.006	−.022	−.004
108A	.52	−2.77	+.43	3.20	.009	−.017	+.003	.005	−.024	−.006
196	.35	−3.14	+.44	3.58	.008	−.038	−.010	.008	−.031	−.005
196A	.35	−3.03	+.52	3.56	.007	−.038	−.009	.005	−.034	−.009
Type V										
109	.26	−3.97	−.09	3.89	.029	−.012	+.016	.006	−.025	−.002
109A	.34	−3.88	.00	3.88	.015	−.024	+.003	.013	−.018	+.005
110	.43	−3.10	+.26	3.35	.030	+.002	+.022	.012	−.013	+.005
110A	.34	−3.00	+.26	3.25	.031	+.003	+.024	.007	−.017	+.003
111	.52	−2.53	+.35	2.88	.015	−.014	+.006	.013	−.008	+.010
111A	.52	−2.25	+.43	2.68	.016	−.010	+.011	.009	−.019	+.001
112	.60	−2.84	+.43	3.27	.008	−.006	+.001	.007	−.017	−.001
112A	.61	−2.59	+.35	2.94	.015	−.012	+.006	.006	−.017	−.001
113	.52	−2.60	+.26	2.86	.008	−.016	+.007	.005	−.021	−.001
113A	.51	−2.47	+.17	2.66	.010	−.013	+.008	.006	−.017	+.002
114	.26	−3.11	+.17	3.28				.003	−.019	−.002
114A	.43	−3.06	+.25	3.31	.001	−.023	−.011	.001	−.020	−.005
115	.34	−2.41	+.17	2.58	.008	−.022	−.002	.007	−.019	−.002
115A	.26	−2.65	+.09	2.73	.008	−.021	−.003	.006	−.022	−.003
116	.26	−2.31	+.09	2.40	.005	−.023	−.006	.007	−.021	−.002
116A	.43	−2.15	+.52	2.67	.007	−.020	−.001	.005	−.018	−.001
117	.51	−2.39	+.34	2.74	.014	−.013	+.005	.007	−.017	−.002
117A	.43	−2.51	+.26	2.77	.010	−.016	.000	.006	−.019	−.003
118	.43	−2.55	+.34	2.90	.013	−.019	+.001	.006	−.018	.000
118A	.34	−2.66	+.34	3.00	.016	−.017	+.006	.009	−.021	+.002
119	.42	−1.78	+.42	2.20	.007	−.017	.000	.008	−.012	+.004
119A	.43	−1.87	+.34	2.21	.011	−.017	−.002	.012	−.011	+.009
197	.43	−2.32	+.43	2.75	.004	−.022	−.001	.001	−.022	−.004
197A	.26	−2.65	+.17	2.82	.003	−.021	−.001	.003	−.021	−.002
Miscellaneous										
120	.34	−2.73	+.09	2.82	.009	−.016	+.001	.006	−.018	−.001
120A	.34	−2.84	+.09	2.92	.007	−.020	−.004	.005	−.020	−.003
121	.52	−2.07	+.17	2.24	.011	−.028	−.003	.007	−.027	−.007
121A	.52	−2.61	+.09	2.70	.011	−.038	−.007	.025	+.007	+.029
122	.35	−2.60	+.26	2.87	.027	−.002	+.018	.012	−.014	+.002
122A	.35	−2.43	+.35	2.77	.015	−.004	+.015	.006	−.018	−.002
123	.74	−2.48	+.74	3.22	.006	−.046	−.021	.006	−.031	−.005
123A	.54	−2.15	+.63	2.78	.004	−.042	−.020	.010	−.033	−.007

TABLE 3.3. *Weight and dimensional changes of concretes*—Continued
(6×8×16-inch blocks)

No.-	Weight change			Absp.	Length change					
	Percent			Percent	Percent					
					Top			Bottom		
	14 d	70 d	98 d	28 d	14 d	70 d	98 d	14 d	70 d	98 d
Type S-Slag										
198	.61	−1.13	+.69	1.82	.007	−.031	−.003	.005	−.032	−.003
198A	.60	−1.20	+.68	1.98	.006	−.034	−.005	.005	−.031	−.003
199	.51	−1.37	+.60	1.97	.008	−.024	+.005	.006	−.026	.000
199A	.52	−1.47	+.60	2.07	.009	−.027	+.003	.008	−.029	.000
200	.69	−0.61	+.87	1.47	.015	−.007	+.015	.010	−.011	+.008
200A	.49	−0.96	+.61	1.56	.006	−.016	+.005	.008	−.013	+.004
Type SA-Slag										
201	.83	−1.75	+1.01	2.76	.005	−.048	−.013	−.005	−.046	−.002
201A	.63	−1.18	+.81	1.99	.004	−.041	−.011	.000	−.037	−.014
202	.63	−2.34	+.81	3.15	.003	−.047	−.013	.002	−.037	−.010
202A	.61	−2.08	+.81	2.89	.006	−.040	−.007	.000	−.035	−.009
203	.72	−2.08	+.91	2.99	.005	−.028	−.005	−.001	−.026	−.009
203A	.73	−2.10	+.91	3.01	.010	−.023	+.001	.003	−.021	−.004

[1] Concretes having a 0.635 W/C ratio listed first for each cement and the concretes with a slump of 5±1 inch indicated by the letter A.

[2] Sufficient cement for only one mix.

3.4. Weight Change of 3×4×16-inch Concrete Prisms—Table 3.4

The results of the weight changes of 3×4×16-inch concrete prisms are given in table 3.4. These prisms were made from the same batches of concrete and were exposed to the same curing conditions as the 6×8×16-inch blocks described in Section 3.3. The percent weight change was calculated in the same manner as stated in Section 3.3. Data in table 3.4 are given for two concrete specimens made from each cement for both series of concretes. Information regarding the two series of concretes is given in Section 3.1.

TABLE 3.4. *Weight change of 3×4×16-inch Concrete prisms*

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70 d	Average	98 d	Average
Type I								
1	0.65		−2.21		−2.55		0.58	
	.61	0.63	−2.18	−2.20	−2.57	−2.56	.52	0.55
1A	.69		−2.19		−2.54		.63	
	.72	.71	−2.14	−2.16	−2.49	−2.52	.72	.67
2	.47		−2.56		−2.93		.42	
	.47	.47	−2.58	−2.57	−2.99	−2.96	.45	.43
2A	.46		−2.88		−3.16		.17	
	.48	.47	−2.76	−2.82	−3.08	−3.12	.27	.22
3	.41		−2.09		−2.40		.36	
	.40	.41	−1.90	−1.99	−2.32	−2.36	.44	.40
3A	.42		−2.33		−2.69		.46	
	.43	.43	−2.40	−2.36	−2.82	−2.75	.26	.36
4	.49		−1.90		−2.39		.42	
	.48	.48	−1.68	−1.79	−2.36	−2.38	.44	.43
4A	.46		−1.90		−2.55		.36	
	.43	.44	−2.37	−2.14	−2.78	−2.66	.35	.36
5	.31				−2.61		.25	
	.34	.32	−2.51	−2.51	−3.29	−2.95	.39	.32
5A	.24		−1.69		−2.65		.27	
	.28	.26	−2.44	−2.06	−3.00	−2.83	.21	.24
6	.62		−2.30		−2.58		.58	
	.59	.61	−2.28	−2.29	−2.55	−2.56	.65	.61
6A	.53		−2.57		−2.91		.31	
	.50	.51	−2.51	−2.54	−2.82	−2.87	.34	.32
7	.50		−1.74		−2.03		.52	
	.50	.50	−1.65	−1.69	−2.03	−2.03	.57	.54
7A	.58		−1.59		−1.94		.59	
	.54	.56	−1.67	−1.63	−2.05	−2.00	.59	.59
8	.40		−2.23		−2.66		.32	
	.34	.37	−2.15	−2.19	−2.61	−2.63	.39	.35
8A	.38		−2.14		−2.59		.35	
	.35	.36	−2.24	−2.19	−2.65	−2.62	.32	.34
9	.46		−2.03		−2.44		.57	
	.48	.47	−1.95	−1.99	−2.40	−2.42	.64	.61
9A	.41		−2.15		−2.59		.45	
	.45	.43	−2.03	−2.09	−2.45	−2.52	.65	.55
10	.69		−2.00		−2.49		.61	
	.62	.65	−1.74	−1.87	−2.46	−2.48	.61	.61
10A	.57		−2.25		−2.70		.46	
	.52	.54	−2.24	−2.24	−2.75	−2.72	.37	.41
11	.62		−1.58		−2.28		.65	
	.60	.61	−1.88	−1.73	−2.35	−2.31	.60	.62
11A	.57		−1.80		−2.35		.50	
	.57	.57	−1.64	−1.72	−2.29	−2.32	.50	.50
12	.50		−1.81		−2.43		.42	
	.63	.57	−1.96	−1.88	−2.49	−2.46	.51	.47
12A	.60		−1.79		−2.59		.44	
	.81	.70	−1.97	−1.88	−2.49	−2.54	.78	.61
13	.63		−1.58		−2.26		.66	
	.66	.65	−2.06	−1.82	−2.46	−2.36	.58	.62
13A	.56		−2.41		−2.86		.31	
	.57	.57	−1.99	−2.20	−2.56	−2.71	.33	.32
14	.72		−1.70		−1.98		.77	
	.75	.74	−1.70	−1.70	−1.93	−1.96	.79	.78
14A	.75		−1.53		−1.77		.80	
	.68	.71	−1.54	−1.53	−1.83	−1.80	.80	.80

TABLE 3.4. *Weight change of 3×4×16-inch concrete prisms*—Continued

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70 d	Average	98 d	Average
Type I								
15	.75		−1.43		−1.68		.67	
	.74	.74	−1.52	−1.48	−1.71	−1.70	.68	.68
15A	.68		−1.51		−1.74		.50	
	.68	.68	−1.60	−1.56	−1.96	−1.85	.58	.54
16	.57		−2.12		−2.28		.26	
	.60	.59	−1.18	−1.65	−1.56	−1.92	.37	.31
16A	.52		−1.49		−1.81		.19	
	.52	.52	−1.79	−1.64	−2.24	−2.03	.24	.22
17	.54		−2.20		−2.31		.34	
	.44	.49	−2.18	−2.19	−2.34	−2.33	.20	.27
17A	.46		−2.23		−2.45		.23	
	.55	.51	−2.11	−2.17	−2.53	−2.49	.36	.30
18	.70		−2.09		−2.33		.61	
	.67	.69	−2.13	−2.11	−2.42	−2.38	.62	.61
18A	.57		−2.40		−2.84		.42	
	.53	.55	−2.46	−2.43	−2.85	−2.85	.42	.42
19	.77		−1.80		−2.17		.82	
	.73	.75	−1.78	−1.79	−2.17	−2.17	.81	.82
19A	.75		−1.79		−2.22		.79	
	.65	.70	−1.85	−1.82	−2.15	−2.18	.65	.72
20	.69		−1.89		−2.24		.57	
	.71	.70	−1.82	−1.86	−2.22	−2.23	.63	.60
20A	.81		−1.34		−1.99		1.03	
	.81	.81	−1.33	−1.33	−2.00	−1.99	1.07	1.05
21	.47		−2.55		−2.86		.14	
	.45	.46	−2.48	−2.52	−2.85	−2.85	.19	.17
21A	.43		−2.18		−2.68		.15	
	.45	.44	−2.51	−2.35	−2.88	−2.78	.22	.19
22	.37		−2.29		−2.69		.21	
	.35	.36	−2.16	−2.23	−2.62	−2.65	.23	.22
22A	.25		−2.32		−2.76		.20	
	.35	.30	−2.30	−2.31	−2.68	−2.72	.25	.23
23	.33		−2.69		−3.08		.19	
	.42	.38	−2.67	−2.68	−3.11	−3.09	.25	.22
23A	.44		−2.60		−3.01		.21	
	.45	.45	−2.60	−2.60	−3.03	−3.02	.31	.28
25	.56		−2.42		−2.86		.32	
	.55	.55	−2.39	−2.40	−2.78	−2.81	.43	.37
25A	.62		−2.33		−2.71		.46	
	.64	.63	−2.34	−2.33	−2.78	−2.75	.44	.45
26	.57		−2.30		−2.73		.31	
	.56	.57	−2.22	−2.26	−2.68	−2.71	.47	.39
26A	.64		−2.00		−2.54		.58	
	.56	.60	−2.23	−2.11	−2.76	−2.65	.42	.50
27	.47		−2.11		−2.83		.16	
	.46	.46	−1.80	−1.95	−2.73	−2.78	.13	.15
27A	.44		−2.16		−2.82		.12	
	.44	.44	−1.75	−1.95	−2.92	−2.87	.11	.11
28	.33		−1.82		−2.58		.11	
	.33	.33	−1.46	−1.64	−2.50	−2.54	.13	.12
28A	.36		−1.52		−2.52		.13	
	.31	.33	−1.12	−1.32	−2.40	−2.46	.19	.16
29	.28		−2.23		−2.87		.20	
	.31	.29	−2.13	−2.18	−2.77	−2.82	.17	.19
29A	.35		−2.23		−2.87		.20	
	.34	.35	−2.45	−2.34	−2.97	−2.92	.22	.21
30	.49		−2.17		−2.60		.26	
	.49	.49	−2.17	−2.17	−2.53	−2.57	.18	.22

TABLE 3.4. *Weight change of 3×4×16-inch concrete prisms*—Continued

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70 d	Average	98 d	Average
Type I								
30A	.52		−2.10		−2.51		.17	
	.51	.52	−2.15	−2.12	−2.49	−2.50	.17	.17
31	.55		−2.01		−2.46		.30	
	.58	.57	−2.11	−2.06	−2.57	−2.52	.27	.28
31A	.57		−2.28		−2.72		.20	
	.53	.55	−2.38	−2.33	−2.84	−2.78	.24	.22
32	.38		−2.09		−2.52		.38	
	.39	.39	−2.02	−2.06	−2.41	−2.47	.35	.37
32A	.50		−1.98		−2.37		.40	
	.47	.48	−1.98	−1.98	−2.39	−2.38	.42	.41
33	.62		−1.77		−2.36		.59	
	.61	.61	−1.98	−1.88	−2.51	−2.44	.51	.55
33A	.59		−2.02		−2.54		.40	
	.57	.58	−2.07	−2.05	−2.45	−2.49	.40	.40
34	.55		−2.15		−2.59		.48	
	.64	.60	−2.18	−2.16	−2.67	−2.63	.62	.55
34A	.43		−2.23		−2.81		.28	
	.38	.40	−2.04	−2.13	−2.68	−2.75	.24	.26
35	.63		−2.06		−2.49		.68	
	.66	.65	−2.11	−2.09	−2.55	−2.52	.62	.65
35A	.55		−2.38		−2.78		.52	
	.55	.55	−2.43	−2.40	−2.87	−2.83	.58	.55
36	.64		−1.64		−2.14		.72	
	.69	.66	−1.67	−1.65	−2.26	−2.20	.74	.73
36A	.48		−1.92		−2.45		.52	
	.58	.53	−1.61	−1.77	−2.30	−2.37	.58	.56
37	.42		−2.80		−3.25		.12	
	.50	.46	−2.66	−2.73	−3.11	−3.13	.34	.23
37A	.46		−2.82		−3.27		.16	
	.43	.45	−2.72	−2.77	−3.24	−3.26	.16	.16
38	.66		−2.02		−2.25		.69	
	.58	.62	−2.11	−2.06	−2.36	−2.31	.57	.63
38A	.62		−2.30		−2.53		.62	
	.61	.61	−2.37	−2.33	−2.57	−2.55	.54	.58
39	.53		−2.40		−2.75		.47	
39A[2]	.50	.51	−2.43	−2.42	−2.78	−2.77	.48	.48
40	.68		−1.21		−1.49		.50	
	.56	.62	−1.03	−1.12	−2.18	−1.85	.45	.48
40A	.55		−1.97		−2.68		.41	
	.51	.53	−1.85	−1.91	−2.58	−2.63	.41	.41
41	.68		−1.64		−2.22		.73	
	.69	.68	−1.84	−1.74	−2.32	−2.27	.76	.74
41A	.80		−1.76		−2.28		.76	
	.79	.79	−1.87	−1.82	−2.34	−2.31	.91	.83
42	.48		−2.49		−2.88		.31	
	.45	.46	−2.51	−2.50	−2.75	−2.81	.26	.28
42A	.53		−2.15		−2.53		.41	
	.50	.51	−2.18	−2.16	−2.52	−2.52	.39	.40
43	.42		−2.56		−2.77		.20	
	.44	.43	−2.44	−2.50	−2.80	−2.79	.24	.22
43A	.39		−2.27		−2.74		.21	
	.40	.39	−2.29	−2.28	−2.70	−2.72	.23	.22
44	.60		−2.22		−2.57		.62	
	.61	.60	−2.24	−2.23	−2.69	−2.63	.62	.62
44A	.56		−2.16		−2.55		.61	
	.49	.52	−2.26	−2.21	−2.78	−2.66	.51	56

TABLE 3.4. *Weight change of 3×4×16-inch concrete prisms*—Continued

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70 d	Average	98 d	Average
Type I								
45	.72		−2.09		−2.52		.61	
	.66	.69	−2.11	−2.10	−2.39	−2.46	.50	.55
45A	.51		−2.50		−2.87		.28	
	.52	.51	−2.51	−2.50	−2.78	−2.83	.27	.28
46	.85		−1.27		−1.80		.93	
	.78	.81	−1.06	−1.17	−1.60	−1.70	.85	.89
46A	.67		−1.32		−1.81		.69	
	.72	.70	−1.24	−1.28	−1.75	−1.78	.79	.74
47	.34		−3.02		−3.42		.15	
	.35	.35	−3.00	−3.01	−3.42	−3.42	.14	.14
47A	.34		−2.90		−3.34		.22	
	.33	.33	−2.90	−2.90	−3.26	−3.30	.20	.21
48	.39		−2.44		−2.79		.38	
	.38	.39	−2.48	−2.46	−2.82	−2.80	.29	.34
48A	.38		−2.57		−3.02		.30	
	.37	.37	−2.55	−2.56	−2.89	−2.95	.27	.28
49	.56		−2.48		−2.86		.46	
	.58	.57	−2.40	−2.44	−2.78	−2.82	.46	.46
49A	.58		−2.37		−2.70		.49	
	.57	.57	−2.17	−2.27	−2.57	−2.64	.48	.49
50	.45		−3.28		−3.42		.24	
	.51	.48	−3.10	−3.19	−3.45	−3.43	.27	.26
50A	.49		−2.80		−3.14		.32	
	.53	.51	−2.81	−2.80	−3.18	−3.16	.42	.37
51	.43		−2.30		−2.59		.40	
	.44	.43	−2.29	−2.29	−2.65	−2.62	.44	.42
51A	.33		−2.49		−2.78		.23	
	.37	.35	−2.22	−2.35	−2.60	−2.69	.37	.30
52	.76		−2.03		−2.42		.77	
	.72	.74	−2.01	−2.02	−2.43	−2.43	.79	.78
52A	.45		−2.36		−2.63		.17	
	.42	.44	−2.35	−2.36	−2.67	−2.65	.24	.20
54	.40		−2.02		−2.32		.27	
	.35	.37	−2.03	−2.03	−2.38	−2.35	.23	.25
54A	.37		−1.88		−2.18		.33	
	.36	.37	−1.87	−1.87	−2.23	−2.20	.34	.33
55	.52		−2.50		−2.76		.23	
	.48	.50	−2.51	−2.50	−2.67	−2.82	.13	.18
55A	.42		−2.66		−2.91		.09	
	.46	.44	−2.61	−2.63	−2.90	−2.90	.16	.13
56	.41		−2.55		−2.98		.22	
	.42	.41	−2.39	−2.47	−2.85	−2.92	.20	.21
56A	.36		−2.31		−2.75		.24	
	.42	.39	−2.22	−2.27	−2.60	−2.67	.23	.24
57	.53		−3.00		−3.34		.30	
	.47	.50	−3.10	−3.05	−3.38	−3.36	.20	.25
57A	.43		−3.02		−3.38		.11	
	.45	.44	−2.88	−2.95	−3.25	−3.32	.15	.13
58	.67		−1.64		−2.13		.65	
	.62	.64	−1.82	−1.73	−2.18	−2.16	.58	.61
58A	.70		−1.50		−1.78		.66	
	.71	.70	−1.63	−1.57	−1.83	−1.81	.67	.67
59	.62		−1.78		−2.19		.50	
	.67	.65	−1.81	−1.79	−2.26	−2.23	.59	.54
59A	.67		−1.58		−2.07		.57	
	.55	.61	−1.77	−1.67	−2.32	−2.20	.44	.51
71	.51		−2.16		−2.58		.55	
	.46	.48	−2.03	−2.10	−2.49	−2.54	.50	.52

TABLE 3.4. *Weight change of 3×4×16-inch concrete prisms*—Continued

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70 d	Average	98 d	Average
Type I								
71A	.48		−2.06		−2.48		.49	
	.45	.46	−1.98	−2.02	−2.45	−2.46	.46	.48
73	.41		−2.11		−2.52		.19	
	.35	.38	−2.49	−2.30	−2.80	−2.66	.15	.17
73A	.47		−2.01		−2.30		.28	
	.51	.49	−2.10	−2.06	−2.48	−2.39	.36	.32
124	.73		−1.30		−2.25		.85	
	.71	.72	−1.57	−1.43	−2.40	−2.32	.80	.83
124A	.55		−1.21		−2.37		.73	
	.54	.54	−2.17	−1.69	−2.82	−2.60	.48	.61
125	.48		−2.40		−2.77		.50	
	.57	.52	−2.35	−2.37	−2.73	−2.75	.58	.54
125A	.54		−2.37		−2.79		.65	
	.54	.54	−2.29	−2.33	−2.71	−2.75	.67	.66
126	.67		−1.20		−2.08		.84	
	.62	.64	−1.18	−1.19	−2.06	−2.07	.86	.85
126A	.55							
	.54	.54	[3]−1.57	−1.57	−2.25	−2.25	.71	.71
127	.44		−2.34		−2.73		.21	
	.58	.51	−2.31	−2.24	−2.53	−2.63	.45	.33
127A	.44		−2.47		−2.96		.16	
	.45	.44	−2.80	−2.64	−3.44	−3.20	.08	.12
128	.49		−1.94		−2.42		.42	
	.53	.51	−1.78	−1.86	−2.30	−2.36	.42	.42
128A	.52		−2.01		−2.59		.38	
	.50	.51	−1.99	−2.00	−2.60	−2.60	.35	.37
129								
	[2].44	.44	−2.73	−2.73	−3.17	−3.17	.01	.01
129A	.41		−2.60		−3.06		−.01	
	.39	.40	−2.54	−2.57	−3.10	−3.08	−.03	−.02
130	.39		−2.37		−2.87		.09	
	.37	.38	−2.37	−2.37	−2.89	−2.88	.05	.07
130A	.47		−2.47		−2.91		.16	
	.42	.44	−2.47	−2.47	−2.99	−2.95	.04	.10
131	.55		−2.18		−2.76		.52	
	.52	.53	−2.07	−2.13	−2.64	−2.70	.64	.58
131A	.61		−2.29		−2.86		.59	
	.57	.59	−2.21	−2.25	−2.82	−2.84	.50	.54
132	.50		−2.31		−2.75		.63	
	.47	.49	−2.32	−2.31	−2.77	−2.76	.39	.51
132A	.43		−2.32		−2.76		.38	
	.57	.50	−1.90	−2.11	−2.33	−2.54	.56	.47
133	.65		−1.76		−2.26		.68	
	.71	.68	−1.05	−1.40	−1.86	−2.06	.75	.71
133A	.62		−1.51		−2.18		.66	
	.60	.61	−1.65	−1.58	−2.23	−2.20	.64	.65
134	.54		−1.80		−2.30		.49	
	.50	.52	−1.25	−1.53	−2.09	−2.20	.44	.46
134A	.57		−1.77		−2.20		.50	
	.51	.54	−1.69	−1.73	−2.20	−2.20	.46	.48
135	.42		−2.73		−3.12		.14	
	.41	.41	−2.72	−2.73	−3.21	−3.17	.14	.14
135A	.35		−3.38		−3.81		.05	
	.32	.34	−3.40	−3.39	−3.63	−3.72	−.01	.02
136	.47		−1.95		−2.40		.43	
	.49	.48	−1.64	−1.80	−2.21	−2.30	.47	.45
136A	.41		−2.23		−2.67		.27	
	.42	.41	−2.07	−2.15	−2.53	−2.60	.27	.27

TABLE 3.4. *Weight change of 3×4×16-inch concrete prisms*—Continued

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70 d	Average	98 d	Average
Type I								
137	.45		−2.52		−2.95		.32	
	.50	.47	−2.30	−2.41	−2.88	−2.91	.38	.35
137A	.41		−2.99		−3.34		.04	
	.39	.40	−2.98	−2.98	−3.34	−3.34	.04	.04
138	.45		−2.25		−2.67		.16	
	.44	.45	−2.19	−2.22	−2.64	−2.65	.19	.17
138A	.48		−1.99		−2.56		.15	
	.44	.46	−1.90	−1.95	−2.56	−2.56	.16	.15
139	.37		−2.49		−2.99		.11	
	.34	.35	−2.47	−2.48	−3.12	−3.05	.08	.10
139A								
140	.35		−2.88		−3.34		.04	
	.40	.37	−2.80	−2.84	−3.30	−3.32	.12	.08
140A								
141	.50		−2.96		−3.36		.24	
	.48	.49	−3.10	−3.03	−3.49	−3.43	.20	.22
141A	.49		−3.22		−3.69		.16	
	.44	.46	−3.21	−3.22	−3.64	−3.67	.13	.15
142	.42		−2.20		−2.68		.24	
	.41	.41	−2.28	−2.24	−2.80	−2.74	.18	.21
142A	.41		−2.35		−2.85		.19	
	.40	.41	−2.32	−2.33	−2.82	−2.84	.16	.17
143	.42		−2.55		−3.02		.24	
	.43	.42	−2.51	−2.53	−2.95	−2.99	.32	.28
143A	.42		−2.55		−3.13		.18	
	.32	.37	−2.68	−2.61	−3.21	−3.17	.11	.14
144	.36		−3.28		−3.60		.09	
	.32	.34	−3.17	−3.23	−3.56	−3.58	−.01	.04
144A	.64		−3.12		−3.53		.27	
	.54	.59	−3.35	−3.24	−3.73	−3.63	.04	.15
145	.39		−2.28		−2.80		.24	
	.42	.40	−2.15	−2.22	−2.71	−2.75	.29	.26
145A	.39		−2.56		−3.05		.18	
	.41	.40	−2.58	−2.58	−3.11	−3.08	.14	.16
146	.38		−2.16		−2.62		.30	
	.37	.37	−2.16	−2.16	−2.69	−2.66	.30	.30
146A	.34		−2.37		−2.90		.25	
	.33	.34	−2.28	−2.32	−2.84	−2.87	.20	.23
147	.47		−1.91		−2.51		.42	
	.50	.48	−1.92	−1.92	−2.49	−2.50	.46	.44
147A	.36		−2.13		−2.66		.31	
	.33	.35	−2.29	−2.21	−2.75	−2.71	.28	.29
148	.44		−1.92		−2.34		.40	
	.39	.42	−1.94	−1.93	−2.36	−2.35	.28	.34
148A	.35		−1.99		−2.46		.19	
	.37	.36	−1.95	−1.97	−2.32	−2.39	.24	.21
149	.65		−2.21		−3.33		.55	
	.55	.60	−2.22	−2.21	−2.54	−2.94	.37	.46
149A	.44		−2.64		−3.49		.12	
	.44	.44	−2.52	−2.58	−3.35	−3.42	.19	.16
150	.39		−2.04		−2.44		.33	
	.41	.40	−1.89	−1.96	−2.30	−2.37	.38	.35
150A	.40		−2.01		−2.43		.35	
	.42	.41	−2.05	−2.03	−2.54	−2.49	.39	.37
151	.44		−2.87		−3.32		.13	
	.41	.42	−2.94	−2.90	−3.37	−3.35	.07	.14

TABLE 3.4. *Weight change of 3×4×16-inch concrete prisms*—Continued

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70 d	Average	98 d	Average
Type I								
151A	.49		−2.94		−3.38		.13	
	.50	.49	−2.90	−2.92	−3.32	−3.35	.12	.13
152	.39		−2.13		−2.51		.21	
	.38	.38	−2.09	−2.11	−2.49	−2.50	.23	.22
152A	.42		−2.31		−2.72		.24	
	.40	.41	−2.25	−2.28	−2.72	−2.72	.25	.25
153	.55		−2.08		−2.58		.52	
	.52	.53	−2.06	−2.07	−2.57	−2.57	.45	.49
153A	.48		−2.09		−2.55		.36	
	.40	.44	−2.13	−2.11	−2.59	−2.57	.32	.34
154	.60		−2.44		−2.78		.48	
	.66	.63	−2.36	−2.40	−2.72	−2.75	.59	.54
154A	.67		−2.65		−3.02		.50	
	.61	.64	−2.64	−2.64	−3.03	−3.02	.38	.44
155	.51		−2.12		−2.53		.38	
	.62	.57	−1.89	−2.00	−2.31	−2.42	.54	.46
155A	.67		−1.89		−2.30		.60	
	.60	.64	−2.06	−1.98	−2.49	−2.40	.55	.57
156	.40		−2.68		−3.05		.20	
	.43	.42	−2.73	−2.71	−3.12	−3.09	.22	.21
156A	.57		−2.69		−3.10		.50	
	.55	.56	−2.74	−2.71	−3.15	−3.13	.44	.47
157	.51		−2.16		−2.60		.30	
	.54	.52	−2.07	−2.12	−2.51	−2.56	.39	.34
157A	.44		−2.53		−2.99		.12	
	.43	.43	−2.57	−2.55	−3.03	−3.01	.09	.11
158	.47		−2.03		−2.60		.53	
	.41	.44	−2.19	−2.11	−2.79	−2.70	.28	.40
158A	.38		−2.24		−2.92		.21	
	.37	.38	−2.26	−2.25	−2.91	−2.92	.24	.23
159	.46		−2.03		−2.55		.30	
	.53	.50	−1.92	−1.98	−2.42	−2.48	.39	.35
159A	.46		−2.12		−2.68		.27	
	.53	.49	−2.14	−2.13	−2.70	−2.69	.31	.29
160	.53		−2.62		−2.98		.42	
	.52	.52	−2.55	−2.58	−2.91	−2.94	.45	.44
160A	.50		−2.92		−3.32		.29	
	.49	.49	−2.72	−2.82	−3.12	−3.22	.27	.28
161	.57		−2.15		−2.60		.62	
	.54	.56	−2.17	−2.16	−2.60	−2.60	.53	.58
161A	.48		−2.52		−3.01		.40	
	.41	.45	−2.69	−2.61	−3.19	−3.10	.12	.26
Type IA								
53	.65		−2.15		−2.78		1.00	
	.61	.63	−2.17	−2.16	−2.83	−2.80	1.01	1.00
53A	.74		−1.58		−2.22		.97	
	.73	.74	−1.63	−1.61	−2.21	−2.22	1.03	1.00
60	.67		−2.72		−3.82		.74	
	.67	.67	−2.60	−2.66	−2.96	−3.39	.90	.82
60A	.86		−1.54		−2.01		.98	
	.81	.84	−1.83	−1.68	2.21	−2.11	.93	.96
61	.85		−2.07		−2.52		1.16	
	.82	.84	−1.73	−1.90	−2.39	−2.45	1.13	1.15
61A	.62		−1.00		−1.95		.95	
	.75	.69	−1.00	−1.00	−1.99	−1.97	.85	.90
52	.76		−1.68		−2.68		.98	
	.81	.79	−1.33	−1.51	−2.37	−2.52	.99	.98
62A	.79		−.28		−1.89		.86	
	.82	.80	−1.41	−.85	−2.26	−2.07	.87	.87

TABLE 3.4. *Weight change of 3×4×16-inch concrete prisms*—Continued

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70 d	Average	98 d	Average
Type IA								
63	.73		−1.74		−2.78		.72	
	.78	.76	−1.76	−1.75	−2.60	−2.69	.87	.79
63A	.79		−1.02		−1.52		.96	
	.70	.74	−1.12	−1.07	−1.44	−1.48	.98	.97
64	.68		−2.06		−2.59		1.03	
	.66	.67	−1.39	−1.72	−2.26	−2.42	1.04	1.04
64A	.69		−1.00		−1.96		1.03	
	.60	.65	−1.78	−1.39	−2.24	−2.10	1.02	1.02
65	1.06		−1.49		−2.23		1.51	
	1.06	1.06	−1.93	−1.71	−2.53	−2.38	1.49	1.50
65A	1.23		−1.39		−1.92		1.40	
	1.15	1.19	−1.46	−1.43	−2.06	−1.99	1.27	1.34
66	.50		−1.92		−2.49		.78	
	.46	.48	−2.03	−1.98	−2.55	−2.52	.78	.78
66A	.62		−1.76		−2.18		.89	
	.65	.64	−1.57	−1.66	−2.11	−2.15	.94	.91
162	.83		−2.66		−3.08		.88	
	1.03	.93	−2.46	−2.56	−2.89	−2.99	1.06	.97
162A	.80		−2.03		−2.38		.80	
	1.04	.92	−1.83	−1.93	−2.18	−2.28	1.02	.91
Type II								
24	.53		−1.92		−2.46		.65	
	.48	.50	−1.98	−1.95	−2.56	−2.51	.56	.60
24A	.47		−1.83		−2.36		.51	
	.47	.47	−1.81	−1.82	−2.40	−2.38	.51	.51
67	.45		−2.65		−3.23		.13	
	.47	.46	−2.66	−2.65	−3.21	−3.22	.16	.14
67A	.47		−2.80		−3.26		.19	
	.52	.49	−2.87	−2.84	−3.32	−3.29	.24	.21
68	.32		−2.42		−2.94		.15	
	.38	.35	−2.57	−2.50	−2.98	−2.96	.20	.18
68A	.39		−2.44		−2.80		.16	
	.40	.39	−2.21	−2.33	−2.70	−2.75	.26	.21
69	.36		−2.56		−2.99		.03	
	.39	.38	−2.68	−2.62	−3.03	−3.01	−.03	.00
69A	.38		−2.67		−3.00		.07	
	.39	.39	−2.33	−2.50	−2.78	−2.89	.08	.07
70	.62		−2.34		−2.60		.58	
	.47	.55	−2.52	−2.43	−2.74	−2.67	.36	.47
70A	.55		−2.18		−2.48		.45	
	.58	.56	−2.17	−2.17	−2.51	−2.50	.53	.49
72	.51		−2.14		−2.50		.27	
	.53	.52	−1.50	−1.82	−2.03	−2.26	.30	.28
72A	.53		−1.97		−2.46		.27	
	.50	.51	−1.59	−1.78	−1.95	−2.20	.35	.31
74	.54		−1.61		−1.78		.43	
	.55	.55	−1.18	−1.40	−1.46	−1.62	.48	.46
74A	.50		−1.34		−1.63		.35	
	.43	.46	−1.80	−1.57	−2.14	−1.89	.32	.34
75	.27		−3.03		−3.38		.23	
	.32	.30	−2.68	−2.85	−3.26	−3.32	.19	.21
75A	.32		−2.66		−3.18		.15	
	.31	.32	−2.90	−2.78	−3.26	−3.22	.13	.14

TABLE 3.4. *Weight change of 3×4×16-inch concrete prisms*—Continued

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70 d	Average	98 d	Average
Type II								
76	.37		−2.29		−3.33		.01	
	.39	.38	−2.78	−2.53	−3.42	−3.38	.01	.01
76A	.41		−2.79		−3.38		−.07	
	.36	.39	−2.37	−2.58	−3.36	−3.37	.04	−.02
77	.44		−2.76		−3.26		.11	
	.44	.44	−3.02	−2.89	−3.41	−3.34	.12	.11
77A	.44		−2.99		−3.29		.09	
	.49	.46	−2.94	−2.97	−3.26	−3.33	.20	.15
78	.32		−2.53		−3.04		.22	
	.34	.33	−2.52	−2.52	−2.98	−3.01	.35	.28
78A	.35		−2.48		−2.93		.20	
	.29	.32	−2.29	−2.39	−2.77	−2.85	.24	.22
79	.33		−2.40		−2.79		.32	
79A	.35	.34	−2.43	−2.41	−2.83	−2.81	.31	.32
80	.54		−2.23		−2.60		.58	
	.60	.57	−2.15	−2.19	−2.55	−2.58	.60	.59
80A	.68		−2.14		−2.49		.63	
	.64	.66	−2.13	−2.14	−2.36	−2.42	.67	.65
81	.71		−2.05		−2.84		.50	
	.69	.70	−1.94	−2.00	−2.87	−2.85	.39	.45
81A	.54		−2.72		−3.29		.23	
	.53	.54	−2.60	−2.66	−3.23	−3.26	.27	.25
82	.44		−2.13		−3.10		.23	
	.42	.43	−2.39	−2.26	−3.04	−3.07	.20	.22
82A	.35		−2.26		−3.09		.05	
	.40	.37	−2.31	−2.28	−3.11	−3.10	.09	.07
83	.52		−2.17		−2.54		.31	
	.55	.54	−1.80	−1.99	−2.47	−2.50	.35	.33
83A	.59		−1.91		−2.65		.38	
	.56	.58	−1.89	−1.90	−2.62	−2.64	.41	.40
84	.49		−2.55		−3.13		.21	
	.44	.47	−2.46	−2.50	−3.15	−3.14	.15	.18
84A	.48		−2.34		−3.10		.24	
	.36	.42	−2.61	−2.47	−3.20	−3.15	.40	.32
85	.58		−1.99		−2.45		.87	
	.50	.54	−2.05	−2.02	−2.52	−2.49	.62	.75
85A	.62		−1.94		−2.41		.67	
	.63	.63	−1.89	−1.91	−2.37	−2.39	.67	.67
86	.87		−1.92		−2.37		.75	
	.84	.86	−2.06	−1.99	−2.40	−2.38	.74	.74
86A	.68		−2.11		−2.56		.53	
	.62	.65	−2.25	−2.18	−2.72	−2.64	.48	.50
87	.65		−2.41		−2.85		.32	
	.58	.61	−2.63	−2.52	−2.75	−2.80	.22	.27
87A	.54		−2.65		−2.84		.15	
	.49	.52	−2.65	−2.65	−2.94	−2.89	.20	.18
88	.23		−3.42		−3.75		−.09	
	.21	.22	−3.26	−3.34	−3.59	−3.67	.00	−.05
88A	.23		−3.47		−3.85		−.05	
	.26	.24	−3.53	−3.50	−3.83	−3.84	−.01	−.03
89	.33		−2.68		−2.92		.17	
	.32	.33	−2.65	−2.66	−3.00	−2.96	.23	.20
89A	.25		−2.70		−3.08		.16	
	.29	.27	−2.67	−2.69	−2.97	−3.03	.12	.14
90	.33		−2.92		−3.29		.00	
	.39	.36	−2.76	−2.84	−3.08	−3.19	.07	.03
90A	.29		−3.08		−3.42		−.12	
	.32	.31	−2.92	−3.00	−3.28	−3.35	−.04	−.08

TABLE 3.4. *Weight change of 3×4×16-inch concrete prisms*—Continued

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70 d	Average	98 d	Average
Type II								
91	.41		−2.80		−3.18		.26	
	.44	.42	−2.70	−2.75	−3.02	−3.10	.25	.25
91A	.38		−2.73		−3.14		.27	
	.40	.39	−2.62	−2.68	−2.94	−3.04	.21	.24
92	.33		−3.56		−3.76		−.12	
	.31	.32	−3.43	−3.50	−3.62	−3.69	−.12	−.12
92A	.42		−3.74		−3.98		−.01	
	.39	.40	−3.80	−3.77	−3.97	−3.98	−.07	−.04
93	.46		−2.19		−2.70		.58	
	.47	.46	−2.22	−2.21	−2.80	−2.75	.49	.53
93A	.53		−2.42		−2.95		.44	
	.60	.57	−2.37	−2.39	−2.94	−2.94	.45	.44
94	.54		−2.61		−2.99		.31	
	.42	.48	−2.69	−2.65	−3.12	−3.05	.18	.25
94A	.46		−2.82		−3.33		.12	
	.43	.45	−2.81	−2.82	−3.21	−3.27	.23	.18
95	.42		−3.66		−3.91		.29	
	.70	.56	−3.01	−3.33	−3.46	−3.69	.54	.41
95A	.72		−2.63		−3.07		.51	
	.57	.65	−3.14	−2.88	−3.41	−3.24	.41	.46
96	.30		−2.79		−3.15		.27	
	.35	.33	−2.75	−2.77	−3.15	−3.15	.27	.27
96A	.37		−2.66		−2.99		.28	
	.40	.39	−2.68	−2.67	−3.05	−3.02	.25	.27
97	.29		−3.38		−3.59		.05	
	.35	.32	−3.31	−3.35	−3.61	−3.60	.05	.05
97A	.32		−3.29		−3.46		.00	
	.32	.32	−3.18	−3.24	−3.48	−3.47	.07	.03
98	.51		−2.94		−3.24		.34	
	.49	.50	−2.72	−2.83	−3.06	−3.15	.40	.37
98A	.62		−2.59		−2.94		.50	
	.38	.50	−2.79	−2.69	−3.10	−3.02	.51	.51
99	.27		−2.98		−3.33		.13	
	.29	.28	−2.85	−2.92	−3.27	−3.30	.19	.16
99A	.40		−2.70		−3.02		.35	
	.54	.47	−2.68	−2.69	−3.02	−3.02	.41	.38
101	.50		−2.77		−3.08		.24	
	.59	.54	−2.74	−2.76	−3.05	−3.06	.36	.30
101A	.43		−3.01		−3.32		.16	
	.48	.46	−2.99	−3.00	−3.31	−3.32	.22	.19
163	.47		−2.61		−3.09		.33	
	.51	.49	−2.53	−2.57	−3.04	−3.07	.38	.35
163A	.51		−2.77		−3.22		.31	
	.51	.51	−2.71	−2.74	−3.14	−3.18	.28	.30
164	.39		−2.61		−3.06		.16	
	.39	.39	−2.57	−2.59	−3.00	−3.03	.12	.14
164A	.35		−2.63		−2.98		.09	
	.37	.36	−2.64	−2.64	−3.02	−3.00	.09	.09
165	.35		−2.64		−3.03		.16	
	.49	.41	−2.38	−2.51	−2.80	−2.92	.33	.24
165A	.39		−2.41		−2.76		.20	
	.36	.38	−2.43	−2.42	−2.80	−2.78	.20	.20
166	.32		−2.72		−3.10		−.03	
	.32	.32	−2.75	−2.74	−3.16	−3.13	.00	−.02
166A	.48		−2.52		−2.88		.19	
	.49	.48	−2.49	−2.50	−2.90	−2.89	.20	.19

TABLE 3.4. *Weight change of 3×4×16-inch concrete prisms*—Continued

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70	Average	98 d	Average
Type II								
167	.38		−3.00		−3.33		.11	
	.42	.40	−3.00	−3.00	−3.38	−3.35	.08	.09
167A	.36		−3.26		−3.64		−.04	
	.35	.35	−3.06	−3.16	−3.48	−3.56	−.03	−.04
168	.49		−2.40		−2.84		.26	
	.54	.51	−2.25	−2.32	−2.80	−2.82	.34	.30
168A	.51		−2.33		−2.80		.31	
	.52	.51	−2.57	−2.45	−2.98	−2.89	.27	.29
169	.41		−2.38		−2.89		.12	
	.38	.39	−2.32	−2.35	−2.81	−2.85	.08	.10
169A	.54		−2.30		−2.80		.31	
	.41	.47	−2.58	−2.44	−3.07	−2.94	.08	.20
170	.53		−2.13		−2.60		.39	
	.52	.52	−1.99	−2.06	−2.49	−2.55	.37	.38
170A	.41		−2.11		−2.81		.28	
	.42	.42	−2.14	−2.12	−2.63	−2.72	.27	.27
171	.58		−1.98		−2.39		.24	
	.55	.56	−2.06	−2.02	−2.48	−2.43	.24	.24
171A	.36		−2.27		−2.77		.04	
	.37	.36	−2.40	−2.33	−2.93	−2.85	.00	.02
172	.40		−2.75		−3.22		.09	
	.38	.39	−2.72	−2.74	−3.12	−3.17	.09	.09
172A	.41		−2.71		−3.18		.18	
	.39	.40	−2.67	−2.69	−3.17	−3.18	.18	.18
173	.45		−2.53		−3.01		.29	
	.47	.46	−2.54	−2.54	−3.05	−3.03	.22	.25
173A	.42		−2.81		−3.32		.13	
	.43	.43	−2.81	−2.81	−3.29	−3.31	.14	.13
174	.27		−3.09		−3.53		−.14	
	.28	.28	−3.00	−3.04	−3.48	−3.50	−.18	−.16
174A	.38		−3.20		−3.65		.04	
	.35	.36	−3.16	−3.18	−3.60	−3.63	−.14	−.05
175	.39		−2.78		−3.23		.05	
	.39	.39	−2.56	−2.67	−3.05	−3.14	.15	.10
175A	.39		−2.93		−3.36		.00	
	.37	.38	−2.93	−2.93	−3.35	−3.36	.03	.01
176	.39		−3.46		−3.84		.05	
	.42	.41	−3.30	−3.38	−3.72	−3.78	.07	.06
176A	.43		−3.58		−3.96		.07	
	.29	.36	−3.51	−3.55	−3.89	−3.92	−.01	.03
177	.41		−2.59		−3.05		.18	
	.37	.39	−2.58	−2.58	−3.03	−3.04	.16	.17
177A	.36		−2.81		−3.25		.09	
	.38	.37	−2.58	−2.70	−3.00	−3.13	.17	.13
178	.31		−3.06		−3.50		−.07	
	.31	.31	−3.04	−3.05	−3.47	−3.48	−.09	−.08
178A	.44		−2.88		−3.29		.03	
	.46	.45	−3.04	−2.96	−3.32	−3.31	.08	.05
179	.51		−2.43		−2.89		.27	
	.50	.50	−2.50	−2.47	−2.94	−2.92	.12	.19
179A	.39		−2.60		−3.02		−.01	
	.35	.37	−2.60	−2.60	−3.06	−3.04	−.01	−.01
Type IIA								
100	.70		−2.51		−2.95		1.06	
	.51	.61	−3.00	−2.76	−3.35	−3.15	.99	1.03
100A	.72		−1.89		−2.37		1.18	
	.73	.72	−2.34	−2.12	−2.67	−2.52	1.23	1.21

TABLE 3.4. *Weight change of 3×4×16-inch concrete prisms*—Continued

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70 d	Average	98 d	Average
Type III								
102	.63		−1.89		−2.22		.64	
	.62	.63	−1.82	−1.86	−2.19	−2.21	.72	.68
102A	.55		−2.09		−2.39		.44	
	.60	.57	−2.09	−2.09	−2.41	−2.40	.55	.50
103	.50		−2.40		−2.64		.47	
	.47	.48	−2.42	−2.41	−2.83	−2.73	.50	.49
103A	.53		−2.03		−2.27		.59	
	.55	.54	−2.01	−2.02	−2.46	−2.36	.67	.63
104	.46		−2.22		−2.65		.43	
	.45	.45	−2.16	−2.19	−2.64	−2.65	.41	.42
104A	.44		−2.39		−2.84		.35	
	.42	.43	−2.40	−2.40	−2.96	−2.90	.15	.25
105	0.43		−1.73		−2.26		.27	
	.46	.45	−1.93	−1.83	−2.20	−2.23	.30	.28
105A	.46		−1.80		−2.16		.32	
	.43	.44	−1.77	−1.78	−2.07	−2.11	.28	.30
106	.34		−2.52		−2.97		.31	
	.39	.36	−2.59	−2.55	−3.02	−3.00	.24	.28
106A	.32		−2.59		−3.01		.27	
	.30	.31	−2.69	−2.64	−3.06	−3.04	.24	.26
180	.43		−2.21		−2.59		.16	
	.42	.42	−2.21	−2.21	−2.62	−2.60	.17	.17
180A	.42		−2.45		−2.90		.27	
	.46	.44	−2.47	−2.46	−2.92	−2.90	.27	.27
181	.61		−1.90		−2.37		.58	
	.58	.60	−1.99	−1.95	−2.43	−2.40	.45	.52
181A	.41		−2.27		−2.72		.19	
	.54	.47	−1.99	−2.13	−2.41	−2.57	.37	.28
182	.49		−1.90		−2.44		.41	
	.56	.52	−1.78	−1.84	−2.26	−2.35	.49	.45
182A	.42		−2.18		−2.71		.18	
	.44	.43	−2.25	−2.21	−2.80	−2.76	.22	.20
183	.52		−1.58		−2.19		.53	
	.47	.50	−1.67	−1.63	−2.21	−2.20	.47	.50
183A	.40		−1.83		−2.37		.29	
	.43	.42	−1.94	−1.88	−2.49	−2.43	.32	.31
184	.57		−1.51		−2.01		.77	
	.66	.62	−1.47	−1.49	−1.96	−1.98	.77	.77
184A	.34		−2.06		−2.62		.29	
	.35	.35	−2.07	−2.07	−2.62	−2.63	.31	.30
185	.45		−1.95		−2.39		.46	
	.55	.50	−1.79	−1.87	−2.23	−2.31	.59	.53
185A	.40		−2.18		−2.67		.24	
	.39	.40	−2.19	−2.18	−2.68	−2.67	.24	.24
186	.23		−2.04		−2.60		.05	
	.32	.28	−1.98	−2.01	−2.50	−2.55	.09	.07
186A	.24		−1.98		−2.52		.05	
	.27	.26	−2.01	−1.99	−2.55	−2.54	.11	.08
187	.60		−1.66		−2.21		.51	
	.66	.63	−1.49	−1.58	−2.08	−2.14	.59	.55
187A	.40		−1.86		−2.42		.27	
	.37	.38	−1.66	−1.76	−2.27	−2.35	.26	.26
188	.45		−1.74		−2.22		.46	
	.64	.54	−1.54	−1.64	−2.02	−2.12	.60	.53
188A	.40		−1.91		−2.49		.23	
	.42	.41	−1.63	−1.77	−2.38	−2.43	.26	.24

TABLE 3.4. *Weight change of 3×4×16-inch concrete prisms*—Continued

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70 d	Average	98 d	Average
Type III								
189	.34		−2.88		−3.29		−.01	
	.34	.34	−2.76	−2.84	−3.17	−3.23	.07	.03
189A	.32		−2.75		−3.24		−.07	
	.31	.32	−2.87	−2.81	−3.38	−3.31	−.11	−.09
190	.35		−2.14		−2.67		.23	
	.38	.37	−2.06	−2.10	−2.61	−2.64	.25	.24
190A	.38		−2.31		−2.92		.12	
	.37	.37	−2.29	−2.30	−2.86	−2.89	.18	.15
191	.78		−1.58		−2.05		.93	
	.82	.80	−1.54	−1.56	−2.01	−2.03	.97	.95
191A	.70		−1.91		−2.49		.61	
	.71	.71	−1.94	−1.93	−2.52	−2.50	.75	.68
192	.39		−1.74		−2.24		.11	
	.39	.39	−1.73	−1.74	−2.27	−2.26	.16	.14
192A	.51		−1.68		−2.23		.19	
	.61	.56	−1.56	−1.61	−2.13	−2.18	.36	.28
193	.58		−2.00		−2.49		.59	
	.60	.59	−2.00	−2.00	−2.53	−2.51	.57	.58
193A	.47		−2.04		−2.57		.27	
	.59	.53	−1.78	−1.92	−2.30	−2.44	.57	.42
Type IIIA								
194	.54		−2.11		−2.66		.70	
	.61	.58	−1.73	−1.92	−2.40	−2.53	.73	.72
194A	.33		−1.61		−2.13		.40	
	.36	.34	−1.66	−1.63	−2.20	−2.15	.43	.41
195	.84		−1.67		−2.11		1.00	
	.92	.88	−1.63	−1.65	−2.05	−2.08	1.01	1.00
195A	.83		−1.23		−1.68		.96	
	.77	.80	−1.26	−1.24	−1.71	−1.70	.97	.96
Type IV								
107	.32		−3.20		−3.50		.12	
	.37	.35	−3.19	−3.19	−3.52	−3.51	.13	.13
107A	.40		−3.15		−3.40		.16	
	.35	.38	−3.06	−3.11	−3.33	−3.37	.17	.17
108	.32		−3.45		−3.86		.05	
	.34	.33	−3.55	−3.50	−3.81	−3.84	.04	.05
108A	.33		−3.43		−3.70		.04	
	.35	.34	−3.13	−3.20	−3.57	−3.64	.03	.03
196	.23		−3.49		−3.81		.18	
	.38	.31	−3.38	−3.43	−3.75	−3.78	.25	.21
196A	.32		−3.63		−3.92		.09	
	.33	.32	−3.51	−3.57	−3.93	−3.93	.19	.14
Type V								
109	.34		−4.03		−4.32		−.12	
	.35	.35	−4.11	−4.07	−4.42	−4.37	−.12	−.12
109A	.35		−3.96		−4.27		−.08	
	.28	.32	−4.00	−3.98	−4.33	−4.30	−.13	−.11
110	.37		−3.06		−3.53		.08	
	.32	.34	−3.13	−3.09	−3.51	−3.52	.09	.09
110A	.43		−2.94		−3.48		.16	
	.43	.43	−2.82	−2.88	−3.33	−3.41	.08	.12
111	.58		−2.49		−2.87		.60	
	.52	.55	−2.51	−2.50	−2.91	−2.89	.54	.57
111A	.46		−2.43		−2.80		.35	
	.45	.45	−2.43	−2.43	−2.66	−2.73	.31	.33

TABLE 3.4. *Weight change of 3×4×16-inch concrete prisms*—Continued

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70 d	Average	98 d	Average
Type V								
112	.41		−2.98		−3.17		.31	
	.45	.43	−2.92	−2.95	−3.37	−3.27	.45	.38
112A	.34		−2.85		−3.21		.19	
	.34	.34	−2.98	−2.92	−3.23	−3.22	.08	.13
113	.67		−2.49		−2.80		.43	
	.70	.69	−2.67	−2.58	−2.93	−2.86	.38	.41
113A	.73		−2.39		−2.78		.53	
	.67	.70	−2.54	−2.46	−2.75	−2.76	.36	.45
114	.31		−3.42		−3.65		−.07	
	.34	.33	−3.53	−3.47	−3.89	−3.77	.05	−.01
114A	.28		−3.50		−3.84		.00	
	.31	.30	−3.40	−3.45	−3.68	−3.76	−.08	−.04
115	.32		−2.92		−3.18		.12	
	.32	.32	−2.57	−2.75	−3.05	−3.12	.15	.13
115A	.28		−2.95		−3.24		.11	
	.28	.28	−2.77	−2.86	−3.16	−3.20	.08	.10
116	.33		−2.64		−2.98		.20	
	.33	.33	−2.47	−2.50	−2.94	−2.96	.24	.22
116A	.32		−2.81		−3.09		.16	
	.32	.32	−2.59	−2.70	−3.08	−3.08	.13	.15
117	.45		−2.79		−3.31		.09	
	.44	.45	−2.81	−2.80	−3.32	−3.32	.20	.15
117A	.39		−2.91		−3.72		.16	
	.47	.44	−2.89	−2.90	−3.40	−3.56	.20	.18
118	.32		−3.12		−3.47		.12	
	.34	.33	−2.89	−3.00	−3.24	−3.36	.16	.14
118A	.35		−2.72		−3.23		.16	
	.35	.35	−3.02	−2.87	−3.32	−3.27	.18	.17
119	.39		−2.27		−2.69		.17	
	.40	.39	−2.28	−2.28	−2.74	−2.71	.15	.16
119A	.33		−2.25		−2.68		.12	
	.36	.35	−2.28	−2.27	−2.69	−2.69	.11	.11
197	.41		−2.63		−3.08		.15	
	.39	.40	−2.53	−2.58	−2.99	−3.03	.22	.18
197A	.31		−2.81		−3.28		.04	
	.36	.34	−2.67	−2.74	−3.18	−3.23	.11	.07
Miscellaneous								
120	.41		−2.80		−3.30		.27	
	.46	.43	−2.62	−2.71	−3.11	−3.20	.27	.27
120A	.41		−2.80		−3.20		.27	
	.42	.42	−2.70	−2.75	−3.26	−3.23	.26	.27
121	----------		−2.06		−2.59		.63	
	.64	.64	−2.11	−2.08	−2.69	−2.64	.62	.63
121A	.54		−2.54		−3.18		.45	
	.57	.55	−2.47	−2.51	−3.12	−3.15	.45	.45
122	.42		−2.34		−3.05		.34	
	.48	.45	2.62	−2.48	−3.22	−3.13	.38	.36
122A	.27		−2.70		−3.35		.05	
	.34	.30	−2.74	−2.72	−3.34	−3.34	.18	.12
123	.80		−2.81		−3.14		1.14	
	.73	.77	−2.81	−2.81	−3.19	−3.17	1.05	1.10
123A	.71		−2.15		−2.51		1.02	
	.71	.71	−2.15	−2.15	−2.53	−2.52	1.07	1.05

TABLE 3.4. *Weight change of 3×4×16-inch concrete prisms*—Continued

Data No.[1]	Weight change, Percent							
	14 d	Average	42 d	Average	70 d	Average	98 d	Average
Type S-Slag								
198	.64		−1.77		−2.11		.75	
	.72	.68	−1.67	−1.72	−2.03	−2.07	.72	.73
198A	.70		−1.78		−2.16		.67	
	.71	.70	−1.80	−1.79	−2.17	−2.16	.61	.64
199	.54		−1.98		−2.41		.53	
	.58	.56	−2.01	−1.99	−2.44	−2.42	.53	.53
199A	.56		−1.91		−2.32		.53	
	.54	.55	−2.00	−1.96	−2.40	−2.36	.53	.53
200	.65		−1.04		−1.48		.68	
	.76	.70	−.96	−1.00	−1.29	−1.39	.76	.72
200A	.70		−1.05		−1.51		.73	
	.67	.68	−1.24	−1.14	−1.58	−1.55	.70	.71
Type SA-Slag								
201	.93		−1.91		−2.33		1.32	
	.97	.95	−2.06	−1.99	−2.52	−2.42	1.13	1.22
201A	1.03		−1.63		−2.04		.93	
	.88	.96	−1.63	−1.63	−2.04	−2.04	.88	.90
202	.80		−2.70		−3.00		.90	
	.75	.77	−2.61	−2.66	−2.94	−2.97	.81	.85
202A	.75		−2.68		−3.13		.83	
	.77	.76	−2.59	−2.64	−2.93	−3.03	.78	.80
203	.79		−2.52		−3.03		.93	
	.87	.83	−2.52	−2.52	−3.04	−3.04	.97	.95
203A	.90		−2.57		−3.08		1.06	
	.82	.86	−2.49	−2.53	−3.03	−3.05	.87	.96

[1] Concretes having a 0.635 W/C ratio listed first for each cement and the concretes with a slump of 5±1-inch indicated by the letter A.

[2] Sufficient cement for one mix only.

[3] Specimen broken.

3.5. Laboratory Freezing and Thawing Durability of Concretes—Table 3.5

The freezing and thawing durability of the concretes were estimated by ascertaining the number of freezing and thawing cycles needed to reduce the dynamic modulus to 60 percent of its original value. These data along with the percentage of weight loss and durability factor are listed in table 3.5.

Four 3×4×16-inch prisms made from each of the cements, two for each of the two series of concretes, were tested. The prisms were cast in steel molds in accordance with the requirements of ASTM Designation C 192–52T [18] except that the molds were lined with plastic and no oil or grease was used. The prisms were made from the same batches of concrete used for the 6×8×16-inch specimens that were used for shrinkage and expansion tests.

The concrete specimens were covered with moist burlap for the first 20 to 24 hours, then stripped and placed in a fog room at 100 percent relative humidity until they were 14 days old. The prisms were then stored on end in laboratory air at 73 °F and 50 percent relative humidity for 4 weeks.

Subsequently, the prisms were placed in water at 40 °F for 24 hours prior to commencing the freezing and thawing cycling. At that time the dynamic Young's modulus of elasticity of the prisms were calculated from their weight and fundamental transverse resonant frequencies and are reported in table 3.5. The fundamental resonance frequencies were determined in accordance with ASTM Designation C 215–69 [19]. In the freezing and thawing tests the specimens were frozen in 0 °F water and thawed in 40 °F water, with each cycle being completed in 2 hours in accordance with ASTM Designation C 290–67 [20]. The tests were continued until there was a 40 percent decrease in dynamic modulus.

Calculated values of the durability factors [20] were based on termination of the tests at 300 cycles or at 40 percent decrease in the original dynamic modulus. In some instances, especially with air-entraining concretes tests had to be continued beyond 300 cycles in order to reach the 40 percent decrease in dynamic modulus.

TABLE 3.5. *Laboratory freezing and thawing durability of concretes*

No. [1]	Gain in wt. after 1 d soaking at 40°F (percent)		Original dynamic modulus, E_0 (psi × 10^{-6})		Number of cycles to failure, interpolated to 60% E_0		Loss in wt during F&T, interpolated to 60% E_0 (percent)		Durability factor [2]	
		Average		*Average*		*Average*		*Average*		*Average*
Type I										
1	2.20		4.49		86		7.2		17	
	2.07	2.14	4.43	4.46	96	91	1.3	4.3	19	18
1A	2.16		4.42		99		1.8		20	
	2.28	2.22	4.22	4.32	90	95	3.8	2.8	18	19
2	2.30		4.52		106		5.2		21	
	2.29	2.30	4.48	4.50	158	131	13.1	9.2	32	27
2A	2.39		4.45		158		10.7		32	
	2.55	2.47	4.37	4.41	155	157	8.8	9.8	31	32
3	1.67		4.98		122		3.2		24	
	1.72	1.70	4.79	4.89	102	112	2.7	3.0	20	22
3A	1.95		4.62		168		8.7		34	
	1.94	1.95	4.64	4.63	172	170	7.5	8.1	34	34
4	1.88		4.75		123		5.5		25	
	1.80	1.84	4.69	4.72	121	122	8.0	6.8	24	25
4A	2.17		4.51		170		10.7		34	
	1.76	1.97	4.49	4.50	192	181	12.9	11.8	38	36
5	1.64		4.71		156		6.5		31	
	1.91	1.78	4.49	4.60	164	160	10.6	8.6	33	32
5A	1.47		4.50		133		8.8		27	
	1.72	1.60	4.58	4.54	155	144	10.3	9.6	31	29
6	2.21		4.69		91		4.0		18	
	1.19	2.20	4.58	4.64	93	92	5.5	4.8	19	19
6A	2.37		4.56		90		6.8		18	
	2.40	2.39	4.54	4.55	100	95	6.6	6.7	20	19
7	1.77		4.87		89		1.1		18	
	1.71	1.74	4.87	4.87	81	85	1.8	1.5	16	17
7A	1.72		4.84		86		1.2		17	
	1.77	1.75	4.96	4.90	65	76	2.0	1.6	13	15
8	1.99		4.70		193		3.4		21	
	1.95	1.97	4.60	4.65	91	97	6.9	5.2	18	20
8A	1.99		4.75		91		3.6		18	
	2.03	2.01	4.58	4.67	93	92	2.6	3.1	19	19
9	2.00		4.84		81		1.5		16	
	1.97	1.99	4.71	4.78	81	81	1.3	1.4	16	16
9A	2.06		4.64		22		.9		4	
	2.10	2.08	4.45	4.55	73	48	1.8	1.4	15	10
10	2.05		4.55		115		5.9		23	
	2.16	2.11	4.50	4.53	117	116	7.2	6.6	23	23
10A	2.07		4.67		100		3.7		20	
	1.98	2.30	4.56	4.62	117	109	7.6	5.7	23	22
11	2.13		4.50		115		4.1		23	
	2.00	2.07	4.75	4.63	127	121	6.0	5.1	25	24
11A	1.72		4.63		117		3.2		23	
	2.04	1.88	4.64	4.64	107	112	6.8	5.0	21	22
12	2.08		4.63		85		7.1		17	
	2.04	2.06	4.76	4.70	87	86	10.6	8.9	17	17
12A	2.24		4.54		84		4.9		17	
	2.16	2.20	4.65	4.60	94	89	8.7	6.8	19	18
13	2.38		4.43		106		5.7		21	
	2.26	2.32	4.48	4.46	99	103	5.7	5.7	20	21
13A	2.32		4.51		138		12.3		28	
	2.42	2.37	4.39	4.45	118	128	8.9	10.6	24	26
14	2.12		4.50		204		7.0		41	
	1.93	2.03	4.39	4.45	142	173	3.4	5.2	28	35
14A	1.84		4.56		198		6.3		40	
	1.66	1.75	4.66	4.61	174	186	3.6	5.0	35	38
15	1.71		4.93		80		7.4		16	
	1.71	1.71	4.83	4.88	76	78	3.4	5.4	15	16
15A	1.86		4.66		66		2.4		13	
	1.77	1.82	4.86	4.76	71	69	4.4	3.4	14	14

TABLE 3.5. *Laboratory freezing and thawing durability of concretes*—Continued

No. [1]	Gain in wt. after 1 d soaking at 40°F (percent)		Original dynamic modulus, E_0 (psi $\times 10^{-6}$)		Number of cycles to failure, interpolated to 60% E_0		Loss in wt during F&T, interpolated to 60% E_0 (percent)		Durability factor [2]	
		Average		*Average*		*Average*		*Average*		*Average*
Type I										
16	2.04		4.44		74		2.2		15	
	1.88	1.96	4.54	4.49	72	73	2.2	2.2	14	15
16A	1.94		4.51		86		2.7		17	
	2.07	2.01	4.53	4.52		86		2.7		17
17	2.17		4.60		107		4.8		21	
	2.00	2.09	4.59	4.60	106	107	6.4	5.6	21	21
17A	2.08		4.48		149		8.7		30	
	2.09	2.09	4.45	4.47	123	136	7.0	7.9	25	28
18	2.13		4.64		98		4.9		20	
	2.13	2.13	4.62	4.63	101	100	3.7	4.3	20	20
18A	2.18		4.60		112		5.7		22	
	2.26	2.22	4.30	4.45	105	109	6.3	6.0	21	22
19	1.88		4.84		42		1.9		8	
	1.84	1.86	4.78	4.81	58	50	3.2	2.6	12	10
19A	1.88		4.85		76		1.5		15	
	1.88	1.88	4.54	4.70	81	79	2.1	1.8	16	16
20	1.90		4.66		102		2.1		20	
	1.87	1.89	4.60	4.63	110	106	3.7	2.9	22	21
20A	1.91		4.68		171		10.4		34	
	1.94	1.93	4.82	4.75	173	172	9.4	9.9	35	35
21	1.92		4.79		231		11.9		46	
	1.95	1.94	4.93	4.86	230	230	12.3	12.1	46	46
21A	1.49		4.93		198		9.7		40	
	1.84	1.67	4.75	4.84	194	196	10.0	9.9	39	40
22	1.44		5.26		153		5.5		31	
	1.58	1.51	5.05	5.16	142	148	5.3	5.4	28	30
22A	1.79		4.81		155		6.3		31	
	1.91	1.85	4.60	4.71	137	146	7.1	6.7	27	29
23	2.16		4.57		168		8.6		34	
	2.11	2.14	4.48	4.53	196	187	9.7	9.2	39	37
23A	2.02		4.56		189		9.1		38	
	2.00	2.01	4.70	4.63	209	199	10.5	9.8	42	40
25	1.90		4.61		195		8.5		39	
	1.97	1.94	4.51	4.56	160	178	5.8	7.2	32	36
25A	1.98		4.42		141		3.9		28	
	2.10	2.04	4.29	4.36	91	116	2.1	3.0	18	23
26	1.94		4.65		66		1.7		13	
	1.97	1.96	4.55	4.60	66	66	1.1	1.4	13	13
26A	1.63		4.76		55		.0		11	
	1.74	1.69	4.70	4.73	58	57	.3	.2	12	12
27	1.96		4.52		177		11.9		35	
	1.57	1.77	4.76	4.64	155	166	6.3	9.1	31	33
27A	1.45		4.80		139		8.9		28	
	1.73	1.59	4.65	4.73	222	181	13.0	11.0	44	36
28	1.50		4.84		151		6.6		30	
	1.93	1.72	4.87	4.86	203	177	9.5	8.1	41	36
28A	1.93		4.79		289		14.9		58	
	1.44	1.69	5.05	4.97	133	211	4.2	9.6	27	43
29	1.90		4.51		83		3.1		17	
	1.80	1.85	4.69	4.60	88	86	2.7	2.9	18	18
29A	1.57		5.02		85		1.7		17	
	1.69	1.63	4.69	4.86	87	86	3.2	2.5	17	17
30	1.65		4.90		202		7.0		40	
	1.79	1.72	4.95	4.93	153	178	7.9	7.5	31	36
30A	1.82		4.78		210		7.4		42	
	1.76	1.79	4.90	4.84	212	211	12.2	9.8	42	42
31	2.02		4.65		181		11.3		36	
	2.12	2.07	4.60	4.63	137	159	6.3	8.8	27	32
31A	2.08		4.53		196		16.8		39	
	1.79	1.94	4.64	4.59	164	180	11.5	14.2	33	36

TABLE 3.5. *Laboratory freezing and thawing durability of concretes*—Continued

No. [1]	Gain in wt. after 1 d soaking at 40°F (percent)		Original dynamic modulus, E_0 (psi × 10^{-6})		Number of cycles to failure, interpolated to 60% E_0		Loss in wt during F&T, interpolated to 60% E_0 (percent)		Durability factor [2]	
		Average		*Average*		*Average*		*Average*		*Average*
Type I										
32	1.91		4.73		85		3.3		17	
	2.08	2.00	4.51	4.62	64	75	1.7	2.5	13	15
32A	1.88		4.87		83		2.4		17	
	1.67	1.78	4.75	4.81	85	84	3.0	2.7	17	17
33	1.97		4.55		60		1.2		12	
	2.18	2.08	4.40	4.48	50	55	.8	1.0	10	11
33A	1.86		4.66		67		1.7		13	
	2.25	2.06	4.31	4.49	50	59	.7	1.2	10	12
34	2.22		4.42		156		10.0		29	
	2.08	2.15	4.56	4.49	154	150	14.1	12.1	31	30
34A	1.97		4.69		156		11.4		31	
	1.91	1.94	4.77	4.73	140	148	6.6	9.0	28	30
35	1.70		4.76		69		1.9		14	
	1.74	1.72	4.95	4.85	66	68	.9	1.4	13	14
35A	2.01		4.70		71		.5		14	
	2.05	2.03	4.66	4.86	71	71	1.0	.8	14	14
36	1.40		5.21		38		.1		8	
	1.35	1.38	5.10	5.16	28	33	[3] (.1)	.0	6	7
36A	1.84		4.75		19		[3] (.2)		4	
	1.66	1.75	4.99	4.87	37	28	1.5	.7	7	6
37	2.51		4.36		86		4.6		17	
	2.30	2.41	4.35	4.36	102	94	5.4	5.0	20	19
37A	2.52		4.20		103		4.5		21	
	2.32	2.42	4.25	4.23	116	110	7.4	6.0	23	22
38	1.90		4.80		212		5.8		42	
	1.94	1.92	4.72	4.76	180	196	6.2	6.0	36	39
38A	2.08		4.57		218		9.8		44	
	2.15	2.12	4.54	4.56	202	210	11.6	10.7	40	42
39	2.42		4.28		24		.0		5	
39A [4]	2.33	2.38	4.37	4.33	23	24	.3	.2	5	5
40	2.02		4.31		116		4.6		23	
	1.84	1.93	4.45	4.38	112	114	2.9	3.8	22	23
40A	1.68		4.49		97		8.1		19	
	2.09	1.89	4.40	4.45	86	92	5.6	6.4	17	18
41	2.04		4.27		38		1.0		8	
	1.95	2.00	4.37	4.32	55	47	1.2	1.1	11	10
41A	2.09		4.20		63		1.9		12	
	2.09	2.09	4.19	4.20	75	68	2.3	2.1	15	14
42	2.58		4.56		93		4.8		19	
	2.55	2.57	4.27	4.42	80	87	4.3	4.6	16	18
42A	2.30		4.68		121		6.4		24	
	2.27	2.29	4.72	4.70	129	125	7.2	6.7	26	25
43	2.39		4.82		21		[3](.1)		4	
	2.28	2.34	4.90	4.86	20	21	.2	.1	4	4
43A	2.32		5.00		25		.0		5	
	2.36	2.34	4.94	4.97	21	23	.2	.1	4	5
44	2.19		4.54		265		10.1		53	
	2.16	2.18	4.62	4.58	280	273	9.5	9.8	56	55
44A	2.08		4.61		261		10.0		52	
	2.18	2.13	4.48	4.55	276	269	10.1	10.1	55	54
45	2.12		4.78		114		6.2		23	
	2.02	2.07	4.97	4.88	112	113	6.3	6.5	22	23
45A	2.20		4.54		97		4.6		19	
	2.25	2.23	4.60	4.57	101	99	7.8	6.2	20	20
46	1.63		5.21		35		.6		7	
	1.59	1.61	5.50	5.37	38	37	.6	.6	8	8
46A	1.59		5.27		36		.5		7	
	1.58	1.59	5.30	5.29	42	39	.4	.5	8	8

TABLE 3.5. *Laboratory freezing and thawing durability of concretes*—Continued

No. [1]	Gain in wt. after 1 d soaking at 40°F (percent)		Original dynamic modulus, E_0 (psi × 10^{-6})		Number of cycles to failure, interpolated to 60% E_0		Loss in wt during F&T, interpolated to 60% E_0 (percent)		Durability factor [2]	
		Average		*Average*		*Average*		*Average*		*Average*
Type I										
47	2.51		4.42		148		6.6		30	
	2.33	2.42	4.43	4.43	133	141	5.9	6.3	27	29
47A	2.55		4.52		167		9.7		33	
	2.38	2.47	4.62	4.57	135	151	7.4	8.6	27	30
48	2.62		4.78		11		[3] (.3)		2	
	2.64	2.63	4.63	4.71	8	10	[3] (.2)	[3] (.3)	2	2
48A	2.70		4.26		15		[3] (.2)		3	
	2.57	2.64	4.55	4.41	11	13	[3] (.2)	[3] (.2)	2	3
49	2.23		4.43		85		2.8		17	
	2.23	2.23	4.50	4.47	83	84	1.3	2.1	17	17
49A	1.84		4.62		66		.7		13	
	1.67	1.76	4.85	4.74	72	69	.1	.4	14	14
50 [5]	2.81		4.19		113		7.5		23	
	2.66	2.74	4.43	4.31	113	113	5.1	6.3	23	23
50A [5]	2.63		4.15		152		7.7		30	
	2.62	2.63	4.35	4.30	152	152	8.8	8.3	30	30
51	2.05		4.56		40		.2		8	
	2.10	2.08	4.48	4.52	48	44	.6	.4	10	9
51A	2.09		4.48		35		.1		7	
	2.05	2.07	4.57	4.53	40	38	.2	.2	8	8
52	2.18		4.56		93		1.2		19	
	2.12	2.15	4.62	4.59	96	95	1.9	1.6	19	19
52A	2.09		4.66		93		1.8		19	
	2.03	2.06	4.70	4.68	102	98	3.5	2.7	20	20
54	1.62		5.02		99		.6		20	
	1.60	1.61	5.10	5.06	93	96	.9	.7	19	20
54A	1.59		4.99		77		.3		15	
	1.64	1.62	4.91	4.95	78	78	.3	.3	16	16
55	2.06		4.87		138		9.2		28	
	2.13	2.10	4.87	4.87	124	131	8.6	8.9	25	27
55A	2.04		4.90		147		14.0		29	
	2.17	2.11	4.65	4.78	123	135	6.2	10.1	25	27
56	2.06		4.66		157		10.1		31	
	2.15	2.11	4.57	4.62	171	164	14.7	12.4	34	33
56A	1.68		4.90		101		4.9		21	
	1.69	1.69	4.83	4.87	125	113	4.9	4.9	25	23
57 [5]	2.58		4.16		103		10.9		21	
	2.54	2.56	4.20	4.18	105	104	7.3	9.1	21	21
57A [5]	2.58		4.22		110		9.1		22	
	2.35	2.47	4.46	4.34	97	104	6.6	7.9	20	21
58	1.81		4.96		27		.0		5	
	1.99	1.90	4.85	4.91	20	24	[3] (.3)	[3] (.2)	4	5
58A	1.91		5.09		22		[3] (.3)		4	
	1.80	1.86	5.17	5.13	24	23	[3] (.1)	[3] (.2)	5	5
59	2.02		4.64		11		[3] (.3)		2	
	2.05	2.04	4.64	4.64	11	11	[3] (.3)	[3] (.3)	2	2
59A	1.97		4.88		11		[3] (.3)		2	
	1.86	1.92	4.83	4.86	11	11	[3] (.3)	[3] (.3)	2	2
71	1.73		4.41		241		12.9		48	
	1.76	1.75	4.45	4.43	217	229	9.7	11.3	43	46
71A	1.71		4.67		165		4.4		33	
	1.73	1.72	4.71	4.69	173	169	6.3	5.4	35	34
73	2.26		4.64		144		6.4		29	
	2.45	2.35	4.44	4.54	80	112	2.8	4.6	16	23
73A	1.72		4.77		147		5.9		30	
	1.84	1.78	4.66	4.72	110	129	2.6	4.3	22	26
124	2.46		4.61		57		3.6		11	
	2.54	2.50	4.66	4.64	41	49	.7	2.2	8	10
124A	2.51		4.66		76		7.6		15	
	2.52	2.52	4.54	4.60	49	62	1.0	4.3	10	12

TABLE 3.5. *Laboratory freezing and thawing durability of concretes*—Continued

No. [1]	Gain in wt. after 1 d soaking at 40°F (percent)		Original dynamic modulus, E_0 (psi × 10^{-6})		Number of cycles to failure, interpolated to 60% E_0		Loss in wt during F&T, interpolated to 60% E_0 (percent)		Durability factor [2]	
		Average		*Average*		*Average*		*Average*		*Average*
Type I										
125	2.15		4.67		103		2.6		21	
	2.20	2.18	4.55	4.61	100	102	3.0	2.8	20	20
125A	2.35		4.45		86		2.3		17	
	2.24	2.30	4.57	4.51	73	80	3.3	2.8	16	16
126	2.09		4.65		25		.8		6	
	2.12	2.10	4.74	4.70	25	25	.4	.6	5	5
126A	2.19		4.72		45		.4		9	
	2.16	2.18	4.69	4.70	10	28	[3] (.2)	.1	2	6
127	2.00		4.60		91		1.3		18	
	2.00	2.00	4.55	4.58	101	96	6.2	3.8	20	19
127A	2.19		4.48		124		5.7		25	
	2.24	2.22	4.35	4.42	125	124	6.0	5.8	25	25
128	1.84		4.53		116		5.4		23	
	1.75	1.80	4.41	4.47	108	112	7.9	6.6	22	22
128A	1.89		4.66		86		3.5		17	
	1.82	1.86	4.72	4.69	100	93	3.7	3.6	20	18
129	2.12		4.78		243		17.2		49	
	2.18	2.15	4.50	4.64	286	264	17.8	17.5	57	53
129A	1.97		4.75		250		13.5		50	
	2.10	2.04	4.75	4.75	241	246	15.7	14.6	48	49
130	1.82		4.77		270		13.7		54	
	1.98	1.90	4.92	4.84	215	242	8.3	11.0	43	48
130A	2.08		4.72		243		11.1		49	
	2.07	2.08	4.60	4.66	266	254	14.5	12.8	53	51
131	2.12		4.99		22		[3] (.5)		4	
	2.19	2.16	4.86	4.92	22	22	[3] (.4)	[3] (.4)	4	4
131A	2.39		4.88		19		[3] (.4)		4	
	2.36	2.38	4.90	4.89	17	18	[3] (.3)	[3] (.4)	3	4
132	2.22		4.84		175		7.5		35	
	2.13	2.18	4.96	4.90	196	186	13.0	10.2	39	37
132A	1.64		5.05		146		5.8		29	
	1.68	1.66	5.02	5.04	168	157	12.0	8.9	34	32
133	1.58		5.02		316		5.7		66	
	1.26	1.42	4.62	4.82	241	278	10.0	7.6	48	57
133A	1.52		4.48		327		9.5		64	
	1.63	1.58	4.74	4.61	321	324	8.0	8.8	66	65
134	1.95		4.87		175		6.4		35	
	1.31	1.63	5.05	4.96	119	147	4.3	5.4	24	30
134A	1.93		4.79		158		5.8		32	
	1.86	1.90	5.10	4.94	160	159	5.5	5.6	32	32
135	2.17		4.57		144		10.6		29	
	2.38	2.28	4.69	4.64	115	130	6.2	8.4	23	26
135A	2.84		4.26		101		6.9		20	
	2.71	2.78	4.23	4.24	119	110	10.8	8.8	24	22
136	1.62		4.93		64		.0		13	
	1.78	1.70	4.92	4.92	65	64	.6	.3	13	13
136A	1.92		4.65		61		.0		12	
	1.92	1.92	4.84	4.74	65	63	1.1	.6	13	12
137	2.06		4.72		122		6.1		24	
	2.14	2.10	4.57	4.64	156	139	10.3	8.2	31	28
137A	2.50		4.31		161		10.8		32	
	2.36	2.43	4.58	4.44	173	167	12.0	11.4	35	34
138	2.00		4.43		152		8.0		30	
	1.84	1.92	4.75	4.59	233	192	16.2	12.1	47	38
138A	1.76		4.75		177		6.4		35	
	1.73	1.76	4.84	4.80	198	188	9.6	8.0	40	38
139	1.95		4.48		220		15.6		44	
	1.98	1.96	4.80	4.64	189	204	9.2	12.4	38	41
139A [4]										
140 [4]	[6] 2.52		[6] 4.36		[6] 122		[6] 6.5		[6] 24	
	[6] 2.60	[6] 2.56	[6] 4.31	[6] 4.34	[6] 165	[6] 144	[6] 14.2	[6] 10.4	[6] 33	[6] 28

TABLE 3.5. *Laboratory freezing and thawing durability of concretes*—Continued

No. [1]	Gain in wt. after 1 d soaking at 40°F (percent)		Original dynamic modulus, E_0 (psi $\times 10^{-6}$)		Number of cycles to failure, interpolated to 60% E_0		Loss in wt during F&T, interpolated to 60% E_0 (percent)		Durability factor [2]	
Type I		*Average*		*Average*		*Average*		*Average*		*Average*
140A [4]										
141	2.76		4.11		92		6.3		18	
	2.87	2.82	4.07	4.09	94	93	5.3	5.8	19	18
141A	2.78		4.00		77		3.5		15	
	2.95	2.86	3.98	3.99	84	80	4.5	4.0	17	16
142	[6] 2.04		[6] 4.77		[6] 56		[6] 0.6		[6] 11	
	[6] 2.02	[6] 2.03	[6] 4.54	[6] 4.66	[6] 56	[6] 56	[6] 1.8	[6] 1.2	[6] 11	[6] 16
142A	[6] 2.04		[6] 4.52		[6] 91		[6] 2.7		[6] 18	
	[6] 2.08	[6] 2.06	[6] 4.50	[6] 4.51	[6] 89	[6] 90	[6] 3.3	[6] 3.0	[6] 18	[6] 18
143	2.21		4.50		40		.6		8	
	2.19	2.20	4.50	4.50	30	35	[3] (.3)	.2	6	7
143A	2.30		4.38		42		.7		8	
	2.38	2.34	4.36	4.37	34	38	.2	.4	7	8
144	[6] 2.46		[6] 4.31		[6] 117		[6] 8.4		[6] 23	
	[6] 2.79	[6] 2.62	[6] 4.13	[6] 4.22	[6] 92	[6] 104	[6] 12.0	[6] 10.2	[6] 18	[6] 20
144A	2.84		3.94		95		19.7		19	
	2.89	2.86	3.97	3.96	82	88	5.3	12.5	16	18
145	2.03		4.80		98		7.8		20	
	2.16	2.10	4.68	4.74	97	98	3.8	5.8	19	20
145A	2.34		4.55		74		2.8		15	
	2.23	2.28	4.63	4.59	95	84	5.0	3.9	19	17
146	2.09		4.92		23		[3] (.2)		5	
	2.10	2.10	5.02	4.97	26	24	[3] (.3)	[3] (.2)	5	5
146A	2.20		4.80		23		[3] (.3)		5	5
	2.27	2.24	4.76	4.78	23	23	[3] (.3)	[3] (.3)	5	5
147	1.96		4.82		34		[3] (.3)		7	
	2.18	2.07	4.81	4.81	28	31	0.5	.1	6	6
147A	1.96		4.83		40		[3] (.3)		8	
	2.05	2.00	4.80	3.82	44	42	[3] (.1)	[3] (.2)	9	8
148	1.88		4.75		72		.3		14	
	1.77	1.82	4.87	4.81	78	75	.4	.4	16	15
148A	1.83		4.78		98		2.1		20	
	1.81	1.82	4.95	4.86	109	104	7.5	4.8	22	21
149	1.95		4.90		95		2.0		19	
	1.91	1.93	4.92	4.91	116	106	5.6	3.8	23	21
149A	2.13		4.57		148		6.6		30	
	2.04	2.08	4.65	4.61	140	144	10.3	8.4	28	29
150	2.02		4.86		34		[3] (.3)		7	
	1.95	1.98	4.78	4.82	29	32	[3] (.2)	[3] (.2)	6	6
150A	1.98		4.87		24		[3] (.4)		5	
	2.06	2.02	4.72	4.80	25	24	[3] (.2)	[3] (.3)	5	5
151	2.33		4.40		170		9.0		34	
	2.39	2.36	4.55	4.48	171	170	16.5	12.2	34	34
151A	2.58		4.23		185		12.3		37	
	2.59	2.58	4.14	4.18	145	165	10.6	11.4	29	33
152	1.77		4.92		100		4.5		20	
	1.77	1.77	5.00	4.96	98	99	1.6	3.0	20	20
152A	2.04		4.80		94		.9		18	
	1.93	1.98	4.80	4.80	102	98	2.5	1.7	20	19
153	1.94		4.85		175		6.6		35	
	1.96	1.95	4.90	4.88	144	160	3.8	5.2	29	32
153A	1.91		4.90		142		8.5		28	
	1.91	1.91	4.83	4.86	138	140	6.3	7.4	28	28
154	2.41		4.43		112		6.7		22	
	2.48	2.44	4.23	4.33	84	98	1.7	4.2	17	20
154A	2.53		4.45		124		5.9		25	
	2.55	2.54	4.30	4.38	128	126	7.1	6.5	26	26
155	2.02		4.36		104		2.4		21	
	1.83	1.92	4.75	4.56	111	108	2.3	2.4	22	22
155A	1.93		4.39		123		4.3		25	
	2.07	2.00	4.51	4.45	130	126	3.7	4.0	26	26

TABLE 3.5. *Laboratory freezing and thawing durability of concretes*—Continued

No. [1]	Gain in wt. after 1 d soaking at 40°F (percent)		Original dynamic modulus, E_0 (psi $\times 10^{-6}$)		Number of cycles to failure, interpolated to 60% E_0		Loss in wt during F&T, interpolated to 60% E_0 (percent)		Durability factor [2]	
		Average		*Average*		*Average*		*Average*		*Average*
Type I										
156	2.26		4.62		183		11.6		37	
	2.33	2.30	4.60	4.61	156	170	14.1	12.8	31	34
156A	2.53		4.54		87		3.7		17	
	2.61	2.57	4.42	4.48	140	114	9.4	6.6	28	22
157	1.85		4.81		96		2.6		19	
	1.72	1.78	4.97	4.89	108	102	2.6	2.6	22	20
157A	2.08		4.56		153		10.9		31	
	2.08	2.08	4.80	4.68	107	130	7.9	9.4	21	26
158	2.15		4.93		37		.1		7	
	1.86	2.00	5.03	4.98	34	36	.4	.2	7	7
158A	2.06		4.96		38		.3		8	
	2.05	2.06	4.98	4.97	32	35	.1	.2	6	7
159	1.88		4.47		43		.0		9	
	1.77	1.82	4.46	4.56	37	40	.2	.1	7	8
159A	1.89		4.66		64		1.2		13	
	1.85	1.87	4.65	4.66	66	65	1.9	1.6	13	13
160	2.44		4.28		142		5.9		28	
	2.29	2.36	4.44	4.36	148	145	6.9	6.4	30	29
160A	2.47		4.24		127		5.9		25	
	2.55	2.51	4.20	4.22	146	136	6.9	6.4	29	27
161	1.98		4.89		55		[3] (.4)		11	
	2.02	2.00	4.89	4.89	62	58	[3] (.3)	[3] (.4)	12	12
161A	2.29		4.44		90		2.6		18	
	2.37	2.33	4.47	4.46	68	79	0.3	1.4	14	16
Type IA										
53	2.87		3.69		517		14.1		82	
	2.64	2.76	3.83	3.76	487	502	14.6	14.4	81	82
53A	2.46		4.02		[7] 435		11.8		82	
	2.23	2.35	4.21	4.12	576	506	12.8	12.3	87	85
60	2.60		3.08		[8] 572		13.4		82	
	2.70	2.65	3.56	3.32	396	484	11.0	12.2	75	79
60A	1.98		4.12		[9] 548		11.8		87	
	2.20	2.11	4.05	4.09	[10] 548	548	12.0	11.9	81	84
61	2.31		3.66		[11] 612		16.1		91	
	2.49	2.40	3.49	3.58	[11] 621	617	15.8	16.0	90	91
61A	1.91		4.14		593		13.9		89	
	1.99	1.95	3.92	4.03	[11] 500	547	11.5	12.7	81	85
62	2.65		3.61		397		14.1		72	
	2.63	2.64	3.51	3.56	460	429	15.4	14.8	86	79
62A	2.18		3.82		277		8.7		55	
	2.17	2.18	4.07	3.95	372	325	12.2	10.5	63	59
63	2.23		3.99		[12] 616		13.9		86	
	2.53	2.38	3.87	3.93	382	499	12.2	13.1	76	81
63A	2.13		4.04		456		12.5		75	
	2.08	2.11	4.22	4.13	469	463	11.9	12.2	79	77
64	2.51		3.76		448		11.9		74	
	2.39	2.45	3.98	3.82	514	481	14.7	13.3	78	76
64A	2.17		4.10		527		13.0		82	
	2.04	2.10	4.12	4.11	542	535	12.8	12.9	75	79
65	2.59		3.42		247		8.9		49	
	2.62	2.61	3.31	3.37	[13] 839	543	19.1	14.0	84	67
65A	2.22		3.51		293		10.3		59	
	2.16	2.19	3.51	3.51	294	294	7.6	9.0	59	59
66	2.53		3.91		[14] 608		17.3		84	
	2.40	2.47	4.14	4.03	511	560	13.9	15.6	78	81
66A	2.17		4.30		[15] 744		14.8		84	
	2.12	2.15	4.41	4.36	618	681	11.5	13.2	83	84
162	2.50		3.59		370		8.7		72	
	2.42	2.46	3.55	3.57	477	424	10.3	9.5	79	76
162A	2.39		4.19		477		10.0		85	
	2.03	2.21	4.13	4.16	484	480	9.0	9.5	71	78

TABLE 3.5. *Laboratory freezing and thawing durability of concretes*—Continued

No. [1]	Gain in wt. after 1 d soaking at 40°F (percent)		Original dynamic modulus, E_0 (psi $\times 10^{-6}$)		Number of cycles to failure, interpolated to 60% E_0		Loss in wt during F&T, interpolated to 60% E_0 (percent)		Durability factor [2]	
		Average		*Average*		*Average*		*Average*		*Average*
Type II										
24	1.90		4.50		41		1.0		8	
	2.01	1.96	4.52	4.51	41	41	.5	.8	8	8
24A	1.81		4.65		37		.5		7	
	1.74	1.78	4.67	4.66	41	39	.3	.4	8	8
67	2.80		4.40		96		13.3		19	
	2.54	2.67	4.55	4.48	82	89	6.3	9.8	16	18
67A	2.99		4.15		69		6.4		14	
	2.86	2.93	4.32	4.24	99	84	11.2	8.8	20	17
68	2.45		4.46		128		8.3		26	
	2.24	2.35	4.56	4.51	134	131	11.1	9.7	27	27
68A	2.65		4.35		88		7.2		18	
	2.13	2.39	4.54	4.45	113	101	7.6	7.4	23	21
69	2.62		4.50		119		10.9		24	
	2.55	2.59	4.40	4.45	111	115	9.2	10.1	22	23
69A	2.48		4.54		148		13.1		30	
	2.45	2.47	4.78	4.66	142	145	13.9	13.5	28	29
70	2.56		4.33		129		8.2		26	
	2.61	2.59	4.32	4.33	101	115	3.7	5.8	20	23
70A	2.23		4.60		168		6.5		34	
	2.34	2.29	4.63	4.62	161	165	4.7	5.6	32	33
72	1.59		5.02		147		8.1		29	
	1.31	1.45	5.18	5.10	93	120	3.4	5.8	19	24
72A	1.57		4.97		106		3.6		21	
	1.55	1.56	5.05	5.01	111	109	3.7	3.7	22	22
74 [3]	2.03		4.60		74		5.2		15	
74A	1.86		4.85		62		1.8		12	
	1.91	1.89	4.69	4.77	67	65	2.1	2.0	13	13
75	2.27		4.63		81		9.3		16	
	2.74	2.76	4.23	4.43	62	72	5.5	7.4	12	14
75A	2.22		4.20		82		5.1		16	
	2.38	2.30	4.58	4.39	72	77	3.4	4.3	14	15
76	2.38		4.24		118		10.7		24	
	1.94	2.16	4.50	4.37	134	126	13.7	12.2	27	26
76A	2.72		4.18		119		13.0		24	
	3.37	3.05	4.62	4.40	137	128	10.1	11.6	27	26
77	3.10		4.05		102		13.6		20	
	2.50	2.80	4.27	4.16	106	104	9.5	11.6	21	21
77A	3.12		4.09		89		10.1		18	
	2.49	2.80	4.43	4.26	128	109	14.8	12.5	26	22
78	1.76		4.79		79		4.0		16	
	1.95	1.86	4.70	4.75	86	83	3.7	3.9	17	17
78A	2.01		4.70		78		1.9		16	
	1.77	1.89	4.93	4.82	81	80	3.5	2.7	16	16
79	2.09		4.66		27		[3] (.2)		5	
	2.19	2.14	4.40	4.53	27	27	.2	.0	5	5
79A [4]										
80	2.24		4.43		82		2.9		16	
	2.37	2.31	4.29	4.37	50	66	1.3	2.1	10	13
80A	2.24		4.40		60		1.5		12	
	2.25	2.25	4.54	4.47	74	67	3.5	2.5	15	14
81	2.31		4.55		96		8.0		19	
	2.60	2.46	4.47	4.51	77	87	5.3	6.7	15	17
81A	2.74		4.40		74		6.5		15	
	2.59	2.67	4.45	4.43	85	80	6.4	6.5	17	16
82	2.35		4.52		97		12.3		19	
	2.46	2.41	4.42	4.47	33	65	1.1	6.7	7	13
82A	2.48		4.33		115		10.2		23	
	2.61	2.55	4.37	4.35	91	103	10.0	10.1	18	21

TABLE 3.5. *Laboratory freezing and thawing durability of concretes*—Continued

No. [1]	Gain in wt. after 1 d soaking at 40°F (percent)		Original dynamic modulus, E_0 (psi × 10^{-6})		Number of cycles to failure, interpolated to 60% E_0		Loss in wt during F&T, interpolated to 60% E_0 (percent)		Durability factor [2]	
		Average		*Average*		*Average*		*Average*		*Average*
Type II										
83	1.98		5.11		113		9.6		23	
	1.87	1.93	4.93	5.02	94	104	7.5	8.6	19	21
83A	1.89		4.96		141		12.8		28	
	1.79	1.84	5.19	5.08	111	126	7.0	9.9	33	31
84	2.30		4.57		121		12.0		24	
	2.46	2.38	4.41	4.49	65	88	3.7	7.9	13	19
84A	2.45		4.37		73		5.8		15	
	2.45	2.45	4.36	4.37	96	85	13.8	9.8	19	17
85	2.37		4.27		311		14.2		60	
	2.40	2.39	4.32	4.30	238	275	9.2	11.7	48	54
85A	2.16		4.55		343		14.3		65	
	2.11	2.14	4.60	4.58	372	358	13.0	13.7	69	67
86	2.46		4.49		24		[3] (.2)		5	
	2.36	2.41	4.67	4.58	23	24	.5	.2	5	5
86A	2.40		4.71		23		[3] (.1)		5	
	2.47	2.44	4.60	4.66	16	20	[3] (.3)	[3] (.2)	3	4
87	2.63		4.29		154		15.4		31	
	2.55	2.59	4.28	4.29	147	151	15.7	15.6	29	30
87A	2.37		4.45		127		12.8		25	
	2.27	2.32	4.49	4.47	129	128	10.3	11.6	26	26
88	3.02		4.45		94		7.2		19	
	3.13	3.08	4.26	4.36	91	93	7.2	7.2	18	19
88A	2.88		4.44		102		13.6		20	
	3.18	3.03	4.35	4.40	85	94	5.6	9.6	17	19
89	2.46		4.52		39		1.0		8	
	2.40	2.43	4.49	4.51	38	39	.8	.9	8	8
89A	2.48		4.73		39		1.5		8	
	2.43	2.46	4.49	4.61	44	42	1.1	1.3	9	9
90	2.46		4.55		102		10.2		20	
	2.55	2.51	4.40	4.48	78	90	8.2	9.2	16	18
90A	2.51		4.45		106		16.8		21	
	2.57	2.54	4.31	4.38	114	110	13.2	15.0	23	22
91	2.41		4.49		41		1.7		8	
	2.54	2.48	4.38	4.44	45	43	1.1	1.4	9	9
91A	2.55		4.35		42		.5		8	
	2.53	2.54	4.35	4.35	45	44	2.9	1.7	9	9
92	3.19		4.35		64		3.4		13	
	3.30	3.25	4.28	4.32	79	72	8.3	5.9	16	15
92A	3.67		4.18		50		5.8		10	
	3.53	3.60	4.03	4.11	59	55	5.3	5.6	12	11
93	2.01		4.60		103		7.7		21	
	2.11	2.06	4.54	4.57	99	101	6.9	7.3	20	21
93A	2.15		4.40		90		4.6		18	
	2.21	2.18	4.30	4.35	86	88	7.2	5.9	17	18
94	2.39		4.06		89		3.3		18	
	2.42	2.41	4.06	4.06	91	90	2.3	2.8	18	18
94A	2.56		3.99		106		7.8		21	
	2.42	2.48	4.00	4.00	90	98	6.0	6.9	18	20
95	3.73		3.62		134		14.2		27	
	3.61	3.67	3.60	3.61	136	135	13.3	13.8	27	27
95A	3.13		3.92		92		7.9		18	
	3.10	3.12	4.04	3.98	101	97	7.1	7.5	20	19
96	2.41		4.52		89		3.9		18	
	2.40	2.41	4.58	4.55	80	85	2.9	3.4	16	17
96A	2.30		4.45		86		9.9		17	
	2.28	2.29	4.63	4.54	85	86	2.2	6.1	17	17
97	3.17		3.97		81		14.1		16	
	3.11	3.14	4.07	4.02	71	76	4.3	9.2	14	15
97A	2.78		4.25		109		6.3		22	
	2.78	2.78	4.34	4.30	108	109	9.8	8.1	22	22

TABLE 3.5. *Laboratory freezing and thawing durability of concretes*—Continued

No. [1]	Gain in wt. after 1 d soaking at 40°F (percent)		Original dynamic modulus, E_0 (psi × 10^{-6})		Number of cycles to failure, interpolated to 60% E_0		Loss in wt during F&T, interpolated to 60% E_0 (percent)		Durability factor [2]	
		Average		*Average*		*Average*		*Average*		*Average*
Type II										
98	2.62		4.38		89		7.2		18	
	2.38	2.50	4.49	4.44	103	96	5.6	6.4	21	20
98A	2.69		4.23		97		7.5		19	
	2.52	2.61	4.32	4.28	103	100	4.3	5.9	21	20
99	2.61		4.45		53		2.5		11	
	2.52	2.57	4.49	4.47	80	67	7.9	5.2	16	14
99A	2.53		4.51		79		5.7		16	
	2.60	2.57	4.67	4.59	62	71	3.4	4.6	12	14
101	2.61		4.62		134		9.5		27	
	2.68	2.65	4.52	4.57	120	127	8.0	8.8	24	26
101A	2.71		4.45		178		9.3		36	
	2.79	2.75	4.40	4.43	168	173	7.8	8.6	34	35
163	2.43		4.31		77		2.7		15	
	2.54	2.48	4.26	4.28	59	68	1.3	2.0	12	14
163A	2.26		4.26		82		4.1		16	
	2.57	2.60	4.28	4.27	68	72	2.1	3.1	13	14
164	2.38		4.54		108		10.5		22	
	2.43	2.40	4.61	4.58	106	107	15.5	13.0	21	22
164A	2.33		4.46		150		8.1		30	
	2.26	2.30	4.51	4.48	158	154	11.8	10.0	32	31
165	2.16		4.56		118		7.2		24	
	2.24	2.20	4.47	4.52	88	103	4.4	5.8	18	21
165A	2.03		5.09		111		8.5		22	
	2.13	2.08	4.81	4.95	111	111	7.5	8.0	22	22
166	2.29		4.54		155		13.3		31	
	2.35	2.32	4.62	4.58	162	158	12.7	13.0	32	32
166A	2.18		4.71		129		6.9		26	
	2.26	2.22	4.62	4.66	142	136	8.6	7.8	28	27
167A	2.45		4.51		140		13.7		28	
	2.50	2.48	4.49	4.50	133	136	10.0	11.8	27	28
168	2.29		4.95		132		4.6		26	
	2.29	2.29	4.86	4.90	128	130	4.5	4.6	26	26
168A	2.28		4.63		137		4.9		27	
	2.37	2.32	4.69	4.66	152	144	6.2	5.6	30	28
169	2.16		4.60		116		12.0		23	
	2.23	2.20	4.63	4.62	118	117	7.6	9.8	24	24
169A	2.21		4.60		116		7.2		23	
	2.26	2.24	4.71	4.66	106	111	5.5	6.4	21	22
170	2.09		4.91		28		.5		6	
	2.19	2.14	4.87	4.89	32	30	.2	.4	6	6
170A	1.96		5.11		32		1.9		6	
	2.18	2.07	4.74	4.92	31	32	4.2	3.0	6	6
171	1.83		4.93		191		14.0		38	
	1.96	1.90	4.81	4.87	125	158	5.5	9.8	25	32
171A	2.20		4.37		142		13.8		28	
	1.99	2.10	4.60	4.48	135	138	12.6	13.2	27	28
172	2.27		4.51		126		8.4		25	
	2.24	2.26	4.45	4.48	91	108	4.6	6.5	18	22
172A	2.45		4.20		94		5.4		19	
	2.38	2.42	4.37	4.28	128	111	15.9	10.6	26	22
173	2.37		4.34		83		5.4		17	
	2.38	2.38	4.43	4.38	90	86	3.8	4.6	18	18
173A	2.54		4.23		56		2.3		11	
	2.57	2.56	4.16	4.20	64	60	3.6	3.0	13	12
174	2.33		4.48		109		4.0		22	
	2.33	2.33	4.56	4.52	141	125	13.6	8.8	28	25
174A	2.60		4.45		110		11.6		22	
	2.66	2.63	4.38	4.42	92	101	4.4	8.0	18	20

TABLE 3.5. *Laboratory freezing and thawing durability of concretes*—Continued

No. [1]	Gain in wt. after 1 d soaking at 40°F (percent)		Original dynamic modulus, E_0 (psi × 10^{-6})		Number of cycles to failure, interpolated to 60% E_0		Loss in wt during F&T, interpolated to 60% E_0 (percent)		Durability factor [2]	
Type II		*Average*		*Average*		*Average*		*Average*		*Average*
175	1.94		4.77		117		3.7		23	
	2.22	2.08	4.56	4.66	157	137	8.9	6.3	31	27
175A	2.57		4.09		141		6.9		28	
	2.57	2.57	4.36	4.22	114	128	5.1	6.0	23	26
176	2.99		4.14		69		16.4		14	
	3.01	3.00	4.02	4.08	47	58	5.8	11.1	9	12
176A	3.34		3.81		31		1.6		6	
	3.35	3.34	3.92	3.86	31	31	.2	.9	6	6
177	2.17		4.50		122		2.0		24	
	2.15	2.16	4.43	4.46	96	109	1.7	1.8	19	22
177A	2.38		4.42		84		2.2		17	
	2.42	2.40	4.31	4.36	77	80	1.6	1.9	15	16
178	2.59		4.45		136		11.8		27	
	2.43	2.51	4.45	4.50	147	142	9.8	10.8	29	28
178A	2.52		4.51		151		10.3		30	
	2.59	2.56	4.48	4.50	103	127	6.7	8.5	21	26
179	1.96		4.60		99		2.8		20	
	2.11	2.04	4.70	4.65	109	104	5.4	4.1	22	21
179A	2.03		4.78		102		5.1		20	
	2.03	2.06	4.78	4.78	116	109	7.2	6.2	23	22
Type IIA										
100	3.24 [17]		3.27		479		14.5		78	
100A	2.71 [17]		3.59		446		12.0		81	
Type III										
102	1.84		4.81		66		.6		13	
	1.77	1.81	4.72	4.77	65	66	.6	.6	13	13
102A	1.95		4.66		66		2.8		13	
	[18]		4.65	4.61	72	69	2.2	2.5	14	14
103	2.13		4.57		274		10.4		55	
	2.09	2.11	4.80	4.69	296	285	12.4	11.4	59	57
103A	1.96		4.90		332		10.4		64	
	1.89	1.93	4.90	4.90	366	349	10.5	10.5	69	67
104	1.94		4.84		146		6.7		29	
	2.00	1.97	4.67	4.76	183	165	12.7	9.7	37	33
104A	2.12		4.88		169		12.1		34	
	2.21	2.17	4.62	4.75	141	155	9.7	10.9	28	31
105	1.57		5.04		184		8.9		37	
	1.80	1.69	4.95	5.00	194	189	3.5	6.2	39	38
105A	1.67		5.02		142		4.5		28	
	1.70	1.69	5.00	5.01	193	168	8.7	6.6	39	34
106	2.27		5.00		89		4.9		18	
	2.36	2.32	4.88	4.94	86	88	5.1	5.0	17	18
106A	2.48		4.95		85		4.4		17	
	2.40	2.44	4.90	4.93	91	88	6.3	5.4	18	18
180	1.73		4.92		228		9.9		46	
	1.70	1.72	5.01	4.96	221	224	9.2	9.6	44	45
180A	1.94		4.80		212		9.5		42	
	1.89	1.92	4.90	4.85	201	207	9.2	9.4	40	41
181	1.74		5.20		158		6.9		32	
	1.82	1.78	4.83	5.02	144	151	5.2	6.0	29	30
181A	1.94		4.75		128		8.8		26	
	1.91	1.92	4.89	4.82	129	128	14.3	11.6	26	26
182	1.58		5.11		105		2.3		21	
	1.57	1.58	5.16	5.14	98	102	5.1	3.7	20	20
182A	1.85		4.95		100		3.3		20	
	1.96	1.90	4.78	4.86	106	103	2.9	3.1	21	20

TABLE 3.5. *Laboratory freezing and thawing durability of concretes*—Continued

No. [1]	Gain in wt. after 1 d soaking at 40°F (percent)		Original dynamic modulus, E_0 (psi × 10^{-6})		Number of cycles to failure, interpolated to 60% E_0		Loss in wt during F&T, interpolated to 60% E_0 (percent)		Durability factor [2]	
		Average		*Average*		*Average*		*Average*		*Average*
Type III										
183	1.64		5.28		54		1.5		11	
	1.62	1.63	5.30	5.29	56	55	.8	1.2	11	11
183A	1.88		5.10		83		2.4		17	
	1.90	1.89	5.07	5.08	86	84	2.2	2.3	17	17
184	1.71		5.32		29		[3] (.3)		6	
	1.72	1.72	5.42	5.37	25	27	[3] (.2)	[3] (.2)	5	6
184A	1.88		5.20		13		[3] (.1)		3	
	1.87	1.88	5.14	5.17	19	16	[3] (.4)	[3] (.2)	4	4
185	1.82		5.02		36		.1		7	
	1.82	1.82	5.02	5.02	37	36	.1	.1	7	7
185A	2.02		4.78		48				10	
	1.89	1.96	4.75	4.76	37	42	.5	.2	7	8
186	1.68		4.95		117		3.4		23	
	1.71	1.70	5.13	5.04	174	146	8.2	5.8	35	29
186A	[17]									
	1.73	1.73	4.71	4.71	141	141	5.4	5.4	28	28
187	1.51		5.11		120		5.4		24	
	1.55	1.53	5.05	5.08	130	125	5.1	5.2	26	25
187A	1.50		4.82		101		8.5		20	
	1.63	1.56	5.10	4.96	120	110	3.6	6.0	24	22
188	1.55		5.11		84		3.8		17	
	1.52	1.54	5.10	5.10	79	82	.8	2.3	16	16
188A	1.34		5.11		99		2.9		20	
	1.72	1.53	4.87	4.99	109	104	2.6	2.8	22	21
189	1.99		4.77		272		14.8		54	
	2.02	2.00	4.74	4.76	283	278	21.3	18.0	57	56
189A	2.20		4.66		264		19.3		53	
	2.26	2.23	4.58	4.62	247	256	17.1	18.2	49	51
190	1.97		4.85		80		3.4		16	
	1.77	1.87	4.86	4.86	76	78	2.5	3.0	15	16
190A	2.00		4.70		105		8.2		20	
	2.05	2.02	4.67	4.68	134	120	5.1	6.6	27	24
191	1.73		4.65		41		[3] (.2)		8	
	1.73	1.73	4.71	4.68	39	40	[3] (.4)	[3] (.3)	8	8
191A	1.92		4.42		44		.1		9	
	1.92	1.92	4.40	4.41	50	47	4.9	2.5	10	10
192	1.54		5.05		157		7.0		31	
	1.44	1.49	5.16	5.10	187	172	6.9	7.0	37	34
192A	1.62		4.95		228		12.2		46	
	1.59	1.60	4.93	4.94	193	210	10.0	11.1	39	42
193	1.90		4.57		230		11.1		46	
	1.84	1.87	4.78	4.68	242	236	11.7	11.4	48	47
193A	1.84		4.89		212		13.0		42	
	1.87	1.86	4.72	4.80	212	212	12.7	12.8	42	42
Type IIIA										
194	1.96		4.07		937		14.6		83	
	1.90	1.93	4.12	4.10	798	868	15.4	15.0	87	85
194A	1.60		4.54		976		14.4		85	
	1.59	1.60	4.62	4.58	845	910	13.3	13.8	86	86
195	1.64		4.09		676		12.0		84	
	1.62	1.63	4.07	4.08	521	598	10.7	11.4	84	84
195A	1.40		4.33		831		13.0		86	
	1.43	1.42	4.52	4.42	692	762	9.9	11.4	91	88
Type IV										
107	2.76		4.37		91		7.8		18	
	2.66	2.71	4.43	4.40	101	96	10.5	9.2	20	19
107A	2.58		4.50		99		7.9		20	
	2.63	2.61	4.43	4.47	98	99	7.2	7.6	20	20

TABLE 3.5. *Laboratory freezing and thawing durability of concretes*—Continued

No. [1]	Gain in wt. after 1 d soaking at 40°F (percent)		Original dynamic modulus, E_0 (psi × 10^{-6})		Number of cycles to failure, interpolated to 60% E_0		Loss in wt during F&T, interpolated to 60% E_0 (percent)		Durability factor [2]	
		Average		*Average*		*Average*		*Average*		*Average*
Type IV										
108	3.48		4.03		106		8.2		21	
	3.17	3.33	4.40	4.21	150	128	9.9	9.1	30	26
108A	3.18		4.17		167		9.6		33	
	2.72	2.95	4.40	4.29	170	169	8.2	8.9	34	34
196	3.39		3.87		34		.6		7	
	3.39	3.39	3.81	3.84	29	32	.0	.3	6	6
196A	3.57		3.56		29		.0		7	
	3.84	3.70	3.61	3.58	26	28	.7	.4	5	6
Type V										
109	3.82		3.74		63		10.1		13	
	3.86	3.84	3.71	3.73	52	58	2.9	6.5	10	12
109A	3.61		3.64		54		2.3		10	
	3.95	3.78	3.65	3.65	37	46	.5	1.4	7	9
110	3.30		4.11		37		.2		7	
	3.10	3.20	4.40	4.26	39	38	.4	.3	8	8
110A	3.01		4.41		49		.5		10	
	3.11	3.06	4.40	4.41	39	44	.4	.5	8	9
111	3.01		4.48		52		.8		10	
	3.03	3.02	4.37	4.43	55	54	1.9	1.4	11	11
111A	2.51		4.67		66		1.2		13	
	2.66	2.59	4.45	4.56	67	66	2.4	1.8	13	13
112	3.28		4.35		31		.4		6	
	3.16	3.22	4.38	4.37	50	42	1.1	0.8	10	8
112A	2.85		4.62		68		2.6		14	
	2.84	2.85	4.51	4.57	86	77	4.5	3.6	17	16
113	2.44		4.55		139		8.9		28	
	2.60	2.52	4.58	4.57	145	142	11.6	10.3	29	29
113A	2.45		4.70		214		13.6		43	
	2.46	2.46	4.72	4.71	144	179	6.5	10.1	29	36
114	2.95		4.24		97		5.7		19	
	2.92	2.94	4.22	4.23	87	92	11.4	8.6	17	18
114A	3.10		4.31		105		5.2		21	
	2.98	3.04	4.34	4.33	83	94	3.0	4.1	17	19
115	2.39		4.43		77		4.3		15	
	2.03	2.21	4.78	4.61	77	77	3.4	3.9	15	15
115A	2.21		4.51		79		4.5		16	
	2.12	2.17	4.42	4.47	86	83	4.6	4.6	17	17
116	2.29		4.64		49		3.2		10	
	2.46	2.38	4.50	4.57	57	53	3.1	3.2	11	11
116A	2.20		4.67		59		2.5		12	
	2.56	2.38	4.46	4.57	44	52	.9	1.7	9	11
117	2.17		4.73		89		8.9		18	
	2.17	2.17	4.55	4.64	84	87	7.9	8.4	17	18
117A	2.74		4.31		83		13.2		17	
	2.72	2.73	4.35	4.33	83	83	11.6	12.4	17	17
118	2.75		4.21		81		13.0		16	
	2.75	2.75	4.18	4.20	59	70	2.9	8.0	12	14
118A	2.27		4.42		67		2.3		13	
	2.80	2.54	4.26	4.34	63	65	3.0	2.7	13	13
119	2.06		4.87		113		7.2		23	
	2.03	2.05	4.87	4.87	102	108	7.8	7.5	20	22
119A	1.99		4.96		130		9.3		26	
	1.93	1.96	4.91	4.94	138	134	9.1	9.2	28	27
197	2.70		4.68		14		[3] (.3)		3	
	2.50	2.60	4.86	4.77	21	18	[3] (.3)	[3] (.3)	4	4
197A	2.58		4.58		17		[3] (.4)		3	
	2.63	2.60	4.63	4.60	14	15	[3] (.4)	[3] (.4)	3	3

TABLE 3.5. *Laboratory freezing and thawing durability of concretes*—Continued

No. [1]	Gain in wt. after 1 d soaking at 40°F (percent)		Original dynamic modulus, E_0 (psi × 10^{-6})		Number of cycles to failure, interpolated to 60% E_0		Loss in wt during F&T, interpolated to 60% E_0 (percent)		Durability factor [2]	
		Average		*Average*		*Average*		*Average*		*Average*
Miscellaneous										
120	2.53		4.55		76		5.2		15	
	2.56	2.54	4.54	4.55	90	83	9.1	7.2	18	17
120A	2.59		4.46		62		5.3		12	
	2.63	2.61	4.37	4.42	78	70	10.4	7.9	16	14
121	2.30		4.26		74		5.8		15	
	2.18	2.24	4.20	4.23	82	78	5.0	5.4	16	16
121A	2.41		4.17		101		16.5		20	
	2.41	2.41	4.12	4.15	100	101	10.3	13.4	20	20
122	2.38		4.65		125		10.7		25	
	2.31	2.35	4.67	4.66	[19] 88	107	[19] 6.0	8.4	[19] 18	22
122A	2.30		4.70		131		9.0		26	
	2.34	2.32	4.65	4.68	100	115	7.9	8.5	20	23
123	2.89		3.56		352		13.9		68	
	2.72	2.81	3.59	3.58	291	322	13.3	13.6	58	63
123A	2.27		3.84		[20] 799		[20] 20.9		87	
	2.30	2.29	3.84	3.84	[21] 632	716	[21] 18.3	9.6	80	84
Type S-Slag										
198	1.80		4.70		29		.3		6	
	1.79	1.80	4.73	4.72	27	28	.2	.2	5	6
198A	1.78		4.71		24		[3] (.1)		5	
	1.72	1.75	4.87	4.79	20	22	.1	.0	4	4
199	1.74		4.85		9		[3] (.2)		2	
	1.86	1.81	4.66	4.76	9	9	.0	[3] (.1)	2	2
199A	1.85		4.66		8		[3] (.2)		2	
	1.86	1.86	4.67	4.66	8	8	[3] (.2)	[3] (.2)	2	2
200	1.39		4.93		58		4.5		12	
	1.44	1.42	4.78	4.86	67	62	2.4	3.4	13	12
200A	1.67		4.52		59		2.6		12	
	1.71	1.69	4.57	4.54	83	71	3.0	2.8	17	14
Type SA-Slag										
201	1.68		4.08		775		15.1		84	
	1.91	1.80	3.76	3.92	596	686	14.1	14.6	79	82
201A	2.02		3.60		677		15.5		80	
	1.71	1.86	4.05	3.82	529	603	11.5	13.5	77	78
202	2.60		3.78		605		19.1		82	
	2.51	2.56	4.01	3.90	416	510	13.9	16.5	72	77
202A	2.59		4.03		503		19.5		74	
	2.56	2.58	4.05	4.04	422	464	16.3	17.9	70	72
203	2.54		3.76		399		16.4		68	
	2.47	2.50	3.78	3.77	353	376	15.0	15.7	65	66
203A	2.52		3.74		265		12.8		53	
	2.54	2.53	3.77	3.76	269	267	11.5	12.2	54	54

[1] Concretes having a 0.635 W/C ratio listed first for each cement and the concretes with a slump of 5±1 inch indicated by the letter A.
[2] Based on 300 cycles or 60 percent E_0.
[3] Gained.
[4] Sufficient cement for one mix only.
[5] Freezing and thawing started at 42 days.
[6] Weighed and sonic determinations made after 1 cycle of freezing and thawing instead of before freezing.
[7] Discontinued at 563 cycles, 62 percent E_0.
[8] Discontinued at 570 cycles, 63 percent E_0.
[9] Discontinued at 541 cycles, 61 percent E_0.
[10] Discontinued at 556 cycles, 62 percent E_0.
[11] Discontinued at 556 cycles, 63 percent E_0.
[12] Discontinued at 554 cycles, 65 percent E_0.
[13] Discontinued at 565 cycles, 74 percent E_0.
[14] Discontinued at 518 cycles, 64 percent E_0.
[15] Discontinued at 565 cycles, 67 percent E_0.
[16] Discontinued at 565 cycles, 65 percent E_0.
[17] Speciment broken.
[18] One specimen only.
[19] Broken at 110 cycles, extrapolated from 72 percent E_0.
[20] Discontinued at 561 cycles. 72 percent E_0.
[21] Discontinued at 561 cycles, 63 percent E_0.

3.6. Dynamic Young's Modulus of Elasticity of Concretes—Table 3.6

The dynamic Young's modulus of elasticity of 3×4×16-inch concrete prisms that were subjected to several curing stages, described below, are listed in table 3.6. These tests were made to obtain information on changes in dynamic modulus as a result of changes in moisture content and other variables. The dynamic modulus was determined from the same concrete prisms that were used in the weight charge tests reported in Section 3.4. These prisms were made from the same batches of concrete that were used for the shrinkage and expansion tests, and the durability tests described in sections 3.3 and 3.5 respectively.

The prisms were cured at 73±1 °F in the molds under damp burlap for the first 24 hours, then placed in a fog room at 100 percent relative humidity until they were 14 days old. They were then placed on end and exposed for 8 weeks to laboratory air at 73 °F and 50 percent relative humidity. Finally, the specimens were placed in water for 4 weeks.

Fundamental transverse frequencies of the concrete prisms were determined in accordance with ASTM Method C 215 [19]. Measurements were made at 1 day, 14 days (after moist curing), 70 days (after 8 weeks drying in laboratory air), at 71 days (after 24 hours in water) and at 98 days (after 4 weeks in water). From these data and the respective weights of the prisms, dynamic Young's modulus of elasticity was calculated for two prisms of each of the two series of concretes.

TABLE 3.6. *Dynamic Young's modulus of elasticity of concretes*

No. [1]	Dynamic modulus E_0, psi $\times 10^{-6}$											
	1 d	Average	14 d	Average	42 d	Average	70 d	Average	71 d	Average	98 d	Average
Type I												
1	1.99		4.95		4.42		4.23		4.15		5.03	
	2.02	2.01	5.10	5.02	4.51	4.46	4.39	4.31	4.25	4.20	5.11	5.07
1A	1.85		4.90		4.39		4.11		4.01		5.03	
	1.82	1.84	4.85	4.88	4.34	4.36	4.14	4.12	4.15	4.08	5.03	5.03
2	1.98		4.78		4.40		4.17		4.29		5.15	
	1.87	1.92	4.74	4.76	4.40	4.40	4.18	4.18	4.23	4.26	5.19	5.17
2A	1.77		4.66		4.48		4.13		4.23		5.04	
	1.91	1.84	4.85	4.76	4.42	4.45	4.25	4.19	4.32	4.28	5.20	5.12
3	2.44		5.10		4.92		4.43		4.71		5.35	
	2.40	2.42	5.00	5.05	4.87	4.90	4.62	4.52	4.66	4.69	5.24	5.30
3A	2.09		4.77		4.57		4.45		4.40		5.05	
	2.11	2.10	4.75	4.76	4.50	4.54	4.56	4.50	4.34	4.37	4.95	5.00
4	2.04		4.90		4.65		4.45		4.34		4.78	
	2.03	2.04	4.86	4.88	4.78	4.72	4.43	4.44	4.31	4.32	4.70	4.74
4A	1.88		4.90		4.80		4.48		4.37		4.83	
	1.71	1.80	4.63	4.76	4.47	4.64	4.17	4.32	4.06	4.22	4.65	4.74

5	2.31		4.74				4.42		4.38		5.05	
		2.31	4.63	4.68	4.70	4.70	4.28	4.35	4.25	4.32	4.95	5.00
5A	2.16		4.55		4.63		4.27		4.20		4.87	
	2.23	2.20	4.60	4.58	4.51	4.57	4.31	4.29	4.13	4.16	4.93	4.90
6	2.14		4.71		4.62		4.42		4.40		5.05	
	2.10	2.12	4.76	4.74	4.60	4.61	4.36	4.39	4.34	4.37	4.98	5.02
6A	1.91		4.83		4.60		4.40		4.34		4.99	
	1.98	1.94	4.79	4.81	4.60	4.60	4.31	3.36	4.30	4.32	5.02	5.00
7	2.53		5.25		4.85		4.63		4.70		5.27	
	2.37	2.45	5.00	5.12	4.63	4.74	4.40	4.52	4.45	4.58	5.00	5.14
7A	2.51		5.11		4.83		4.62		4.66		5.18	
	2.39	2.45	5.18	5.14	4.70	4.77	4.51	4.57	4.61	4.64	5.20	5.19
8	2.72		4.97		4.72		4.53		4.40		5.05	
	2.60	2.66	4.78	4.88	4.61	4.66	4.39	4.46	4.36	4.38	4.96	5.00
8A	2.52		4.95		4.80		4.48		4.43		5.08	
	2.52	2.52	4.86	4.90	4.68	4.74	4.45	4.46	4.26	4.34	5.05	5.07
9	2.00		4.89		4.53		4.18		4.29		5.14	
	1.95	1.98	4.75	4.82	4.39	4.46	4.20	4.19	4.15	4.22	4.96	5.05
9A	1.78		4.57		4.30		4.11		4.04		4.85	
	1.85	1.83	4.87	4.72	4.49	4.40	4.22	4.16	4.23	4.14	5.00	4.92
10	2.11				4.63		4.60		4.24		5.00	
	2.11	2.11	4.74	4.74	4.84	4.74	4.45	4.52	4.39	4.32	4.97	4.98
10A	2.05		4.60		4.45		4.28		4.15		4.83	
	2.15	2.10	4.71	4.66	4.61	4.53	4.42	4.35	4.34	4.24	4.94	4.88
11	2.24		4.71		4.70		4.33		4.29		4.95	
	2.33	2.28	4.81	4.76	4.56	4.63	4.53	4.44	4.32	4.30	5.02	4.98
11A	2.36		4.86		4.81		4.50		4.43		5.17	
	2.29	2.32	4.78	4.82	4.75	4.78	4.45	4.48	4.34	4.38	5.04	5.10
12	2.60		5.00		5.07		4.85		4.72		5.24	
	2.53	2.56	5.05	5.02	4.90	4.98	4.71	4.78	4.51	4.62	5.17	5.22
12A	2.30		4.94		5.07		4.78		4.58		5.11	
	2.20	2.25	4.75	4.84	4.73	4.90	4.59	4.68	4.36	4.47	5.01	5.06
13	2.34		4.65		4.71		4.62		4.45		5.05	
	2.29	2.32	4.69	4.67	4.69	4.70	4.53	4.58	4.38	4.42	5.02	5.04
13A	2.20		4.70		4.60		4.45		4.34		4.95	
	2.29	2.24	4.73	4.72	4.75	4.68	4.63	4.54	4.51	4.42	4.92	4.94
14	1.70		4.83		4.20		4.05		4.10		4.86	
	1.73	1.72	4.93	4.88	4.34	4.27	4.17	4.11	4.26	4.18	4.92	4.89
14A	1.81		5.03		4.51		4.30		4.40		5.06	
	1.85	1.83	5.18	5.10	4.51	4.51	4.32	4.31	4.33	4.36	5.08	5.07
15	2.62		4.93		4.95		4.87		4.83		5.17	
	2.39	2.50	4.80	4.86	4.70	4.82	4.63	4.75	4.57	4.70	4.99	5.08
15A	2.49		4.90		4.88		4.77		4.80		5.19	
	2.50	2.50	4.99	4.94	4.89	4.88	4.80	4.78	4.75	4.78	5.20	5.20
16	1.91		4.80		4.40		4.33		4.32		4.95	
	2.01	1.96	4.96	4.88	5.20	4.80	4.85	4.59	4.92	4.62	5.20	5.08
16A	1.88		4.91		4.96		4.77		4.78		5.20	
	1.88	1.88	4.85	4.88	4.86	4.91	4.51	4.64	4.43	4.60	5.02	5.11

TABLE 3.6. *Dynamic Young's modulus of elasticity of concretes*—Continued

No. [1]	Dynamic modulus E_0, psi $\times 10^{-6}$											
	1 d	Average	14 d	Average	42 d	Average	70 d	Average	71 d	Average	98 d	Average
Type 1												
17	2.17		4.79		4.54		4.48		4.38		5.05	
	2.16	2.16	4.90	4.84	4.68	4.61	4.62	4.55	4.63	4.50	5.20	5.12
17A	1.90		4.72		4.49		4.45		4.37		4.99	
	1.97	1.93	4.81	4.76	4.63	4.56	4.45	4.45	4.37	4.37	5.05	5.02
18	2.28		4.81		4.57		4.48		4.37		5.09	
	2.37	2.32	4.81	4.81	4.65	4.61	4.49	4.48	4.43	4.40	5.24	5.16
18A	2.21		4.73		4.60		4.40		4.30		5.05	
	2.22	2.22	4.85	4.79	4.61	4.60	4.40	4.40	4.28	4.29	5.11	5.08
19	2.26		5.02		4.69		4.47		4.40		5.05	
	2.22	2.24	4.87	4.94	4.51	4.60	4.40	4.44	4.35	4.38	5.11	5.08
19A	2.20		5.05		4.63		4.41		4.43		5.24	
	2.12	2.16	4.97	5.01	4.59	4.61	4.37	4.39	4.40	4.42	5.06	5.15
20	2.27		4.98		4.62		4.54		4.42		4.96	
	2.28	2.28	5.01	5.00	4.60	4.61	4.51	4.52	4.42	4.42	4.97	4.96
20A	2.11		4.90		4.56		4.50		4.40		4.95	
	2.18	2.14	4.87	4.88	4.56	4.56	4.51	4.50	4.40	4.40	4.92	4.94
21	2.00		4.71		4.49		4.31		4.31		4.90	
	2.21	2.10	5.18	4.94	4.92	4.70	4.73	4.52	4.72	4.52	5.29	5.10
21A	2.06		4.90		4.83		4.56		4.48		5.02	
	2.04	2.05	4.83	4.86	4.60	4.72	4.44	4.50	4.33	4.40	4.96	4.99
22	2.59		5.15		4.90		4.83		4.79		5.31	
	2.60	2.60	5.21	5.18	5.08	4.99	4.87	4.85	4.87	4.83	5.40	5.36
22A	2.34		5.15		4.95		4.81		4.75		5.34	
	2.22	2.28	5.02	5.08	4.75	4.85	4.62	4.72	4.55	4.65	5.15	5.24
23	1.81		4.84		4.49		4.30		4.35		5.26	
	1.63	1.72	4.77	4.80	4.45	4.47	4.14	4.22	4.34	4.34	5.12	5.19
23A	1.59		4.80		4.40		4.15		4.17		5.12	
	1.62	1.60	4.85	4.82	4.35	4.38	4.08	4.12	4.29	4.23	5.20	5.19
25	1.18		4.91		4.40		4.03		4.12		5.05	
	1.18	1.18	4.85	4.88	4.30	4.35	4.01	4.02	4.25	4.18	5.05	5.05
25A	0.99		4.87		4.33		4.06		4.15		5.08	
	1.03	1.01	4.55	4.71	4.09	4.21	3.72	3.89	3.84	4.00	4.75	4.92
26	1.45		5.05		4.73		4.45		4.35		5.12	
	1.42	1.44	5.02	5.04	4.79	4.76	4.45	4.45	4.43	4.39	5.18	5.15
26A	1.20		5.05		4.82		4.47		4.37		5.12	
	1.42	1.31	5.13	5.09	4.70	4.86	4.51	4.49	4.41	4.39	5.18	5.15
27	1.97		4.78		4.80		4.54		4.30		5.30	
	2.05	2.01	4.82	4.80	4.92	4.86	4.58	4.56	4.49	4.40	5.05	5.18
27A	2.01		4.79		4.72		4.57		4.31		5.33	
	1.93	1.97	4.76	4.78	4.89	4.80	4.49	4.53	4.43	4.37	5.02	5.17
28	1.96		5.03		5.10		4.87		4.75		5.39	
	1.85	1.90	4.81	4.92	5.09	5.10	4.70	4.78	4.45	4.60	5.14	5.26
28A	1.80		4.88		5.02		4.59		4.49		5.24	
	1.79	1.79	4.97	4.92	5.39	5.20	4.68	4.64	4.63	4.56	5.33	5.28

29	2.03		4.75		4.68		4.48		4.37		5.01	
	2.09	2.06	4.91	4.83	5.00	4.84	4.80	4.64	4.67	4.52	5.15	5.08
29A	1.91		4.63		4.71		4.50		4.40		4.98	
	1.93	1.92	4.65	4.64	4.53	4.62	4.35	4.42	4.23	4.32	4.95	4.96
30	2.09		4.90		4.62		4.36		4.32		4.92	
	2.08	2.08	4.90	4.90	4.71	4.66	4.40	4.38	4.40	4.36	4.90	4.91
30A	2.14		5.05		4.80		4.55		4.45		5.10	
	2.19	2.16	5.06	5.06	4.71	4.76	4.62	4.58	4.55	4.50	5.11	5.10
31	2.02		5.02		4.84		4.51		4.48		5.11	
	1.90	1.96	4.82	4.92	4.58	4.71	4.42	4.46	4.27	4.38	4.96	5.04
31A	1.85		4.82		4.60		4.42		4.30		4.92	
	1.89	1.87	4.85	4.84	4.56	4.58	4.40	4.41	4.27	4.28	4.99	4.96
32	2.32		4.80		4.54		4.35		4.35		4.95	
	2.29	2.30	4.87	4.84	4.69	4.62	4.59	4.47	4.43	4.39	5.05	5.00
32A	2.29		4.99		4.89		4.58		4.66		5.23	
	2.30	2.30	4.93	4.96	4.75	4.82	4.61	4.60	4.58	4.62	5.11	5.17
33	3.68		4.99		4.71		4.31		4.32		5.08	
	3.77	3.72	4.90	4.94	4.57	4.64	4.23	4.27	4.15	4.24	5.02	5.05
33A	3.65		4.91		4.73		4.33		4.27		5.05	
	3.58	3.62	4.94	4.92	4.54	4.64	4.38	4.36	4.38	4.32	5.09	5.07
34	3.35		4.71		4.50		4.28		4.23		4.88	
	2.87	3.11	4.68	4.70	4.38	4.44	4.14	4.21	4.20	4.22	4.83	4.86
34A	3.64		4.83		4.62		4.33		4.28		4.96	
	3.52	3.58	4.93	4.88	4.80	4.71	4.49	4.41	4.55	4.42	5.05	5.00
35	1.38		4.93		4.57		4.29		4.38		5.02	
	1.48	1.43	5.10	5.02	4.70	4.64	4.40	4.34	4.46	4.42	5.16	5.09
35A	1.37		4.82		4.40		4.15		4.29		4.94	
	1.29	1.33	4.95	4.88	4.51	4.46	4.22	4.18	4.29	4.29	5.02	4.98
36	2.00		5.05		4.90		4.70		4.58		5.15	
	1.91	1.96	5.00	5.02	4.80	4.85	4.57	4.64	4.46	4.52	5.10	5.12
36A	1.98		5.06		4.82		4.62		4.66		5.22	
	1.96	1.97	5.00	5.03	4.92	4.87	4.63	4.62	4.54	4.60	5.09	5.25
37	1.57		4.60		4.37		4.12		4.04		4.90	
	1.52	1.54	4.52	4.56	4.30	4.34	3.98	4.05	3.98	4.01	4.80	4.85
37A	1.54		4.54		4.33		4.00		4.00		4.80	
	1.52	1.53	4.63	4.58	4.48	4.40	4.12	4.06	4.03	4.02	4.90	4.85
38	2.32		4.96		4.77		4.60		4.57		5.18	
	2.19	2.26	4.86	4.91	4.61	4.69	4.40	4.50	4.49	4.53	5.07	5.12
38A	2.08		4.71		4.57		4.36		4.28		4.95	
	2.10	2.09	4.87	4.79	4.59	4.58	4.42	4.39	4.40	4.34	4.99	4.97
39	1.82		4.80		4.31		4.00		3.96		5.02	
	1.81	1.82	4.77	4.78	4.23	4.27	4.00	4.00	3.93	3.94	4.92	4.97
[2]39A												
40	1.86		4.72		4.75		4.24		4.20		4.90	
	1.93	1.90	4.78	4.75	4.95	4.85	4.42	4.33	4.35	4.28	4.95	4.92
40A	1.86		4.80		4.50		4.30		4.25		5.00	
	1.90	1.88	4.74	4.77	4.50	4.50	4.20	4.25	4.16	4.20	4.90	4.95

TABLE 3.6. *Dynamic Young's modulus of elasticity of concretes*—Continued

No. [1]	Dynamic modulus E_0, psi $\times 10^{-6}$											
	1 d	Average	14 d	Average	42 d	Average	70 d	Average	71 d	Average	98 d	Average
Type I												
41	1.68		4.93		4.48		4.20		4.18		4.93	
	1.68	1.68	4.87	4.90	4.34	4.82	4.12	4.16	4.06	4.24	4.87	4.90
41A	1.49		4.69		4.28		4.07		3.98		4.72	
	1.52	1.50	4.70	4.70	4.12	4.20	3.92	4.00	3.87	3.92	4.70	4.71
42	1.85		4.46		4.45		4.31		4.24		4.93	
	1.97	1.91	4.62	4.54	4.65	4.55	4.53	4.42	4.45	4.34	5.05	4.99
42A	2.07		4.69		4.67		4.59		4.48		5.24	
	2.15	2.11	4.72	4.70	4.83	4.75	4.66	4.62	4.55	4.52	5.14	5.19
43	1.92		4.90		4.86		4.73		4.71		5.30	
	1.91	1.92	4.75	4.82	4.75	4.80	4.62	4.68	4.51	4.61	5.03	5.17
43A	2.13		5.09		5.10		4.92		4.87		5.45	
	1.97	2.05	5.02	5.06	4.97	5.04	4.86	4.89	4.80	4.84	5.28	5.36
44	1.46		4.58		4.31		4.24		4.25		4.79	
	1.50	1.48	4.75	4.66	4.42	4.36	4.37	4.30	4.30	4.28	4.87	4.83
44A	1.52		4.83		4.57		4.55		4.48		5.01	
	1.51	1.52	4.84	4.84	4.60	4.58	4.55	4.55	4.48	4.48	4.98	5.00
45	2.09		5.11		4.82		[3] 2.49					
	2.18	2.14	5.24	5.18	4.85	4.84	4.75	4.75	4.66	4.66	5.24	5.24
45A	1.91		4.98		4.60		4.53		4.40		5.02	
	1.91	1.91	4.90	4.94	4.57	4.58	4.50	4.52	4.42	4.41	4.96	4.99
46	3.01		5.51		5.17		5.06		5.09		5.50	
	3.18	3.10	5.67	5.59	5.40	5.28	5.27	5.16	5.16	5.12	5.70	5.60
46A	3.26		5.73		5.42		5.29		5.24		5.70	
	3.17	3.22	5.59	5.66	5.33	5.38	5.20	5.24	5.12	5.18	5.63	5.66
47	1.66		4.64		4.42		4.28		4.38		4.99	
	1.59	1.62	4.50	4.57	4.31	4.36	4.25	4.26	4.20	4.29	4.80	4.90
47A	1.66		4.52		4.36		4.25		4.34		4.92	
	1.69	1.68	----------	4.52	4.42	4.39	4.30	4.28	4.34	4.34	4.87	4.90
48	1.65		4.72		4.66		4.60		4.52		5.24	
	1.66	1.66	4.59	4.66	4.53	4.60	4.92	4.76	4.45	4.48	5.08	5.16
48A	1.64		4.70		4.68		4.55		4.52		5.20	
	1.60	1.62	4.70	4.70	4.61	4.64	4.90	4.72	4.43	4.48	5.15	5.18
49	1.11		4.98		4.36		4.25		4.28		4.94	
	1.17	1.14	5.02	5.00	4.42	4.39	4.20	4.22	4.31	4.30	5.00	4.97
49A	1.16		5.00		4.35		4.30		4.23		4.95	
	1.22	1.19	5.20	5.10	4.65	4.50	4.37	4.34	4.37	4.30	4.99	4.97
50	1.89		4.55		4.25		4.04		----------		4.77	
	1.90	1.90	4.36	4.46	4.05	4.15	3.95	4.00	----------	----------	4.73	4.75
50A	2.02		4.50		4.28		4.14		----------		4.77	
	2.02	2.02	4.60	4.55	4.25	4.26	4.15	4.14	----------	----------	4.87	4.82

51	2.10		4.88		4.49		4.45		----		5.03	
	2.00	2.05	4.75	4.82	4.40	4.44	4.02	4.24	----	----	4.96	5.00
51A	2.01		4.81		4.40		4.33		----		5.02	
	2.17	2.09	5.02	4.92	4.56	4.48	4.50	4.42	----	----	5.11	5.06
52	1.92		4.79		4.66		4.52		----		5.10	
	1.95	1.94	4.80	4.80	4.65	4.66	4.50	4.51	----	----	5.15	5.12
52A	2.18		5.12		4.80		4.75		----		5.37	
	2.11	2.14	4.96	5.04	4.70	4.75	4.60	4.68	----	----	5.00	5.18
54	3.06		5.35		4.92		4.84		----		5.46	
	2.98	3.02	5.26	5.30	4.90	4.91	4.79	4.82	----	----	5.38	5.42
54A	3.05		5.40		5.00		4.88		----		5.60	
	3.00	3.02	5.39	5.40	4.98	4.99	4.90	4.89	----	----	5.53	5.56
55	1.93		5.17		4.65		4.49		4.62		5.05	
	2.07	2.00	5.18	5.18	4.77	4.71	4.58	4.54	4.74	4.68	5.18	5.12
55A	1.91		5.15		4.66		4.51		4.63		5.06	
	1.92	1.92	5.17	5.16	4.67	4.66	4.48	4.50	4.60	4.62	5.08	5.07
56	1.95		4.83		4.52		4.39		4.45		4.94	
	2.10	2.02	4.85	4.84	4.65	4.58	4.54	4.46	4.49	4.47	4.99	4.96
56A	2.14		5.09		4.83		4.65		4.69		5.23	
	2.02	2.08	4.93	5.01	4.68	4.76	4.65	4.65	4.51	4.60	5.00	5.12
57	1.54		4.63		4.22		4.05		----		4.99	
	1.50	1.52	4.64	4.64	4.17	4.20	3.98	4.02	----	----	4.92	4.96
57A	1.73		4.88		4.42		4.35		----		5.11	
	1.64	1.68	4.82	4.85	4.45	4.44	4.30	4.32	----	----	5.08	5.10
58	2.58		4.98		5.01		4.93		4.87		5.35	
	2.58	2.58	5.18	5.08	4.86	4.94	4.91	4.92	4.79	4.83	5.43	5.39
58A	2.44		5.07		4.99		4.97		4.86		5.35	
	2.45	2.44	5.08	5.08	4.95	4.97	4.82	4.90	4.78	4.82	5.35	5.35
59	2.02		4.93		4.70		4.68		4.64		5.27	
	2.05	2.04	5.02	4.98	4.78	4.74	4.69	4.68	4.72	4.68	5.39	5.33
59A	2.03		4.97		4.80		4.71		4.69		5.30	
	2.17	2.10	4.98	4.98	4.84	4.82	4.68	4.70	4.72	4.70	5.27	5.28
124	1.84		4.84		4.95		4.51		4.58		5.30	
	1.77	1.80	4.78	4.81	4.92	4.94	4.43	4.47	4.54	4.56	5.30	5.30
124A	1.78		4.74		5.02		4.48		4.55		5.28	
	1.79	1.78	4.75	4.74	4.65	4.84	4.36	4.42	4.45	4.50	5.23	5.26
125	1.61		5.07		4.54		4.39		4.45		5.20	
	1.56	1.58	4.94	5.00	4.51	4.52	4.35	4.37	4.49	4.47	5.22	5.21
125A	1.34		4.72		4.30		4.08		4.20		4.95	
	1.41	1.38	5.00	4.86	4.56	4.43	4.30	4.19	4.42	4.31	5.18	5.06
126	1.78		4.93		4.99		4.43		4.49		5.28	
	1.82	1.80	4.95	4.94	5.05	5.02	4.45	4.44	4.58	4.54	5.25	5.26
126A	1.81		4.97		(-)[4]							
	1.79	1.80	4.89	4.93	4.78	4.78	4.43	4.43	4.46	4.46	5.20	5.20
127	2.40		5.08		5.06		5.04		4.80		5.48	
	2.34	2.37	4.90	4.99	4.85	4.96	4.84	4.94	4.66	4.73	5.26	5.37
127A	2.06		4.75		4.76		4.71		4.46		5.11	
	1.97	2.02	4.57	4.66	4.51	4.64	4.49	4.60	4.28	4.37	4.91	5.01

TABLE 3.6. *Dynamic Young's modulus of elasticity of concretes*—Continued

No. [1]	Dynamic modulus E_0, psi $\times 10^{-6}$											
	1 d	Average	14 d	Average	42 d	Average	70 d	Average	71 d	Average	98 d	Average
128	2.39		4.86		4.80		4.77		4.51		5.03	
	2.52	2.46	4.98	4.92	4.91	4.86	4.89	4.83	4.65	4.58	5.12	5.08
128A	2.35		4.95		4.71		4.65		4.45		4.97	
	2.40	2.38	4.92	4.94	4.63	4.67	4.60	4.62	4.37	4.41	4.92	4.94
129	2.50		5.29									
	2.39	2.44	5.02	5.16	4.65	4.65	4.52	4.52	4.65	4.65	5.36	5.36
129A	2.31		5.23		4.74		4.58		4.68		5.35	
	2.35	2.33	5.18	5.20	4.89	4.82	4.65	4.62	4.78	4.73	5.45	5.40
130	2.25		5.27		4.82		4.59		4.69		5.36	
	2.29	2.27	5.29	5.28	4.80	4.81	4.59	4.59	4.70	4.70	5.36	5.41
130A	2.03		5.02		4.62		4.39		4.58		5.33	
	2.14	2.08	5.18	5.10	4.68	4.65	4.45	4.42	4.57	4.58	5.35	5.34
131	2.11		5.15		5.19		5.10		4.90		5.53	
	2.11	2.11	5.20	5.18	5.19	5.19	5.04	5.07	4.97	4.94	5.53	5.53
131A	1.90		4.80		4.79		4.70		4.56		5.10	
	2.04	1.97	5.10	4.95	5.08	4.94	5.00	4.85	4.93	4.74	5.44	5.27
132	1.84		4.93		4.59		4.32		4.48		5.36	
	1.88	1.86	5.06	5.00	4.77	4.68	4.52	4.42	4.60	4.54	5.46	5.41
132A	1.88		5.25		4.92		4.70		4.84		5.63	
	2.10	1.99	5.85	5.55	5.49	5.20	5.20	4.95	5.35	5.10	6.20	5.92
133	2.13		4.93		4.61		4.73		4.40		5.00	
	2.28	2.20	4.98	4.96	4.92	4.76	4.76	4.74	4.69	4.54	5.15	5.08
133A	2.29		4.84		4.67		4.52		4.38		4.90	
	2.35	2.32	4.89	4.86	4.62	4.64	4.51	4.52	4.36	4.37	5.01	4.96
134	2.14		5.14		5.03		4.89		4.81		5.34	
	2.10	2.12	4.94	5.04	5.00	5.02	4.88	4.88	4.74	4.78	5.11	5.22
134A	1.97		5.00		4.83		4.71		4.69		5.24	
	1.93	1.95	5.02	5.01	4.91	4.87	4.76	4.74	4.66	4.68	5.15	5.20
135	1.73		4.81		4.64		4.56		4.46		5.36	
	1.78	1.76	4.90	4.86	4.74	4.69	4.69	4.62	4.56	4.51	5.44	5.40
135A	1.50		4.23		4.08		4.00		3.93			
	1.68	1.59	4.54	4.38	4.35	4.22	4.25	4.12	4.26	4.10	5.12	4.98
136	2.15		5.20		4.90		4.75		4.69		5.22	
	2.22	2.18	5.24	5.22	5.16	5.03	4.95	4.85	4.90	4.80	5.36	5.29
136A	2.07		4.95		4.70		4.55		4.47		4.98	
	2.16	2.11	5.02	4.98	4.80	4.75	4.65	4.60	4.55	4.51	5.00	4.99
137	2.38		5.00		4.91		4.80		4.55		5.02	
	2.24	2.31	4.87	4.94	4.82	4.86	4.65	4.72	4.51	4.53	5.17	5.10
137A	2.06		4.54		4.36		4.26		4.09		5.06	
	2.06	2.06	4.65	4.60	4.47	4.42	4.36	4.31	4.20	4.14	4.95	5.00
138	1.44		5.02		4.48		4.33		4.58		5.45	
	1.48	1.46	5.10	5.06	4.65	4.56	4.48	4.40	4.69	4.64	5.50	5.48

138A	1.44		5.15		4.86		4.60		4.78		5.60	
	1.51	1.48	4.90	5.02	4.70	4.78	4.39	4.50	4.51	4.64	5.33	5.46
139	2.20		4.75		4.61		4.41		4.34		5.04	
	2.06	2.13	4.44	4.60	4.42	4.52	4.20	4.30	4.11	4.22	4.77	4.90
139A [2]												
140	1.75		4.78		4.50		4.49		4.40		5.04	
	1.72	1.73	4.65	4.72	4.44	4.47	4.41	4.45	4.30	4.35	4.90	4.97
140A [2]												
141	2.46		4.44		4.42		4.40		4.05		4.81	
	2.40	2.43	4.29	4.36	4.19	4.30	4.17	4.28	3.95	4.00	4.68	4.74
141A	2.30		4.22		4.11		4.12		3.87		4.61	
	2.36	2.33	4.29	4.26	4.22	4.16	4.07	4.10	3.91	3.89	4.61	4.61
142	2.12		5.11		4.85		4.82		4.54		5.23	
	2.16	2.14	5.06	5.08	4.84	4.84	4.82	4.82	4.67	4.60	5.26	5.24
142A	1.82		4.85		4.64		4.58		4.47		5.01	
	1.95	1.88	5.03	4.94	4.86	4.75	4.84	4.71	4.66	4.56	5.24	5.12
143	1.96		4.80		4.61		4.56		4.29		5.04	
	2.02	1.99	4.81	4.80	4.61	4.61	4.50	4.53	4.25	4.27	5.17	5.10
143A	1.93		4.92		4.69		4.60		4.39		5.19	
	1.83	1.88	4.66	4.79	4.47	4.58	4.36	4.48	4.15	4.27	4.97	5.08
144	1.42		4.45		4.03		3.90		4.05		4.90	
	1.45	1.44	4.55	4.50	4.20	4.12	4.02	3.96	4.16	4.10	4.99	4.94
144A	1.38		4.25		3.93		3.76		3.74		4.67	
	1.33	1.36	4.16	4.20	3.82	3.88	3.63	3.70	3.63	3.68	4.53	4.60
145	2.07		4.84		4.80		4.74		4.51		5.17	
	2.12	2.10	4.85	4.84	4.89	4.84	4.85	4.80	4.51	4.51	5.17	5.17
145A	2.08		4.90		4.75		4.66		4.60		5.15	
	1.93	2.00	4.86	4.88	4.71	4.73	4.67	4.66	4.45	4.52	5.19	5.17
146	2.22		5.35		5.30		5.29		5.14		5.74	
	2.00	2.11	4.95	5.15	4.98	5.14	4.93	5.11	4.79	4.96	5.32	5.53
146A	1.80		4.96		4.95		4.90		4.74		5.31	
	1.90	1.85	5.06	5.01	5.05	5.00	5.03	4.96	4.87	4.80	5.41	5.36
147	2.46		4.89		4.95		4.86		4.75		5.35	
	2.38	2.42	4.87	4.88	4.87	4.91	4.82	4.84	4.73	4.74	5.30	5.32
147A	2.50		4.94		4.92		4.86		4.78		5.41	
	2.34	2.42	4.71	4.82	4.65	4.78	4.59	4.72	4.42	4.60	5.07	5.24
148	2.22		5.15		4.86		4.77		4.84		5.44	
	2.26	2.24	5.01	5.08	4.75	4.80	4.67	4.72	4.60	4.72	5.32	5.38
148A	2.32		5.06		4.83		4.80		4.78		5.34	
	2.29	2.30	5.11	5.08	4.87	4.85	4.80	4.80	4.81	4.80	5.43	5.38
149	2.47		5.00		4.75		4.40		4.63		5.34	
	2.57	2.52	5.00	5.00	4.76	4.76	4.65	4.52	4.57	4.60	5.28	5.31
149A	2.36		4.85		4.53		4.55		4.36		5.08	
	2.44	2.40	4.90	4.88	4.67	4.60	4.50	4.52	4.45	4.40	5.14	5.11
150	2.58		4.85		4.88		4.95		4.80		5.30	
	2.80	2.69	5.11	4.98	5.31	5.10	5.32	5.14	5.12	4.96	5.63	5.46
150A	2.73		5.08		5.13		5.04		4.95		5.51	
	2.52	2.62	4.87	4.98	4.92	5.02	4.95	5.00	4.72	4.84	5.17	5.34
151	1.59		4.56		4.41		4.22		4.30		5.15	
	1.66	1.63	4.66	4.61	4.50	4.46	4.34	4.28	4.35	4.32	5.26	5.20
151A	1.58		4.38		4.33		4.14		4.17		5.08	
	1.60	1.59	4.49	4.44	4.36	4.34	4.20	4.17	4.22	4.20	5.09	5.08

TABLE 3.6. *Dynamic Young's modulus of elasticity of concretes*—Continued

No. [1]	Dynamic modulus E_0, psi $\times 10^{-6}$											
	1 d	Average	14 d	Average	42 d	Average	70 d	Average	71 d	Average	98 d	Average
Type I												
152	3.02		5.30		5.08		4.95		4.94		5.61	
	2.89	2.96	5.02	5.16	4.87	4.98	4.74	4.84	4.73	4.84	5.32	5.46
152A	2.34		4.78		4.60		4.41		4.42		5.05	
	2.62	2.48	5.05	4.92	4.90	4.75	4.71	4.56	4.70	4.56	5.40	5.22
153	2.11		5.16		5.00		4.95		4.92		5.53	
	2.03	2.07	4.83	5.00	4.74	4.87	4.67	4.81	4.65	4.78	5.22	5.38
153A	2.41		5.18		4.97		4.97		4.95		5.58	
	2.26	2.34	5.02	5.10	4.80	4.88	4.77	4.87	4.77	4.86	5.39	5.48
154	2.14		4.82		4.62		4.54		4.40		5.19	
	2.12	2.13	4.84	4.83	4.67	4.64	4.60	4.57	4.44	4.42	5.17	5.18
154A	1.60		4.40		4.20		4.00		4.00		4.81	
	1.69	1.64	4.54	4.47	4.33	4.26	4.19	4.10	4.17	4.08	4.94	4.88
155	2.30		4.91		4.52		4.39		4.30		5.15	
	2.33	2.32	4.79	4.85	4.50	4.51	4.39	4.39	4.28	4.29	5.12	5.14
155A	2.11		4.90		4.56		4.40		4.34		5.19	
	2.13	2.12	4.96	4.93	4.59	4.58	4.42	4.41	4.35	4.34	5.23	5.21
156	2.41		4.86		4.83		4.82		4.63		5.32	
	2.38	2.40	4.84	4.85	4.77	4.80	4.66	4.74	4.48	4.56	5.16	5.24
156A	2.00		4.55		4.53		4.47		4.30		4.92	
	2.06	2.03	4.57	4.56	4.54	4.54	4.47	4.47	4.35	4.32	5.00	4.96
157	2.08		4.88		4.75		4.75		4.52		5.06	
	2.35	2.22	5.12	5.00	4.96	4.80	5.00	4.88	4.86	4.69	5.46	5.26
157A	2.02		4.86		4.71		4.64		4.42		5.15	
	2.00	2.01	4.91	4.88	4.77	4.74	4.71	4.68	4.46	4.44	5.27	5.21
158	2.14		5.02		4.91		4.88		4.90		5.45	
	2.18	2.16	4.96	4.99	5.02	4.96	4.96	4.92	4.89	4.90	5.37	5.41
158A	2.15		4.85		4.82		4.78		4.68		5.02	
	2.30	2.22	5.11	4.98	5.00	4.91	4.97	4.88	4.94	4.81	5.55	5.28
159	3.08		5.01		4.68		4.57		4.49		5.16	
	3.02	3.05	4.90	4.96	4.61	4.64	4.50	4.54	4.41	4.45	5.08	5.12
159A	3.03		5.07		4.73		4.62		4.51		5.19	
	2.90	2.96	4.84	4.96	4.54	4.64	4.40	4.51	4.35	4.43	4.98	5.08
160	1.85		4.86		4.38		4.22		4.27		5.10	
	1.85	1.85	4.83	4.84	4.32	4.35	4.18	4.20	4.25	4.26	5.02	5.06
160A	1.52		4.52		4.03		3.88		3.92		4.73	
	1.68	1.60	4.87	4.70	4.41	4.22	4.22	4.05	4.22	4.07	5.07	4.90
161	2.90		5.14		4.93		4.87		4.82		5.52	
	2.93	2.92	5.14	5.14	4.89	4.91	4.86	4.86	4.78	4.80	5.32	5.42
161A	2.60		4.92		4.67		4.62		4.55		5.02	
	2.61	2.60	4.88	4.90	4.63	4.65	4.57	4.60	4.46	4.50	4.97	5.00

Type IA												
53	1.41		3.81		3.73		3.65		3.62		4.22	
	1.46	1.44	3.86	3.84	3.83	3.78	3.73	3.69	3.69	3.66	4.19	4.20
53A	1.70		4.24		4.30		4.15		4.11		4.64	
	1.63	1.67	4.08	4.16	4.12	4.21	4.01	4.08	3.97	4.04	4.47	4.56
60	1.39		3.75		3.51		3.39		3.61		4.26	
	1.37	1.38	3.73	3.74	3.44	3.48	3.33	3.36	3.51	3.56	4.18	4.22
60A	1.80		4.27		4.17		3.94		4.08		4.78	
	1.70	1.75	4.13	4.20	3.89	4.03	3.77	3.86	3.87	3.98	4.66	4.72
61	1.56		3.79		3.68		3.55		3.53		4.23	
	1.48	1.52	3.69	3.74	3.64	3.66	3.45	3.50	3.41	3.47	4.08	4.16
61A	2.02		4.45		4.55		4.18		4.19		4.79	
	1.99	2.00	4.28	4.37	4.49	4.52	4.08	4.13	4.08	4.14	4.61	4.70
62	1.77		3.64		3.78		3.64		3.56		4.10	
	1.72	1.74	3.61	3.62	4.05	3.92	3.75	3.70	3.68	3.62	4.08	4.09
62A	2.12		4.25		4.64		4.37		4.30		4.68	
	2.21	2.16	4.35	4.30	4.48	4.56	4.35	4.36	4.25	4.28	4.75	4.72
63	1.49		3.84		3.91		3.73		3.66		4.24	
	1.61	1.55	4.11	3.98	4.18	4.04	3.98	3.86	3.93	3.80	4.56	4.40
63A	1.75		4.19		4.54		4.22		4.21		4.64	
	1.73	1.74	4.18	4.18	4.57	4.56	4.15	4.18	4.15	4.18	4.58	4.61
64	1.42		3.92		3.81		3.61		3.70		4.33	
	1.46	1.44	3.98	3.95	4.00	3.90	3.79	3.70	3.81	3.76	4.44	4.38
64A	1.59		4.12		4.19		3.88		3.96		4.58	
	1.60	1.60	4.08	4.10	3.89	4.04	3.75	4.24	3.82	3.89	4.55	4.56
65	1.45		3.70		3.54		3.31		3.39		4.05	
	1.30	1.38	3.46	3.58	3.24	3.39	3.08	3.20	3.18	3.28	3.79	3.92
65A	1.80		3.86		3.59		3.45		3.56		4.13	
	1.77	1.78	3.82	3.84	3.57	3.56	3.41	3.44	3.53	3.54	4.16	4.14
66	1.18		4.24		4.16		4.00		4.10		4.66	
	1.89	1.54	4.19	4.22	3.96	4.06	3.83	3.92	3.97	4.04	4.51	4.58
66A	2.07		4.47		4.35		4.23		4.19		4.82	
	2.11	2.09	4.73	4.60	4.65	4.50	4.40	4.32	4.36	4.28	4.88	4.85
162	1.75		3.51		3.36		3.28		3.32		3.96	
	1.74	1.74	3.52	3.52	3.40	3.38	3.31	3.30	3.33	3.32	4.03	4.00
162A	2.19		3.97		3.89		3.77		3.80		4.47	
	2.22	2.20	4.08	4.02	4.04	3.96	3.86	3.82	3.84	3.82	4.57	4.52
Type II												
24	1.95		4.83		4.50		4.28		4.31		5.14	
	1.86	1.90	4.95	4.89	4.48	4.49	4.30	4.29	4.31	4.31	5.14	5.14
24A	2.09		5.03		4.59		4.48		4.44		5.34	
	2.00	2.04	4.95	4.99	4.51	4.55	4.31	4.40	4.37	4.40	5.20	5.27
67	1.34		4.62		4.60		4.30		4.36		5.15	
	1.39	1.36	4.63	4.62	4.57	4.58	4.29	4.30	4.31	4.34	5.12	5.14
67A	1.31		4.70		4.54		4.33		4.40		5.24	
	1.26	1.28	4.61	4.65	4.49	4.52	4.28	4.30	4.34	4.37	5.20	5.22
68	1.71		4.57		4.40		4.14		4.15		5.01	
	1.80	1.76	4.73	4.65	4.40	4.40	4.18	4.16	4.23	4.19	5.18	5.10
68A	1.90		4.74		4.40		4.22		4.25		5.21	
	1.92	1.91	4.67	4.70	4.50	4.45	4.25	4.24	4.28	4.26	5.11	5.16

TABLE 3.6. *Dynamic Young's modulus of elasticity of concretes*—Continued

No. [1]	Dynamic modulus E_0, psi $\times 10^{-6}$											
	1 d	Average	14 d	Average	42 d	Average	70 d	Average	71 d	Average	98 d	Average
Type II												
69	1.98		4.85		4.78		4.59		4.48		5.30	
	1.93	1.96	4.72	4.78	4.60	4.69	4.42	4.50	4.40	4.44	5.09	5.20
69A	1.93		4.70		4.50		4.33		4.34		5.05	
	1.94	1.94	4.85	4.78	4.77	4.63	4.54	4.44	4.48	4.41	5.25	5.15
70	1.75		4.37		4.37		4.16		4.06		4.91	
	1.86	1.80	4.55	4.46	4.42	4.40	4.24	4.20	4.31	4.18	5.10	5.00
70A	2.00		4.84		4.75		4.55		4.55		5.30	
	1.99	2.00	4.80	4.82	4.70	4.72	4.52	4.54	4.53	4.54	5.30	5.30
71	1.46		4.72		4.17		3.88		4.11		4.90	
	1.41	1.44	4.67	4.70	4.23	4.20	3.94	3.91	4.14	4.12	4.87	4.88
71A	1.65		4.97		4.38		4.09		4.31		5.05	
	1.63	1.64	4.78	4.88	4.33	4.36	4.01	4.05	4.20	4.26	4.92	4.98
72	1.87		5.03		4.63		4.39		4.46		5.30	
	1.92	1.90	5.05	5.04	4.83	4.73	4.65	4.52	4.71	4.58	5.24	5.27
72A	1.92		4.93		4.74		4.48		4.57		5.20	
	1.99	1.96	5.10	5.02	5.08	4.91	4.84	4.66	4.88	4.72	5.40	5.30
73	1.61		4.75		4.55		4.14		4.32		5.08	
	1.70	1.66	4.98	4.86	4.52	4.54	4.25	4.20	4.37	4.34	5.34	5.21
73A	1.82		5.11		4.68		4.46		4.55		5.40	
	1.80	1.81	5.08	5.10	[3] 4.68	4.68	----------	4.46	----------	4.55	----------	5.40
74	1.78		4.90		4.86		4.70		4.65		5.17	
	1.83	1.80	5.03	4.97	5.29	5.08	5.12	4.91	5.03	4.84	5.37	5.27
74A	1.83		5.00		5.20		5.07		5.05		5.34	
	1.87	1.85	4.97	4.98	4.86	5.03	4.60	4.84	4.63	4.84	5.20	5.27
75	1.72		4.49		4.25		4.10		4.21		5.11	
	1.66	1.69	4.33	4.41	4.36	4.30	4.11	4.10	4.14	4.17	5.00	5.06
75A	1.89		4.52		4.55		4.36		4.37		5.24	
	1.90	1.90	4.53	4.52	4.30	4.42	4.20	4.28	4.15	4.26	5.21	5.23
76	1.20		4.25		4.65		4.20		4.20		5.00	
	1.22	1.21	4.30	4.28	4.40	4.52	4.07	4.13	4.03	4.12	5.05	5.02
76A	1.31		4.34		4.45		4.25		4.27		5.11	
	1.29	1.30	4.35	4.34	4.66	4.56	4.39	4.32	4.26	4.26	5.11	5.11
77	1.39		4.35		4.23		4.02		3.98		4.86	
	1.42	1.40	4.45	4.40	4.14	4.18	3.90	3.96	3.96	3.97	4.92	4.89
77A	1.38		4.43		4.15		3.93		4.00		4.89	
	1.31	1.34	4.34	4.38	4.13	4.14	3.84	3.88	3.93	3.96	4.84	4.86
78	1.85		4.85		4.62		4.30		4.32		5.11	
	1.80	1.82	4.79	4.82	4.55	4.58	4.25	4.28	4.32	4.32	5.06	5.08
78A	1.82		4.85		4.57		4.26		4.31		5.11	
	1.80	1.81	4.85	4.85	4.65	4.61	4.24	4.25	4.36	4.34	5.12	5.12
79	1.75		5.00		4.56		4.26		4.37		5.37	
	1.78	1.76	5.09	5.04	4.65	4.60	4.38	4.32	4.48	4.40	5.40	5.38
79A [2]												

80	1.50		4.71		4.14		3.93		4.07		5.17	
	1.50	1.50	4.69	4.70	4.10	4.12	3.83	3.88	4.06	4.06	5.20	5.18
80A	1.51		4.99		4.37		4.20		4.37		5.44	
	1.43	1.47	4.75	4.87	4.14	4.26	3.96	4.08	4.12	4.24	5.24	5.34
81	1.58		4.70		4.75		4.36		4.34		5.05	
	1.58	1.58	4.64	4.67	4.73	4.74	4.34	4.35	4.27	4.30	4.96	5.00
81A	1.51		4.66		4.46		4.25		4.15		4.96	
	1.55	1.53	4.65	4.66	4.57	4.52	4.30	4.28	4.28	4.22	4.96	4.96
82	1.54		4.67		4.82		4.40		4.32		5.15	
	1.46	1.50	4.63	4.65	4.64	4.73	4.33	4.36	4.22	4.27	4.97	5.06
82A	1.39		4.60		4.68		4.35		4.18		5.50	
	1.47	1.43	4.79	4.70	4.78	4.73	4.40	4.38	4.37	4.27	5.11	5.06
83	2.10		5.12		4.87		4.82		4.66		5.18	
	2.26	2.18	5.13	5.12	5.05	4.96	5.04	4.93	4.86	4.76	5.34	5.26
83A	2.22		5.06		5.08		5.08		4.85		5.43	
	2.37	2.30	5.20	5.13	5.26	5.17	5.16	5.12	4.99	4.92	5.46	5.44
84	1.86		4.81		4.78		4.69		4.51		5.13	
	1.91	1.88	4.82	4.82	4.78	4.78	4.72	4.70	4.51	4.51	5.15	5.14
84A	1.83		4.70		4.69		4.59		4.43		5.03	
	1.88	1.86	4.84	4.77	4.75	4.72	4.69	4.64	4.51	4.47	5.11	5.07
85	1.78		4.57		4.36		4.26		4.28		4.95	
	1.80	1.79	4.51	4.54	4.37	4.36	4.25	4.26	4.22	4.25	4.90	4.92
85A	2.04		4.77		4.59		4.53		4.45		5.13	
	1.89	1.96	4.71	4.74	4.53	4.56	4.43	4.48	4.37	4.41	5.07	5.10
86	1.32		4.85		4.87		4.79		4.69		5.26	
	1.02	1.17	4.79	4.82	4.65	4.76	4.62	4.70	4.50	4.60	5.27	5.26
86A	1.04		4.78		4.71		4.70		4.52		5.20	
	1.22	1.13	4.95	4.86	4.93	4.82	4.85	4.78	4.75	4.64	4.43	5.31
87	0.94		4.69		4.37		4.25		4.17		5.00	
	1.62	1.28	4.74	4.72	4.35	4.36	4.33	4.29	4.33	4.25	5.14	5.07
87A	1.04		4.69		4.29		4.25		4.23		5.00	
	1.13	1.08	4.69	4.69	4.34	4.32	4.22	4.23	4.20	4.22	5.10	5.05
88	1.92		4.43		4.26		4.17		4.18		4.88	
	2.03	1.98	4.64	4.54	4.43	4.34	4.32	4.24	4.41	4.30	5.00	4.94
88A	1.78		4.46		4.31		4.17		4.25		4.93	
	1.74	1.76	4.25	4.36	4.14	4.22	4.03	4.10	4.13	4.19	4.80	4.87
89	2.24		4.89		4.89		4.91		4.63		5.19	
	1.90	2.07	4.66	4.78	4.64	4.76	4.56	4.74	4.46	4.54	5.02	5.10
89A	1.87		4.76		4.65		4.65		4.57		5.18	
	1.94	1.90	4.86	4.81	4.78	4.72	4.79	4.72	4.56	4.56	5.18	5.18
90	1.85		4.88		4.46		4.54		4.45		5.25	
	1.71	1.78	4.75	4.82	4.36	4.41	4.42	4.48	4.32	4.38	5.08	5.16
90A	1.81		4.70		4.23		4.33		4.23		5.05	
	1.85	1.83	4.87	4.78	4.46	4.34	4.45	4.39	4.41	4.32	5.18	5.12
91	1.41		4.56		4.26		4.33		4.18		4.86	
	1.49	1.45	4.50	4.53	4.25	4.26	4.32	4.32	4.20	4.19	4.81	4.84
91A	1.48		4.46		4.20		4.25		4.14		4.80	
	1.56	1.52	4.56	4.51	4.32	4.26	4.37	4.31	4.25	4.20	4.87	4.84
92	1.52		4.42		4.23		4.37		4.16		4.93	
	1.63	1.58	4.70	4.56	4.35	4.29	4.33	4.35	4.34	4.25	5.03	4.98
92A	1.22		4.03		3.90		4.25		3.90		4.60	
	1.32	1.27	4.32	4.18	4.10	4.00	4.28	4.26	4.10	4.10	4.86	4.73

TABLE 3.6. *Dynamic Young's modulus of elasticity of concretes*—Continued

No. [1]	Dynamic modulus E_0, psi $\times 10^{-6}$											
	1 d	Average	14 d	Average	42 d	Average	70 d	Average	71 d	Average	98 d	Average
Type II												
93	1.48		4.88		4.11		4.26		4.30		5.00	
	1.51	1.50	4.99	4.93	4.56	4.34	4.39	4.32	4.49	4.40	5.08	5.04
93A	1.30		4.69		4.24		4.19		4.15		4.86	
	1.38	1.34	4.83	4.76	4.45	4.34	4.31	4.25	4.29	4.22	4.96	4.91
94	1.30		4.57		3.98		3.92		3.88		4.80	
	1.38	1.34	4.75	4.66	4.15	4.06	3.98	3.95	4.05	3.96	4.96	4.88
94A	1.16		4.55		3.93		3.79		3.76		4.72	
	1.22	1.19	4.65	4.61	3.98	3.96	3.87	3.83	3.92	3.84	4.84	4.78
95	.95		3.75		3.42		3.26		----------		4.49	
	.96	.96	3.90	3.82	3.59	3.50	3.50	3.38	----------	----------	4.61	4.55
95A	1.31		4.40		4.20		3.98		----------		4.94	
	1.36	1.34	4.34	4.37	4.01	4.10	3.76	3.87	----------	----------	4.94	4.94
96	1.69		4.85		4.45		4.23		4.34		5.03	
	1.72	1.70	4.97	4.91	4.54	4.50	4.34	4.28	4.40	4.37	5.22	5.12
96A	1.65		4.99		4.45		4.45		4.35		5.09	
	1.66	1.66	5.02	5.00	4.50	4.48	4.32	4.39	4.34	4.34	5.22	5.16
97	1.52		4.40		3.96		3.90		----------		4.99	
	1.48	1.50	4.51	4.46	4.12	4.04	4.03	3.96	----------	----------	5.04	5.02
97A	1.54		4.57		4.11		4.07		----------		4.98	
	1.60	1.57	4.54	4.56	4.20	4.16	4.17	4.12	----------	----------	5.09	5.04
98	1.50		4.75		4.34		4.14		----------		5.12	
	1.54	1.52	4.85	4.80	4.43	4.38	4.25	4.20	----------	----------	5.15	5.14
98A	1.43		4.83		4.45		4.29		----------		5.10	
	1.39	1.41	4.75	4.79	4.30	4.38	4.12	4.20	----------	----------	5.09	5.10
99	1.82		4.75		4.31		4.21		----------		5.09	
	1.88	1.85	4.60	4.68	4.38	4.34	4.25	4.23	----------	----------	5.00	5.04
99A	1.89		5.03		4.59		4.51		----------		5.34	
	1.98	1.94	4.72	4.88	4.51	4.55	4.38	4.44	----------	----------	5.30	5.32
101	1.98		4.87		4.60		4.50		----------		5.08	
	2.06	2.02	5.02	4.94	4.74	4.67	4.59	4.54	[5] 4.60	[5] 4.60	5.33	5.20
101A	1.78		4.66		4.38		4.25		----------		4.93	
	1.80	1.79	4.78	4.72	4.47	4.42	4.35	4.30	----------	----------	5.30	5.12
163	1.66		4.57		4.09		3.94		4.15		5.13	
	1.73	1.70	4.60	4.58	4.27	4.18	4.08	4.01	4.25	4.20	5.18	5.16
163A	1.72		4.63		4.17		4.02		4.18		5.17	
	1.69	1.70	4.67	4.65	4.19	4.18	4.00	4.01	4.16	4.17	5.17	5.17
164	1.88		4.84		4.59		4.48		4.50		5.39	
	1.82	1.85	4.85	4.84	4.65	4.62	4.53	4.59	4.50	4.50	5.35	5.37
164A	2.12		4.94		4.56		4.49		4.56		5.42	
	2.12	2.12	4.84	4.89	4.63	4.60	4.50	4.50	4.48	4.52	5.37	5.40

165	1.88		4.69		4.52		4.46		4.38		5.19	
	1.84	1.86	4.82	4.76	4.68	4.60	4.64	4.55	4.54	4.46	5.31	5.25
165A	2.06		4.95		4.77		4.76		4.71		5.40	
	2.13	2.10	4.93	4.94	4.82	4.80	4.80	4.78	4.70	4.70	5.42	5.41
166	2.40		4.96		4.86		4.91		4.66		5.42	
	2.30	2.35	4.87	4.92	4.82	4.84	4.82	4.87	4.56	4.61	5.30	5.36
166A	2.07		4.85		4.82		4.80		4.56		5.27	
	2.06	2.06	4.94	4.90	4.95	4.88	4.90	4.85	4.64	4.60	5.37	5.32
167	1.61		4.86		4.55		4.42		4.42		5.34	
	1.55	1.58	4.75	4.80	4.45	4.50	4.30	4.36	4.31	4.36	5.18	5.26
167A	1.67		4.61		4.36		4.24		4.28		5.17	
	1.83	1.75	4.83	4.72	4.57	4.46	4.41	4.32	4.45	4.36	5.43	5.30
168	2.40		4.77		4.71		4.64		4.50		5.08	
	2.50	2.45	5.05	4.91	4.98	4.84	4.86	4.75	4.74	4.62	5.40	5.24
168A	2.36		5.11		4.95		4.85		4.72		5.40	
	2.14	2.25	4.74	4.92	4.62	4.78	4.55	4.70	4.43	4.58	5.07	5.24
169	2.73		5.01		5.02		5.00		4.80		5.38	
	2.62	2.68	4.85	4.93	4.94	4.98	4.85	4.92	4.68	4.74	5.27	5.32
169A	2.42		4.81		4.82		4.77		4.62		5.23	
	2.41	2.42	4.75	4.78	4.65	4.74	4.64	4.70	4.42	4.52	5.02	5.12
170	2.24		4.78		4.80		4.75		4.56		5.17	
	2.31	2.28	5.00	4.89	5.07	4.94	5.01	4.88	4.84	4.70	5.48	5.32
170A	2.13		4.95		4.94		4.91		4.75		5.38	
	2.28	2.20	4.99	4.97	5.04	4.99	4.98	4.94	4.85	4.80	5.49	5.44
171	1.62		5.05		4.70		4.59		4.69		5.68	
	1.63	1.62	5.05	5.05	4.68	4.69	4.54	4.56	4.66	4.68	5.67	5.68
171A	1.60		4.72		4.32		4.27		4.38		5.29	
	1.54	1.57	4.69	4.70	4.25	4.28	4.14	4.20	4.36	4.37	5.27	5.28
172	1.38		4.93		4.40		4.37		4.34		5.25	
	1.42	1.40	4.87	4.90	4.47	4.44	4.45	4.41	4.32	4.33	5.30	5.28
172A	1.14		4.48		4.11		4.07		3.95		4.89	
	1.21	1.18	4.69	4.58	4.29	4.20	4.24	4.16	4.15	4.05	5.07	4.98
173	1.81		4.75		4.56		4.49		4.39		5.38	
	1.83	1.82	4.72	4.74	4.53	4.54	4.44	4.46	4.34	4.36	5.23	5.30
173A	1.57		4.35		4.11		4.04		3.99		4.92	
	1.64	1.60	4.59	4.47	4.33	4.22	4.25	4.14	4.19	4.09	5.12	5.02
174	2.39		4.36		4.46		4.36		4.31		4.99	
	2.51	2.45	4.55	4.46	4.70	4.58	4.62	4.49	4.45	4.38	5.18	5.08
174A	2.18		4.40		4.49		4.38		4.28		5.03	
	2.28	2.23	4.40	4.40	4.47	4.48	4.36	4.37	4.25	4.26	5.06	5.04
175	1.65		4.54		4.28		4.08		4.18		5.09	
	1.67	1.66	4.57	4.56	4.46	4.37	4.22	4.15	4.25	4.22	5.20	5.14
175A	1.61		4.53		4.21		4.06		4.13		5.05	
	1.68	1.64	4.42	4.48	4.14	4.18	3.96	4.01	4.03	4.08	4.97	5.01
176	1.16		4.06		3.84		3.78		3.82		4.97	
	1.17	1.16	4.09	4.08	4.03	3.94	3.92	3.85	3.96	3.89	5.04	5.00
176A	1.14		4.15		3.98		3.91		3.94		5.13	
	1.10	1.12	4.11	4.13	3.95	3.96	3.85	3.88	3.94	3.94	5.06	5.10

TABLE 3.6. *Dynamic Young's modulus of elasticity of concretes*—Continued

No. [1]	Dynamic modulus E_0, psi $\times 10^{-6}$											
	1 d	Average	14 d	Average	42 d	Average	70 d	Average	71 d	Average	98 d	Average
Type II												
177	1.65		4.51		4.30		4.14		4.16		5.02	
	1.73	1.69	4.71	4.61	4.51	4.40	4.33	4.24	4.34	4.25	5.19	5.10
177A	1.67		4.72		4.31		4.22		4.29		5.19	
	1.68	1.68	4.70	4.71	4.45	4.38	4.30	4.26	4.30	4.30	5.18	5.18
178	2.01		4.77		4.79		4.67		4.60		5.34	
	2.06	2.03	4.81	4.79	4.83	4.81	4.75	4.71	4.63	4.61	5.40	5.37
178A	1.95		4.71		4.74		4.68		4.56		5.33	
	1.84	1.90	4.48	4.60	4.55	4.64	4.47	4.58	4.34	4.45	5.08	5.20
179	1.96		4.90		4.73		4.59		4.48		5.29	
	2.01	1.98	4.94	4.92	4.80	4.76	4.65	4.62	4.55	4.52	5.42	5.36
179A	2.11		4.85		4.70		4.59		4.49		5.20	
	2.25	2.18	4.97	4.91	4.77	4.74	4.75	4.67	4.61	4.55	5.46	5.33
Type IIA												
100	1.41		3.76		3.64		3.50		3.61		4.42	
	1.23	1.32	3.56	3.66	3.28	3.46	3.17	3.34	3.32	3.46	4.18	4.30
100A	1.47		3.69		3.62		3.43		3.58		4.29	
	1.42	1.44	3.62	3.66	3.36	3.49	3.28	3.36	3.39	3.48	4.23	4.26
Type III												
102	2.66		5.21		4.75		4.60		4.58		5.03	
	2.61	2.64	5.19	5.20	4.66	4.70	4.48	4.54	4.52	4.55	5.00	5.02
102A	2.59		5.22		4.76		4.60		4.49		4.97	
	2.49	2.54	5.09	5.16	4.56	4.66	4.43	4.52	4.35	4.42	4.87	4.92
103	2.53		4.79		4.45		4.35		4.39		5.05	
	2.49	2.51	4.74	4.76	4.42	4.44	4.24	4.30	4.33	4.36	5.00	5.02
103A	2.70		5.02		4.65		4.55		4.63		5.30	
	2.79	2.74	5.11	5.06	4.77	4.71	4.61	4.58	4.69	4.66	5.40	5.35
104	3.16		5.05		4.68		4.42		4.57		5.06	
	3.40	3.28	5.25	5.15	4.87	4.78	4.77	4.60	4.52	4.54	5.15	5.10
104A	3.11		5.09		4.62		4.42		4.46		5.05	
	2.98	3.04	4.91	5.00	4.40	4.51	4.33	4.38	4.43	4.44	4.92	4.98
105	2.42		5.15		4.89		4.86		4.58		5.20	
	2.41	2.42	5.09	5.12	4.65	4.77	4.72	4.79	4.55	4.56	5.20	5.20
105A	2.67		5.43		4.90		4.85		4.92		5.37	
	2.61	2.64	5.35	5.39	4.90	4.90	4.85	4.85	4.93	4.92	5.37	5.37
106	2.13		4.84		4.76		4.70		4.63		5.17	
	2.16	2.14	4.93	4.88	4.83	4.80	4.70	4.70	4.51	4.57	5.27	5.22
106A	2.13		4.97		4.85		4.74		4.70		5.24	
	2.27	2.20	5.01	4.99	4.85	4.85	4.77	4.76	4.72	4.71	5.27	5.26

180	2.96		5.03		4.86		4.78		4.73		5.24	
	2.96	2.96	5.05	5.04	4.91	4.88	4.82	4.80	4.78	4.76	5.28	5.26
180A	2.92		5.11		4.91		4.80		4.77		5.29	
	2.90	2.91	5.08	5.10	4.89	4.90	4.77	4.78	4.71	4.74	5.25	5.27
181	2.82		5.09		4.83		4.67		4.70		5.24	
	2.79	2.80	4.96	5.02	4.64	4.74	4.56	4.62	4.56	4.63	5.08	5.16
181A	2.85		4.93		4.68		4.60		4.55		5.10	
	2.92	2.88	5.19	5.02	4.80	4.74	4.71	4.66	4.71	4.63	5.22	5.16
182	3.23		5.08		5.02		4.93		4.72		5.07	
	3.23	3.23	5.08	5.08	4.91	4.96	4.91	4.92	4.70	4.71	5.05	5.06
182A	3.01		4.92		4.74		4.67		4.51		4.85	
	3.06	3.04	4.99	4.96	4.80	4.77	4.74	4.70	4.57	4.54	4.95	4.90
183	3.35		5.18		5.14		5.11		4.92		5.28	
	3.32	3.34	5.02	5.10	4.93	5.04	4.93	5.02	4.72	4.82	5.13	5.20
183A	3.40		5.30		5.32		5.29		5.08		5.32	
	3.16	3.28	4.95	5.12	4.90	5.11	4.89	5.09	4.65	4.86	4.98	5.15
184	3.32		5.10		5.16		5.14		5.08		5.44	
	3.47	3.40	5.36	5.23	5.36	5.26	5.40	5.27	5.27	5.18	5.62	5.53
184A	3.20		5.08		5.09		5.11		4.97		5.20	
	3.33	3.26	5.25	5.16	5.24	5.16	5.21	5.16	5.07	5.02	5.34	5.27
185	3.19		4.95		4.85		4.82		4.71		5.08	
	3.28	3.24	5.15	5.05	4.94	4.90	4.92	4.87	4.77	4.74	5.12	5.10
185A	3.17		5.08		4.82		4.79		4.72		5.07	
	3.06	3.12	4.92	5.00	4.74	4.78	4.71	4.75	4.50	4.61	4.85	4.96
186	2.90		4.96		4.88		4.85		4.79		5.17	
	3.21	3.06	5.34	5.15	5.17	5.02	5.18	5.02	5.05	4.92	5.45	5.31
186A	3.14		5.01		4.96		4.99		4.83		5.22	
	3.24	3.19	5.18	5.10	5.25	5.10	5.22	5.10	5.05	4.94	5.46	5.34
187	3.21		5.05		5.05		5.02		4.85		5.26	
	3.25	3.23	5.05	5.05	5.05	5.05	5.02	5.02	4.83	4.84	5.22	5.24
187A	3.20		4.89		4.90		4.87		4.70		5.08	
	3.43	3.32	5.14	5.02	5.19	5.04	5.15	5.01	4.96	4.83	5.35	5.22
188	3.25		5.07		4.92		4.90		4.72		5.16	
	3.29	3.27	5.10	5.08	5.10	5.01	5.14	5.02	4.83	4.78	5.28	5.22
188A	3.15		5.14		5.01		4.99		4.77		5.13	
	3.30	3.22	5.29	5.22	5.27	5.14	5.19	5.09	4.95	4.86	5.31	5.22
189	2.59		4.78		4.61		4.58		4.45		5.15	
	2.62	2.60	4.75	4.76	4.64	4.62	4.56	4.57	4.43	4.44	5.13	5.14
189A	2.73		4.90		4.82		4.78		4.62		5.27	
	2.61	2.67	4.80	4.85	4.67	4.74	4.60	4.69	4.45	4.54	5.15	5.21
190	3.26		4.98		5.08		5.06		4.85		5.31	
	3.16	3.21	4.97	4.98	5.08	5.08	5.03	5.04	4.79	4.82	5.20	5.26
190A	2.87		4.81		4.89		4.87		4.67		5.11	
	2.88	2.88	4.86	4.84	4.91	4.90	4.88	4.88	4.69	4.68	5.07	5.09
191	3.61		4.90		4.61		4.47		4.41		4.96	
	3.68	3.64	4.95	4.92	4.69	4.65	4.58	4.52	4.53	4.47	5.12	5.04
191A	3.61		4.90		4.60		4.46		4.44		4.93	
	3.38	3.50	4.65	4.78	4.33	4.46	4.20	4.33	4.15	4.30	4.69	4.81
192	3.17		5.40		5.29		5.24		5.10		5.46	
	3.12	3.14	5.36	5.38	5.24	5.26	5.19	5.22	5.04	5.07	5.41	5.44
192A	2.83		5.01		5.03		5.04		4.87		5.19	
	2.92	2.88	5.30	5.16	5.24	5.14	5.21	5.12	5.02	4.94	5.35	5.27

TABLE 3.6. *Dynamic Young's modulus of elasticity of concretes*—Continued

No. [1]	Dynamic modulus E_0, psi $\times 10^{-6}$											
	1 d	Average	14 d	Average	42 d	Average	70 d	Average	71 d	Average	98 d	Average
Type III												
193	2.79		4.83		4.75		4.76		4.63		5.16	
	2.74	2.76	4.76	4.80	4.67	4.71	4.64	4.70	4.48	4.56	5.09	5.12
193A	2.85		4.95		4.95		4.92		4.75		5.26	
	3.01	2.93	5.04	5.00	5.09	5.02	5.06	4.99	4.89	4.82	5.44	5.35
Type IIIA												
194	2.15		3.96		4.02		4.00		3.90		4.29	
	2.11	2.13	3.94	3.95	4.01	4.02	3.98	3.99	3.87	3.88	4.24	4.26
194A	2.78		4.64		4.72		4.69		4.59		4.93	
	2.70	2.74	4.46	4.55	4.54	4.63	4.52	4.60	4.44	4.52	4.81	4.87
195	2.41		4.27		4.11		4.09		4.02		4.41	
	2.45	2.43	4.29	4.28	4.17	4.14	4.11	4.10	4.07	4.04	4.46	4.44
195A	2.71		4.49		4.42		4.35		4.27		4.67	
	2.71	2.71	4.38	4.44	4.37	4.40	4.27	4.31	4.21	4.24	4.61	4.64
Type IV												
107	1.66		4.54		4.19		4.06		4.26		5.36	
	1.51	1.58	4.48	4.51	4.22	4.20	4.03	4.04	4.20	4.23	5.21	5.28
107A	1.63		4.50		4.13		3.93		4.17		5.22	
	1.70	1.66	4.45	4.48	4.10	4.12	4.00	3.96	4.11	4.14	5.15	5.18
108	1.32		3.82		4.03		3.92		3.89		4.78	
	1.35	1.34	4.00	3.91	4.09	4.06	3.99	3.90	3.95	3.92	4.93	4.86
108A	1.44		4.14		4.20		4.14		4.17		4.99	
	1.44	1.44	4.14	4.14	4.30	4.25	4.15	4.14	4.15	4.16	5.02	5.00
196	1.23		3.90		3.58		3.47		[5] 3.84		4.93	
	1.27	1.25	3.95	3.92	3.64	3.61	3.52	3.50	[5] 3.85	[5] 3.84	4.94	4.94
196A	1.12		3.98		3.61		3.44		[5] 3.83		5.00	
	1.16	1.14	3.96	3.97	3.68	3.64	3.51	3.48	[5] 3.84	[5] 3.84	5.02	5.01
Type V												
109	2.39		3.55		3.59		3.44		3.53		4.42	
	2.30	2.34	3.55	3.55	3.59	3.59	3.43	3.44	3.57	3.55	4.54	4.48
109A	2.34		3.63		3.75		3.53		3.61		4.57	
	1.50	1.92	3.56	3.60	3.64	3.70	3.46	3.50	3.54	3.58	4.57	4.57
110	3.05		4.19		4.43		4.27		3.92		4.96	
	3.05	3.05	4.21	4.20	4.45	4.44	4.27	4.27	4.20	4.06	4.99	4.98
110A	3.07		4.29		4.51		4.29		4.26		5.02	
	3.54	3.30	4.35	4.32	4.63	4.57	4.51	4.80	4.29	4.28	5.03	5.02
111	1.73		4.37		4.59		4.45		4.40		5.15	
	1.69	1.71	4.35	4.36	4.50	4.54	4.43	4.44	4.37	4.38	5.00	5.08
111A	1.89		4.54		4.74		4.61		4.51		5.20	
	1.88	1.88	4.52	4.53	4.68	4.71	4.55	4.58	4.56	4.54	5.15	5.18

112	1.82		4.32		4.48		4.27		4.34		5.10	
	1.71	1.76	4.30	4.31	4.40	4.44	4.22	4.24	4.25	4.30	5.00	5.05
112A	1.98		4.57		4.62		4.43		4.43		5.28	
	1.88	1.93	4.55	4.56	4.53	4.58	4.41	4.42	4.40	4.42	5.20	5.24
113	1.76		4.81		4.63		4.50		4.43		5.16	
	1.61	1.68	4.63	4.72	4.47	4.55	4.35	4.42	4.25	4.34	4.99	5.08
113A	1.75		4.78		4.71		4.53		4.45		5.21	
	1.72	1.74	4.75	4.76	4.56	4.64	4.45	4.49	4.34	4.40	5.10	5.16
114	1.56		4.60		4.47		4.34		4.46		5.11	
	1.51	1.54	4.43	4.56	4.28	4.38	4.17	4.26	4.40	4.43	4.96	5.04
114A	1.52		4.50		4.40		4.25		4.50		5.12	
	1.61	1.56	4.46	4.48	4.36	4.38	4.24	4.24	4.41	4.46	4.99	5.06
115	1.64		4.74		4.32		4.25		4.33		5.21	
	1.63	1.64	4.77	4.76	4.55	4.44	4.31	4.28	4.41	4.37	5.24	5.22
115A	1.54		4.60		4.21		4.20		4.25		5.05	
	1.53	1.54	4.59	4.60	4.29	4.25	4.37	4.28	4.23	4.24	5.03	5.04
116	1.75		4.87		4.55		4.48		4.60		5.34	
	1.69	1.72	4.80	4.84	4.62	4.58	4.57	4.52	4.50	4.55	5.25	5.30
116A	1.43		4.60		4.26		4.06		4.25		5.09	
	1.44	1.44	4.53	4.56	4.40	4.33	4.34	4.20	4.19	4.22	4.96	5.01
117	1.77		4.61		4.48		4.36		4.29		4.93	
	1.72	1.74	4.75	4.68	4.56	4.52	4.48	4.42	4.35	4.32	5.07	5.00
117A	1.65		4.63		4.48		4.39		4.31		5.03	
	1.57	1.61	4.47	4.55	4.30	4.39	4.25	4.32	4.20	4.26	4.90	4.97
118	1.34		4.33		4.16		4.03		3.98		4.97	
	1.39	1.36	4.40	4.36	4.21	4.18	4.15	4.09	4.11	4.04	4.99	4.98
118A	1.16		3.95		3.98		3.86		3.88		4.59	
	1.27	1.22	4.14	4.04	3.95	3.97	3.96	3.91	3.93	3.90	4.71	4.65
119	1.72		4.99		4.89		4.77		----------		5.32	
	1.75	1.74	5.04	5.02	4.90	4.90	4.75	4.76	----------	----------	5.40	5.36
119A	1.84		4.95		4.85		4.77		----------		5.30	
	1.92	1.88	5.06	5.00	4.95	4.90	4.82	4.80	----------	----------	5.30	5.30
197	2.13		4.80		4.81		4.82		[6] 4.73		5.25	
	2.28	2.20	4.95	4.88	4.96	4.88	4.91	4.86	[6] 4.88	[6] 4.80	5.41	5.33
197A	2.26		4.90		4.92		4.86		[6] 4.84		5.37	
	2.14	2.20	4.80	4.85	4.88	4.90	4.86	4.86	[6] 4.78	[6] 4.81	5.34	5.36
Miscellaneous												
120	1.55		4.57		4.51		4.20		4.20		5.01	
	1.56	1.56	4.70	4.64	4.73	4.62	4.56	4.38	4.45	4.32	5.05	5.03
120A	1.43		4.60		4.49		4.40		4.30		4.99	
	1.30	1.36	4.40	4.50	4.37	4.43	4.17	4.28	4.11	4.20	4.80	4.90
121	2.06		----------		4.40		4.10		4.25		5.10	
	1.95	2.00	4.62	4.62	4.27	4.34	4.00	4.05	4.00	4.12	4.89	5.00
121A	1.68		4.45		4.17		3.92		3.94		4.78	
	1.77	1.72	4.57	4.51	4.25	4.21	4.00	3.96	4.08	4.01	4.82	4.80
122	2.06		4.91		4.77		4.54		4.55		5.11	
	2.03	2.04	4.75	4.83	4.48	4.62	4.28	4.41	4.31	4.43	5.03	5.07
122A	2.14		5.11		4.74		4.56		4.60		5.25	
	2.12	2.13	4.84	4.98	4.55	4.64	4.38	4.47	4.42	4.51	5.08	5.17

TABLE 3.6. *Dynamic Young's modulus of elasticity of concretes*—Continued

No. [1]	Dynamic modulus E_0, psi $\times 10^{-6}$											
	1 d	Average	14 d	Average	42 d	Average	70 d	Average	71 d	Average	98 d	Average
123	1.49		3.51		3.31		3.22		3.42		4.50	
	1.48	1.48	3.40	3.46	3.31	3.31	3.20	3.21	3.32	3.37	4.30	4.40
123A	1.85		4.12		3.94		3.77		3.92		4.87	
	1.78	1.82	3.97	4.04	3.86	3.90	3.74	3.76	3.82	3.87	4.80	4.84
Type S—Slag												
198	2.23		4.43		[7] 4.24		4.17		4.10		5.15	
	2.24	2.24	4.44	4.44	[7] 4.23	[7] 4.24	4.04	4.10	4.14	4.12	5.06	5.10
198A	2.19		4.37		[7] 4.27		4.14		4.10		5.05	
	2.27	2.23	4.45	4.41	[7] 4.35	[7] 4.31	4.25	4.20	4.32	4.21	5.17	5.11
199	2.06		4.86		[7] 4.45		4.31		4.19		5.19	
	1.99	2.02	4.78	4.82	[7] 4.32	[7] 4.38	4.08	4.20	4.05	4.12	5.05	5.12
199A	1.93				[7] 4.22		4.02		3.97		4.94	
	2.01	1.97	4.85	4.85	[7] 4.32	[7] 4.27	4.14	4.08	4.11	4.04	5.09	5.02
200	1.89		5.11		[7] 4.38		4.23		4.54		5.09	
	2.00	1.94	5.07	5.09	[7] 4.35	[7] 4.36	4.17	4.20	4.44	4.49	4.95	5.02
200A	1.77		4.91		[7] 4.10		3.91		4.15		4.79	
	1.76	1.76	4.95	4.93	[7] 4.12	[7] 4.11	3.97	3.94	4.16	4.16	4.78	4.78
Type SA—Slag												
201	1.92		3.74		3.61		3.52		3.62		4.54	
	1.70	1.81	3.43	3.58	3.26	3.44	3.18	3.35	3.24	3.43	4.10	4.32
201A	2.17		4.00		3.89		3.77		3.87		4.78	
	2.26	2.22	4.10	4.04	3.97	3.93	3.86	3.82	3.97	3.92	4.90	4.84
202	1.66		3.96		3.65		3.56		3.64		4.72	
	1.71	1.68	4.04	4.00	3.78	3.72	3.69	3.62	3.71	3.68	4.78	4.75
202A	1.62		3.97		3.72		3.63		3.63		4.71	
	1.73	1.68	4.20	4.08	3.92	3.82	3.78	3.70	3.85	3.74	4.97	4.84
203	1.12		3.66		3.53		3.52		3.39		4.19	
	1.17	1.14	3.78	3.72	3.68	3.60	3.61	3.56	3.55	3.47	4.30	4.24
203A	1.09		3.63		3.56		3.49		3.36		4.14	
	1.17	1.13	3.79	3.71	3.65	3.60	3.61	3.55	3.52	3.44	4.36	4.25

[1] Concrete having a 0.635 W/C ratio listed for each cement and the concretes with a slump of 5±1 inch indicated by the letter A.
[2] Sufficient cement for only one mix.
[3] Specimen cracked.
[4] Specimen broken.
[5] Measured at 70 days and 3 hours instead of at 71 days.
[6] Measured at 72 days instead of at 71 days.
[7] Measured at 47 days instead of at 42 days.

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