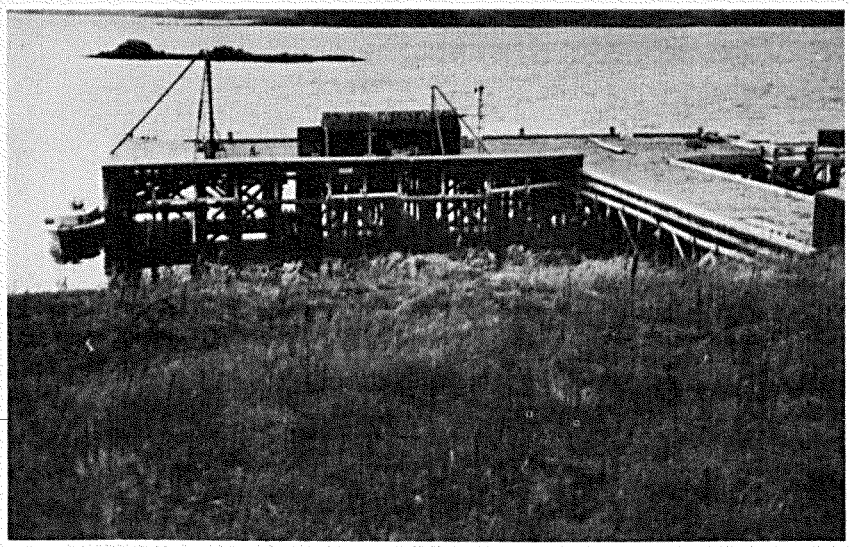

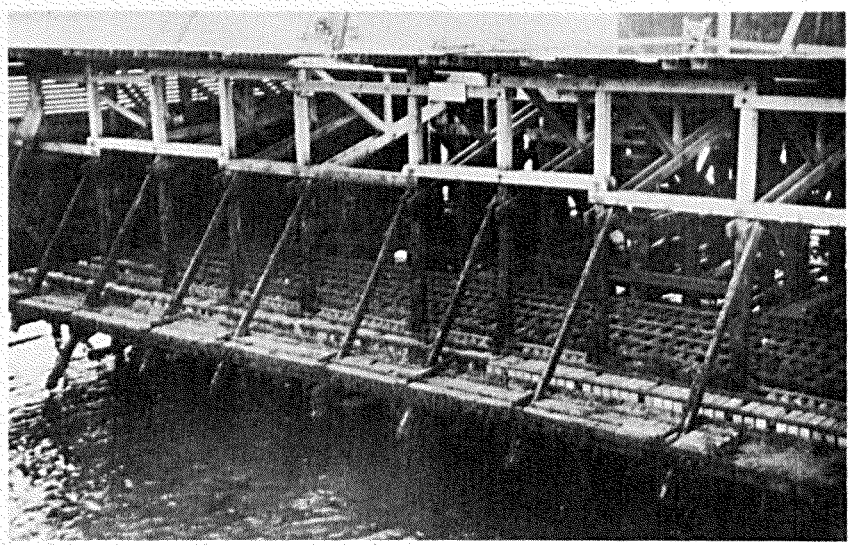

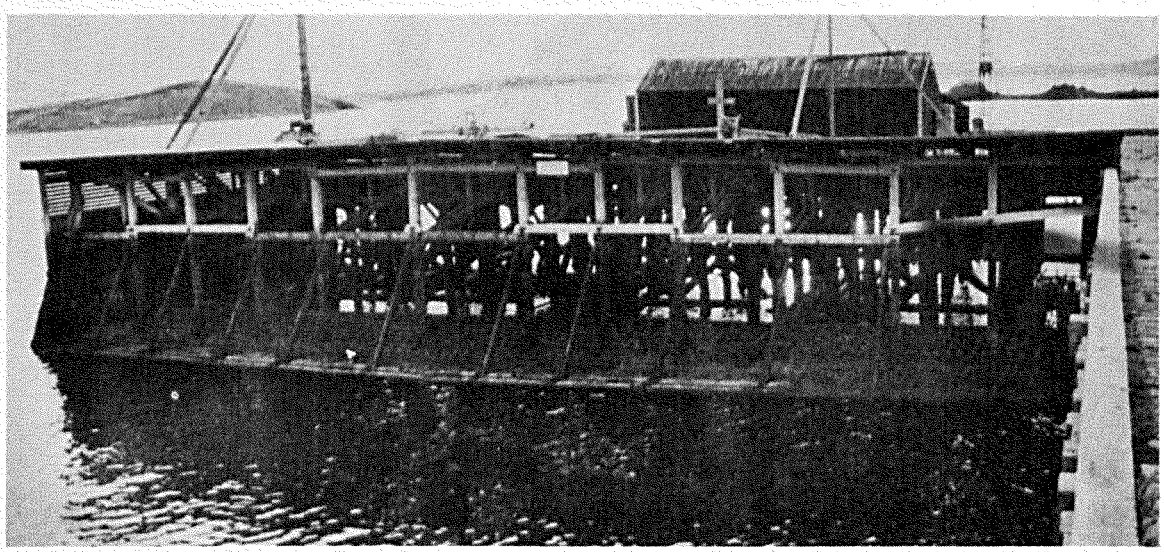

Frontispiece. Exposure station at Treat Island, Maine

CORPS OF ENGINEERS, U. S. ARMY

CONCRETE RESEARCH

THIRD INTERIM REPORT

SUPPLEMENT NO. 1

DURABILITY OF CONCRETE EXPOSED TO NATURAL WEATHERING

TECHNICAL MEMORANDUM NO. 6-226

WATERWAYS EXPERIMENT STATION

VICKSBURG, MISSISSIPPI

ARMY-WES-VICKSBURG, MISS.

JUNE 1950

PREFACE

The resistance of concrete to natural weathering has been studied since 1936 at an experimental exposure station located at Treat Island, Cobscook Bay, Maine, and since 1940 at a similar station at Salt Run, St. Augustine, Florida. The programs of investigation at these stations and at others located in New York State have previously been reported in Waterways Experiment Station Technical Memorandum No. 6-226, "Durability of Concrete Exposed to Natural Weathering," dated August 1947. Included in this supplement to Technical Memorandum No. 6-226 are data developed from those investigations which have been continued since 1947 and descriptions of several programs which have been initiated since that date. Further supplements will be issued from time to time as warranted by the data developed in these programs, pending a more complete report on those phases of the investigations not previously described.

Authority for the work reported herein is contained in multiple letter of the Office, Chief of Engineers, dated 14 September 1948, subject, "Civil Works Investigations of Office, Chief of Engineers," item CW 604-Concrete "Continuation of Permanent Exposure Stations." The studies were conducted under the supervision of Herbert K. Cook and Bryant Mather by E. J. Callan, L. K. Farrior and M. H. Peabody. This report was prepared by E. J. Callan.

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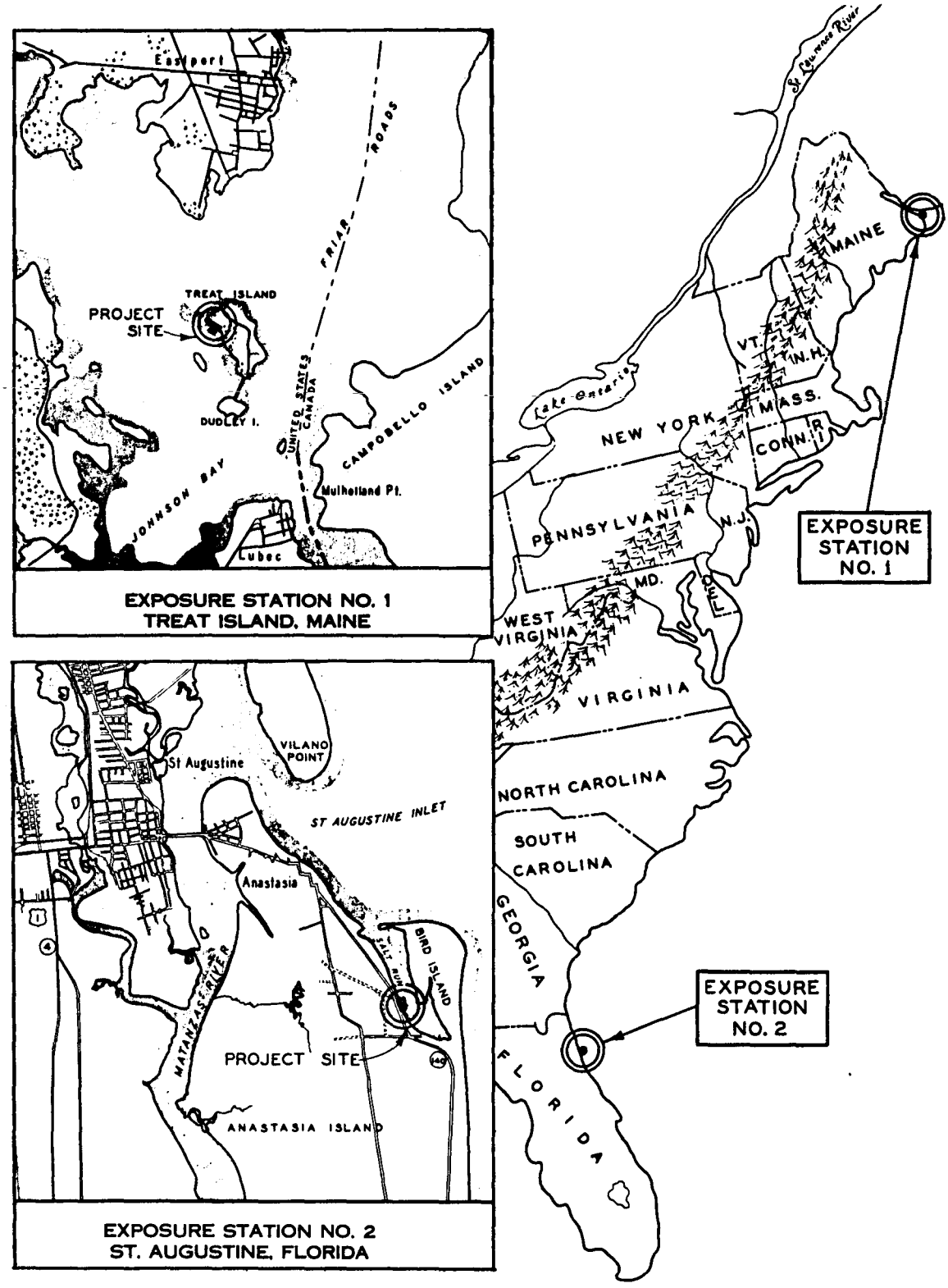


Fig. 1. Location and vicinity maps of exposure stations 1 and 2

DURABILITY OF CONCRETE EXPOSED TO NATURAL WEATHERING

SUPPLEMENT NO. 1

PART I: EXPOSURE STATIONS AND TEST METHODS

1. The resistance of concrete to natural weathering has been studied since 1936 at an exposure station located at Treat Island, Cobscook Bay, Maine, and since 1940 at a similar station at Salt Run, St. Augustine, Florida. (Additional stations in New York State have been abandoned.) Figure 1 shows locations of the exposure stations.

Treat Island

2. The Treat Island, Maine, experimental exposure installation (frontispiece and fig. 1) consists of a wharf with a rack situated at mean-tide elevation upon which specimens are exposed and subjected to twice-daily reversal of tides. During winter months the alternate exposure to freezing air and submergence in sea water at approximately 34 F produce vigorous thermal shock and frequent and severe cycles of freezing-and-thawing in the concrete. The low temperature of the water (maximum annual range 30-42 F) prevents or greatly inhibits any chemical reactions between the concrete and the dissolved salts in the sea water.

3. During the winters of 1947-48 and 1948-49, the following number of cycles and degrees of freezing-and-thawing in the concrete specimens were attained:

Winter	Cycles of Freezing-and-thawing	Total Degrees
1947-8	131	979
1948-9	105	630

The number of degrees is computed by subtracting from 28 F the lowest temperature reached, during each cycle, at the center of a 6- by 6- by 36-in. concrete prism installed on the rack, and totaling for the entire number of cycles. The 28 F temperature was chosen as the approximate freezing point of concrete saturated with sea water. Figure 2 shows graphically the intensity of weathering at Treat Island since 1940.

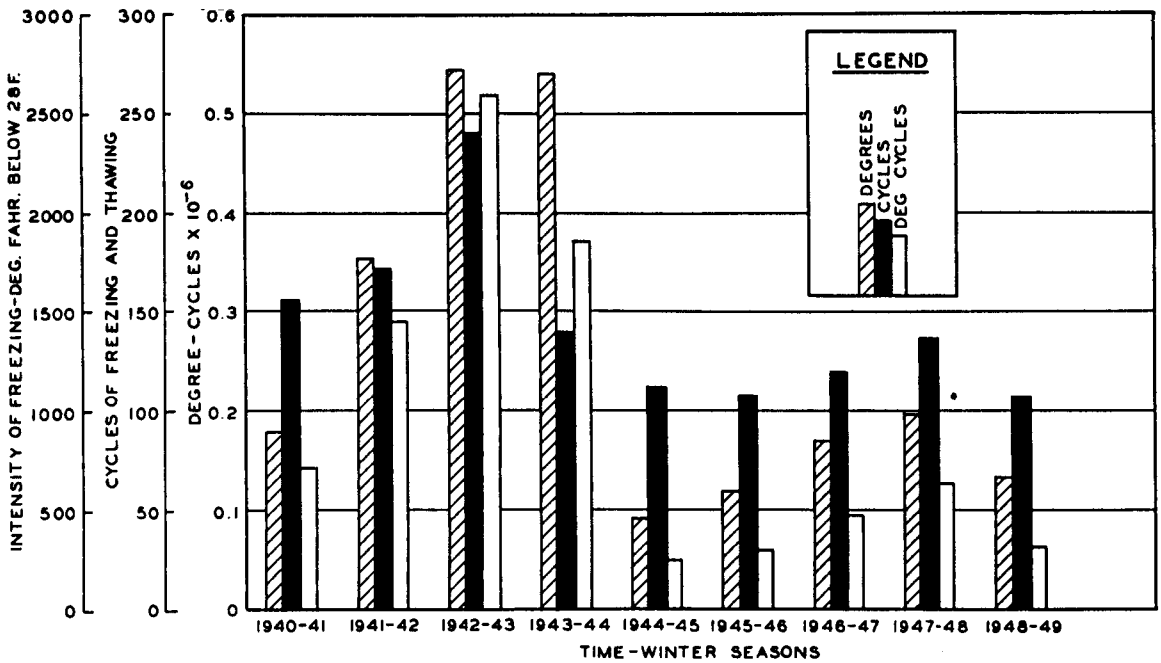


Fig. 2. Annual variation in exposure of concrete specimens subjected to freezing-and-thawing at Treat Island, Maine

4. To evaluate the exposure, consideration must be given to the variable intensity of the cycles of freezing-and-thawing. This has been done by basing the comparison of groups of specimens on degree-cycles rather than merely on cycles. The degree-cycles of exposure for a specimen are obtained by multiplying the total number of degrees by the total number of cycles since installation, for each specimen or group of specimens. A more valid comparison of exposure for groups of specimens

installed at various times is thus obtained.

St. Augustine

5. To afford a comparison of the effects of sea water on concrete specimens, apart from the effects of freezing-and-thawing, the experimental exposure station located at Salt Run near St. Augustine, Florida, (fig. 1) was instituted in 1940. The specimens at this installation are exposed on a mean-tide rack similarly to those at Treat Island. No freezing-and-thawing has been encountered at this location. The mean water temperature of about 70 F is conducive to attack on the concrete specimens by the dissolved salts in the sea water should such tendency to reaction exist.

Test Methods

6. Wherever possible, the concrete specimens at both installations are subjected to test for dynamic modulus of elasticity at regular intervals during the exposure. For certain types such as spherical specimens, cores with inclosed ends, and 8-cu-ft concrete cubes, this testing is not feasible; the majority of specimens, however, are tested in the following manner. The specimen is supported in a horizontal position at the nodes and caused to vibrate in its fundamental flexural mode. The resonant frequency is obtained by observing the maximum indication on a suitable meter as the applied frequency is varied. From this value, together with the shape, dimensions, and specific gravity of the specimen, the dynamic modulus of elasticity is determined. The moduli so determined are expressed as percentages of the initial dynamic modulus obtained prior to

installation on the exposure rack (relative dynamic modulus of elasticity = Rel E, %).

7. The relative durability of a specimen tested as described above is calculated from the relative modulus of elasticity and the number of degree-cycles. Where the relative dynamic modulus is 50 per cent or greater for a given number of degree-cycles, the durability factor (DFE) is equal to the relative modulus in per cent. In cases where the relative modulus is less than 50 per cent at a given number of degree-cycles, the durability factor is computed as follows:

$$DFE = \frac{50N}{M}$$

Where: DFE = durability factor,

N = number of degree-cycles at which the relative modulus of elasticity reached 50 per cent, and

M = number of degree-cycles for which the durability factor is desired.

8. Visual inspection of all specimens is made weekly at Treat Island to ascertain the condition of the specimens and to determine the approximate dates on which specimens fail between testing periods. More detailed inspection of specimens not amenable to testing is made, at times comparable to the testing periods, to determine the condition of such specimens and to permit comparisons of durability for these specimens. Specimens are regarded as having failed when they separate into pieces, when the relative dynamic modulus of elasticity is less than 50 per cent, or, in special cases when the purpose of the specimen is limited to study of such features, when failure at a joint plane, or of the surface, has occurred.

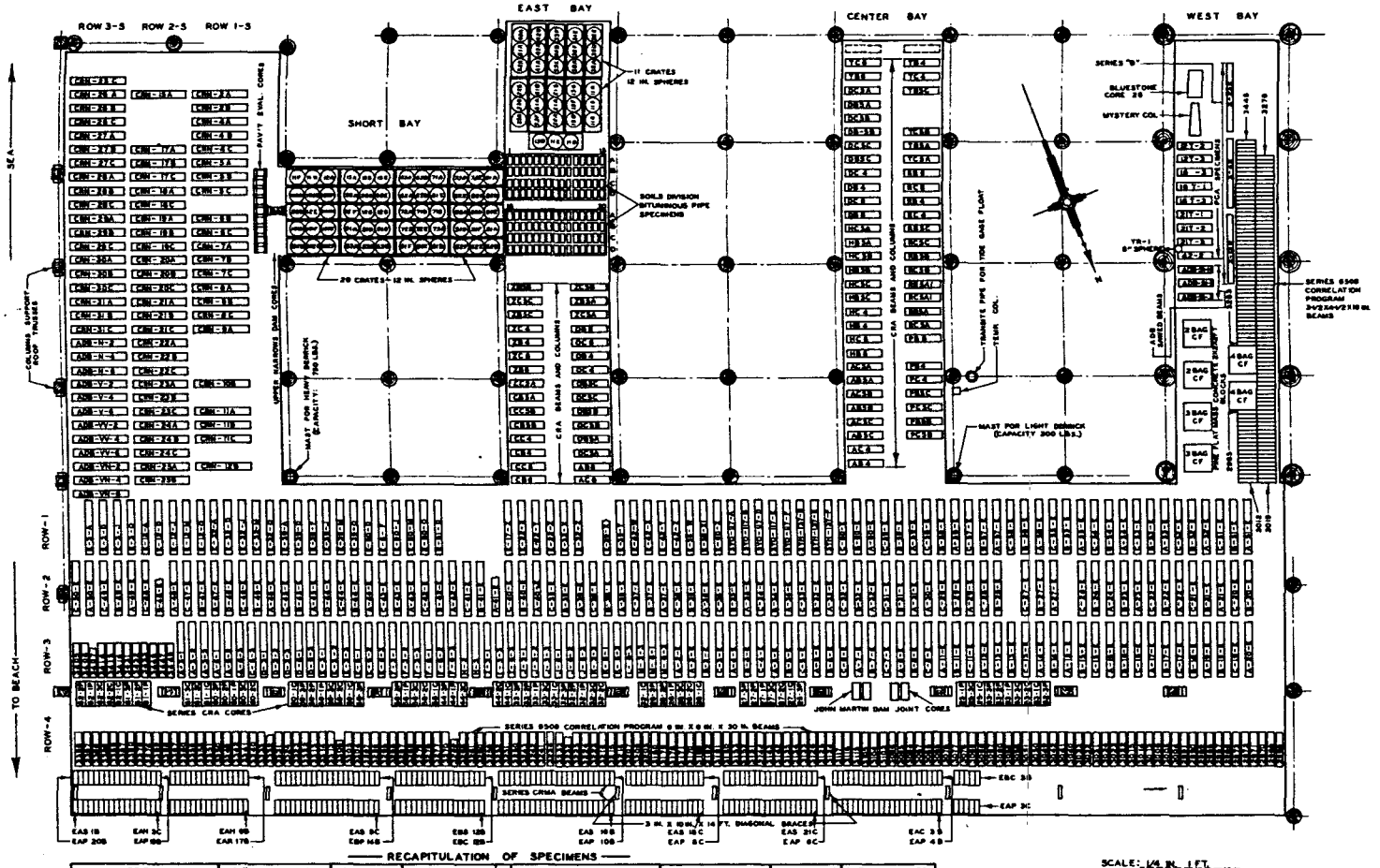
Summary of Specimens

9. At present there are exposed at Treat Island 1168 concrete specimens representing 16 programs of investigation. (There are also 136 bituminous-coated metal pipe specimens exposed as part of investigational work of the Flexible Pavement Branch, Soils Division, Waterways Experiment Station.) A summary of the concrete specimens appears in the tabulation on the following page. Their location on the exposure rack is shown by figure 3.

Summary of Concrete Specimens Exposed at Treat Island as of May 1949

Series	Size of Specimen, in.	Date Exposed	Number Exposed	No. in Sound Condition	% Failure	Deg-Cy. x 10^6	Cycles F-&-T	Changes Since 1947
B	5 x 5 x 60	June 1936	43	3	93	(a)	1847	- - - -
CR-E(1940)	6 x 6 x 48	Oct 1940	271	19	93	12.51	1222	7 failed
CR-E(1941)	6 x 6 x 48	Oct 1941	38	4	90	9.93	1067	No change
CR-E(1942)	6 x 6 x 48	Oct 1942	48	13	73	6.84	899	3 failed
PCA	6 x 6 x 30	Oct 1941	66	6	91	9.90	1065	3 failed
ADB(Cast)	6 x 6 x 48	Dec 1941	12	12	0	9.48	1039	No change
ADB(Sawed)	5-1/2 x 6 x 30	Oct 1943	3	3	0	4.26	711	No change
CR-J(b)	8 x 16	Oct 1942	10	2	80	6.84	899	No change
CR-J(c)	12 x 24	Dec 1943	40	1	98	3.86	688	No change
CR-N	6 x 6 x 48	Oct 1942	94	63	33	6.84	899	11 failed
SY	6 x 6 x 48	Oct 1942	18	8	56	6.84	899	No change
CRM-A	3-1/2 x 4-1/2 x 20	Feb 1943	300	285	5	(d) 1.00	(d) 354	
						4.32	719	14 failed
CRM-A	24 x 20 box	June 1946	14	14	0	(e)	(e)	No change
SA-34	12 diam.	Oct 1943	93	93	0	4.26	711	No change. Removed to top of wharf 7/49
NBS	6 x 6 x 48	Oct 1943	116	25	78	4.26	711	Rapid disintegration
CR-NVR	6 x 6 x 48	Oct 1943	182	150	18	4.17	703	5 failed
32	6 x 12	Jan 1944	18	9	50	3.38	640	1 failed
CR-A	6 x 6 x 30	Nov 1944	90	84	7	2.71	569	3 failed
66	6 x 8	May 1946	68	68	0	1.00	354	None failed
6029	24 x 24 x 24	Sept 1947	6	6	0	0.38	236	Light spalling
6508	6 x 6 x 30	Dec 1948	150	150	0	0.07	105	No change
6508	3-1/2 x 4-1/2 x 16	Dec 1948	150	150	0	0.07	105	No change

Notes: (a) Not known.
(b) John Martin Dam padded joint cores.
(c) Bluestone Dam joint core.
(d) Since removal from insulated boxes, 1946.
(e) Stored on top of wharf, not exposed to tidal action or sea-water weathering exposure.



SCALE: 1/4 IN. 1 FT.

RECAPITULATION OF SPECIMENS

SERIES	SIZE OF SPEC.	NO. OF SPEC.	DATE INSTALLED
SERIES "B"	5 IN. X 5 IN. X 60 IN.	3	10 JUNE 1936
CR-E (OLD)	6 IN. X 6 IN. X 48 IN.	24	21 OCTOBER 1940
PCA	6 IN. X 6 IN. X 30 IN.	9	31 OCTOBER 1941
ADB (CAST BEAMS)	6 IN. X 6 IN. X 48 IN.	12	9 DECEMBER 1941
JOHN MARTIN DAM JOINT CORES	6 IN. DIAM.	2	10 OCTOBER 1942
CR-N (COLUMNS)	6 IN. X 6 IN. X 48 IN.	67	21 OCTOBER 1942
CR-E (NEW)	DO	15	21 OCTOBER 1942
ST SYRACUSE BEAMS	DO	9	21 OCTOBER 1942
CRM-A HORIZONTAL	3-1/2 IN. X 4-1/2 IN. X 20 IN.	150	3 FEBRUARY 1943
CRM-A VERTICAL	3-1/2 IN. X 4-1/2 IN. X 20 IN.	150	3 FEBRUARY 1943

SERIES	SIZE OF SPEC.	NO. OF SPEC.	DATE INSTALLED
POZZOLITH N. B. S.	6 IN. X 6 IN. X 48 IN.	42	8 OCTOBER 1943
ADB - 31 (JAMMED BEAMS)	5-1/2 IN. X 6 IN. X 30 IN.	3	11 OCTOBER 1943
CR - NYR	6 IN. X 6 IN. X 48 IN.	155	12 OCTOBER 1943
SPHERES	12 IN. DIAM., 6 IN. DIAM.	83, 1	15 OCTOBER 1943
CRA PADDED CORES	6 IN. DIAM. X 12 IN	48	10 DECEMBER 1943
UPPER NARROWS DAM CORES	8 IN. DIAM.	1	10 JANUARY 1944
PAVEMENT CORES	DO	8	10 JANUARY 1944
CRA BEAMS AND COLUMNS	6 IN. X 6 IN. X 30 IN.	88	4 NOVEMBER 1944
CORRELATION PROGRAM 8504 BEAMS	6 IN. X 6 IN. X 30 IN.	150	10 DECEMBER 1944
CORRELATION PROGRAM 8506 BEAMS	3-1/2 IN. X 4-1/2 IN. X 10 IN.	150	8 DECEMBER 1944
BITUMINOUS COATED PIPE	4 IN. X 7 IN. IN 2 RACKS	120	13 DECEMBER 1944

Fig. 3. Layout of specimens; exposure rack, Treat Island, Me. 1 January 1949

PART II: CONTINUING PROGRAMS OF INVESTIGATION

Cement Durability Program (Series CR-E)

Treat Island group

10. 1940 installation. Of 26 6- by 6- by 48-in. columns of this series which remained on the Treat Island rack following the May 1947 inspection, 20 now remain after nine winters of exposure (1222 cycles of freezing-and-thawing). All of the five specimens made with cement E-61 remaining in 1947 have failed by disintegration. Cement E-61 was unique among those included in this program, being "hydro-plastic" cement containing Vinsol resin, aquagel, soapstock, and diatomaceous earth. It was an air-entraining cement but contained other additives and was manufactured as an oil-well cement. One broken specimen made with cement E-32 was discarded in December 1948. The 20 remaining specimens show relative E of 100+ per cent, except one whose relative E is 94 per cent. Table 1 gives the values of relative E for these specimens.

11. 1941 installation. Three of four specimens of this group remaining at Treat Island in May 1947 are still in sound condition after eight winters of exposure (1065 cycles of freezing-and-thawing). One broken specimen from this group made with cement E-32 was also discarded in December 1948. Table 1 gives the values of relative E for these specimens.

12. 1942 installation. All but one of the 14 specimens of the group installed at Treat Island in October 1942 which were in sound condition in 1947 are still sound after seven winters (899 cycles of freezing-and-thawing), except for minor spalling and edge deterioration,

and have relative E greater than 100 per cent. One specimen made with cement E-42 is cracked on one end. Table 2 gives the values of relative E in per cent for these specimens.

St. Augustine group

13. After nine years of nonfreezing weathering, only 9 of the 152 6- by 6- by 48-in. concrete specimens originally installed at St. Augustine have failed. Eight of these (E-58-E,H,K; E-32-E,H,K; and E-3-E,K) were made with cements containing more than 12.0 per cent tricalcium aluminate (C_3A). The other specimen which failed is E-24-H. The record of inspection of these specimens is given in table 3. As noted in table 3 other specimens have been broken in handling. Cements E-3, 32, and 58 were the only ones among the 51 represented in this group that contained more than 12.0 per cent C_3A.

Natural Cement Program (Series CR-N)

14. Sixty-two of the 94 6- by 6- by 48-in. specimens of this series originally installed at Treat Island in October 1942 remain in sound condition after seven winters of exposure (899 cycles of freezing-and-thawing). Seven specimens have failed since the May 1947 inspection. Two of these were made with a blend of plain portland cement and natural cement CRN 9.3, which contained a grinding aid of such type as to assist in the entrainment of air. Three specimens which failed in this period contained a blend of plain portland cement and natural cement CRN 9.5 to which had been added 0.05, 0.15, and 0.20 per cent Vinsol resin (natural cements CRN 9.51, 9.53 and 9.54, respectively). Five of the

six specimens containing natural cement CRN 9.51 have failed. The remaining two specimens which failed subsequent to the May 1947 inspection contained blends of plain portland cement with natural cements CRN 9.2 and CRN 9.3, respectively. Both of these natural cements contained a grinding aid. In each of these cases the specimen which failed is the second from a group of three to have done so. Table 4 contains the records of inspections from May 1947 for the specimens in this program. The remaining specimens are in good condition with relative moduli of elasticity well over 100 per cent.

Neutralized Vinsol Resin Program (Series CR-NVR)

15. After six winters of exposure at Treat Island (703 cycles of freezing-and-thawing) 150 of the 182 6- by 6- by 48-in. specimens of this program installed in October 1943 remain in sound condition. Six specimens have failed in the past two winters. Five of the specimens were mixed at reduced pressure, three containing trap rock and two gravel. One of the specimens containing gravel was made with a portland cement interground with 0.03 per cent flake Vinsol resin. The other specimens were made with plain portland cement. The sixth failed specimen contained portland cement interground with 0.01 per cent neutralized Vinsol resin (NVR), gravel coarse aggregate, and was mixed in air.

16. The 150 specimens remaining are in good condition except for minor spalling and scaling. Except for one specimen with relative modulus of 98 per cent, they have relative moduli of elasticity in excess of 100 per cent (table 5). Table 6 is a summary of these data to date by classes of specimens and treatment. This table shows that the results from

additional inspections tend to confirm the order of durability previously established (see TM 6-226). Exposure of these specimens is being continued.

Portland Cement Association Durability Program (Series PCA)

17. Of the nine 6- by 6- by 48-in. specimens of this program remaining on the exposure rack at Treat Island subsequent to the May 1947 inspection, six are in sound condition. After eight winters of exposure (1063 cycles of freezing-and-thawing) the condition of these nine specimens is as follows:

Specimen No.	Cement	Relative E %	Notes	Condition May 1949
12-T-2	I-Treated	104	a,b	Excellent. Slight spalling and bottom deterioration
12-T-3	I-Treated	103	a,b	Excellent. Top spall
16-3	I-Plain	---	b	Failed. Middle zone
16-T-1	I-Treated	83	a	Sound. Slight spalling
16-T-3	I-Treated	96	a	Sound. Slight spalling
21-T-1	II-Treated	44	a	Failed. Bottom spalls with considerable deterioration
21-T-2	II-Treated	102	a	Excellent. Scaling and end spalls
21-T-3	II-Treated	105	a	Excellent. Slight spalling
42-2	IV-Plain	48		Failed. Heavy top and bottom spalls

Notes: a. Cement containing 0.04 per cent Vinsol resin.
b. Specimens formed against Celotex form-lining.

At the present time all of the specimens made with the plain cements have failed. Exposure of the six sound specimens is being continued.

National Bureau of Standards Pozzolith Program (Series NBS)

18. After six winters of exposure (711 cycles of freezing-and-thawing) only 25 of the 116 6- by 6- by 48-in. specimens of this series installed at Treat Island have relative moduli of elasticity above 50 per cent. All of the plain-cement specimens have failed, as well as 74 per cent of those containing Pozzolith and having an average 3-1/2-in. slump, and 61 per cent of those containing Pozzolith and having an average 6-in. slump. Of the remaining specimens, 40 per cent have relative moduli less than 100 per cent (see table 7). The majority of the specimens remaining are in rather poor condition, with extensive scaling, spalling, and end-deterioration. Figure 4 shows typical specimens in this group. Deterioration by internal expansion is indicated from the considerable attenuation encountered in obtaining flexural frequency readings. The exposure of these specimens is being continued.

Fig. 4. Characteristic condition of series NBS specimens -- December 1948

Membrane Curing Program (Series CR-M-A)

1943 installation

19. There were initially installed on the exposure rack at Treat

Island 300 3-1/2- by 4-1/2- by 20-in. concrete specimens of this series. These specimens were installed in wooden boxes with insulation around all surfaces of the specimens except the faces. Half of the specimens were cast horizontally against dry bases and moist soil bases, and the other half cast vertically with surfaces formed against plywood, Celotex, or Hydron form linings. In May 1947, to accelerate the results of the exposure and to permit differentiations in the durabilities of the various mixtures to be shown, the specimens were removed from the boxes and placed on the exposure rack exposed to weathering effects on all surfaces.

20. After a total exposure of six and one-half winters (719 cycles of freezing-and-thawing) and an uninsulated exposure of two winters (236 cycles), 285 of the original 300 specimens remain in relatively sound condition. Table 8 presents the results of the tests to date. All of the specimens which failed were among those cured with various membrane-forming compounds. Six were cast horizontally on a dry base, two horizontally against a moist soil base, three vertically against plywood, and two each vertically against Celotex and Hydron.

21. The relative moduli of elasticity of all but eight of the 285 specimens remaining are well over 100 per cent. The general appearance of the vertically formed specimens is considerably better than that of the horizontally cast specimens. Those cast horizontally show considerable spalling and deterioration, particularly in the sections cast against the dry and soil bases, with those cast against dry bases somewhat worse in appearance. The finished surfaces are in general quite good and show few signs of attack. Exposure of this group is being continued.

1946 installation

22. After three winters of exposure on top of the wharf at Treat Island, the 14 box specimens are in excellent condition and no changes have been noted. Exposure is being continued.

Admixture Program (Series CR-A)

23. After five winters of exposure at Treat Island (569 cycles of freezing-and-thawing) 85 of the 90 6- by 6- by 30-in. beams of this series remain in sound condition. All but one of these have relative moduli of elasticity in excess of 100 per cent. Of the five which failed, four represent concrete without admixture, and one represents concrete made with saponified tallow. The remaining specimen with modulus less than 100 per cent was made with plain cement plus Anti-Hydro. The condition of the other specimens is excellent as indicated by the record of inspections given in table 9. Exposure is being continued.

Miscellaneous Programs at Treat Island

Construction joint program (Series CR-J)

24. The three remaining cores of this program (two John Martin Dam, encased, 8-in.-diameter joint cores and one non-cased, 12-in.-diameter by 18-in.-long Bluestone Dam core) are in sound condition, no changes in condition having been noticed since those reported in TM 6-226.

Upper Narrows Dam program (Series 32)

25. The remaining 6-in.-diameter core drilled from Upper Narrows Dam, Yuba River, near Smartville, California, failed at 535 cycles. The

nine pavement evaluation cores installed for comparison are still in excellent condition except for two which have insulating pads gone. They remain upon the exposure rack.

Rome Air Depot program (Series CR-ADB)

26. All nine of the 6- by 6- by 48-in. specimens cast from field batches used in the runway at Rome Air Depot are still in excellent condition with relative moduli of elasticity well above 100 per cent after eight winters of exposure (1039 cycles of freezing-and-thawing). The three 6- by 6- by 48-in. beams sawed from a runway slab are also in excellent condition with relative moduli of 100, 99, and 100 per cent after six winters (711 cycles of freezing-and-thawing). Exposure is being continued.

Syracuse Air Base program (Series CR-SY)

27. After seven winters of exposure (899 cycles of freezing-and-thawing) all of the eight remaining 6- by 6- by 48-in. specimens cast from field batches used in the runway pavement at Syracuse Air Base are still in excellent condition with relative moduli in excess of 100 per cent. Exposure is being continued.

Mass concrete investigation (Series 66)

28. After three winters of exposure (354 cycles of freezing-and-thawing), all of the 68 6-in.-diameter padded cores of this program are sound but differences in the appearances of the exposed faces of the variously treated specimens are appearing. As of May 1948, 14 of 34 cores formed against oiled wood showed face spalling. Only 2 of the 34

formed against Celotex absorptive form-lining showed face spalls. Since May 1948 one additional core with wood-formed face has developed spalling; no additional cores with Celotex-formed faces have done so. On the other hand, scaling of the faces of the plain cores has increased from 1 to 9 of 34 in the period May 1948 to May 1949, and from 1 to 2 of 34 for the Celotex-formed cores in the same period. Edge raveling has not been observed to increase. Exposure is being continued.

Stewart Field program (Series SA-34)

29. No changes in any of the 93 12-in.-diameter, spherical specimens of this program have occurred in the period subsequent to that reported in TM 6-226. Due to specimen shape, it is not feasible to test these specimens for fundamental frequency, and inspections were limited to visual inspection and tapping to locate "dead spots." Due to the need for additional space on the exposure rack, exposure of this group was discontinued in June 1949, and the specimens have been stored on top of the wharf.

Passamaquoddy program (Series CR-B)

30. The three remaining 5- by 5- by 60-in. specimens of this group are still in sound condition after 1847 cycles of freezing-and-thawing and have an average relative dynamic moduli of elasticity of 6.7×10^6 psi. One specimen shows slow progressive deterioration of one end, but is essentially sound.

PART III: NEW PROGRAMS OF INVESTIGATION

Pine Flat Dam Program (Series 6029)

1947 installation

31. The purpose of this program was to determine the durability of aggregates proposed for use in Pine Flat Dam, Kings River, California, when used in lean, mass-concrete mixtures. Six 8-cu-ft concrete cubes were installed on the exposure rack at Treat Island in September 1947. Figure 5 is a general view of the installation. The aggregates used were pit-run sand and gravel from Mill Creek, near the Pine Flat Dam site. The particles were predominantly of hard, dense, igneous rock types. The pertinent characteristics of the six cubes follow:

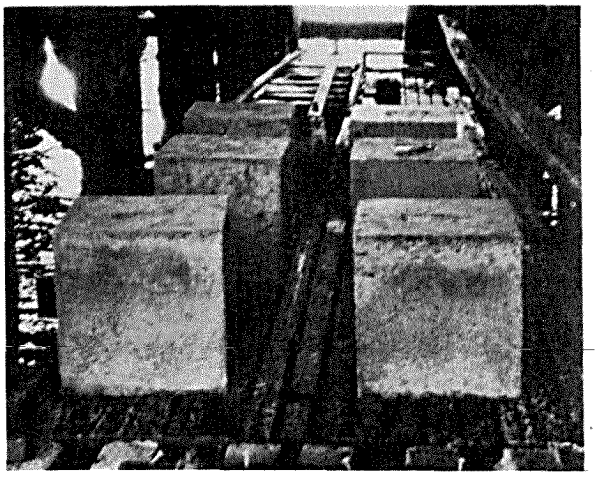


Fig. 5. 8-cu-ft cubes made with types II and IV cement and cement factors of 2, 3 and 4 bags per cu yd for investigating durability of aggregate proposed for use in Pine Flat Dam, California.

Cube No.	Type and Brand of Cement	Cement Factor bag/cu yd	Theoretical Unit Weight lb/cu ft
1	II Lone Star	2.0	166.2
2	IV Calaveras	2.0	166.2
3	II Lone Star	3.0	166.0
4	IV Calaveras	3.0	166.0
5	II Lone Star	4.0	165.8
6	IV Calaveras	4.0	165.8

32. After two winters of exposure (236 cycles of freezing-and-thawing) the six cubes are in sound condition except for minor raveling

of the edges and some spalling. Figures 6, 7 and 8 show, respectively, one of the 2-, 3-, and 4-bag cement factor cubes.

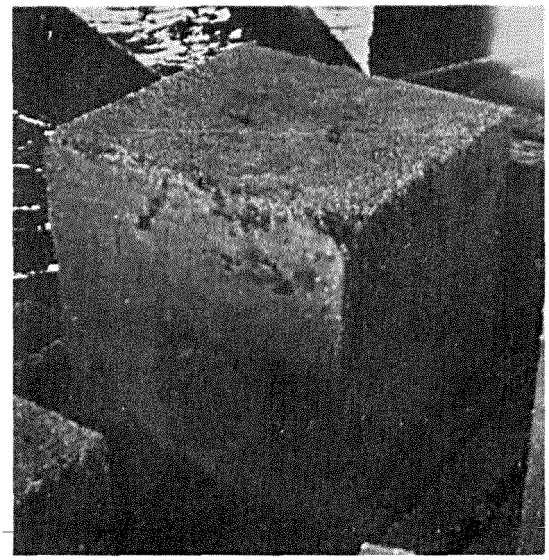


Fig. 6. Cube made with type II cement, 2 bags per cu yd cement factor, showing slight spalling

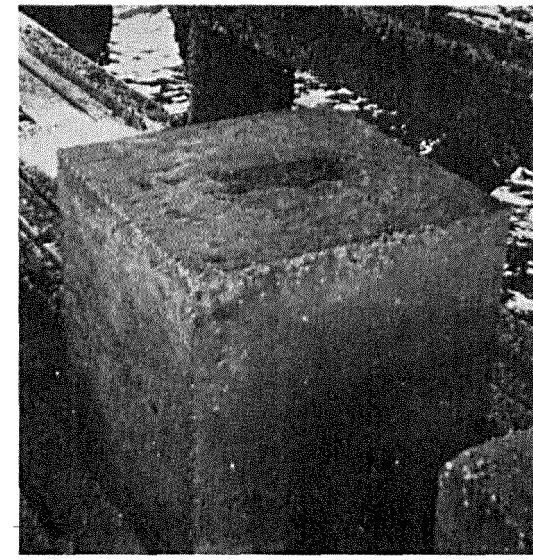


Fig. 7. Cube made with type IV cement, 3 bags per cu yd cement factor, showing spalls and disintegration on edges

1949 installation

33. The purpose of this group is to determine the durability of lean mass-concrete mixtures containing aggregates proposed for use in Pine Flat Dam. The aggregates consist of pit-run sand and gravel from Avocado Pit, Kings River, California. Type IV Permanente low-heat cement was used. In the fall of 1949 three 10-in.-diameter by 18-in.-long cores were installed on the

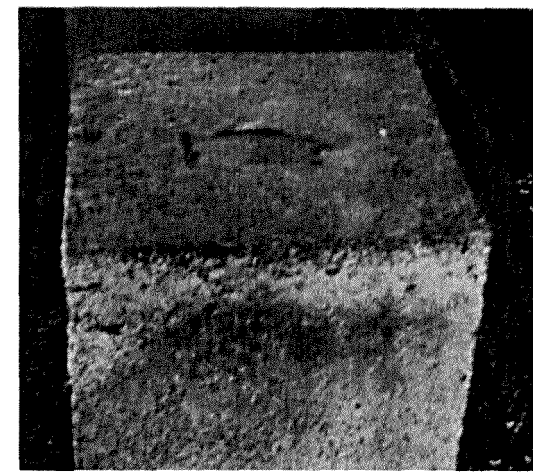


Fig. 8. Cube made with type IV cement, 4 bags per cu yd cement factor, showing small spall on corner

exposure rack at Treat Island. These cores were taken from three 8-cu-ft cubes which were cast from concrete based on 2.0, 2.5 and 4.0 bags per cu yd actual cement factor, respectively. The cores are exposed horizontally in a non-insulated condition.

Comparative Field and Laboratory Durability Program (Series 6508)

34. The primary purpose of this investigation is to evaluate the comparative effects of natural freezing-and-thawing at the Treat Island exposure and of accelerated freezing-and-thawing in the laboratory. Secondary purposes are to compare the effects of the natural exposure on large and small specimens, and to evaluate the relative durabilities of concretes containing combinations of various aggregates. For this program 300 specimens were installed at Treat Island in December 1948. Half were 3-1/2 by 4-1/2 by 16 in. in size; the remainder were 6 by 6 by 30 in. and were duplicates of the smaller specimens. Additional duplicate specimens were tested in accelerated freezing-and-thawing in the laboratory.

35. All combinations contained type II cement and had a water-cement ratio of 5.5 gal per bag. The aggregates used were:

Type	Source
Limestone	Illinois
Granite	Virginia
Quartzite	South Dakota
Chert gravel (non-crushed)	Arkansas
Chert gravel (crushed)	Arkansas
Non-chert gravel	North Dakota
Mississippi River sand	Illinois
Natural chert sand	Louisiana
Natural non-chert sand	North Dakota
Natural siliceous sand	Mississippi

In addition, the limestone, granite, and quartzite were processed into manufactured sands and used in the program. Forty-eight combinations of six coarse and eight fine aggregates were used. In addition, two combinations (quartzite sand + quartzite and limestone sand + limestone) were repeated. The 50 groups of specimens were installed at Treat Island.

36. After one winter of exposure (105 cycles of freezing-and-thawing) no marked changes have occurred in the specimens. Table 10 summarizes the results so far recorded for the specimens of the natural exposure program. The relative moduli of elasticity are about 90 per cent for all specimens. No comparisons can yet be drawn and exposure is being continued.

Prepakt Concrete Investigation (Series 6518)

37. The purpose of this investigation is to determine the durability of Prepakt concrete cores exposed to natural freezing-and-thawing. Nine cores of 10-in. diameter by 16-in. length were installed on the exposure rack at Treat Island in the fall of 1949. The cores were taken from a 70-cu-yd test block of Prepakt concrete. The aggregates used consist of granite coarse aggregate from Greystone, North Carolina, and manufactured limestone sand from Buchanan, Virginia. The prepacked coarse aggregate was grouted with a grout consisting of sand, type II portland cement, Alfesil, Intrusion Aid, and water. The durability of the cores exposed at Treat Island will be compared with other concrete cores similarly exposed, and also with duplicate cores tested in accelerated laboratory freezing-and-thawing.

Vacuum Concrete Investigation (Series 6502)

38. As part of a study of vacuum-treated concrete, 44 concrete cores have been exposed at Treat Island to determine the durability of vacuum-treated mass concrete when subjected to natural weathering. Additional companion cores have been subjected to accelerated laboratory freezing-and-thawing.

39. The aggregates used in this study consist of crushed limestone and manufactured limestone sand from the Bull Shoals project, Arkansas. Type II cement was used. Thirty-six cores 10 in. in diameter and either 16 or 18 in. long and eight cores of 8-in. diameter by 9-1/2-in. length were installed. Thirty of the 10-in.-diameter specimens were taken from a large test block 10 by 10 by 15 ft in size. Twelve cores were from the "upstream", and 14 cores from the "downstream" face of the block, and four were drilled from the bulkhead face. Half of the face cores consist of interior mass concrete (cement factor 3.0 bags per cu yd) and the remainder consist of exterior concrete (cement factor 4.0 bags per cu yd). The bulkhead cores were taken so as to include the plane of contact of the exterior and interior concrete. The remaining 14 cores were drilled from horizontally cast blocks consisting of concrete processed as follows:

No. of Cores	Size of Block ft	Cement Factor bags/cu yd	Max. Size Aggregate in.	Treatment
2	6.5 x 8.5 x 0.75	3.0	3	Screeded, not vacuumed
2	6.5 x 8.5 x 0.75	3.0	3	Vacuum-treated immediately after screeding

No. of Cores	Size of Block ft	Cement Factor bags/cu yd	Max. Size Aggregate in.	Treatment
2	6.5 x 8.5 x 0.75	3.0	3	Screeded, vacuum-treated 20 min prior to time of initial set
2	6.5 x 8.5 x 0.75	3.0	3	Screeded, vacuum-treated midway between screeding and time of initial set
2*	6.5 x 8.5 x 1.5	3.0	6	Screeded, vacuum-treated at optimum time
4*	6.5 x 8.5 x 3.0	3.0	6	Screeded, vacuum-treated at optimum time

* 10-in. diameter by 18-in length. All others are 8-in. diameter by 9-1/2-in. length.

Mt. Morris Dam Investigation (Series 6057)

40. Eleven 10-in.-diameter by 18-in.-long concrete cores were exposed at Treat Island, Maine, in the fall of 1949. These cores have been taken from concrete placed at Mt. Morris Dam, New York, between May and August 1949. The aggregates used consisted of crushed limestone and manufactured limestone sand from Leroy, New York; and the cement was Federal Portland Cement Company type II-A. Five of the cores were taken from the upstream face and represent exterior concrete of 4.0 bags per cu yd cement factor. The remaining six cores represent interior concrete of 3.1 bags per cu yd cement factor. Pertinent features of the specimens are given on the following page.

CRD Serial No.	Mt. Morris Core No.	Type of Concrete	Cement Factor bags/cu yd
Buf-4 Con-1	20	Exterior	3.98
Buf-4 Con-2	21	Exterior	3.98
Buf-4 Con-3	22	Exterior	3.98
Buf-4 Con-5	24	Exterior	3.98
Buf-4 Con-6	24A	Exterior	3.98
Buf-4 Con-8	3A	Interior	3.06
Buf-4 Con-9	3B	Interior	3.06
Buf-4 Con-11	7	Interior	3.07
Buf-4 Con-12	8	Interior	3.10
Buf-4 Con-14	9B	Interior	3.10
Buf-4 Con-15	10	Interior	3.07

TABLES

Table 1

CEMENT DURABILITY PROGRAM (SERIES CR-E) 1940-1941 INSTALLATIONS

RECORD OF INSPECTION -- CONCRETE COLUMNS AT TREAT ISLAND

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Date / Deg-Cy x 10^{-6}	May 1947 7.31		May 1948 10.73		Dec 1948 10.73		May 1949 12.51	
				E	E, %	E	E, %	E	E, %	E	E, %
E-3-A[a]	4.60	142		6.15	134	5.76	125	5.68	123	5.73	125
E-3-D	4.60			6.07	132	5.68	123	5.68	123	5.68	123
E-3-J	4.29			5.79	135	5.43	127	5.41	126	5.41	126
E-3-O	4.33			5.71	132	5.30	122	5.33	123	5.36	124
E-12-A[a]	4.96	148		6.83	138	6.49	131	6.39	129	6.45	130
E-12-D	5.27			7.07	134	6.95	132	6.95	132	6.98	133
E-12-J	4.98			7.25	145	6.89	138	6.76	136	6.80	137
E-12-M	5.36			7.61	142	7.12	133	6.80	127	7.12	133
E-12-O	5.30			7.59	143	7.14	135	7.00	132	7.20	136
E-32-A[a]	4.25	142		4.96	117	NR*	-	5.02	118	-	(b)
E-32-D	3.94			6.15	156	5.79	147	6.00	152	5.76	146
E-32-J	3.52			5.79	164	5.46	155	5.36	152	5.41	154
E-32-M	3.94			5.93	150	NR	-	5.93	150	-	(b)
E-32-O	3.94			5.79	147	5.46	139	5.57	141	5.41	137
E-39-A[a]	4.40	142		5.57	126	5.28	120	5.25	119	5.28	120
E-39-D	4.60			5.58	121	NR	-	5.26	114	5.06	110
E-39-F	4.75			5.84	123	5.41	114	5.25	111	5.14	108
E-39-J	4.75			5.87	124	-	-	5.09	107	5.36	113

* NR = No reading was obtainable.

(Concluded on next page)

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Table 1 (Concluded)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Date / Deg-Cy x 10^{-6}	May 1947 7.31		May 1948 10.73		Dec 1948 10.73		May 1949 12.51	
				E	E, %	E	E, %	E	E, %	E	E, %
E-39-M	4.85			6.20	128	5.79	119	5.76	119	5.68	117
E-39-C	4.96			5.22	105	NR*	-	5.04	102	4.68	94
E-60-D	4.01	142		5.20	130	4.81	120	4.74	118	4.76	119
E-60-F	4.08			5.28	130	4.96	122	4.91	120	4.93	121
E-60-J	3.41			4.78	140	4.38	128	4.34	127	4.34	127
E-60-M	4.08			5.06	124	4.54	111	4.51	111	4.51	111
E-60-D	4.13			5.28	128	4.87	118	4.87	118	4.87	118
E-61-D	3.90	142		4.47	115	4.27	109	NR	-	(c)	46
E-61-F	3.96			4.96	125	5.13	130	(c)	50	(c)	43
E-61-J	3.76			4.71	125	(c)	49	(c)	49	(c)	42
E-61-M	3.85			5.03	131	(c)	50	(c)	50	(c)	43
E-61-O	3.83			4.41	115	(c)	50	(c)	50	(c)	43

[a] 1941 Installation Deg-Cy x 10^{-6}: 5/47 5.39
5/48 8.35
5/49 9.93

[b] Specimens broken in handling; discarded 12/48.

[c] Specimens failed.

* NR = No reading was obtainable.

Table 2

CEMENT DURABILITY PROGRAM (SERIES CR-E) 1942 INSTALLATION

RECORD OF INSPECTION -- CONCRETE COLUMNS AT TREAT ISLAND

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Date / Deg-Cy x 10^{-6}	May 1947 3.17		May 1948 5.54		Dec 1948 5.54		May 1949 6.84	
				E	E, %	E	E, %	E	E, %	E	E, %
E-17-Z	5.96	148		7.45	125	NR*	-	6.83	115	6.83	115
E-22-X	6.42			8.04	125	NR	-	6.98	109	6.68	104
E-22-Y	6.05			7.39	122	NR	-	6.34	105	6.34	105
E-22-Z	5.90			7.53	128	7.03	119	6.89	117	6.89	117
E-32-X	4.71	142		5.87	125	5.38	114	5.30	113	5.25	111
E-32-Z	4.38			5.59	127	5.28	121	5.09	116	4.78	109
E-39-X	5.09	142		5.87	115	5.75	113	5.80	114	5.72	112
E-39-Y	4.24			5.30	125	4.99	118	4.87	115	4.87	115
E-42-W	5.94	148		7.61	128	7.12	120	6.95	117	-	47
E-42-X	5.99			7.30	122	6.49	108	6.66	111	6.39	107
E-42-Y	5.36			6.55	122	5.77	108	5.99	112	5.99	112
E-42-Z	5.68			6.89	128	6.49	114	6.34	112	6.34	112
E-56-W	5.79	148		NR	-	NR	-	NR	-	-	47
E-56-XI	5.61			6.83	122	6.20	111	6.23	111	6.14	109
E-60-Z	5.02	142		6.24	124	5.82	116	5.71	114	5.71	114

* NR = No reading was obtainable with available equipment.

Table 3

CEMENT DURABILITY PROGRAM (SERIES CR-E) 1940 INSTALLATION

RECORD OF INSPECTION -- CONCRETE COLUMNS AT ST. AUGUSTINE

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Mar 1944 E	Mar 1944 E, %	June 1946 E	June 1946 E, %	May 1948 E	May 1948 E, %	Condition - Aug 1949
E-1-E	5.74	148	6.83	119	6.86	120	6.80	118	Sound
E-1-H	5.61		6.70	119	6.86	122	6.52	116	Sound
E-1-K	5.68		6.83	120	7.14	126	6.68	118	Sound
E-2-E	5.83	148	7.07	121	7.02	120	7.17	123	Sound
E-2-H	5.96		7.07	119	7.20	121	7.12	119	Sound
E-2-K	5.74		6.83	119	7.08	123	6.80	118	Sound
E-3-E	4.67	142	5.59	120	-	F	-	F	Broken in 2 pieces
E-3-H	4.61		5.49	119	5.43	118	5.02	109	Weak
E-3-K	4.38		5.28	120	5.04	115	3.92	89	Drummy
E-4-E	5.77	148	6.66	115	6.80	118	6.49	112	Sound
E-4-H	5.88		6.86	117	6.98	119	6.80	116	Sound
E-4-K	6.05		6.63	110	6.77	112	6.73	111	Sound
E-5-E	5.65	148	6.76	120	7.02	124	6.83	121	Sound
E-5-H	5.51		6.83	124	6.86	125	6.68	121	Sound
E-5-K	5.68		6.83	120	7.02	124	6.86	121	Sound
E-6-E	5.49	148	6.60	120	6.52	119	6.60	120	Sound
E-6-H	5.27		6.45	122	6.41	122	5.83	111	Drummy
E-6-K	5.44		6.32	116	6.86	126	6.68	123	Sound

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Table 3 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Mar 1944 E	Mar 1944 E, %	June 1946 E	June 1946 E, %	May 1948 E	May 1948 E, %	Condition - Aug 1949
E-7-E	5.71	148	7.12	125	7.52	132	7.35	129	Sound
E-7-H	5.83		7.00	120	7.36	126	6.80	117	Broken in 2 pieces
E-7-K	5.55		6.83	123	-	B	-	B	Broken in 2 pieces, west 1/2 lost
E-8-E	5.77	148	7.14	124	7.46	129	7.17	124	Sound
E-8-H	6.05		7.25	120	7.68	127	7.10	117	Weaker than other two
E-8-K	5.85		6.95	119	7.08	121	7.14	122	Sound
E-9-E	5.63	148	6.60	117	6.86	122	5.90	105	Lost in ocean
E-9-H	5.49		6.83	124	7.20	131	6.98	127	Weak
E-9-K	5.79		6.95	120	7.02	121	7.32	126	Sound
E-10-E	5.36	148	7.00	131	7.42	138	7.28	136	Sound
E-10-H	5.74		7.25	126	7.52	131	7.17	125	Sound
E-10-K	5.33		7.12	134	7.42	139	-	-	Sound
E-11-E	5.79	148	6.98	120	7.36	127	-	B	Broken in 2 pieces, west 1/2 lost
E-11-H	5.65		7.00	124	7.20	127	-	B	Broken in 2 pieces
E-11-K	5.85		7.07	121	7.20	123	7.17	123	Sound
E-12-E	5.33	148	6.49	122	6.56	123	6.55	123	Sound
E-12-H	5.03		6.45	128	6.71	133	6.34	126	Sound
E-12-K	5.17		6.36	123	6.50	126	6.52	126	Sound
E-13-E	5.55	148	6.83	123	6.71	121	6.76	122	Sound
E-13-H	5.74		6.98	121	-	B	-	B	Broken in 2 pieces, east 1/2 lost
E-13-K	5.88		6.95	118	7.20	122	7.28	124	Sound

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Table 3 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Mar 1944 E	Mar 1944 E, %	June 1946 E	June 1946 E, %	May 1948 E	May 1948 E, %	Condition - Aug 1949
E-14-E	5.85	148	6.83	117	6.92	118	6.86	117	Sound
E-14-H	5.03		6.45	128	6.56	130	6.80	135	Sound
E-14-K	5.44		6.73	124	6.86	126	7.42	136	Sound
E-15-E	5.23	148	6.89	132	7.20	138	7.14	136	Sound
E-15-H	5.36		7.07	132	7.36	137	7.12	133	Sound
E-15-K	5.74		7.00	122	7.30	127	7.32	127	Sound
E-16-E	5.51	148	6.98	127	7.27	132	7.30	132	Sound
E-16-H	5.49		7.14	130	7.27	132	7.25	132	Sound
E-16-K	5.74		7.12	124	7.20	125	7.30	137	Sound
E-17-E	5.49	148	6.70	122	6.86	125	6.80	124	Sound
E-17-H	5.68		6.89	121	7.20	127	6.83	120	Sound
E-17-K	5.41		6.63	123	7.02	130	7.04	130	Sound
E-18-E	4.72	148	6.76	143	7.20	153	7.12	151	Sound
E-18-H	5.27		7.00	133	7.52	143	7.42	141	Sound
E-18-K	5.27		6.98	132	7.33	139	7.25	138	Sound
E-19-E	5.23	148	6.45	123	6.74	129	6.55	125	Sound
E-19-H	5.17		6.45	124	6.41	124	6.45	125	Sound
E-19-K	5.20		6.36	122	6.29	121	6.52	125	Sound, east end weaker
E-20-E	5.77	148	6.73	116	7.36	128	7.04	122	Sound
E-20-H	5.46		6.86	126	7.42	136	7.17	131	Sound
E-20-K	5.10		6.66	131	6.95	136	7.36	144	Sound

(Continued on next page)

Table 3 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Mar 1944 E	Mar 1944 E, %	June 1946 E	June 1946 E, %	May 1948 E	May 1948 E, %	Condition - Aug 1949
E-22-E	5.83	148	6.63	114	6.95	119	6.80	117	Sound
E-22-H	5.55		6.83	123	6.86	124	7.17	129	Sound
E-22-K	5.71		6.70	117	7.05	123	6.95	122	Sound
E-23-E	5.41	148	7.25	134	7.36	136	7.30	135	Sound
E-23-H	5.09		7.12	140	7.20	141	7.17	141	Sound
E-23-K	5.10		7.25	142	7.42	145	7.20	141	Sound
E-24-E	5.23	148	6.34	121	6.23	119	5.88	112	Sound
E-24-H	4.90		-	F	-	F	-	F	Broken in 2 pieces, west 1/2 lost
E-24-K	5.55		6.32	114	6.09	110	5.77	104	Drummy
E-25-E	5.09	148	6.66	131	7.02	138	7.00	137	Sound
E-25-H	4.96		6.60	133	7.02	142	7.17	145	Sound
E-25-K	5.13		6.70	131	-	B	-	B	Broken in 2 pieces, east 1/2 gone
E-26-E	5.71	148	6.73	118	6.80	119	6.95	122	Sound
E-26-H	5.79		6.83	118	6.71	116	6.73	116	Sound
E-26-K	5.83		6.83	117	6.86	118	7.04	121	Sound
E-27-E	5.77	148	7.14	124	7.36	128	7.20	125	Sound
E-27-H	5.57		7.12	128	7.27	131	7.49	134	Sound
E-27-K	5.90		7.20	122	7.36	125	7.45	126	Sound
E-28-E	5.90	148	7.25	123	7.52	127	7.42	126	Sound
E-28-H	6.14		7.25	118	7.36	120	7.42	121	Sound
E-28-K	6.05		7.12	118	7.20	119	7.25	120	Sound

(Continued on next page)

Table 3 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Mar 1944 E	Mar 1944 E, %	June 1946 E	June 1946 E, %	May 1948 E	May 1948 E, %	Condition - Aug 1949
E-31-E	5.83	148	6.89	118	7.20	123	7.28	125	Sound
E-31-H	5.55		6.73	121	6.86	124	7.25	131	Sound
E-31-K	5.79		6.83	118	6.86	118	6.95	120	Sound
E-32-E	4.02	142	5.06	126	5.01	125	-	F	Broken in 2 pieces, failed
E-32-H	3.99		5.13	128	5.01	126	-	F	Broken in 2 pieces, failed
E-32-K	4.02		5.17	128	5.14	128	-	F	All gone
E-33-E	5.27	148	6.45	122	6.56	124	6.36	121	Sound
E-33-H	5.41		6.52	121	6.65	123	6.36	118	Sound, weaker than other 2
E-33-K	5.57		6.63	119	6.71	120	6.34	114	Sound
E-36-E	5.17	148	6.83	132	-	B	-	B	Broken in 2 pieces
E-36-H	5.27		6.63	126	6.86	130	-	B	Broken in 2 pieces, west 1/2 lost
E-36-K	5.74		6.95	121	6.86	120	7.04	123	Sound
E-37-E	4.60	148	6.42	140	6.65	145	6.83	148	Sound
E-37-H	4.98		6.45	129	6.56	132	6.92	139	Sound
E-37-K	5.03		6.52	130	6.71	133	6.44	128	Sound
E-38-E	5.83	148	6.98	120	6.80	117	6.98	120	Sound
E-38-H	5.68		6.86	121	6.74	119	6.26	110	Sound
E-38-K	5.79		6.83	118	6.71	116	6.49	112	Sound
E-39-E	4.41	142	5.33	121	5.27	120	5.14	117	Sound
E-39-H	4.32		5.23	121	5.14	119	5.23	121	Sound
E-39-K	4.63		5.59	121	5.57	120	5.28	114	Sound

(Continued on next page)

Table 3 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Mar 1944 E	Mar 1944 E, %	June 1946 E	June 1946 E, %	May 1948 E	May 1948 E, %	Condition - Aug 1949
E-40-E	5.65	148	6.60	117	7.20	127	6.55	116	Sound
E-40-H	5.68		6.55	115	7.08	125	6.66	117	Sound
E-40-K	5.83		6.63	114	7.27	125	6.66	114	Sound
E-41-E	5.61	148	6.70	119	6.71	120	6.68	119	Sound
E-41-H	5.68		6.66	117	6.56	115	6.68	118	Sound
E-41-K	5.79		6.63	114	6.41	111	6.60	114	Sound
E-42-E	5.49	148	6.86	125	7.02	128	6.86	125	Sound
E-42-H	5.37		6.76	126	7.20	134	7.12	133	Sound
E-42-K	5.24		6.66	127	7.02	134	6.83	130	Sound
E-43-E	5.90	148	6.89	117	7.02	119	7.12	121	Sound
E-43-H	5.88		6.83	116	-	B	-	B	Broken and lost
E-43-K	5.79		6.83	118	6.86	118	6.80	117	Sound, weaker than E-43-E
E-44-E	5.79	148	6.86	118	6.71	116	6.86	118	Sound
E-44-H	5.63		6.60	117	6.50	115	6.52	116	Sound
E-44-K	5.83		6.52	112	-	B	-	B	Broken in 2 pieces
E-45-E	5.71	148	6.83	120	6.23	109	6.55	115	Sound
E-45-H	5.65		6.66	118	6.74	119	6.80	120	Sound
E-45-K	5.63		6.83	121	6.86	122	7.14	127	Sound
E-46-E	6.03	148	6.98	116	7.52	125	7.28	121	Sound
E-46-H	5.65		6.83	121	7.14	126	6.98	124	Sound
E-46-K	5.83		7.07	121	7.02	120	7.12	122	Sound

(Continued on next page)

Table 3 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Mar 1944 E	Mar 1944 E, %	June 1946 E	June 1946 E, %	May 1948 E	May 1948 E, %	Condition - Aug 1949
E-47-E	5.51	148	7.00	125	7.20	131	6.95	126	Sound
E-47-H	5.41		6.89	127	7.36	136	6.52	120	Sound
E-47-K	5.68		6.98	123	6.86	121	6.95	122	Sound
E-51-E	4.82	148	6.36	132	6.41	133	6.11	127	Sound
E-51-H	4.77		6.34	133	6.41	134	5.90	124	Sound
E-51-K	4.77		6.26	131	6.23	131	5.77	121	Sound
E-53-E	5.44	148	6.89	127	6.86	126	6.95	128	Sound
E-53-H	5.55		7.00	126	7.02	126	7.32	132	Sound
E-53-K	5.41		6.86	127	6.86	127	6.95	128	Sound
E-56-E	5.55	148	7.00	126	6.86	124	-	B	Broken in 2 pieces
E-56-H	5.44		7.25	133	7.02	129	7.28	134	Sound
E-56-K	5.51		7.14	130	6.95	126	7.04	128	Sound
E-57-E	5.27	148	6.98	132	6.95	132	7.00	133	Sound
E-57-H	5.03		7.07	140	7.20	143	7.39	147	Sound
E-57-K	4.77		6.83	143	6.59	138	6.60	138	Sound
E-58-E	5.61	148	4.47	80	-	F	-	F	All gone, failed
E-58-H	5.49		-	-	-	F	-	F	All gone, failed
E-58-K	5.06		4.93	97	-	F	-	F	All gone, failed
E-60-E	3.77	142	4.83	128	4.61	122	4.63	123	Sound
E-60-H	3.77		4.83	128	4.61	122	4.74	126	Sound
E-60-K	3.70		4.81	130	4.76	129	4.54	123	Sound

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Table 3 (Concluded)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Mar 1944 E	Mar 1944 E, %	June 1946 E	June 1946 E, %	May 1948 E	May 1948 E, %	Condition - Aug 1949
E-61-E	3.74	142	4.58	125	4.79	128	-	B	Broken in 2 pieces, west 1/2 gone
E-61-H	This specimen was broken prior to installation								
E-61-K	3.59		4.47	124	4.71	131	4.34	121	Sound
E-62-E	5.51	148	6.98	127	-	B	-	B	Lost
E-62-H	5.36		6.95	130	7.20	134	7.14	133	Sound
E-62-K	5.55		6.73	121	7.20	130	7.12	128	Sound
E-63-E	5.77	148	7.25	127	7.52	130	7.53	135	Sound
E-63-H	5.61		7.12	127	7.52	134	7.45	133	Sound
E-63-K	5.46		7.07	130	7.36	135	7.45	136	Sound
E-64	No specimens made with this cement were installed at this station								

Note: F = failed, due to deterioration
B = broken in handling

TM 6-226, p 13, states that 3 each representing 52 cements or a total of 156 specimens were installed; actually due to the omission of E-64 and the loss of specimen E-61-H prior to installation, the total number of specimens installed was 152, representing 51 cements.

Table 4

NATURAL CEMENT PROGRAM (SERIES CR-N)

RECORD OF INSPECTION -- CONCRETE COLUMNS AT TREAT ISLAND

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Inspection Date Deg-Cy x 10^{-6} Apr 1944 0.94		May 1946 2.12		May 1947 3.17		May 1948 4.54		Dec 1948 4.54		May 1949 6.84	
			E	E, %	E	E, %	E	E, %	E	E, %	E	E, %	E	E, %
1A	4.93	148	-	19	-	8	-	6	-	4	-	4	-	3
1B 13.2	4.72		-	7	-	3	-	2	-	2	-	2	-	1
1C	5.00		5.41	108	-	25	-	16	-	12	-	12	-	8
2A	4.93	148	5.96	121	6.56	133	6.86	139	6.34	129	6.20	126	6.23	126
2B 13.3	5.77		6.49	112	7.08	123	7.42	129	6.92	120	6.80	118	6.80	118
2C	5.63		-	-	-	-	-	-	-	-	-	-	-	-
3A	5.33	148	-	19	-	8	-	6	-	4	-	4	-	3
3B 13.4	5.71		-	19	-	8	-	6	-	4	-	4	-	3
3C	5.03		-	19	-	8	-	6	-	4	-	4	-	3
4A	4.93	148	5.77	117	6.23	126	6.55	133	6.08	123	5.99	122	6.05	123
4B 14.6	5.36		6.28	117	6.86	128	7.20	134	6.66	124	6.52	122	6.52	122
4C	4.50		5.74	127	6.09	135	6.34	141	5.88	131	5.74	128	5.74	128
5A	4.72	148	5.68	120	6.23	132	5.51	117	6.03	128	5.96	126	5.96	126
5B 14.7	5.23		6.03	115	6.56	125	6.92	132	6.44	123	6.34	121	6.34	121
5C	4.93		5.77	117	6.23	126	6.49	132	5.99	122	5.85	119	5.88	119
6A	4.77	148	5.90	123	6.38	134	-	36	-	25	-	25	-	17
6B 14.8	5.30		6.28	118	6.86	129	7.20	136	-	50	-	50	-	33
6C	4.55		5.61	123	5.94	131	NR*	-	5.63	124	5.44	120	5.51	121

* NR = No reading was obtainable

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Table 4 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Inspection Date Deg-Cy x 10^{-6} Apr 1944 0.94		May 1946 2.12		May 1947 3.17		May 1948 4.54		Dec 1948 4.54		May 1949 6.84	
			E	E, %	E	E, %	E	E, %	E	E, %	E	E, %	E	E, %
7A	4.82	148	5.83	121	6.38	132	6.70	139	6.14	127	5.55	115	6.08	126
7B 14.10	4.44		5.61	126	5.94	134	6.26	141	5.77	130	5.99	135	5.71	129
7C	4.47		5.55	124	5.94	133	6.05	135	5.63	126	5.57	125	NR*	-
8A	4.82	148	5.65	117	6.09	126	6.36	132	5.94	123	5.85	121	5.90	122
8B 14.11	4.57		5.63	123	6.06	133	6.34	139	5.90	129	5.77	126	5.83	128
8C	4.47		5.33	119	5.74	128	5.90	132	5.57	125	5.41	121	5.27	118
9A	5.03	148	6.11	121	6.56	130	6.95	138	6.45	128	6.34	126	6.34	126
9B 14.12	5.09		5.85	115	6.38	125	6.28	123	-	43	-	43	-	28
9C	4.34		5.55	128	5.09	117	4.69	108	-	50	-	50	-	33
10A	4.69	148	5.55	118	-	30	-	20	-	14	-	14	-	9
10B 14.14	5.06		5.96	118	6.38	126	6.70	132	6.08	120	6.05	120	5.99	118
10C	4.65		5.41	116	3.63	78	-	50	-	35	-	35	-	23
11A	5.37	148	6.03	112	6.56	122	6.83	127	6.34	118	6.26	117	6.17	115
11B 14.15	5.03		5.83	116	6.38	127	6.55	130	6.17	123	6.08	121	6.03	120
11C	4.47		5.41	121	5.77	129	5.88	131	5.37	120	5.33	119	5.24	117
12A	5.37	148	6.36	118	6.86	128	6.52	121	-	45	-	45	-	30
12B 14.16	4.88		5.90	121	6.50	133	6.70	137	6.20	127	6.17	126	6.32	130
12C	5.03		2.36	47	-	22	-	15	-	10	-	10	-	6
13A	5.23	148	-	7	-	3	-	2	-	2	-	2	-	1
13B 14.18	5.33		-	19	-	8	-	6	-	4	-	4	-	3
13C	4.21		-	19	-	8	-	6	-	4	-	4	-	3

* NR = No reading was obtainable

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Table 4 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Inspection Date Deg-Cy x 10^{-6} Apr 1944 0.94 E	Apr 1944 0.94 E, %	May 1946 2.12 E	May 1946 2.12 E, %	May 1947 3.17 E	May 1947 3.17 E, %	May 1948 4.54 E	May 1948 4.54 E, %	Dec 1948 4.54 E	Dec 1948 4.54 E, %	May 1949 6.84 E	May 1949 6.84 E, %
14A	5.51	148	-	-	-	2	-	1	-	1	-	1	-	1
14B 14.20	5.30		6.05	114	-	49	-	33	-	22	-	22	-	15
14C	5.00		-	19	-	8	-	6	-	4	-	4	-	3
15A	5.03	148	6.20	123	-	26	-	17	-	12	-	12	-	8
15B 14.22	5.13		5.94	116	6.56	128	5.27	103	-	49	-	49	-	33
15C	4.75		-	-	-	-	-	-	-	-	-	-	-	-
16A	5.83	148	-	19	-	8	-	6	-	4	-	4	-	3
16B 14.24	5.03		5.99	119	6.56	130	-	48	-	33	-	33	-	22
16C	4.82		5.90	122	5.66	117	4.93	102	-	35	-	35	-	23
17A	4.67	148	5.68	121	6.23	133	6.44	138	5.94	127	5.90	126	5.90	126
17B 14.26	4.82		5.88	122	6.42	133	6.63	138	6.14	127	6.11	127	6.03	125
17C	5.41		6.11	113	6.71	124	6.89	127	6.36	118	6.28	116	6.20	115
18A	5.27	148	6.20	117	6.86	130	7.07	134	6.63	126	6.55	124	6.49	123
18B 14.28	4.73		-	-	-	-	-	-	-	-	-	-	-	-
18C	5.41		6.08	112	6.62	122	6.86	127	6.28	116	6.28	116	6.20	115
19A	4.65	148	5.65	121	6.09	131	6.28	135	5.99	129	5.74	123	5.79	125
19B 14.30	4.82		5.83	121	6.23	129	6.45	134	-	49	-	49	-	33
19C	5.30		5.96	112	6.50	123	6.83	129	6.34	120	6.26	118	6.20	117
20A	4.82	148	6.08	126	6.71	139	6.95	144	6.44	134	6.42	133	6.28	130
20B 14.32	4.77		5.71	119	6.23	131	6.42	134	5.90	124	5 90	124	5.85	123
20C	5.06		5.83	115	6.38	126	6.66	132	6.23	123	6.05	120	6.05	120

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Table 4 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Inspection Date Deg-Cy x 10^{-6} Apr 1944 0.94		May 1946 2.12		May 1947 3.17		May 1948 4.54		Dec 1948 4.54		May 1949 6.84	
			E	E, %	E	E, %	E	E, %	E	E, %	E	E, %	E	E, %
21A	4.65	148	5.57	120	6.12	132	6.28	135	5.83	125	5.79	125	5.77	124
21B 14.34	4.77		5.71	119	6.23	131	6.36	133	5.88	123	5.79	121	5.77	121
21C	5.10		5.88	115	6.47	127	6.70	131	6.26	123	6.17	121	6.14	120
22A	4.93	148	6.03	122	6.68	135	6.89	140	6.44	131	6.34	129	6.49	132
22B 14.36	4.96		5.88	118	6.71	135	6.55	132	6.23	126	-	50	-	33
22C	5.06		5.96	118	6.50	128	6.76	133	6.32	125	6.20	123	6.20	123
23A	4.62	148	5.79	125	6.35	137	6.52	141	6.11	132	6.03	131	6.05	131
23B	4.82		5.85	121	6.38	132	6.55	136	6.14	127	6.03	125	5.99	124
23C 14.38	4.30		5.20	121	5.66	132	5.77	134	5.33	124	5.27	123	5.20	121
23C A			-	-	-	-	-	-	-	-	-	-	-	-
24A	5.00	148	5.61	112	6.09	122	6.36	127	5.90	118	5.83	117	5.83	117
24B 14.39	4.82		5.68	118	6.23	129	6.52	135	5.88	122	5.79	120	5.79	120
24C	5.09		5.83	114	6.38	125	6.55	129	6.05	119	6.03	118	5.96	117
25A	5.10	148	5.85	115	6.50	127	6.73	132	6.23	122	6.17	121	6.14	120
25B 14.40	4.69		5.63	120	6.09	130	6.34	135	5.79	123	5.74	122	5.74	122
25C	4.90		5.65	115	6.09	124	6.28	128	5.83	119	5.74	117	5.74	117
26A	4.85	148	5.65	116	6.09	126	6.28	129	5.85	121	5.85	121	5.85	121
26B 14.42	4.42		5.27	119	5.66	128	5.88	133	5.49	124	5.37	121	5.36	121
26C	4.93		5.77	117	6.23	126	6.49	132	5.94	120	5.94	120	5.90	120
27A	5.33	148	5.85	110	6.50	122	6.68	125	6.26	117	6.20	116	6.14	115
27B 14.43	4.93		5.74	116	6.29	128	6.52	132	6.03	122	5.96	121	5.90	120
27C	4.93		5.61	114	6.09	124	6.23	126	5.83	118	5.77	117	5.83	118

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Table 4 (Concluded)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Inspection Date Deg-Cy x 10^{-6} Apr 1944 0.94		May 1946 2.12		May 1947 3.17		May 1948 4.54		Dec 1948 4.54		May 1949 6.84	
			E	E, %	E	E, %	E	E, %	E	E, %	E	E, %	E	E, %
28A	4.96	148	5.83	118	6.42	129	6.68	135	6.20	125	6.17	124	6.11	123
28B 14.44	4.88		5.77	118	6.35	130	6.49	133	5.99	123	5.94	122	5.90	121
28C	5.23		5.96	114	6.56	125	6.70	128	6.22	119	6.14	117	6.05	116
29A	4.74	142	5.46	115	6.23	131	6.20	131	5.76	122	5.68	120	5.65	119
29B 14.46	4.81		5.59	116	6.50	135	6.42	133	5.73	119	5.68	117	5.65	117
29C	4.87		5.57	114	6.42	132	6.32	130	5.82	120	5.82	120	5.79	119
30A	5.33	142	5.98	112	6.80	128	6.88	129	6.38	120	6.29	118	6.20	116
30B 14.47	4.38		5.28	120	6.03	138	5.93	135	5.46	125	5.57	127	5.41	124
30C	5.23		5.90	113	6.71	128	6.62	127	6.18	118	6.09	116	6.03	115
31A	4.61	142	5.46	119	6.23	135	6.29	136	5.84	127	5.82	126	5.79	126
31B 14.48	5.06		5.82	115	6.71	133	6.59	130	6.09	120	6.00	119	5.93	117
31C	5.02		5.76	115	6.66	132	6.55	130	6.09	121	5.96	119	5.90	118

Table 5

NEUTRALIZED VINSOL RESIN PROGRAM (SERIES CR-NVR)

RECORD OF INSPECTION -- CONCRETE COLUMNS AT TREAT ISLAND

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Date / Deg-Cy x 10^{-6}	May 1947 1.45		May 1948 3.17		Dec 1948 3.17		May 1949 4.17	
				E	E, %	E	E, %	E	E, %	E	E, %
A-1-E	5.46	148		-	1	-	0	-	0	-	0
B-1-E	5.71			-	3	-	1	-	1	-	1
C-1-E	5.55			-	4	-	2	-	2	-	1
A-2-E	5.23	148		6.44	123	6.20	119	6.23	119	6.14	117
B-2-E	5.83			-	1	-	0	-	0	-	0
C-2-E	5.71			-	1	-	0	-	0	-	0
A-3-E	4.30	148		6.42	149	6.05	141	5.96	139	5.99	139
B-3-E	5.30			7.00	132	6.05	114	6.68	126	6.68	126
C-3-E	5.33			7.25	136	6.80	128	6.80	128	6.73	126
A-4-E	4.87	153		6.64	142	7.31	157	6.39	137	6.29	135
B-4-E	4.99			7.01	140	6.56	132	6.56	132	6.56	132
C-4-E	5.49			5.85	106	-	34	-	34	-	26
A-5-E	5.27	148		7.28	138	6.66	126	6.95	132	6.95	132
B-5-E	5.55			7.42	134	6.98	126	7.04	127	7.00	126
C-5-E	5.41			7.28	135	7.12	132	7.12	132	7.20	133
A-6-E	5.23	148		7.42	142	7.00	134	6.95	133	7.17	137
B-6-E	5.83			6.98	120	6.49	111	6.80	117	6.80	117
C-6-E	5.65			7.32	130	6.95	123	6.95	123	6.28	111

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Table 5 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Date / Deg-Cy x 10^{-6}	May 1947 1.45 E	May 1947 1.45 E, %	May 1948 3.17 E	May 1948 3.17 E, %	Dec 1948 3.17 E	Dec 1948 3.17 E, %	May 1949 4.17 E	May 1949 4.17 E, %
A-7-E	4.09	148		6.45	158	5.79	142	5.79	142	5.85	143
B-7-E	4.55			6.28	138	5.90	130	5.90	130	6.20	136
C-7-E	4.55			6.68	147	6.32	139	6.28	138	6.52	143
A-8-E	5.21	153		7.27	139	6.81	131	6.85	132	7.10	136
B-8-E	5.21			7.55	145	7.14	137	7.10	136	7.10	136
C-8-E	5.63			7.58	135	7.14	127	7.06	125	7.06	125
A-9-E	5.83	148		-	(1)	-	0	-	0	-	0
B-9-E	5.74			-	(2)	-	1	-	1	-	1
C-9-E	5.77			-	(4)	-	2	-	2	-	1
A-10-E	5.57	148		-	(1)	-	0	-	0	-	0
B-10-E	5.90			-	(1)	-	0	-	0	-	0
C-10-E	5.65			-	(1)	-	0	-	0	-	0
A-11-E	5.46	153		7.18	131	6.89	126	6.81	125	6.89	126
B-11-E	5.38			7.41	138	7.04	131	6.98	130	6.92	129
C-11-E	5.24			7.01	134	6.59	126	6.56	125	6.72	128
A-12-E	5.41	153		7.10	131	6.72	124	6.70	124	6.70	124
B-12-E	5.46			-	(3)	-	2	-	2	-	1
C-12-E	5.69			-	(4)	-	2	-	2	-	1
A-13-E	5.65	148		7.39	131	7.07	125	6.93	123	6.98	124
B-13-E	5.24			7.61	145	7.20	137	7.17	137	7.14	136
C-13-E	5.27			7.25	138	6.86	130	6.76	128	6.80	129

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Table 5 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Date / Deg-Cy x 10^{-6}	May 1947 1.45		May 1948 3.17		Dec 1948 3.17		May 1949 4.17	
				E	E, %	E	E, %	E	E, %	E	E, %
A-14-E	5.94	148		5.30	89	-	34	-	34	-	26
B-14-E	5.68			7.17	126	6.63	117	6.66	118	6.52	115
C-14-E	5.83			-	(3)	-	2	-	2	-	1
A-15-E	4.82	148		7.03	146	6.70	139	6.66	138	6.66	138
B-15-E	4.90			7.00	143	6.68	136	6.52	133	6.55	134
C-15-E	4.82			6.95	144	6.52	135	6.49	135	6.46	134
A-16-E	5.42	153		7.52	139	7.04	130	7.04	130	7.01	129
B-16-E	4.81			7.14	148	6.72	140	6.72	140	6.70	139
C-16-E	5.74			7.78	136	7.36	128	7.31	127	7.31	127
A-17-E	5.63	148		7.28	129	6.52	116	6.55	116	6.55	116
B-17-E	5.41			7.32	135	6.86	127	6.76	125	6.80	126
C-17-E	4.96			7.07	143	6.66	134	6.49	131	6.60	133
A-18-E	5.23	148		-	(2)	-	(1)	-	(1)	-	(1)
B-18-E	5.63			7.35	131	6.83	121	6.76	120	6.83	121
C-18-E	5.20			-	(4)	-	2	-	2	-	1
A-19-E	4.28	148		6.45	151	6.08	142	6.05	141	6.03	141
B-19-E	4.30			6.11	142	5.77	134	5.71	133	5.77	134
C-19-E	4.62			6.49	140	6.11	132	6.05	131	6.05	131
A-20-E	4.63	153		6.77	146	6.45	139	6.29	136	6.32	137
B-20-E	4.67			6.72	144	6.41	137	6.89	148	6.20	133
C-20-E	4.84			7.10	147	6.67	138	6.56	136	6.50	134

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Table 5 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Date / Deg-Cy x 10^{-6}	May 1947 1.45		May 1948 3.17		Dec 1948 3.17		May 1949 4.17	
				E	E, %	E	E, %	E	E, %	E	E, %
A-21-E	3.85	137		5.83	151	5.51	143	5.48	142	5.45	142
B-21-E	4.06			5.60	138	5.78	142	5.72	141	5.66	139
C-21-E	3.71			5.78	156	5.48	148	5.40	146	5.40	146
A-22-E	4.82	148		7.17	149	6.83	142	6.70	139	6.68	139
B-22-E	5.27			7.73	147	7.32	139	7.04	134	7.28	138
C-22-E	4.72			7.25	154	6.80	144	6.80	144	6.73	143
A-23-E	3.26	137		4.92	151	4.63	142	4.59	141	4.59	141
B-23-E	3.38			5.43	161	5.19	154	5.11	151	5.11	151
C-23-E	3.30			-	-	-	-	-	-	-	-
A-24-E	4.47	148		6.80	152	6.36	142	6.32	141	6.28	141
B-24-E	4.34			6.70	154	6.34	146	6.28	145	6.26	144
C-24-E	4.11			6.73	163	6.36	155	6.26	152	6.28	153
A-25-E	4.90	148		-	(4)	-	2	-	2	-	1
B-25-E	4.93			-	(27)	-	12	-	12	-	9
C-25-E	4.65			-	(4)	-	2	-	2	-	1
A-26-E	4.79	148		-	(1)	-	0	-	0	-	0
B-26-E	4.85			-	(1)	-	0	-	0	-	0
C-26-E	4.93			-	(1)	-	0	-	0	-	0
A-27-E	4.14	148		6.55	158	6.20	150	6.20	150	6.14	148
B-27-E	3.97			6.28	158	5.90	149	5.94	150	5.85	147
C-27-E	4.25			6.52	153	6.05	142	5.99	141	5.99	141

(Continued on next page)

Table 5 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Date / Deg-Cy x 10^{-6}	May 1947 1.45		May 1948 3.17		Dec 1948 3.17		May 1949 4.17	
				E	E, %	E	E, %	E	E, %	E	E, %
A-28-E	4.23	153		4.63	109	-	50	-	50	-	38
B-28-E	4.56			6.32	138	6.39	140	-	50	-	38
C-28-E	4.50			6.50	145	6.09	135	6.17	137	6.12	136
A-29-E	5.02	142		7.10	141	6.67	133	6.67	133	6.67	133
B-29-E	4.87			6.80	140	6.38	131	6.32	130	6.38	131
C-29-E	4.54			7.07	156	6.67	148	6.62	146	6.62	146
A-30-E	5.20	148		7.49	144	7.07	136	7.04	135	6.95	134
B-30-E	5.61			-	(2)	-	1	-	1	-	1
C-30-E	5.30			-	(2)	-	1	-	1	-	1
A-31-E	4.09	148		6.67	151	6.66	163	6.66	163	6.55	160
B-31-E	4.52			6.68	148	6.32	140	6.23	138	6.23	138
C-31-E	4.21			6.86	163	6.45	153	6.45	153	6.39	152
A-32-E	4.45	153		7.01	158	6.64	149	6.50	146	6.56	147
B-32-E	4.92			7.16	146	6.72	137	6.67	136	6.70	136
C-32-E	4.63			7.23	156	6.81	147	6.77	146	6.72	145
A-33-E	4.93	148		6.98	141	6.60	134	6.49	132	6.55	133
B-33-E	5.27			7.20	137	6.69	127	6.66	126	6.49	123
C-33-E	5.13			6.76	132	6.34	124	6.20	121	6.23	121
A-34-E	5.17	148		7.07	137	6.70	130	6.70	130	6.63	128
B-34-E	5.33			7.20	135	6.80	128	6.70	126	-	44
C-34-E	5.27			6.95	132	6.05	115	6.03	114	5.17	98

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Table 5 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Date / Deg-Cy x 10^{-6}	May 1947 1.45		May 1948 3.17		Dec 1948 3.17		May 1949 4.17	
				E	E, %	E	E, %	E	E, %	E	E, %
A-35-E	4.47	148		6.42	143	5.99	134	5.88	132	5.90	132
B-35-E	4.72			6.45	137	6.05	128	6.03	128	5.96	126
C-35-E	4.42			5.94	134	5.61	117	5.51	125	5.55	126
A-36-E	4.67	153		6.72	144	6.26	134	6.23	133	6.23	133
B-36-E	5.06			6.85	135	6.50	129	6.41	127	6.32	125
C-36-E	4.63			6.47	140	6.06	131	5.92	128	5.94	128
A-37-E	4.63	142		6.55	142	6.18	134	6.12	132	6.09	132
B-37-E	4.63			6.74	145	6.38	138	6.26	135	6.24	135
C-37-E	4.87			6.91	142	6.53	134	6.45	132	6.38	131
A-38-E	5.24	148		7.63	146	7.12	136	7.07	135	7.00	134
B-38-E	5.23			7.35	140	6.89	132	6.83	131	6.80	130
C-38-E	4.75			7.32	154	6.89	145	6.83	144	6.73	142
A-39-E	4.09	148		6.45	158	6.05	148	6.05	148	6.03	147
B-39-E	4.52			6.49	144	6.05	134	6.05	134	6.03	133
C-39-E	4.01			6.52	163	5.88	147	5.83	145	5.94	148
A-40-E	4.53	153		6.95	153	6.56	145	6.50	144	6.45	142
B-40-E	5.10			7.16	140	6.72	132	6.67	131	6.64	130
C-40-E	4.81			7.10	147	6.59	137	6.56	136	6.50	135
A-41-E	5.65	148		7.09	125	7.01	124	7.01	124	7.00	124
B-41-E	5.30			7.53	142	7.04	133	6.98	132	6.95	131
C-41-E	5.27			7.61	144	7.25	138	7.12	135	7.25	138

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Table 5 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Date / Deg-Cy x 10^{-6}	May 1947 1.45		May 1948 3.17		Dec 1948 3.17		May 1949 4.17	
				E	E, %	E	E, %	E	E, %	E	E, %
A-42-E	4.82	148		6.70	139	6.20	129	6.11	127	6.45	134
B-42-E	5.27			7.32	139	6.80	129	6.66	126	6.70	127
C-42-E	5.41			7.53	139	6.95	129	6.89	127	6.86	127
A-43-E	4.93	142		6.62	134	6.20	126	6.09	124	6.09	124
B-43-E	4.89			6.95	142	6.50	133	6.41	131	6.45	132
C-43-E	4.83			7.10	147	6.67	138	6.64	138	6.59	136
A-44-E	4.47	148		6.26	140	5.88	132	5.83	130	5.83	130
B-44-E	5.00			6.80	136	6.36	127	6.34	127	6.34	127
C-44-E	4.96			6.89	139	6.55	132	6.45	130	6.45	130
D-44-E	4.30			6.49	151	6.17	144	6.08	141	6.11	142
A-45-E	5.57	148		7.30	131	6.89	124	6.80	122	6.76	121
B-45-E	5.68			7.45	131	7.04	124	6.98	123	6.86	121
C-45-E	5.46			7.25	133	6.80	125	6.70	123	6.98	128
A-46-E	5.00	148		7.14	143	6.73	135	6.66	133	6.68	134
B-46-E	5.46			7.20	132	6.76	124	6.68	122	6.86	126
C-46-E	5.03			6.60	131	6.20	123	6.08	121	6.34	126
D-46-E	4.93			6.80	138	6.45	131	6.34	129	6.34	129
A-47-E	4.91	142		6.74	137	6.36	130	6.29	128	6.32	129
B-47-E	5.28			7.03	133	6.67	126	6.62	125	6.55	124
C-47-E	5.20			6.70	129	6.39	123	6.32	122	6.53	126
A-48-E	5.03	148		6.89	137	6.52	130	6.45	128	6.63	132
B-48-E	5.60			6.70	120	6.53	117	6.62	118	6.57	117
C-48-E	4.98			6.66	134	6.20	125	6.17	124	6.11	123

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Table 5 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Date / Deg-Cy x 10^{-6}	May 1947 1.45		May 1948 3.17		Dec 1948 3.17		May 1949 4.17	
				E	E, %	E	E, %	E	E, %	E	E, %
A-49-E	5.46	142		6.95	127	6.59	121	6.50	119	6.59	121
B-49-E	5.20			6.74	130	6.32	122	6.29	121	6.24	120
C-49-E	5.43			7.00	129	6.59	121	6.50	120	6.50	120
A-50-E	5.00	148		7.00	140	6.55	131	6.45	129	6.49	130
B-50-E	5.03			-	4	-	2	-	2	-	1
C-50-E	5.13			6.86	134	6.42	125	6.34	124	6.32	123
A-51-E	5.43	142		6.91	127	6.53	120	6.45	119	6.38	118
B-51-E	5.43			7.07	130	6.67	123	6.53	120	6.67	123
C-51-E	5.14			6.95	135	6.50	127	6.47	126	6.42	125
A-52-E	4.82	148		6.44	134	6.08	126	5.94	123	5.94	123
B-52-E	4.67			6.52	140	6.14	132	6.03	129	6.05	130
C-52-E	4.75			6.70	141	6.32	133	6.20	131	6.20	131
A-53-E	4.99	142		6.66	134	6.29	126	6.26	126	6.24	125
B-53-E	5.33			6.98	131	6.42	121	6.38	120	-	45
C-53-E	5.06			7.10	140	6.77	134	6.70	132	6.70	132
A-54-E	4.82	148		6.63	137	6.20	129	6.14	127	6.17	128
B-54-E	5.03			6.76	134	6.34	126	6.32	126	6.20	123
C-54-E	5.17			7.14	138	6.68	129	6.55	127	6.60	128
A-55-E	4.92	140		6.58	134	6.20	126	6.09	124	6.09	124
B-55-E	4.98			6.43	129	6.00	121	6.00	121	5.95	120
C-55-E	4.98			6.25	125	6.15	124	6.12	123	6.06	122

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Table 5 (Concluded)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Date / Deg-Cy x 10^{-6}	May 1947 1.45		May 1948 3.17		Dec 1948 3.17		May 1949 4.17	
				E	E, %	E	E, %	E	E, %	E	E, %
A-56-E	4.30	142		5.76	134	5.79	135	5.68	132	5.71	133
B-56-E	4.51			5.87	130	5.82	129	5.73	127	5.71	127
C-56-E	4.74			6.36	134	5.98	126	6.00	127	5.90	125
A-57-E	5.14	142		6.62	129	6.24	121	6.17	120	6.09	119
B-57-E	5.30			6.62	125	6.12	116	6.09	115	6.15	116
C-57-E	5.33			6.88	129	6.42	121	6.45	121	6.32	119
A-58-E	4.90	148		6.49	132	6.14	125	6.05	124	6.03	123
B-58-E	4.85			6.23	128	5.71	118	5.65	117	5.68	117
C-58-E	4.96			6.42	129	6.05	122	5.94	120	5.90	119
A-59-E	5.06	142		6.41	127	6.07	120	5.96	118	5.93	117
B-59-E	5.20			6.20	119	5.68	109	5.65	109	5.54	107
C-59-E	5.03			6.20	123	5.82	116	5.76	115	5.76	115
A-60-E	4.63	142		5.87	127	5.54	120	5.54	120	5.41	117
B-60-E	4.41			5.30	120	4.76	108	4.81	109	4.79	109
C-60-E	4.67			6.00	128	5.73	123	5.65	121	5.87	126

Table 6

NEUTRALIZED VINSOL RESIN PROGRAM (SERIES CR-NVR)

DURABILITY FACTORS (DFE) AT 4.17×10^{-6} DEGREE-CYCLES, MAY 1949

	Mixed at Atmospheric Pressure								Mixed at Low Pressure			
Coarse Aggregate:	Long Island Gravel				Conn. Trap Rock				Long Island Gravel		Conn. Trap Rock	
Type & Amt of Admix.	None	0.03 VR	0.01 NVR	0.02 NVR	None	0.03 VR	0.01 NVR	0.02 NVR	None	0.03 VR	None	0.03 VR
Cement A	1	130	131	131	130	141	129	132	39	122	98	132
Cement B	1	130	123	126	128	135	128	124	0	47	42	132
Cement C	125	142	121	122	135	146	85	128	41	140	135	146
Cement D	4	137	101	122	145	150	126	128	0	45	71	143
Cement E	126	133	118	113	128	143	120	117	90	135	129	136

Note: Specimens initially installed 12 October 1943.

Cycles of freezing-and-thawing = 703.

Table 7

NATIONAL BUREAU OF STANDARDS POZZOLITH PROGRAM (SERIES NBS)

CONCRETE COLUMNS INSTALLED AT TREAT ISLAND

CEMENT FACTOR FOR ALL SPECIMENS: 5.95 ± 0.10 BAGS/CU YD

No.	W/C, gpb	Slump In.	Brand & Specification of Cement	Location of Mill	Admixture	Initial E x 10^{-6}, psi	DFE May 1949, 711 Cycles (4.26×10^{-6} degree-cycles)
A	6.05	3-1/2	N. American 191b	Security, Md.	None	4.82	6
A-3	5.31	3-1/2			Pozz.	5.30	71
A-6	5.56	5-3/4			Pozz.	5.15	83
B	6.08	3-1/2	Green Bag 191b	Neville Is., Pa.	None	4.65	0
B-3	5.46	3			Pozz.	4.75	6
B-6	5.74	5-3/4			Pozz.	4.67	7
C	5.88	3-1/4	Lone Star 206a	Norfolk, Va.	None	4.80	1
C-3	4.99	3-1/2			Pozz.	5.41	3
C-6	5.30	6-1/4			Pozz.	5.21	19
D	5.92	3-1/2	Huron 206a	Alpena, Mich.	None	4.66	15
D-3	5.14	3-1/2			Pozz.	5.21	90
D-6	5.53	6			Pozz.	5.01	85
E	6.24	3-3/4	Wyandotte 206a	Wyandotte, Mich.	None	4.59	3
E-3	5.48	3-1/4			Pozz.	5.15	46
E-6	5.77	5-3/4			Pozz.	4.95	35
F	6.06	3-1/2	Nazareth 206a	Nazareth, Pa.	None	4.62	0
F-3	5.22	3-1/2			Pozz.	5.27	59
F-6	5.69	6-1/4			Pozz.	5.03	62

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Table 7 (Concluded)

No.	W/C, gpb	Slump In.	Brand & Specification of Cement		Location of Mill	Admixture	Initial E x 10^{-6}, psi	DFE May 1949, 711 Cycles (4.26×10^{-6} degree-cycles)
G	6.19	3-3/4	Lone Star	206a	Hudson, N. Y.	None	4.51	0
G-3	5.22	3-1/2				Pozz.	5.19	10
G-6	5.48	5-1/2				Pozz.	4.94	8
H	6.33	4	Lone Star	201a	Hudson, N. Y.	None	4.51	39
H-3	5.67	3-1/2				Pozz.	5.29	5
H-6	6.01	5-3/4				Pozz.	4.94	8
I	5.84	3-1/2	Alpha	191b	Birmingham, Ala.	None	4.52	4
1-3	5.14	3-1/2				Pozz.	5.12	46
1-6	5.29	6				Pozz.	5.24	50
J	6.07	3-1/2	Alpha	206a	Ironton, O.	None	4.75	3
J-3	5.07	3-3/4				Pozz.	5.16	114
J-6	5.26	6				Pozz.	5.02	117
K	6.17	3-1/2	Penn-Dixie	191b	Clinchfield, Ga.	None	4.55	2
K-3	5.31	3-1/2				Pozz.	5.25	27
K-6	5.54	5-3/4				Pozz.	5.11	78
L	6.21	3-3/4	Florida	206a	Hookers Pt., Fla.	None	4.58	1
L-3	5.27	3-1/2				Pozz.	5.02	15
L-6	5.63	6				Pozz.	4.89	35
M	5.90	3-1/2	Santa Clara	Low Heat	Permanente, Cal.	None	4.33	1
M-3	5.07	3-1/4				Pozz.	4.80	52
M-6	5.45	5-3/4				Pozz.	4.54	92

Table 8

MEMBRANE CURING PROGRAM (SERIES CR-M-A)

RECORD OF INSPECTION -- CONCRETE BEAMS AT TREAT ISLAND

Material Tested	Serial No.	Soil Base A E	Soil Base A E, %	Soil Base B E	Soil Base B E, %	Dry Base A E	Dry Base A E, %	Dry Base B E	Dry Base B E, %	Plywood A E	Plywood A E, %	Celotex A E	Celotex A E, %	Hydron A E	Hydron A E, %	Plywood B E	Plywood B E, %	Celotex B E	Celotex B E, %	Hydron B E	Hydron B E, %
Aquastatic I-C	1	7.2	124	-	-	-	-	-	-	6.7	137	6.7	137	6.8	133	-	-	-	-	-	-
		7.5	125	8.2	119	-	-	8.1	121	6.7	131	6.6	135	6.8	133	6.6	129	6.3	124	7.1	118
Aquastatic FMST	2	-	-	-	-	8.3	141	-	-	7.2	131	7.2	126	7.3	118	-	-	-	-	-	-
		7.5	125	6.7	105	-	-	7.7	122	7.1	129	6.9	119	7.0	113	6.6	140	6.7	120	6.1	111
Barrett Div.	3	7.8	122	-	-	-	-	-	-	6.6	127	7.0	125	6.7	114	-	-	7.1	125	6.8	119
		8.0	125	7.6	119	-	-	8.0	123	6.8	131	6.4	121	5.0	85	6.7	131	-	-	-	-
Curecote Black	4	7.5	123	-	-	6.9	119	-	-	6.3	134	7.1	129	6.3	119	-	-	-	-	-	-
		7.2	118	8.2	128	7.7	126	7.8	120	6.5	138	6.9	130	7.0	125	6.6	129	6.9	130	6.7	120
Hunt Process Black	5	-	-	-	-	-	-	-	-	6.9	141	6.5	116	7.0	127	-	-	-	-	-	-
		8.1	127	8.5	123	4.0	67	7.4	125	6.0	118	7.3	128	6.3	115	-	-	5.9	104	-	-
Masterkure	6	7.8	132	-	-	8.8	154	-	-	6.5	155	6.9	147	6.8	139	-	-	-	-	-	-
		7.5	125	5.9	92	7.1	125	7.4	121	6.3	150	6.9	141	6.8	139	7.3	138	6.3	119	7.2	131
Klearcure #70	7	7.8	128	-	-	9.1	149	-	-	-	-	7.2	131	5.8	109	-	-	-	-	-	-
		6.8	111	6.2	98	6.7	110	9.0	148	6.5	125	7.3	128	6.6	120	6.6	135	6.8	128	7.1	125
Ritecure-G	8	8.0	136	-	-	7.0	127	-	-	7.0	163	7.0	149	7.0	152	-	-	-	-	-	-
		8.2	132	8.0	129	5.5	100	7.6	129	6.7	163	6.8	145	6.7	143	6.8	155	7.3	138	7.3	138
Truscon #203	9	8.1	133	3.2	52	7.5	127	-	-	6.8	139	6.9	123	6.5	133	-	-	-	-	-	-
		6.9	121	-	-	8.1	137	9.3	143	6.3	154	7.0	125	6.3	119	6.9	144	-	-	5.8	105
Sealkure	10	7.6	125	-	-	7.0	121	-	-	3.0	70	6.0	102	3.6	68	-	-	-	-	-	-
		8.1	133	8.9	139	6.5	112	7.9	125	5.8	135	6.4	121	6.5	123	6.5	138	-	-	6.0	105
Water cure-Plain	11	7.9	134	-	-	4.9	80	-	-	5.6	124	6.8	128	7.3	149	-	-	-	-	-	-
		7.9	139	8.0	129	7.3	120	7.8	124	6.6	140	6.7	126	6.0	118	6.8	133	7.2	124	7.9	123
Air cure-Plain	12	7.9	146	-	-	8.0	151	-	-	6.3	137	6.6	147	7.2	147	-	-	-	-	-	-
		7.7	148	8.4	131	8.0	160	8.0	154	6.7	146	7.0	149	6.7	137	7.5	170	7.4	151	7.5	147
Pozzolith PS 4	13	6.9	135	-	-	7.3	133	-	-	6.8	133	6.7	143	6.0	122	-	-	-	-	-	-
		7.1	134	7.6	129	7.4	135	-	-	6.7	131	6.1	130	6.2	132	-	-	No dry base B made			
Pozzolith P 21	14	6.7	129	-	-	6.6	135	-	-	6.2	138	5.9	137	5.9	140	-	-	-	-	-	-
		6.9	144	7.1	137	6.6	135	8.3	126	6.5	138	6.1	136	5.9	131	7.4	116	7.7	120	7.3	116
Pozzolith P 24	15	7.4	132	-	-	7.0	132	-	-	6.4	136	6.8	126	7.3	128	-	-	-	-	-	-
		7.3	146	7.6	123	6.6	132	7.4	128	6.5	144	6.7	131	7.2	126	7.1	127	6.2	119	7.3	118
Pozzolith P 53	16	7.2	136	-	-	6.2	132	-	-	5.8	141	6.1	136	5.9	131	-	-	-	-	-	-
		6.8	133	7.2	129	6.4	136	6.4	121	6.1	142	6.2	138	6.0	133	5.7	124	5.5	120	5.8	126
Pozzolith P 58 (HP-7)	17	6.8	136	-	-	5.9	134	-	-	5.5	145	5.6	140	5.5	134	-	-	No dry base B made			
		6.7	140	7.4	130	6.2	141	-	-	5.8	145	6.2	144	5.5	134	-	-	-	-	-	-
Anti Hydro (Air cure)	18	7.5	150	-	-	7.5	142	-	-	6.8	151	6.9	138	7.0	137	-	-	-	-	-	-
		7.7	143	7.4	132	7.7	145	7.2	171	7.0	149	6.8	142	6.8	133	6.6	143	6.7	137	7.3	135
Vinxol resin (Water cure)	19	7.4	132	-	-	6.9	153	-	-	6.3	143	6.0	133	6.1	130	-	-	-	-	-	-
		7.2	138	7.7	131	6.3	131	6.3	129	6.5	141	6.2	138	6.2	132	6.1	133	6.0	122	6.6	118
Plastiment (Water cure)	20	9.6	135	-	-	8.1	131	-	-	6.8	139	6.1	115	5.3	100	-	-	-	-	-	-
		9.0	136	7.8	126	7.8	134	7.3	122	6.9	141	6.8	128	4.9	89	5.9	102	6.6	114	7.5	114
Sisalkraft-Plain	21	7.8	137	-	-	8.2	149	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8.1	135	5.9	97	4.9	84	6.7	118	-	-	-	-	-	-	-	-	-	-	-	-

Note: Values based on readings in December 1948 and May 1949.

Table 9

ADMIXTURE PROGRAM (SERIES CR-A)

RECORD OF INSPECTION -- CONCRETE BEAMS AT TREAT ISLAND

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Date / Deg-Cy x 10^{-6}	May 1946 0.23		May 1948 1.92		Dec 1948 1.92		May 1949 2.71	
				E	E, %	E	E, %	E	E, %	E	E, %
PC5A	5.69	156		6.44	113	-	14	-	14	-	10
PB5A	6.31			2.20	35	-	4	-	4	-	3
PC5B	5.69			6.44	113	-	-	3.56	63	-	45
PB5B	5.94			6.82	115	6.84	115	6.84	115	6.84	115
PC5C	5.69			6.69	118	6.32	111	6.47	114	6.58	116
PB5C	6.18			7.09	115	6.96	113	6.99	113	6.90	112
PC4	5.25	150		6.13	117	6.19	118	6.20	118	6.77	129
PB4	5.48			6.07	111	6.19	113	6.25	114	6.20	113
PC6	5.82	156		6.44	111	-	30	-	30	-	21
PB6	6.06			6.96	115	6.96	115	7.03	116	6.97	115
RC5A	5.25	150		6.19	118	6.19	118	6.24	119	6.20	118
RB5A	5.71			6.44	113	6.56	115	6.60	116	6.64	116
RC5A1	5.36			6.17	115	6.19	115	6.27	117	6.26	117
RB5A1	5.48			6.19	113	6.32	115	6.33	115	6.33	116
RC5B	5.03			6.01	119	6.07	121	6.08	121	6.08	121
RB5B	5.48			6.29	115	6.39	117	6.35	116	6.39	117
RC5C	5.48			6.25	114	6.32	115	6.36	116	6.33	116
RB5C	5.48			6.19	113	6.25	114	6.26	114	6.26	114
RC4	4.55	145		5.41	119	5.31	117	5.39	119	5.30	116
RB4	4.86			5.52	114	5.52	114	5.52	114	5.41	111
RC6	5.36	150		6.07	113	6.13	114	6.08	113	6.08	113
RB6	5.25			6.32	120	6.41	122	6.08	116	6.20	118

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Table 9 (Continued)

Specimen Number	Initial E x 10^{-6}, psi	Density lb/cu ft	Date / Deg-Cy x 10^{-6}	May 1946 0.23		May 1948 1.92		Dec 1948 1.92		May 1949 2.71	
				E	E, %	E	E, %	E	E, %	E	E,%
TC5A	5.47	153		6.44	118	6.43	118	6.44	118	6.31	115
TB5A	6.19			6.82	110	7.02	113	6.97	113	7.02	113
TC5B	4.90	153		5.94	121	6.04	123	6.04	123	6.07	124
TB5B	5.94			6.57	111	6.70	113	6.69	113	6.57	111
TC5C	5.59			5.35	96	-	50	-	50	-	35
TB5C	5.82			6.57	113	6.57	113	6.66	114	6.63	114
TC4	5.35	153		6.25	117	6.13	115	6.13	115	6.76	126
TB4	5.70	153		6.13	108	6.07	106	6.05	106	6.31	111
TC6	5.70			6.50	114	6.57	115	6.53	115	6.19	109
TB6	5.70	153		6.82	120	6.94	122	6.93	122	6.89	121
DC5A	5.48	150		6.25	114	6.32	115	6.33	115	6.39	117
DB5A	5.83			6.69	115	6.75	116	6.77	116	6.77	116
DC5B	5.25			5.83	111	5.83	111	5.86	112	5.84	111
DB5B	5.36			6.19	115	6.19	115	6.25	117	6.20	116
DC5C	5.03			5.95	118	5.95	118	5.96	118	5.96	118
DB5C	5.14			5.83	113	5.95	116	5.87	114	5.84	114
DC4	4.86	145		5.52	114	5.52	114	5.47	113	5.41	111
DB4	4.75			5.41	114	5.18	109	5.18	109	5.08	107
DC6	5.25	150		6.07	116	6.07	116	6.04	115	5.96	113
DB6	5.36			6.38	119	6.38	119	6.20	116	6.45	120
HC5A	5.52	148		6.42	116	6.48	117	6.47	117	6.42	116
HB5A	5.75			6.79	118	6.73	117	6.40	111	6.73	117
HC5B	5.18			5.87	113	5.99	116	6.73	130	6.05	117
HB5B	5.18	148		5.99	116	6.11	118	5.99	116	6.11	118
HC5C	5.41			6.48	120	6.23	115	6.37	118	6.35	117
HB5C	5.41			6.23	115	6.29	116	6.26	116	6.23	115

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Table 10

COMPARATIVE FIELD AND LABORATORY FREEZING-AND-THAWING TESTS (SERIES 6508)

RECORD OF INSPECTION -- CONCRETE BEAMS AT TREAT ISLAND

		3-1/2- x 4-1/2- x 16-in. Beams				6- x 6- x 30-in. Beams			
Fine Aggregate	Coarse Aggregate	Specimen No.	Initial E x 10^{-6}, psi	May 1949 E	May 1949 E, %	Specimen No.	Initial E x 10^{-6}, psi	May 1949 E	May 1949 E, %
Granite	Granite	3001	5.09	5.19	102	3004	4.82	5.11	106
		3002	4.79	4.93	103	3005	5.08	5.23	103
		3003	4.96	5.16	104	3006	4.80	4.99	104
Quartzite	Granite	3010	5.09	5.19	102	3013	5.29	5.13	97
		3011	5.09	5.14	101	3014	4.99	5.34	107
		3012	5.24	5.40	103	3015	5.39	5.66	105
Natural sil. sand	Granite	3019	5.21	5.37	103	3022	5.15	5.61	108
		3020	4.94	5.09	103	3023	5.00	5.40	108
		3021	5.10	5.35	105	3024	5.07	5.53	109
Limestone	Granite	3028	4.47	4.51	101	3031	4.36	4.58	105
		3029	4.58	4.67	102	3032	4.39	4.52	103
		3030	4.75	4.84	102	3033	4.28	4.54	106
Chert sand	Granite	3247	5.52	5.63	102	3250	4.97	5.32	107
		3248	5.06	5.11	101	3251	4.97	5.37	108
		3249	5.26	5.42	103	3252	5.32	5.59	105
Non-chert sand	Granite	3256	4.84	4.98	103	3259	4.67	5.00	107
		3257	4.69	4.78	102	3260	4.67	5.09	109
		3258	4.95	5.10	103	3261	4.69	5.02	107
Cherty river sand	Granite	3238	4.75	5.03	106	3241	4.96	5.11	103
		3239	4.73	5.06	107	3242	5.20	5.30	102
		3240	4.93	5.08	103	3243	4.97	5.32	107

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Table 10 (Continued)

Fine Aggregate	Coarse Aggregate	3-1/2- x 4-1/2- x 16-in. Beams Specimen No.	Initial E x 10^{-6}, psi	May 1949 E	E, %	6- x 6- x 30-in. Beams Specimen No.	Initial E x 10^{-6}, psi	May 1949 E	E, %
Miss. River sand	Granite	3265	5.24	5.40	103	3268	5.02	5.42	108
		3266	5.02	5.17	103	3269	5.27	5.37	102
		3267	5.35	5.56	104	3270	4.95	5.30	107
Granite	Quartzite	3037	5.51	5.62	102	3040	5.48	5.48	100
		3038	5.14	5.09	99	3041	5.46	5.57	102
		3039	5.49	5.54	101	3042	5.43	5.48	101
Quartzite	Quartzite	3064	6.33	6.39	101	3067	6.42	6.61	103
		3065	6.20	6.26	101	3068	6.10	5.86	96
		3066	6.26	6.13	98	3069	6.08	6.08	100
Natural sil. sand	Quartzite	3046	6.78	6.78	100	3049	6.29	6.42	102
		3047	6.11	6.11	100	3050	6.55	6.55	100
		3048	6.63	6.56	99	3051	6.31	6.37	101
Limestone	Quartzite	3055	5.29	5.29	100	3058	5.44	5.55	102
		3056	5.43	5.38	99	3059	5.75	5.92	103
		3057	5.57	5.74	103	3060	5.59	5.87	105
Chert sand	Quartzite	3274	7.27	7.27	100	3277	6.61	6.68	101
		3275	6.96	7.24	104	3278	7.10	7.31	103
		3276	7.02	7.09	101	3279	6.13	6.31	103
Non-chert sand	Quartzite	3319	6.08	5.90	97	3322	6.06	6.12	101
		3320	6.09	6.03	99	3323	6.34	6.34	100
		3321	6.20	5.95	96	3324	5.94	6.06	102
Cherty river sand	Quartzite	3283	5.88	5.82	99	3286	6.38	6.44	101
		3284	5.78	5.90	102	3287	5.97	5.97	100
		3285	6.03	5.85	97	3288	6.29	6.35	101

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Table 10 (Continued)

Fine Aggregate	Coarse Aggregate	3-1/2- x 4-1/2- x 16-in. Beams				6- x 6- x 30-in. Beams			
		Specimen No.	Initial E x 10^{-6}, psi	May 1949 E	May 1949 E, %	Specimen No.	Initial E x 10^{-6}, psi	May 1949 E	May 1949 E, %
Miss. River sand	Quartzite	3292	6.50	6.56	101	3295	6.32	6.32	100
		3293	6.49	6.49	100	3296	6.22	6.34	102
		3294	6.42	6.36	99	3297	6.69	6.42	96
Granite	Limestone	2965	5.19	5.24	101	2968	5.57	5.68	102
		2966	5.20	5.25	101	2969	5.34	5.61	105
		2967	5.19	5.19	100	2970	5.30	5.51	104
Quartzite	Limestone	2977	5.41	5.52	102	2971	5.39	5.61	104
		2978	5.46	5.41	99	2972	5.18	5.59	108
		2979	5.25	5.25	100	2973	5.28	5.54	105
Natural sil. sand	Limestone	2992	5.50	5.50	100	2989	5.63	5.86	104
		2993	5.76	5.88	102	2990	5.94	6.06	102
		2994	5.89	5.83	99	2991	5.99	5.87	98
Limestone	Limestone	2983	5.09	5.09	100	2986	4.94	5.04	102
		2984	4.83	4.88	101	2987	5.00	4.95	99
		2985	4.93	4.98	101	2988	4.93	5.27	107
Chert sand	Limestone	3211	5.92	5.86	99	3214	5.92	5.86	99
		3212	5.46	5.41	99	3215	5.79	5.91	102
		3213	5.68	5.74	101	3216	5.61	5.67	101
Non-chert sand	Limestone	3220	5.41	5.57	103	3223	5.34	5.39	101
		3221	5.22	5.06	97	3224	5.41	5.30	98
		3222	5.32	5.32	100	3225	5.54	5.76	104
Cherty river sand	Limestone	3202	5.23	5.23	100	3205	5.07	5.07	100
		3203	5.11	4.80	94	3206	5.39	5.44	101
		3204	4.95	4.90	99	3207	5.04	4.99	99

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Table 10 (Continued)

Fine Aggregate	Coarse Aggregate	3-1/2- x 4-1/2- x 16-in. Beams				6- x 6- x 30-in. Beams			
		Specimen No.	Initial E x 10^{-6}, psi	May 1949 E	May 1949 E, %	Specimen No.	Initial E x 10^{-6}, psi	May 1949 E	May 1949 E, %
Miss. River sand	Limestone	3229	5.37	5.42	101	3232	5.69	5.92	104
		3230	5.52	5.46	99	3233	5.89	5.65	96
		3231	5.54	5.43	98	3234	5.42	5.53	102
Granite	Chert (uncrushed)	3112	5.32	5.32	100	3115	5.33	5.22	98
		3113	5.16	5.21	101	3116	5.49	5.65	103
		3114	5.16	5.21	101	3117	5.52	5.85	106
Quartzite	Chert (uncrushed)	3121	5.44	5.60	103	3124	5.68	5.51	97
		3122	5.44	5.49	101	3125	5.62	5.34	95
		3123	5.55	5.61	101	3126	5.77	5.60	97
Natural sil. sand	Chert (uncrushed)	3130	5.38	5.33	99	3133	6.21	5.90	95
		3131	5.23	5.33	102	3134	5.68	5.68	100
		3132	5.36	5.41	101	3135	5.76	5.70	99
Limestone	Chert (uncrushed)	3139	4.97	5.07	102	3142	5.00	5.15	103
		3140	4.57	4.62	101	3143	5.16	5.06	98
		3141	4.77	4.91	103	3144	5.13	5.03	98
Chert sand	Chert (uncrushed)	3346	5.83	5.71	98	3349	5.89	5.89	100
		3347	5.88	5.64	96	3350	6.08	6.08	100
		3348	5.94	5.76	97	3351	6.12	6.30	103
Non-chert sand	Chert (uncrushed)	3364	6.04	5.92	98	3367	5.17	5.38	104
		3365	5.47	5.41	99	3368	5.41	5.52	102
		3366	5.81	5.64	97	3369	5.40	5.51	102
Cherty river sand	Chert (uncrushed)	3375	5.49	5.43	99	3378	5.54	5.65	102
		3376	5.45	5.34	98	3379	5.58	5.52	99
		3377	5.31	5.47	103	3380	5.58	5.63	101

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Table 10 (Continued)

Fine Aggregate	Coarse Aggregate	3-1/2- x 4-1/2- x 16-in. Beams				6- x 6- x 30-in. Beams			
		Specimen No.	Initial E x 10^{-6}, psi	May 1949 E	May 1949 E, %	Specimen No.	Initial E x 10^{-6}, psi	May 1949 E	May 1949 E, %
Miss. River sand	Chert (uncrushed)	3355	6.09	5.91	97	3358	5.85	5.91	101
		3356	5.81	5.66	97	3359	5.88	6.00	102
		3357	5.87	5.75	98	3360	5.78	5.95	103
Granite	Chert (crushed)	3157	4.95	5.20	105	3160	5.19	5.40	104
		3158	4.81	5.00	104	3161	4.92	5.02	102
		3159	5.07	5.27	104	3162	4.99	4.89	98
Quartzite	Chert (crushed)	3166	5.28	5.28	100	3169	5.41	5.41	100
		3167	5.32	5.43	102	3170	5.42	5.42	100
		3168	5.33	5.44	102	3171	5.71	5.71	100
Natural sil. sand	Chert (crushed)	3175	5.84	5.90	101	3178	5.78	5.84	101
		3176	5.67	5.73	101	3179	5.63	5.69	101
		3177	5.62	5.62	100	3180	6.15	6.03	98
Limestone	Chert (crushed)	3148	4.70	4.79	102	3151	4.66	4.71	101
		3149	4.52	4.61	102	3152	4.69	4.78	102
		3150	4.58	4.67	102	3153	4.72	4.63	98
Chert sand	Chert (crushed)	3393	5.24	5.45	104	3396	5.45	5.61	103
		3394	5.25	5.35	102	3397	5.43	5.59	103
		3395	5.58	5.75	103	3398	5.53	5.75	104
Non-chert sand	Chert (crushed)	3402	5.40	5.56	103	3405	4.53	5.25	116
		3403	5.10	5.25	103	3406	5.16	5.42	105
		3404	5.15	5.30	103	3407	5.18	5.49	106
Cherty river sand	Chert (crushed)	3384	5.12	5.27	103	3387	4.87	5.06	104
		3385	5.11	5.31	104	3388	4.94	5.09	103
		3386	5.07	5.27	104	3389	5.25	5.30	101

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Table 10 (Continued)

Fine Aggregate	Coarse Aggregate	3-1/2- x 4-1/2- x 16-in. Beams				6- x 6- x 30-in. Beams			
		Specimen No.	Initial E x 10^{-6}, psi	May 1949 E	May 1949 E, %	Specimen No.	Initial E x 10^{-6}, psi	May 1949 E	May 1949 E, %
Miss. River sand	Chert (crushed)	3411	5.10	5.35	105	3414	5.16	5.42	105
		3412	5.05	5.15	102	3415	5.20	5.46	105
		3413	5.14	5.45	106	3416	4.98	5.38	108
Granite	Non-chert gravel	3100	5.73	5.90	103	3103	5.56	5.67	102
		3101	5.20	5.30	102	3104	5.36	5.52	103
		3102	5.62	5.79	103	3105	5.53	5.97	108
Quartzite	Non-chert gravel	3073	6.10	6.04	99	3076	6.20	6.45	104
		3074	6.08	5.96	98	3077	6.32	6.57	104
		3075	6.34	6.09	96	3078	6.30	6.17	98
Natural sil. sand	Non-chert gravel	3091	6.48	6.67	103	3094	6.06	6.36	105
		3092	6.37	6.50	102	3095	6.42	6.55	102
		3093	6.59	6.66	101	3096	6.03	6.27	104
Limestone	Non-chert gravel	3082	4.79	4.74	99	3085	5.10	5.25	103
		3083	5.16	4.85	94	3086	5.53	5.53	100
		3084	5.00	4.90	98	3087	5.12	5.32	104
Chert sand	Non-chert gravel	3328	6.51	6.25	96	3331	6.35	6.48	102
		3329	6.22	6.28	101	3332	6.19	-	-
		3330	6.25	6.06	97	3333	5.94	6.24	105
Non-chert sand	Non-chert gravel	3310	6.37	6.12	96	3313	5.82	5.88	101
		3311	5.96	5.90	99	3314	5.94	5.70	96
		3312	6.48	6.22	96	3315	5.98	5.98	100
Cherty river sand	Non-chert gravel	3301	6.08	6.02	99	3304	5.76	5.93	103
		3302	5.84	5.61	96	3305	5.71	5.82	102
		3303	6.02	5.84	97	3306	5.28	5.49	104

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Table 10 (Concluded)

Fine Aggregate	Coarse Aggregate	3-1/2- x 4-1/2- x 16-in. Beams				6- x 6- x 30-in. Beams			
		Specimen No.	Initial E x 10^{-6}, psi	May 1949 E	May 1949 E, %	Specimen No.	Initial E x 10^{-6}, psi	May 1949 E	May 1949 E, %
Miss. River sand	Non-chert gravel	3337	6.21	6.09	98	3340	6.40	6.34	99
		3338	6.13	6.01	98	3341	6.13	6.31	103
		3339	6.39	6.26	98	3342	6.67	6.67	100
Quartzite	Quartzite (Re-Run)	3428	5.86	6.27	107	3431	5.77	6.17	107
		3429	5.98	6.28	105	3432	5.82	6.11	105
		3430	5.89	6.30	107	3433	5.71	6.11	107
Limestone	Limestone (Re-Run)	3443	4.45	4.58	103	3446	4.38	4.69	107
		3444	3.97	4.17	105	3447	4.73	4.82	102
		3445	4.54	4.68	103	3448	4.48	4.79	107